ADOPTION OF IMPROVED MAIZE AND COMMON BEAN VARIETIES IN MOZAMBIQUE

By

Helder Lopes

A THESIS

Submitted to
Michigan State University
In partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Agricultural, Food, and Resource Economics

2010

ABSTRACT

ADOPTION OF IMPROVED MAIZE AND COMMON BEAN VARIETIES IN MOZAMBIQUE

By

Helder Lopes

Household adoption of new agricultural technologies, including improved maize and bean varieties in Mozambique, is still relatively low. As a result, the average maize and common bean production remains low.

This study identifies factors that are associated with households' adoption of improved maize and bean varieties, using *Trabalho de Inquérito Agrícola* (TIA) 2007 data and the probit model to estimate the likelihood of household adoption of improved varieties of maize and common beans at both the national and regional levels.

At the national level, the results indicate that household head's education, access to extension services and credit are associated with the household's adoption decision. However, association membership is negatively associated with the adoption decision. Education and extension are only statistically significant for the improved maize analysis. These findings suggest that households who had access to support services are more likely to adopt improved varieties. Household adoption of improved maize and bean varieties could be increased from the current 12% and 15% percent adoption rates, respectively, if 1) the current extension programs are strengthened to better respond to households' information needs, as well as to serve more households in different geographical areas, and 2) household access' to credit is expanded.

DEDICATED

I dedicate all of my works and life to Jesus Christ, the only Son of almighty God.

This thesis is dedicated to

my wife “Anata,” for her never ending love, support, and encouragement,

my daughters “Paia and Cipi,” your presence inspires my life very much,

and to my father, mother, brothers, and sister for their love and support.

ACKNOWLEDGEMENT

I would like to extend my sincere and great gratitude to Dr. Richard Bernsten, my major professor, for all of his extraordinary and excellent guidance, advice, and encouragements for my study program and thesis. I am also grateful to my academic committee members: Dr. Cynthia Donovan, Dr. Eric Crawford, Dr. Russell Freed, and Dr. Songqing Jin for their excellent advice, guidance, and constructive criticisms.

I would not have been able to pursue the master program in the Department of Agricultural, Food, and Resource Economics at Michigan State University without the financial support from the United States Agency for International Development (USAID) through the Academy for Educational Development (AED). Therefore, my great gratitude is to the USAID and all the AED staff.

This thesis would not have been completed without permission to use the Mozambique Agricultural Household Survey data, known as TIA (*Trabalho de Inquerito Agricola)*. Thank you to the Ministry of Agricultural of Mozambique for providing and allowing me to use the TIA 2007 survey data for my thesis. Thank you also to David Mather, Helder Zavale, and Ellen Payongayong for their help and guidance.

Thank you to all professors, staff, and colleagues in the department of AFRE. It was wonderful to learn together with you, and took part in this great academic community -- I will miss you all. Lastly, I would like to convey my special thanks to my host family and all of the people who have been helping me in my life. Your kindness and generosity will make me miss you so much. May the almighty GOD bless and be with us always.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AED – Academy for Educational Development

CAP – Censo Agro-Pecuário

CDF – Cumulative Distributive Function

FAO – Food and Agriculture Organization

GDP – Gross Domestic Product

IV – Improved Varieties

INE – Instituto Nacional de Statistica

LPM – Linear Probability Model

MADER – Ministry of Agriculture and Rural Development

MDG – Millennium Development Goals

MINAG – Ministry of Agriculture

NGO – Non-Government Organization

PARPA – Plano de Acção Para a Redução da Probeza Absoluta

PROAGRI – Programa Nacional de Desenvolvimento Agrária

TIA - Trabalho de Inquérito Agrícola

UPA – Unidade Primaria de Amostragem

USAID – United States Agency for International Development

CHAPTER I: INTRODUCTION

1.1. Introduction

This chapter presents a brief introduction to the thesis. The chapter is divided into eight sections. The second section presents a general background of the thesis, focusing on agricultural development and staple foods (e.g., maize and beans) production in Mozambique. The third section describes problem statements of the study, including a brief description on the technology adoption pattern in Mozambique and the reason to conduct this study. The fourth section reviews the research questions, including what factors are believed to be associated with household adoption of improved maize and common bean varieties. The fifth section presents the general and specific objectives of the study. The sixth section describes the hypothesis testing. The seventh section describes the structure of the thesis. The last section summarizes the chapter.

1.2.General Background

Over the past decade, Mozambique has made remarkable progress in its economic development, which is indicated by an increase in household income and assets holdings, improved quality of public services, and a reduction in poverty by 15% between 1996 and 2003 (World Bank, 2008). Despite this economic improvement, more than one-half of the population still lives in poverty. Most poor people live in rural areas, where subsistence agriculture is their main economic activity.

The agricultural sector plays a very important role in the socio-economic development of Mozambique because most of the population, who live in rural areas, is heavily dependent on agriculture for their livelihood. This sector also provides employment to over 75% of the population and from 2005-2008, and the agricultural sector accounts for an averaged 28 percent of the country's Gross Domestic Product (World Bank, 2008; Corzine, 2008; FAO, 2009; Tomo, 2009).

Despite the agricultural sector being a very important component of the country's economy, its performance is still relatively low. The government has attempted to address low agricultural productivity through its "Strategy Plan to Reduce Poverty," referred to by its Portuguese acronym PARPA II (Plano de Acção Para a Redução da Probeza Absoluta)," focuses on promoting sustained agricultural production and growth by increasing investment in agricultural research and extension services, improving agricultural infrastructure, and increasing agricultural inputs-outputs accessibility. In this key planning document, the government also identifies agricultural technology as an important means for reducing hunger and poverty.

The Mozambique agriculture sector is characterized by farm households who grow crops for subsistence on rainfed land using manual cultivation techniques and with little use of purchased inputs. According to Bias and Donovan (2003), households grow three categories of crops: 1) basic staple food crops, such as maize and cassava, which are grown by most farm households; 2) food crops for diversification or with regional specialization, such as beans, groundnuts, sorghum, millet, rice, cashews, and sweet potatoes; and 3) cash crops, such as cotton, tobacco, tea, and sugar cane. Mozambique can increase the production of all of these crops by using its enormous potential of natural resources, improving agricultural infrastructure, and increasing household adoption of improved crop varieties and other new agricultural technologies.

To increase the population's access to food, improve nutrition, and reduce poverty in rural areas, it is necessary to progressively transform the subsistence-oriented agricultural sector into a more productive sector. According to Zavale et al. (2005), staple food crop production in Mozambique could be expanded through a substantial increase in improved seed production, improvements in seeds distribution system, and an increase in households' adoption of improved varieties. Furthermore, they argue that Mozambique's current demography trends and population growth projections indicate that improving agricultural productivity, especially increasing the production of maize, beans, rice, and other staple food crops, is required to insure food security for all of the population, increase households' income, and avoid a future increase in poverty due to food shortages.

1.3. Problem Statement

Maize and common beans *(Phaseolus vulgaris)* are two important staple food crops that are widely produced and consumed throughout the country and provide income to households in rural areas. Approximately 90% of the country's maize is produced in the northern region, which is the most productive agricultural region of the country. In contrast, the south and the central regions are typically deficit in basic foods, depending upon the year. Maize, which accounts for 35% of the total cultivated areas, is grown by 79% of the country's farmers. However, households' average maize yield is relatively low, ranging from 250 to 800 kg/hectare, compared to 830 to 3,000 kg/hectare in Southern Africa. On the other hand, common beans are also a staple food crop that is produced by households in some regions of the country. An analysis used TIA 2002-2006 survey data estimated that, on average, small-and medium-scale farmers produced

55,022.8 tons during 2006-2006 (Corzine, 2008; Zalave et al., 2005; Bias and Donovan, 2003; Instituto Nacional de Statistica, 2010).

For developing countries, new agricultural technologies have the potential to reduce poverty and food shortage. In many developed and developing countries, new agricultural technologies have increased agricultural productivity, contributed to the overall economic growth, and ensured food security (Bandeira and Rasul, 2005; Cornejo and McBridge, 2002). According to Uaiene et al. (2009), many new agricultural technologies are currently available in Mozambique, including improved open-pollinated maize varieties (OPV), hybrid maize seed, input packages (e.g., fertilizer, pesticide), improved farm storage techniques, and small scale irrigation technologies (e.g., treadle pumps). Unfortunately, while available in principle, households' awareness of and access to these new technologies is distinctly limited in practice.

To encourage households to adopt new agricultural technologies and increase agricultural productivity, the government and non-government organizations may need to increase the number of extension agents and expand their diffusion programs (Gemo 2006). However, Uaiene et al. (2009) report that since 2004, the number of public extension agents has declined from 708 to approximately 600 agents, and only 15% of rural households have access to extension services from either the government or non-government organizations. This suggests that the number of households who are aware of and have access to new agricultural technologies, including improved maize and bean varieties, is relatively small.

Improved varieties (e.g., improved maize and beans) have the potential to increase production, as well as increase the income and improve the standard of living for farm households. Unfortunately, the rate of agricultural technology adoption in Mozambique remains low. For example, Uaiene et al. (2009), basing their analysis of TIA 2005 survey data, report that approximately seven and 11% of agricultural households planted improved maize and bean varieties, respectively. Furthermore, they report that less than five percent of households applied fertilizer and pesticide to their food crops. Improved maize and bean varieties have a potential to increase agricultural productivity in Mozambique, if they were widely diffused and adopted. However, deciding if they should adopt improved varieties, households compared the benefits and costs of improved varieties with traditional varieties. According to some experts, few households cultivate improved varieties of maize and other staple food crops due to their questionable economic profitability. For example, in Mozambique, in good years when yields are high, households receive low prices. Furthermore, the price of grain does not increase in bad years, despite low production because the government and non-government organizations distribute food grain to alleviate hunger.

Mozambique needs to increase maize and bean production to secure food and increase nutrition for all populations, especially those that live in rural areas. A few empirical studies, such as from Uaiene et al. (2009), Zavale et al. (2005) and Bandeira and Rasul (2005) report that one of the factors that affect low production of maize in Mozambique is the lack of use of improved varieties. Given the fact that adoption of agricultural technologies in Mozambique is still relatively low, this study will use the 2007 Mozambique Agricultural Household Survey data, known as TIA (*Trabalho de Inquérito Agrícola*) to identify factors associated with households' adoption of improved maize and bean varieties in the 2006/2007 agricultural year.

1.4.Research Objectives

The general objective of this study is to use the 2007 TIA data to describe the maize and bean production systems, and analyze households' adoption of improved maize and bean varieties in rural areas of Mozambique. Drawing on the result of the analysis, this study proposes policy recommendations to stakeholders, which will enable them to better understand options for improving maize and bean production.

The specific objectives of this study are to:

1) Describe the maize and bean production systems in Mozambique
2) Estimate the rate of adoption of improved maize and bean varieties in the 2006/2007 agricultural year, by provinces, family size, age, and education level of household heads.
3) Use probit analysis to identify factors that are associated with households' adoption of improved maize and bean varieties at the national and regional levels.
4) Identify constraints that institutions face in promoting the diffusion of improved maize and bean varieties.
5) Provide recommendations to relevant stakeholders (e.g., the government) for accelerating the household adoption of improved maize and bean varieties.

1.5. Research Questions

1) To what extent does the adoption of improved maize and bean varieties affect the production of maize and bean varieties in Mozambique?
2) What percentage of households adopted improved maize and bean varieties in the 2006/2007 agricultural year?

3) What factors are associated with household adoption of improved maize and bean varieties?
4) What constraints are associated with household adoption of improved maize and bean varieties?
5) What policies are needed to increase household adoption of improved maize and bean varieties in Mozambique?

1.6. Hypothesis

The government of Mozambique has invested significant resources to strengthen agricultural research, extension services, and create agricultural associations. However, agricultural productivity and household adoption of improved maize and bean varieties are still relatively low.

Factors hypothesized to be positively associated with households' technological adoption behaviors in Mozambique, include farmers' socio-demography characteristics (e.g., household head's age and education), institutional factors (e.g., access to extension services and credit), and risks and economic attributes (e.g., flood, and whether or not household plant cotton and tobacco). This study hypothesizes that the specific factors that are associated with household adoption of improved maize and bean varieties are household size *(HH_Size)*; household head's age *(HH_Age),* education *(HH_Educ),* gender *(HH_Sex),* and salaried employment *(HH_Sal_Emp);* household had access to extension services *(Acc_Ext),* credit *(Acc_Credit),* and price information from markets *(Acc_Price_Info)*; membership in an agricultural association *(Mem_Ass);* used of animal tractions *(Use_Ani_Traction);* and a household grew cotton or tobacco in the previous year *(Cotton* or *Tobacco).* In contrast, the impact of flood *(Risk_Flood),* drought

(Risk_Drought), and damage by wild animals *(Risk_Wild_Ani)* on crop productions in the last two years are hypothesized to be negatively associated with household adoption decision.

1.7. Organization of Thesis

This thesis is structured into seven chapters. Chapter II presents a literature review of agricultural technologies adoption in developing countries, focusing on factors associated with households' adoption decisions. Chapter III provides an overview of Mozambique's socio-economic characteristics, demography, and the agricultural sector. Chapter IV presents an overview on the Mozambique Agricultural Household Survey, focusing on the objectives and implementation of the TIA 2007 survey. Chapter V describes the method of analysis. Chapter VI presents the result of the analysis and its implications for improving agricultural productivity, focusing on the adoption rates of improved maize and bean varieties, as well as the interpretation of adoption likelihood at the national and regional levels. Chapter VII summarizes the main finding of the research, highlights its policy implications, identifies limitations, and makes recommendations for future research.

1.8. Chapter Summary

The productivity of the agricultural sector in Mozambique is still relatively low because most farm households grow basic staple food crops (e.g., maize, beans and cassava) and cash crops (e.g., tea, cotton, tobacco and sugar cane) for subsistence on rainfed land, and use manual cultivation techniques and with little use of modern inputs. Mozambique has a potential to increase agricultural productivity by using its enormous potential natural resources and transforming agriculture sector from the subsistence-oriented to a more productive sector. In PARPA II, the government gives priority to promoting sustained agricultural production and growth by increasing agricultural research and extension services, improving agricultural infrastructure, increasing agricultural inputs-outputs accessibility, and identifying agricultural technology as an important means for reducing hunger and poverty.

Modern agricultural technologies, including improved maize and bean varieties, have the potential to increase crop production, as well as increase income and standard of living for farm households in Mozambique, if new agricultural technologies are widely diffused and adopted. Unfortunately, the rates of new agricultural technologies (e.g., improved maize and bean varieties) adoption remain low. This study uses data from TIA 2007 to identify factors associated with farm household adoption of improved varieties. Descriptive statistics, probit regressions, and marginal effect analyses are used to provide information on the adoption rate, and estimate factors associated with households' varietal adoption decisions. Drawing on the result, this study proposes policy recommendation to stakeholders, which will enable them to better understand options for increasing maize and bean production.

CHAPTER II: LITERATURE REVIEW

2.1. Introduction

This chapter reviews the literature on the adoption of agricultural technologies in developing countries. The chapter is divided into four sections. The second section reviews the literature on the definition and conceptualization of technological adoption. The third section presents the literature on factors that are associated with farmers' adoption behaviors, focusing on farmers' socio-demography characteristics, institutional factors, farmers' perceptions and characteristics of technologies, and risks and economic attributes. The last section summarizes the chapter.

2.2. Definition and Conceptualization of the Technological Adoption

Agricultural research focuses on developing new technologies to improve agricultural productivity and farmers' well-being. The rapid adoption of new agricultural technologies in developed and some developing countries has increased agricultural productivity, contributed to overall economic growth, and reduced food insecurity and poverty (Bandeira et al, 2005; Cornejo and McBridgje, 2002).

The definition and conceptualization of agricultural technology adoption varies among experts. In their study of adoption of agricultural technology in developing countries, Feder et al. (1985) conceptualize adoption of agricultural technologies at two different levels: aggregate and individual (farm-level) adoption. They define aggregate technology adoption and diffusion as "the process of the spread of a new technology within a region." Aggregate adoption is measured at the population level, rather than at the individual level. In contrast, the authors define individual adoption as "the degree of use of a new technology in long-run equilibrium, when the farmer has full information about the new technology and its potential."

Boughton and Staatz (1993), using a sub-sector approach to design agriculture research in Mali, argue that farm-level adoption of improved agricultural technology is an important factor affecting the level of economic return to agricultural research. Factors affecting farm-level adoption includes off-farm economic constraint and opportunities that are communicated through off-farm inputs and outputs market. The rate of technology adoption at the farm-level depend on the extent to which the technology enables farmers to respond to evolving off-farm clients' preferences for different product characteristics (e.g., quality, seasonal availability, lot size), as reflected in market prices.

Doss (2003), who conducted a study of farm-level technology adoption in eastern Africa, makes a distinction between discrete and continuous technology adopters among typical farmers who use either unimproved or improved inputs. The author defines "a farmer … as being an adopter if he or she… is found to be using any improved materials." With respect to the adoption of improved varieties, discrete adoption refers to a farmer who stops using a local (traditional) variety and adopts an improved variety. In contrast, continuous adoption refers to "situations where farmers increasingly planting more land to improved varieties, while continuing to grow some local varieties." Furthermore, Doss emphasizes that defining agricultural technological adoption is complex. Studies carried out by CIMMYT have used several different adoption definitions to distinguish between, for example, varieties that were originally introduced as improved hybrids, but have been repeatedly recycled (e.g., farmers plant seed from a previous harvest) versus planting new certified seeds. The author also argues that it is necessary to distinguish between farmers who continue to use a newly adopted technology from those who discontinue using it.[1]

2.3. Factors Associated With Farmers Adoption Decision

Farmers' decisions about technological adoption are inherently dynamic--farmers do not simply decide to permanently adopt a modern technology. Rather, before adopting a new agricultural technology (e.g., improved varieties or other technologies), farmers ask a series of questions including: is there any other technology (e.g., other improved variety) that is higher-yielding? And what resources (e.g., land and capital) need to be allocated to support the use of the new technology (Doss, 2003)?

Farmers' technological adoption behavior is associated with many factors. In a study of the adoption of agricultural and forestry technologies by smallholder in tropical areas, Pattanayak et al. (2003), classify factors associated with technological adoption into four categories: preferences and resource endowments, market incentives, biophysical factors, and risk and uncertainty. Doss et al. (2003), in the study of the adoption of maize and wheat technologies in eastern Africa, propose a similar framework. They classify factors associated with farmers' adoption decisions into four categories: farmers' socio-demography characteristics, institutional factors, farmers' perception of the characteristics of technologies, and economic attributes.

[1] In the TIA 2007 survey, improved varieties are defined as varieties that are commercially packaged and sold. Therefore, in this study, the definition of improved maize and beans adoption is limited to the adoption of improved maize and bean varieties that were commercially packaged and sold. Adopters are limited to farm households who used commercially packaged of maize and bean varieties in the 2006/2007 agricultural year.

2.3.1. Farmers' Socio-demography Characteristics

According to Doss et al. (2003), numerous studies of technologies adoption in developing countries have used farmers' socio-demography characteristics (e.g., household heads' gender, age, education, household size) to explain household adoption behaviors. A few of these studies report that the rate of technology adoption is higher among male-headed households, compared to female-headed households because of discrimination (i.e., women have less access to external inputs, services, and information due to socio-cultural values).

Adesina and Forson (1995), who studied farmers' adoption of new agricultural technology in Burkina Faso and Guinea, report that both young and old sorghum farmers in Burkina Faso adopt new technology. Young farmers adopt the technology because they have long term plans and are willing to take risks. On the other hand, old farmers adopt it because they have accumulated capital or have greater access to credit, due to their age. However, the effect of farming experience (measured by the age of the household head) is not always positively associated with farmers' adoption behaviors. For example, Zavale et al. (2005) report that older farmers in Mozambique are less likely to adopt improved maize variety than younger farmers.

Feder et al. (1985) provide empirical evidence on the importance of human capital (e.g., farmer's education) on technology adoption. They argue that education enhances the ability of farmers to acquire, synthesize, and quickly respond to disequilibria, thereby increasing their likelihood of adoption of new agricultural technologies. According Adegbola and Gardebroek (2007), educated farmers are able to better process information, allocate inputs more efficiently, and more accurately assess the profitability of new technology, compared to farmers with no education. Zavale et al. (2005) and

Uaiene et al. (2009) report that the level of education attained by households in Mozambique is positively associated with households' adoption behaviors. The authors suggest that education positively influences households to quickly respond to their current low agricultural productivity by adopting new agricultural technologies that increase productivity, household income and its standard of living. However they also report that most household heads in Mozambique are illiterate and had attended school for only a few years.

According to Feder et al. (1985), some new agricultural technologies, including improved varieties, are more labor intensive, compared to traditional varieties. Thus, labor shortage may prevent farmers from adopting new agricultural technology. The authors argue that a household with a large number of family members who are available to work on the farm are more likely to adopt new technologies than household with a small number of family members.

2.3.2. Institutional Factors

Institutional factors (e.g., having access to extension services, credit, roads, price information from markets, being a member of an agricultural association) have been widely used to assess farmers' adoption behavior. Pattanayak et al. (2003) argue that access to extension services provided by the government, NGOs, and other stakeholders play a very important role in the adoption of new agricultural technologies. Farmers who are exposed to information about new technologies by extension agents (through training, group discussion, plots demonstration, and other form of information delivery) tend to adopt new technologies. An empirical study by Boughton and Staatz (1993) suggests that in Mali, the farm-level adoption rates for improved maize varieties could be significantly increased by an extension program that tailors varietals promotion to individual farmers' needs and circumstances.

Capital constraints and limited access to credits hinder the adoption of agricultural technologies. These factors especially apply to new inputs or technologies that require a high initial capital investment and high operational costs (Feder et al. 1985). However, a few empirical studies report that some new technologies that do not require a high initial capital investment (e.g., improved varieties) also have low adoption rates because farmers do not have sufficient capital and access to credits. For example, Uaiene et al. (2009) and Zavale et al. (2005), who analyzed agricultural technologies adoption in Mozambique, using TIA 2002 and 2005 data, report that difficulty in accessing credit appears to be one of the major constraints to adoption.

Bandiera and Rasul (2005), who analyze social networks and technology adoption in Northern Mozambique, report that the likelihood of adopting new technologies is high among farmers who have access to paved road, markets, and farmer associations because they are more likely to be exposed to information about the potential benefits of new technologies, contact with extension agents, as a result of market exposure, and from interactions with other association members.

2.3.3. Farmers' Perception of Characteristics of Technologies

Perceptions of the characteristics of new agricultural technology are also important factors that are associated with farmers' demand for new agricultural technologies (Adesina and Forson, 1995). Farmers may subjectively evaluate the technical and cultural aspects of technologies differently. Thus, understanding farmers' perceptions is important in designing and promoting agricultural technologies (Uiene et al., 2009). In general, farmers' perceptions of the characteristics of new agricultural technologies are divided into three main categories: yield performance, cost requirements, and risks.

Feder et al. (1985) argue that yield performance (or expected yield of new varieties) is one of the characteristics of improved varieties that affect farmers' technological adoption behaviors. Several empirical studies show that the adoption rate of improved varieties is high, if the varieties meet farmers' expectations. An improved variety will be adopted at exceptionally high rates, if the new variety is technically and economically superior to local varieties. Improved varieties are technically superior if they produce higher yield than traditional varieties. For example, Adesina and Forson (1995) report that farmers in Burkina Faso adopted a modern sorghum variety because it gave high yield, compared to the traditional sorghum variety that farmers planted in previous agricultural years.

Neill and Lee (2001) argue that farmers' adoption of new agricultural technologies is also affected by farmers' perception of the amount of initial capital investment and labor requirements they will have to allocate if they adopt the underlying technology. Martel et al. (2000), who conducted a case study of the marketing of dry beans in Honduras, argue that farmers adopt new agricultural technologies because they perceive that a new technology could reduce labor requirements and other associated costs, and reduce losses due to risk (i.e., crop diseases) during production and/or post harvesting. Furthermore, they argue that bean farmers always compare the new bean variety to their current variety. Farmers are more likely to adopt a new bean variety if it performs well under different environmental conditions, shows economic profitability, and is resistant/tolerant to disease and insects.

Adegbola and Gardebroek (2007), who analyzed the effect of information sources on technology adoption and modification in Benin, report that in addition to considering yields, direct costs, and profits associated with improved maize seeds, farmers also consider seed characteristics that reduce risks, because damages from insects and/or disease during maize production and storage can result in substantial yield losses and poor grain quality. In some circumstances, these losses not only increase the risk of food insecurity for the farmers' households, but may also decrease farmers' income -- if the losses in quantity are not sufficiently compensated for by a price increased due to deficit in national supply. With respect to risks, several other studies report that farmers also consider environmental aspects, such as whether or not the improved varieties were developed for local climate and soil fertility conditions (Ramirez, 2003), or for variations in local agro-ecological patterns (Doss, 2003).

2.3.4. Risks and Economic Attributes

Farmers have heterogeneous beliefs about new agricultural technologies and the economic profitability of new agricultural technologies is uncertain. Early adopters are farmers who adopt first, while late-adopters wait and observe the experiences of early-adopters. After obtaining information about the technology from early-adopters, they decide whether or not to adopt the technology based on the economic profitability (Shampine, 1998; Basley and Case, 1993). According to Feder et al. (1985) and Adegbola and Gardebroek (2007), farmers who are aware of a certain agricultural technology component will decide whether or not to adopt it by evaluating the expected economic profitability or benefit that they anticipated will be gained, taking into account the initial investment and variable costs. An agricultural technology is more likely to be adopted if the gain or profit exceeds the aggregate investment and variable costs. Furthermore, they argue that the technological adoption rate varies over time because socioeconomic groups have different adoption behaviors and farmers' adoption decisions for the next growing period depends on the initial impact of the technology, profitability, and other farmers previous experience. Researchers of technological adoption studies often use economic attributes variables (e.g., farm size, land tenure, farm location, farmers' growing other cash crops, and adoption of other complementary technologies like fertilizer) to explain farmers' adoption behaviors.

With respect to the impact of farm size and land tenure on farmers' adoption behavior, Uaiene et al. (2009) and Pattanayak et al. (2003) find no consistent relationship between these two factors. They report that farmers with easy access to land are less likely to adopt land-saving technologies (e.g., fertilizer and pesticide) because land is abundant. Furthermore, land owner are more likely to adopt agro-forestry and other conservation technologies to preserve their land.

Cornejo and McBride (2002), who conducted a study of adoption of bioengineered crops in the United States, evaluate the impact of farm location (e.g., distance from roads, soil fertility, and climate condition in that location) on new technology adoption. They argue that farmers who own land with poor biophysical production conditions usually adopt new agricultural technologies (e.g., fertilizer) to alleviate these conditions. In contrast, despite good soil conditions and climates, farmers may still consider the accessibility to roads, and agricultural inputs and outputs market.

Boughton and Staatz (1993) argue that rapid adoption of improved maize in Mali was facilitated by the prior development of cotton. Adoption of improved maize varieties is associated with mechanization used in a cotton project because farmers need appropriate equipment to plow and weed their farms in a timely manner. In addition, the availability of residual fertilizer from the previous year's cotton fields reduces farmers' cash outlays for maize production.

Pandey (1999), who conducted a study of rice production technology adoption in the Philippines, found that fertilizer responsiveness of modern varieties was one of the factors that led to a rapid increase in yields and the level of fertilizer use. Drawing on this finding, they suggested that agricultural technologies can be introduced as a package, if the technology components are complementary.

2.4. Chapter Summary

The rapid responses to new agricultural technologies in some developing countries has resulted in a sustainable agricultural development and increased agricultural productivity, which has contributed to overall economic growth, ensuring food security, and reducing poverty.

Adoption of technologies may be conceptualized at two different levels: aggregate and individual (farm-level) levels of adoption. Aggregate adoption is defined as the adoption of an agricultural technology by a population within a region. In contrast, farm-level new technological adoption is defined as when an individual farmer adopts a new technology. The farm-level new technological adoption is an important factor affecting the level of economic return to agricultural research. Factors affecting farm-level adoption include off-farm economic constraint and opportunities that are communicated through off-farm input and output markets. Also, the rate of new technology adoption at the farm-level depends on the extent to which the new technology enables farmers to respond to the evolving preferences of off-farm clients for different product characteristics, as reflected in market prices.

Defining agricultural technological adoption is complex. Studies carried out by CIMMYT have used several different adoption definitions to distinguish between, for example, varieties that were originally introduced as certified hybrids but have been repeatedly recycled (e.g., farmers plant seed from a previous harvest) versus planting new hybrids. Also, it is necessary to distinguish between farmers who continue to use a newly adopted technology from those who discontinue using it.

Farmers' adoption of new agricultural technologies is influenced by many factors. In general, these factors are classified into four categories: farmers' socio-demography characteristics, institutional factors, farmers' perception on characteristics of technologies, and risks and economic attributes. Association between these factors and farmers' adoption behaviors is not always consistent. Many agricultural technology adoption studies have shown that while a factor may be associated positively in a region, but the same factor may have an inverse (or no) association in other studies or in different regions/countries. Adoption studies attempt to explain the association between various factors and farmers' adoption behaviors, and estimated the magnitude and the significance of the estimated parameters.

CHAPTER III: KEY ASPECTS OF MOZAMBIQUE

3.1. Introduction

This chapter presents an overview of Mozambique. The chapter is divided into five sections. The second section presents physical and socio-economic characteristics, including geography and agro-ecology, climate, and demographic features. The third section provides a brief background on Mozambique's economy, focusing on macroeconomic and financial policy, infrastructure, roads, transportation, electrification, and poverty. The fourth section describes Mozambique's agricultural sector, focusing on agricultural development and its challenges, livestock production, agricultural land use, agricultural inputs use, and cash and staple food crops production. The fifth section summarizes the chapter.

3.2. Physical and Socioeconomic Characteristic

3.2.1. Geography and Agro-ecology

Mozambique, which is located along Africa's southeast coast, has an area of 309,494 square miles (801,590 km^2) – slightly larger than Texas (268,601 square miles). The country is bordered by Tanzania on the north, Malawi, Zambia, and Zimbabwe on the west, and South Africa and Swaziland on the south. Administratively, Mozambique is divided into ten provinces (*provicias)* and a capital city, 128 districts (*distritos*), and 405 administrative posts (*postos administativos).* The country terrain includes lowlands (mostly along coastal area in the east), uplands in the center, high plateaus in the northwest, and mountains in the west (FAO, 2009; Nation Master, 2009; CIA World Fact Book, 2009).

Figure 3.1.Map of 94 Districts Participated in TIA 2007

Source: TIA, 2007

3.2.2. A Brief History of Mozambique

Mozambique gained independence from Portugal in 1975, after almost five centuries under Portuguese colonial administration. However, until the early 1990s, Mozambique faced challenges to develop due to a complicated historical heritage that included a period of colonization that put little emphasis on human capital, a failed socialist experience, large-scale emigration, economic dependence on neighboring countries such as South Africa, drought, and a long civil war. Since the long civil war ended in 1992, as a result of the peace agreement between opposing groups, Mozambique has made remarkable progress in its economic development and is now considered one of the most politically stable countries in Africa (PARPA II, 2006).

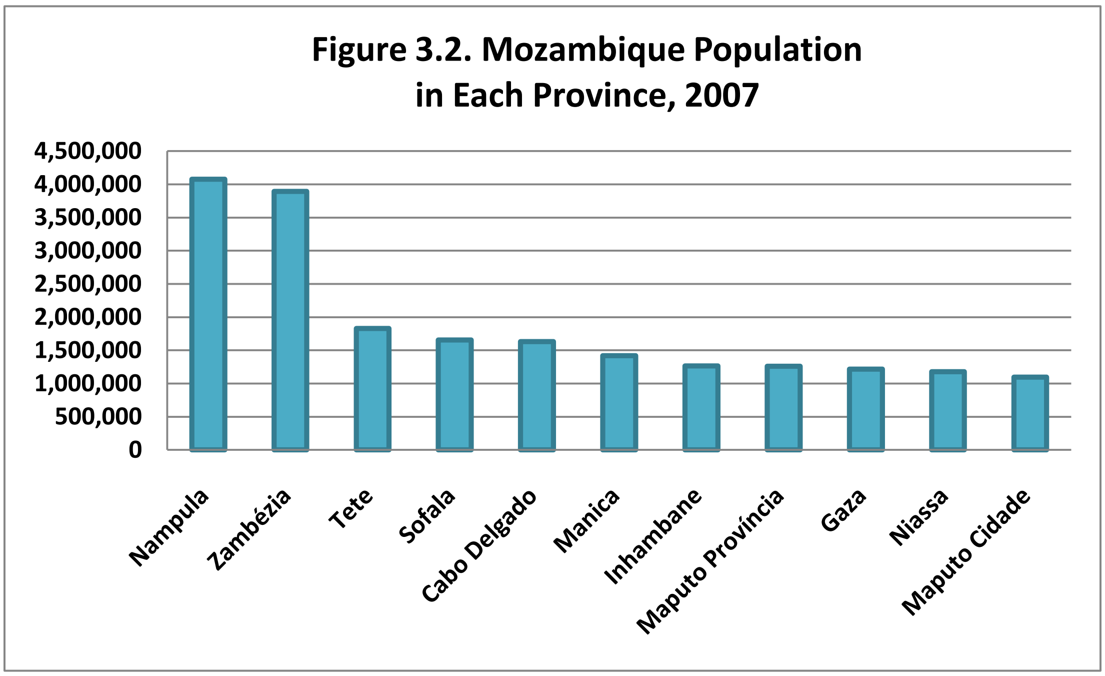
3.2.3. Climate

Similar to many countries in Sub-Saharan Africa, Mozambique has areas with a tropical and subtropical climate and two seasons, a dry and a wet season. The dry season is from April to September and the wet season is from October to March. Climatic conditions vary, depending on altitude. Rainfall is heaviest along the coasts, but decreases in the northern and southern parts of the country. Annual precipitation also varies, depending on the regions. However, it ranges between 500-900mm. In addition, Mozambique is drained by five principal rivers and several smaller ones (FAO, 2009; Nation Master, 2009; CIA World Fact Book, 2009).

3.2.4. Demographic Features

According to the Instituto Nacional de Estatistíca (2009), in 2007 Mozambique had a total population of 20,905,585. Nampula Province is the most populated province, with more than 4 million people; while Maputo city is the least populated area with only 1.09 million people (Figure 3.2).

From 2005 to 2007, the population grew at annual rate of 2.4 percent (World Bank, 2008). Population density averaged 24 people per square kilometer. In 2007, the birth and death rates were 38.5 and 20.5 per 1,000, respectively, the infant mortality rate was 109.93 deaths per 1,000 live births, the sex ratio at birth was 1.02 male per female, and the fertility rate was 5.3 children per woman (INE, 2009; CIA World Factbook 2009).



Source: Instituto Nacional de Statistica (INE), 2009

3.3. The Economy

3.3.1. Macroeconomic and Financial Policy

Several factors have contributed to the country’s economic expansion and development, including macroeconomic stability, policy reform in all sectors, growth in agriculture, post-war reconstruction, mega-projects, and strong support from its development partners (donors). The World Bank (2008) reported that over the period 1996-2005, Mozambique GDP grew at an average rate of eight percent per year, which was the highest in Africa for a non oil-producing country. At the same period, the government of Mozambique raised the living standard of three million people to above the poverty line. This achievement contributed to a 35% decrease in infant and child (under five years old) mortality, and a 65% increase in primary school enrollment. However, these achievements are also attributed to the end of the civil war – referred to as the post-conflict effect.

The government 2006-2009 Action Plan for the Reduction of Absolute Poverty, known as PARPA II (*Plano de Acção para Redução da Pobreza Absoluta*) gave priority to implementing development strategies and policy reforms that focus on developing human capital, good governance, ensuring macroeconomic stability, investing in basic infrastructures, and improving agriculture and the rural economy. Overall, the goal of the government's plan was to help the country to achieve a sustainable economic development and growth, increase productivity in agricultural sector, and increase standard of living and reduce poverty by 15% (PARPA II, 2006).

Between 2005 and 2008, Mozambique's GDP increased by eight percent annually, although the growth rate decreased in 2007 and 2008, compared to the previous two years. It is estimated that in 2008 income per capita average \$340. The inflation rate averaged slightly below six percent from 2005 to 2007. The services sector is the biggest contributor to GDP (47%), followed by the agricultural sector (28%), and the industrial sector (26%) (Table 3.1). Additionally, imports (free on board) totaled \$3.633 billion, which was greater than the export revenue of \$2.511 billion in 2008. Mozambique's export commodities are contributed by several sectors. The country main exports are aluminum, cashews, prawns, cotton, sugar, tobacco, bulk electricity, and natural gas (World Bank, 2009).

Table 3.1. Mozambique's Economic Growth Indicators, 2005-2008 [a]

Economic Indicators	Year				Total	Mean
	2005	2006	2007	2008*		
Services, etc. (% of GDP)	48	46	47	47	188	47
Agriculture (% of GDP)	27	28	28	28	111	28
Industry (% of GDP)	25	27	26	25	103	26
GDP (US$ billions)	7	7	8	10	32	8
GDP growth (annual %)	8	9	7	7	31	8

*Estimates (other sources report different numbers)[2].
[a] Source: World Bank, Development Indicators Database, April 2009

Mozambique's financial system is considered weak, characterized by only a few financial institutions. Limited access to credit is a challenge that hinders agricultural and overall economic development. The government's Strategy Plan for Reduction of Poverty seeks to overcome this constraint by developing a modern financial system that is comprehensive in social and geographical terms (PARPA II, 2006). The goal is to increase the monetization of the nation's economy and finance activities of the productive sectors. These improvements in the financial system are expected to help farmers to access sufficient capital to purchase agricultural inputs (e.g., improved seeds, fertilizer, pesticide, tractors, labor), and thereby stimulate adoption of agricultural technologies, increase agricultural productivity, increase farmers' income, and improve farmers' standard of living.

[2] The CIA factbook estimates that GDP per capita in Mozambique was $900 in 2008, and the GDP composition by sector was (Agriculture: 23.4%; Industry: 30.7%; and Services: 45.9%).

3.3.2. Infrastructure, Road and Transportation, and Electrification

A lack of infrastructure in all productive sectors is a key constraint to development in Mozambique. The World Bank (2008) reports that the rural population's poor access to good road networks and high transport costs hinder both social development and economic productivity. Poor road access between rural and urban areas is a major constraint for increasing agricultural productivity. This challenge limits rural farmers' and rural communities' ability to access government services, agricultural inputs and market agricultural, and other home industry products. Road density per land area is estimated to be 0.05 kilometers of road per square kilometers. Currently, rural roads serve only approximately 41% of the rural population. Furthermore, the percentage of the population with access to the road networks declines in the wet season due to poor road conditions. The objectives of the government's road development strategy is to increase the rural population's access to the road networks in order to facilitate marketing of agricultural inputs and outputs, which is essential for developing the rural sector.

The energy sector plays a crucial part of the social-economic development in Mozambique. Increasing production and distribution of energy for both domestic or household consumption and business activities is essential for the country. While Mozambique has a huge potential for the production of hydroelectric power, the index of rural community access to electricity is relatively low. The government seeks to increase access to electricity by replacing district-level diesel electric plants with the national electric grid, developing potential natural resources for a hydroelectric generation, and identifying alternative sources of electricity generation to use in areas that are isolated from the national electricity grids (PARPA II, 2006).

3.3.3 Poverty

Poverty in Mozambique is defined as "the impossibility, owing to the inability and/or lack of opportunity for individuals, families, and communities to have access to the minimum basic conditions, according to the society's basic standards" (PARPA II, 2006). Between 1997 and 2003, the country successfully reduced the headcount poverty index by approximately 15% -- from 69% to 54%. With continued progress in overall economic development, by 2009 the headcount poverty index was expected to decline from 54% to 45% (PARPA II, 2006).

Despite the fact that the poverty index declined over the past decade, the situation is still critical for Mozambique because ten million Mozambicans still live under the poverty line of approximately $2 per capita per day (PARPA II, 2006). The incidence of poverty varies between region, due to each province and region having a different level of access to market and opportunities for economic diversification. Furthermore, the incidence of poverty is highest in rural areas.

The World Bank (2008) reports that Mozambique has a relatively high level of absolute poverty and malnutrition, and per capita income was US$340 in 2006, which was low compared to the Sub-Saharan African average of US$500. In order to reduce poverty and meet the Millennium Development Goals (MDG), the World Bank suggests that the country should make significant investments in health care, water, and sanitation services; improve the quality of higher education; and improve gender equity, especially in rural areas. Since poverty is more prevalent in rural areas, increasing agricultural productivity through the diffusion of agricultural technologies and the rehabilitation of infrastructure is also needed to reduce poverty and hunger.

3.4. Agricultural Sector

3.4.1. Agricultural Sector Development and Challenges

In Mozambique, small-scale subsistence farming is the dominant agricultural activity. Approximately 95% of the cultivated area is rainfed. The country's subsistence farms, which average two hectares in size, are cultivated by family members who grow basic food crops (e.g., maize, rice, cassava, groundnuts, beans, sweet potatoes, and sugar cane) mainly for household consumption. On the other hand, a small number of commercial farms focus on exportable and/or cash crops (World Bank, 2008; Corzine, 2008; FAO 2009).

According to the World Bank (2008), agricultural development is hindered by most farmers living at a near-subsistence level, frequent drought, underutilized irrigation systems, weak rural financial services, poor rural road networks, and low productivity. To achieve sustainable agricultural development, the government has developed a strategy that focuses primarily on improving agricultural productivity, developing efficient irrigation systems, improving access to financial services and market, strengthening and expanding value chains, increasing agricultural commodities exports, and encouraging private sector to participate in agricultural development (PARPA II, 2006).

Despite its low productivity, the agricultural sector plays a very important role in Mozambique's economy. The World Bank estimates that the agricultural sector accounted for an average of 28% of GDP during 2005-2008. This sector also employs three-fourths of the total labor force (FAO, 2009, World Bank, 2008). Another factor that makes the agricultural sector important is the export of agricultural commodities, including sugar, cashew nuts, cotton lint, tobacco, copra, and tea. According to FAO (2009), exports of sugar, cotton, and tobacco increased from 2004 to 2006 (Table 3.2).

During the period from 2002 to 2006, the country exported an average of approximately 48,000 tons of sugar, 25,000 tons of maize, and 1,000 tons of tea. This indicates that Mozambique has a potential to earn export revenue by increasing the production and export of agricultural commodities that are in demand in the international market.

Table 3.2. Mozambique's Agricultural Export Commodities (MT), 2002 – 2006

Commodities	Year					Mean
	2002	2003	2004	2005	2006	
Sugar Raw Centrifugal	14,000	24,997	43,402	78,151	80,645	48,239
Cashew nuts, with shell	38,447	32,659	39,731	33,492	24,053	33,676
Maize	5,522	3,267	11,965	931	103,210	24,979
Cotton lint	20,274	24,681	19,577	21,235	28,081	22,770
Tobacco	8,328	11,423	11,701	11,701	34,183	15,467
Copra	5,092	5,092	87	87	25	2,077
Tea	2,424	937	586	317	505	954

Source: FAO, April 2009

3.4.2. Livestock Production

Mozambique has the potential to develop its natural resources to increase livestock production for household consumption and to generate income through sales. The most important livestock for household consumption are chickens, goats, sheep, hogs, geese, and rabbits. In contrast, livestock such as cattle are produced mainly for sale. The Ministry of Agriculture (2006) estimated that the inventory (population) of small-and medium-size livestock varied from year-to-year during 2002 to 2006. During this five-year period, chickens were the most important small-scale livestock (17.6 million), followed by goats (4.7 million) and geese (5.7 thousand). Cattle, one of the most important big-scale livestock, accounted for more than a million in population during 2002 to 2006 (Table 3.3).

Table: 3.3. The Small- and Medium-Size Livestock Population in Mozambique, 2002 - 2006.

Description	TIA02	TIA03	TIA04 a)	TIA05	TIA06 b)	Mean
Chicken	22,318,927	17,646,679	15,931,840	14,217,000	18,080,152	17,638,920
Goat	4,912,126	4,747,901	4,838,451	4,929,000	4,254,896	4,736,475
Hogs	1,600,884	1,354,070	1,492,535	1,631,000	1,183,203	1,452,338
Cattle	791,179	969,317	1,106,159	1,243,000	1,054,797	1,032,890
Sheep	183,116	136,194	166,597	197,000	144,916	165,565
Rabbit	83,369	60,887	62,944	65,000	95,904	73,621
Goose	5,205	12,448	7,224	2,000	1,676	5,711

a) Estimate data
b) Preliminary data

Source: Ministério da Agricultura/ Direcção Nacional de Economia - Inquéritos Agricolas, 2009

3.4.3. Agricultural Land Use

Mozambique has a total land area of approximately 78, 638 square kilometers, of which 62 percent (48,800 square kilometers) is agricultural land, 24 percent (19,162 square kilometers) is forest land, and 14 percent (10,676 square kilometers) is used for other purposes. Of the total agricultural land, 90 percent (44,000 square kilometers) is permanent meadows and pasture, nine percent (4,450 square kilometers) is arable land, and only one percent (350 square kilometers) is for permanent crops (Table 3.4).

According to FAO (2009), disputes over land, pasture, water and other abundant natural resources among community members are rare, due to Mozambique having a low population density (estimated: 24 people per square kilometer, 2007). However, Mozambique’s land law, which allows individuals or companies to acquire land for their commercial interests, has increased the number of foreign farming companies seeking land to produce cash crops.

Given its abundant natural resource, Mozambique has a potential to increase the production of staple food crops, cash crops, and livestock through both intensification of land use and expanding the area of the typical farm, which is currently less than two hectares. However, farmers can only expand their farms size if they are supported by a development program that increases farmers' knowledge, helps farmers to access capital, strengthens the input and output marketing system, and increases farmers' use of agricultural technologies.

Table 3.4.Mozambique's Land & Agricultural Land Distribution (000ha), 2007

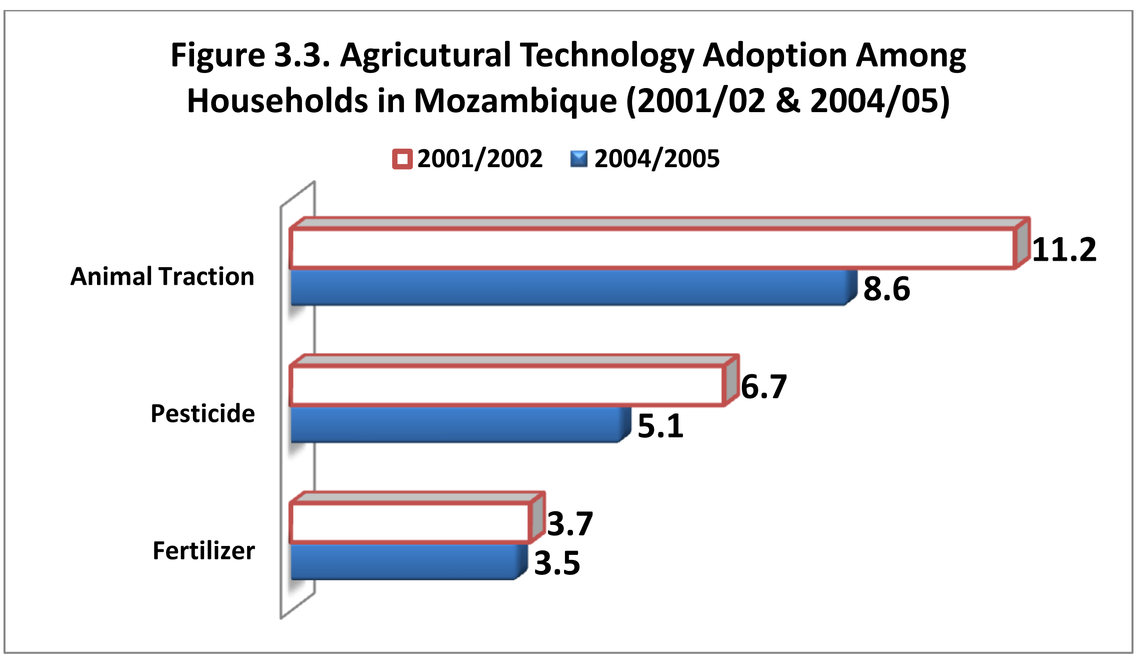
Land Distribution	Area (ha)	Percentage
Agricultural area	48,800	62%
Forest area	19,162	24%
Other land	10,676	14%
Total Land area	**78,638**	**100%**
Agricultural Land Distribution		
Permanent meadows and pastures	44,000	90%
Arable land	4,450	9%
Permanent crops	350	1%
Total Agricultural Land	**48,800**	**100%**

Source: FAO, 2010

3.4.4. Agricultural Inputs Use

According to Uaiene et al. (2009), while modern agricultural inputs are currently available in Mozambique, farmers' adoption is still relatively low. The use of modern inputs (e.g., tractors, ploughs, improved seeds, fertilizers, pesticides, and irrigation) is limited to larger farms in the lowland (FAO, 2009; Bias and Donovan 2003). Various factor that limit farmers' adoption of modern agricultural inputs including farmers' socio-demography characteristics (e.g., household head's education, age, gender), economic attributes (e.g., access to market, income), farmers' preferences (e.g., varieties that are disease tolerant), institutional factors (e.g., access to extension services and credit), and availability of new technologies (Feder et al., 1985; Doss et al., 2003).

Based on analysis of TIA data (2002, 2005), the adoption rate for fertilizer, pesticide, and animal traction was estimated to be below 12% (Figure 3.3). Various technologies adoption studies (e.g., Uaiene et al., 2009, Zavale et al., 2005) have indentified many factors that contribute to low agricultural productivity in Mozambique, including the low adoption rate of modern agricultural inputs. These empirical studies suggest that to increase agricultural productivity, stakeholders (e.g., the government, research institutions, and private sector) must invest in strengthening agricultural research and extension programs.



Source: TIA 2002 and 2005. Copy from Uaiene et al, 2009.

3.4.5. Cash Crops and Staple Foods Production

As Mozambique's agriculture sector supplies some of its local-produced cash crops to international markets, it is important to review trends in the (2003-2007) harvested area of the country's most important cash crops. FAO estimated that the average harvested area of the five most important cash crops ranged from an average of 169,000ha to 6,000ha: sugar cane (169,000 ha), coconuts (70,400 ha) cashew nuts (50,000 ha), sunflower seeds (22,000 ha), tobacco (8,260 ha), and tea (5,670 ha). Sugar cane, tobacco, and coconut are processed before they are sold in international markets (Table 3.5).

For cashew nuts and sunflower seeds, the harvested area remained constant from 2003 to 2007, (Table 3.5). However, for most cash crops, the harvested areas varied from year-to-year. For example, the harvested area for sugar cane ranged from 150,000 to 185,000 hectares and ranged from 7,900 to 8,500 hectares for tobacco.

Table 3.5.Mozambique's Cash Crops Harvested Area (000 ha), 2003 - 2007

			Year			
Commodities	**2003**	**2004**	**2005**	**2006**	**2007**	**Mean**
Sugar cane	160	150	185	170	180	169
Coconuts	70	72	70	70	70	70.4
Cashew nuts, with shell	50	50	50	50	50	50
Sunflower seeds	22	22	22	22	22	22
Tobacco	8.5	8.5	8.5	7.9	7.9	8.26
Tea	5.65	5.65	5.65	5.7	5.7	5.67

Source: FAO, April 2009.

In contrast, staple food crops are mainly produced for domestic consumption. FAO (2010) data indicates that from 2004 to 2008, the average harvested area and production of the important food crops were cassava (1,391,120 ha, 5,950,925 MT), groundnuts (946,100 ha, 1,338,964 MT), pulses (408,552 ha, 205,000 MT), rice (294,384 ha, 131,432 MT) and sorghum (169,720 ha, 93,319 MT) (Table 3.6).

Increasing production of food crops to meet domestic consumption is necessary to guarantee household food security and reduce poverty. It is possible to increase food crops by allocating more land to these crops, encouraging farmers to adopt agricultural technologies, and rehabilitating irrigation infrastructure.

Table 3.6. Harvested Area (ha) and Production (MT) of Important Crops, 2004-2008

Crops	2004	2005	2006	2007	2008	Mean
Harvested Area (Ha)						
Cassava	1,311,600	1,230,000	1,664,000	1,350,000	1,400,000	1,391,120
Groundnuts, with shell	1,068,500	1,105,000	857,000	850,000	850,000	946,100
Pulses	528,761	488,000	406,000	300,000	320,000	408,552
Rice	293,921	293,000	295,000	295,000	295,000	294,384
Sorghum	178,601	180,000	160,000	165,000	165,000	169,720
Production (MT)						
Cassava	6,412,770	6,500,000	6,764,609	5,038,623	5,038,623	5,950,925
Groundnuts, with shell	1,437,040	1,403,000	1,417,800	1,152,050	1,284,930	1,338,964
Pulses	205,000	205,000	205,000	205,000	205,000	205,000
Rice	177,419	174,000	99,173	104,655	101,914	131,432
Sorghum	90,232	93,000	85,977	102,932	94,454	93,319

Source: FAO, 2010

3.4.6. Maize and Beans

Maize and beans are two staple food crops that are widely produced primarily for domestic consumption. Empirical studies (e.g., Zavale et al., 2005; Uaiene et al., 2009) report that households' adoption of improved varieties for food crops such as maize, rice, groundnuts, beans, and cowpeas is relatively low. In the 2004/2005 agricultural year, the adoption of improved varieties varied among provinces (Table 3.7). For example, only approximately seven percent of farm households planted improved maize varieties and approximately 11% planted improved bean varieties. This suggests that there is a potential to expand the diffusion of agricultural technologies, including improved varieties to farm households in Mozambique.

Table 3.7. Percentage of Household Adopted Improved Varieties in Mozambique by Province , 2004-2005

Province	Improved Varieties					
	Maize	Rice	Small Groundnut	Large Groundnut	Beans	Cowpeas
Cabo Delgado	2	0	1	2	0	0
Gaza	4	6	10	5	7	4
Inhambane	5	9	12	7	30	7
Manica	15	0	6	8	15	5
Maputo	13	7	50	12	26	10
Nampula	6	4	2	3	11	4
Niassa	6	3	2	0	2	3
Sofala	5	2	3	4	9	3
Tete	11	8	6	3	4	3
Zambezia	5	4	3	8	7	3
Total	**72**	**43**	**95**	**52**	**111**	**42**
Average	**7.2**	**4.3**	**9.5**	**5.2**	**11.1**	**4.2**

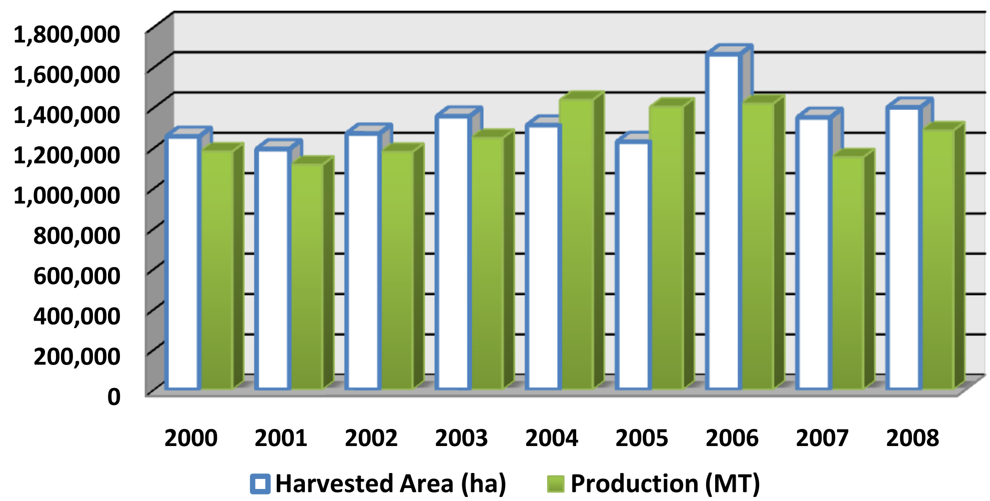
Source: TIA 2005. Copied from Uaiene et al, 2009

Maize is mainly produced by subsistence farmers on rainfed land. FAO (2009) estimated that in 2004, maize production was1.41 million metric tons, but decreased in the two subsequent years. In addition, from 2001 to 2006, the area planted to maize increased from approximately 1.2 to 2.7 million hectares. However, in 2007, the maize harvested area decreased to 1.3 million hectares (Figure 3.4). According to Uaiene et al. (2009), variation in the quantity and distribution of rainfall in regions of the country affects the production of maize, beans and other food crops. For example, from 2000 to 2008, maize and other food crop production were severely affected by drought, especially in the center and southern regions. However, as the result of good rainfall in the 2004 to

2006 agricultural years, the production of maize, beans, and other food crops was good in these seasons (Fews Net, 2009).

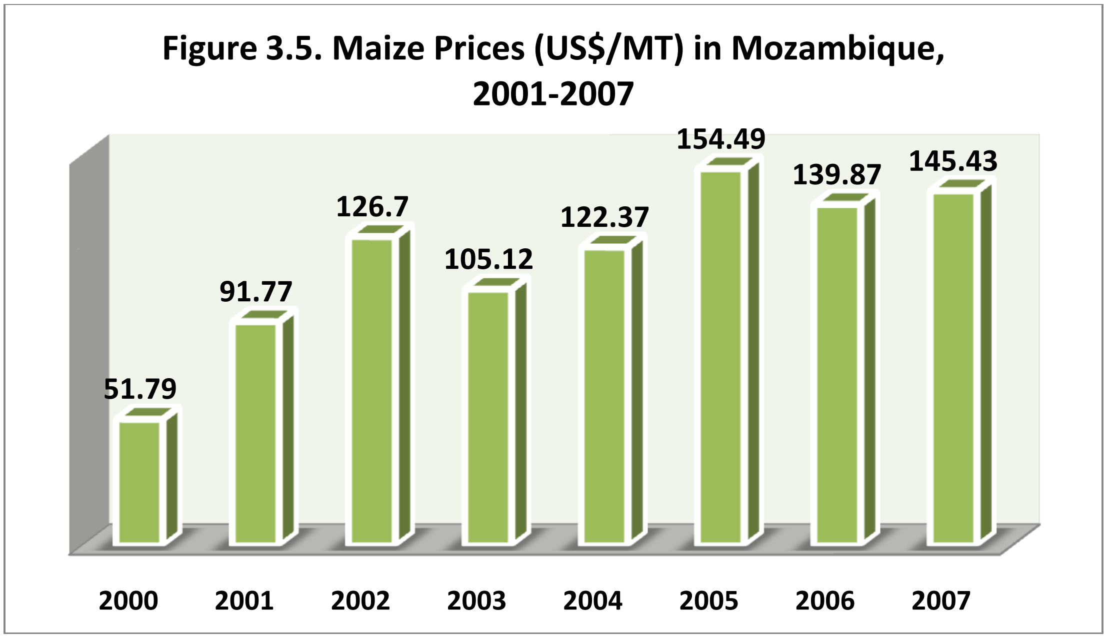
Domestic maize consumption is expected to continue increase, due to population growth. However, the flow of food (e.g., maize and beans) from surplus area in the north to deficit provinces in the south is affected by inadequate access to roads, high transportation costs, and market preferences of traders. Given these factors, it appears to be more profitable for traders to import food products from neighboring countries such as South Africa, than to transport them from the northern to the southern region of the country (Corzine, 2008; Fews Net, 2009).

Figure 3.4. Maize Harvested Area & Production in Mozambique, 2000-2008



Source: FAO, 2009

Domestic food prices of most agriculture commodities, including maize, beans, groundnuts, and sweet potatoes, vary from year-to-year, depending on average rainfall, yield, and import of food products (Fews Net, 2009). In general, FAO (2009) estimates that from the 2002 to the 2007 agricultural year, the maize price increased steadily, from about $52/MT in 2000 to $145/MT in 2007 (Figure 3.4).



Source: FAO, 2009

3.5. Chapter Summary

Mozambique lies on the eastern coast of Southern Africa. Following independence from Portugal in 1975, a civil war erupted and continued until 1992, when a peace accord was signed. In 2007, the total population in Mozambique was 20,905,585. Nampula Province is the most populated province (4 million people) and Maputo Cidade is the least populated area (1.09 million).

As a result of post-conflict recovery programs, Mozambique has made remarkable progress in terms of political stability and economic development, including a reduction of poverty and rapid GDP growth. However, the country still struggles to meet its economic development objective and reduce the incidence of poverty.

Increasing the productivity of the agricultural sector is a key challenge facing Mozambique. In 2008, the agricultural sector accounted for 28% of the GDP and employed over 75% of the labor force. Developing efficient irrigation systems, improving road networks, expanding access to financial and marketing services, and expanding agricultural value chains is needed for Mozambique to increase agricultural productivity and achieve sustainable agricultural and economic development.

Mozambique has the potential to develop its enormous natural resources to increase its production of staple food crops, cash crops, and livestock. Staple food crops (e.g., maize, beans, and cassava), which are produced by subsistence smallholders on rainfed land, are mainly grown for domestic consumption. Mozambique's agricultural sector supplies some of its cash crops (e.g., copra, cotton, tea, and tobacco) to international markets. This indicates that Mozambique has a potential to earn export revenue by increasing the production and export of agricultural commodities that in demand in the international market. Small, medium, and large-scale livestock are produced for household consumption and to generate income through sales. The most important livestock are cattle, chickens, goats, sheep, hogs, geese, and rabbits.

While some modern agricultural inputs (e.g., improved seeds, fertilizer, pesticide, and tractors) are currently available in Mozambique, farmers' adoption to these technologies is still relatively low. For example, an analysis of TIA 2002 and 2005 data reported that only seven and 11% farmers adopt improved maize and beans, respectively. In addition, farmers' adoption to fertilizer, pesticide, and animal traction was below 12%. To increase adoption of modern agricultural inputs and agricultural productivity, the government, research institutions, and private sector must invest in strengthening agricultural research and extension programs.

CHAPTER IV: THE MOZAMBIQUE AGRICULTURAL HOUSEHOLD SURVEY

4.1. Introduction

This chapter presents an overview on the Mozambique Agricultural Household Survey, commonly known by its Portuguese acronym TIA – "*Trabalho de Inquérito Agrícola.*" The chapter is divided into sixth sections. The second section presents a brief background of TIA. The third section reviews the purpose of the TIA 2007 survey. The fourth section discusses the implementation of the survey, including the sample size, when the survey was conducted, the survey instrument, and the classification of farms. The fifth section describes data transformation. The last section summarizes the chapter.

4.2. An Overview on the Trabalho de Inquérito Agrícola (TIA)

At the time of independence and in the post-war period, Mozambique lacked information about the structure and the dynamic of agriculture and livestock production. To address this situation, the Ministry of Agriculture (MINAG) developed TIA. The TIA surveys are designed to collect data that is representative of rural zones, at both the provincial and national levels. The TIA surveys are designed to collect detailed data about crop production, demographic characteristics, and access to infrastructure for each household and community in the sample. The first TIA (1993) was undertaken in 20 districts. Subsequently, the number of sample districts and households was expanded. In addition, the content and survey methods were improved over time, with some variation in content for selected TIA years. Table 4.1 shows number of households and districts covered by TIA survey from 2002 to 2008.

Table 4.1. TIAs Number of Households and Sample Districts, 2002-2008

	TIA02	TIA03	TIA05	TIA06	TIA07	TIA08
Number of Households	4,908	4,935	6,159	6,248	6,075	5,968
Number of Districts	80	80	94	94	94	128

Source: TIA, 2009

Data collected through TIA was envisioned to generate official statistics describing the agricultural sector in Mozambique. It was also expected that the analysis of TIA data would contribute to measuring the performance of the agricultural sector by providing data that could be used to monitor and evaluate the implementation of government policies that targeted the agricultural sector. To answer the research questions described in Chapter I, this study analyzes TIA 2007 of the small-and medium-scale farm survey data, which is the latest data set that is available. This study does not use the TIA 2008 data because survey documents are not available.

4.3. 2007 TIA Objectives

4.3.1. General Objectives

The general objectives of TIA 2007 survey were to:

1. Collect data about crops and livestock production;
2. Improve the estimation of cultivated areas, crops, and livestock production;
3. Obtain data to help in monitoring the implementation of the Agricultural Sector Public Investment Program (Portuguese acronym PROAGRI II – "*Programa Nacional de Desenvolvimento Agrário*") and the Action Plan for Poverty Reduction (Portuguese acronym PARPA II – "*Plano de Acção para Redução da Pobreza Absoluta*").

4.3.2. Specific Objectives

The specific objectives of TIA 2007 were to:

1. Evaluate households' crops and livestock production and to identify main sources of agricultural and non-agricultural income;
2. Obtain information about households' resource endowment, access to services and information, and the use of agricultural inputs;
3. Obtain information about aggregate rural households' income from agricultural product marketing and other sources;
4. Gather basic data to help in evaluating how the livestock sector has changed since the implementation of the Agriculture and Livestock Census (Portuguese acronym CAP – "Censo Agro-Pecuário") in 2000.

4.4. Implementation of TIA 2007

TIA 2007, which was implemented by the Department of Statistics within the Directorate of Economics of the Ministry of Agriculture (MINAG), was conducted from September 3 to November 20, 2007. The data collected covered the 2006/2007 agricultural year (September 2006 to August 2007). The survey solicited household and community level information by interviewing selected households and chiefs of communities and/or key informants. The sample was stratified by province and agro-ecological zones, and the survey was undertaken in 94 of Mozambique's 128 districts. A total of 6,075 small-and medium-scale farm households were interviewed in 658 primary sampling units (Portuguese acronym UPA – "*Unidade Primaria de Amostragem*"). The number of UPAs sampled in each district varied considerably, ranging between 1 and 14 (TIA, 2007).

TIA 2007 was well organized and heavily supervised, with technical staff and enumerators attending training at the national and provincial levels prior to the survey. Coordination and logistical support from the national to the UPAs level was also well structured. The survey employed 190 enumerators, 49 mobile data entry staff, 26 provincial supervisors, and 94 SDAE technical staff. To facilitate data verification, data were entered into laptop computer at the field sites by data entry specialists. TIA 2007 also used technological innovations, such as measuring field size using satellite based GPS instruments (TIA, 2007).

The TIA 2007 questionnaire, which was the main instrument used to collect data, was designed based on previous TIA questionnaires and the 2000 CAP (Censo Agro-Pecuário). TIA 2007 was ambitious; it attempted to cover a range of topics through a farm-level survey and a community-level survey. In the small and medium-scale farm surveys, interviews were conducted with household heads to solicit household level-information. The questionnaire for the small-and medium-scale farm surveys included the following topics: household characteristics (household identification, and number of household members); access to services, associations, credits, and disasters effects; income indicators (salaried employment, self employment, and remittances and pension); field area measurement; relative annual crops areas; production and sales of grains, peanuts, pulses, cassava, and potato; production and sale of cash crops (e.g., tobacco, cotton, coconut, and cashew nut); production of horticultural crops; livestock production and sales; access to livestock agents services; agricultural inputs used (type of labors, animal traction, and other inputs); and food security and household vulnerability.

For the community-level survey, chiefs of communities and/or key informants were interviewed to collect UPAs-level information. The community-level questionnaire included the following topics: location and characteristics of the respondent; the occurrence of natural disaster, animal diseases, and emergency assistance programs; temporary labor activities; access to agricultural inputs markets; agricultural products price at the producer level; the used of improved crop varieties; food security indicators; access to electricity and communication services; infrastructure; mechanism to obtain land; and incidence of fires.

The TIA 2007 classification of farms into three categories, small-, medium-, and large-size (Table 4.2), was based on indicators of the households' total agricultural and animal productions assets (e.g., cultivated area, number of cattle, goat/sheep/hogs, and poultry). Cultivated area was defined as the total non-irrigated area for annual and permanent crops; excluding pastures.

Based on these indicators, small-scale farms were defined as farms with less than 10 hectares of cultivated area, less than 10 head of cattle, less than 50 goats/sheep/hogs, and/or less than 5,000 poultry. Medium-scale farms were defined as those with 10-50 hectares of cultivated area, between 10 and 100 head of cattle, between 50 and 500 goats/sheep/hogs, and/or between 5,000 and 20,000 poultry. Large-scale farms were defined as farms that had one or more component higher than the medium scale limit. For irrigated land, horticultural crops, and plantations, small-scale farms were those with less than five hectares; medium-scale farms were those with five to 10 hectares; and large-scale farms were those with over 10 hectares.

Table 4.2. TIA Farms Classification, 2007

Factors	Small	Farm Size Medium	Large
Cultivated Area (ha)	< 10	< 50	≥ 50
Cattle Production	< 10	< 100	≥ 100
Goat/Sheep/Hog Production	< 50	< 500	≥ 500
Poultry Production	> 5,000	< 20,000	≥ 20,000

Source: TIA, 2007

4.5. Data Transformation

This study analyzes adoption of improved maize and bean varieties at the household level. The TIA 2007 small-and medium-scale farms survey data was collected at both the field and the household levels. To do the household level adoption analysis, the field level data sets were transformed to the household level data.

Transformation of the field level data to the household level requires knowledge about identification of the field and the household level data, variables in the data sets, and variables that are employed in the Probit adoption of improved maize and bean varieties models. Eight field level data sets were collapsed and transformed, including the farm household characteristics data set, which contains several explanatory variables (e.g., household size, household head's education, age, sex, and salaried employment); and the production and sales data sets that contain variables whether or not households adopt improved maize and bean varieties, respectively. In addition, after the data transformation, the different household data sets need to be merged. It is necessary to use appropriate Stata command to collapse and merge data.

4.6. Chapter Summary

TIA 2007 was implemented with the objective to obtain data that would help in monitoring the implementation of PROAGRI II and PARPA II, evaluate crops and livestock production, estimate households' income from agriculture and non-agriculture activities, and obtain information about households' access to services and information.

The department of Statistics of the Ministry of Agriculture carried out the TIA 2007 in 94 districts, interviewing 6,075 small-and medium-size farm household in 658 Primary Sampling Unit. Questionnaire for small-and medium-scale farmers covered several topic, including household characteristics; access to extension services, associations, credits, and disasters effects; income indicators; field area measurement; relative annual crops area; production and sales of food, cash and annual crops; livestock production and sales; access to livestock agents services; agricultural inputs used (type of labors, animal traction, and other inputs); and food security and household vulnerability.

For the community-level survey, chiefs of communities and/or key informants were interviewed to collect UPAs-level information. Information collected from the chiefs of communities and/or key informants include the occurrence of natural disaster, animal diseases, and emergency assistance programs; access to agricultural inputs markets; agricultural products price at the producer level; access to electricity and communication services; infrastructure; mechanism to obtain land; and incidence of fires.

The TIA 2007 survey classified farmers into three categories: small-, medium-, and large-scale farmers. The first two categories included farmers, who had a maximum of 10 and 50 hectares cultivated areas, 10 and 100 cattle, 50 and 500 goats/sheep/hogs, and 5,000 and 20,000 poultries.

CHAPTER V: THE EMPIRICAL TECHNOLOGY ADOPTION MODEL

5.1. Introduction

This chapter presents the empirical technology adoption model that is used to evaluate the household[3]-level decision of whether or not a household adopted improved maize or bean variety in the 2006/2007 agricultural year. The chapter is divided into four sections. The second section presents descriptive statistics; the probit model, including reasons why the probit model is selected over the logit model; and the marginal effect. The third section describes the dependent and independent variables used in the model. The fourth section summarizes the chapter.

5.2.Descriptive Statistics, Probit Adoption Model, and Marginal Effect.

5.2.1. Descriptive Statistics

Prior to the analysis of the probit adoption model to assess farm households' decision of whether or not to adopt an improved maize or bean variety, a series of descriptive statistics were estimated using Stata (version 10) statistical software to explore the research questions described in Chapter I. The descriptive statistical analysis describes the distribution of maize-and/or bean-producing households at the national, the regional, and the provincial levels. Furthermore, it also summarizes the improved maize and bean varietal adoption rates by regions and provinces, family size, and household head's age and education.

[3] In this study, a household is defined as all persons living in the same house and sharing their meals together. Households derive their livelihood mainly from agriculture, utilize almost exclusively family labor, use very little capital, and have relatively small-size farms.

5.2.2. Probit Adoption Model

The dependent variables in the adoption model are 0, 1 dummy variables, which indicate one if a household planted an improved maize or bean variety in the 2006/2007 agricultural year, and zero if otherwise. According to Gujarati (2004), there are three approaches for estimating the qualitative response of dummy dependent variables: 1) linear probability model (LPM); 2) logit model; and 3) probit model.

The linear probability model (LPM) is a typical regression model, but the dependent variable is a dummy variable. The conditional expectation of the dependent variable, given independent variables is interpreted as the conditional probability. However, Wooldridge (2009) and Gujarati (2004) argue that the linear probability model has some drawbacks, including non-normality of the error term, the probabilities can be less than zero or greater than one, and the partial effect of any independent variable (appearing in the level form) is constant. These limitations of the linear probability model can be overcome by the logit or the probit model.

Logit and probit models are based on logistic and normal cumulative distribution functions (CDF), respectively. Gujarati (2004) argues that logit and probit probability models have several features to overcome the disadvantages of the linear probability model, including 1) as an independent variables, X_i increases, the probability of adoption (i.e., $P_i = (Y=1|X)$ increases, but only in the 0-1 interval; and 2) the relationship between P_i and X_i is nonlinear. Therefore, the probability approaches zero as X_i approaches negative infinity and the probability approaches one as X_i approaches positive infinity.

Both logit and probit models are quite similar, but the logistic distribution has slightly fatter tails. Therefore, the conditional probability approaches zero or one at a slower rate in the logit than in the probit model (Gujarati, 2004). This study uses the probit adoption model to analyze households' adoption decision[4] because it is an appropriate econometric model for the binary dependent variable and the error term is assumed to be normally distributed.

The probit model, also known as the normit model, estimates the effects of X_i on the response probability, $P_i = (Y=1|X)$. The model assumes that households make decisions based upon a utility maximization objective. The conceptual framework of the analysis model used in this study is similar to the model that Uaiene et al. (2009) and Zavale et al. (2005) used to estimate households' technology adoption. The model assumes that households' decisions whether or not to adopt improved maize and bean varieties depend on unobservable utility index (or a latent variable) that is determined by household specific attributes X (e.g., household head's gender, age, and education; access to extension services and credit; membership in an agricultural association). The probit model of improved maize and bean varietal adoption is derived from an underlying latent variable model, which is expressed as:

$$\mathbf{Y_i^* = \beta_0 + \beta_{ij}X_{ij} + e_i} \qquad (5.1.)$$

Where $\mathbf{Y_i^*}$ is an underlying index reflecting the difference between the utility of adopting and not adopting improved maize and bean varieties; $\boldsymbol{\beta_0}$ is the intercept, $\boldsymbol{\beta_{ij}}$ is a vector of parameters to be estimated; $\mathbf{X_{ij}}$ is independent variables which explain maize

[4] Wooldridge, 2009: in the probit and the logit models, it is assumed that the standard error (e) is independent of x. Therefore, the error term either has the standard logistic distribution or the standard normal distribution. In either the probit or the logit models, the error term is symmetrically distributed about zero. Economists tend to favor the probit model over the logit model for the binary dependent variable case because they assume that the probit model has an error term that is normally distributed.

and bean varieties adoption; and $\mathbf{e_i}$ is the standard normally distributed error term that is independent of X_j and is symmetrically distributed about zero.

From the latent variable model *(5.1)* and the assumptions given, the household adoption of improved maize and bean varieties model is derived as

$$\mathbf{P(Y_i^* = 1|x) = F(\beta_0 + \beta_{ij}X_{ij})} \qquad (5.2)$$

Where F is the function that ensures the likelihood of adopting improved maize and bean varieties are strictly between zero and one. Therefore, a farm household adopts improved varieties if $Y_i^* > 0$, and otherwise if $Y_i^* \leq 0$.

In the case of a normal distribution function, the model to estimate the probability of observing a household using a new technology can be explicitly stated as:

$$\boldsymbol{P\ (Y_i^* = 1|x) = \mathrm{F}(\beta X) = \int_{-\infty}^{\beta X} \frac{1}{\sqrt{2\pi}} \mathbf{exp}(-z^2/2)dz} \qquad (5.3)$$

Where P is the probability that the *i*th household used improved varieties and 0 otherwise; X is the K by 1 vector of the independent variables; z is the standard normal variable, i.e., $Z \sim N(0,\sigma^2)$; and β is the K by 1 vector of the coefficients to be estimated.

5.2.3. Marginal Effect after Probit Regression

In most applications, once parameter estimates from the probit or the logit regressions are obtained, a natural next step is to consider the marginal effects. According to Corneliben (2005) and Gujarati (2004), regression analysis usually aims at estimating the marginal effect of an independent variable on the dependent variable, controlling for the influence of other independent variables. In the linear regression model, the estimated parameters can be interpreted as marginal effects. In non-linear regression models or the binary regression models (e.g., probit and logit models), parameter estimates cannot be interpreted as marginal effects. The marginal effect of an independent variable (e.g., household had access to extension services) is obtained by calculating the derivative of the outcome probability with respect to an independent variable.

Wooldridge (2009) and Gujarati (2004) argue that in most applications of binary regression models (e.g., probit model), the primary goal is to explain the effects of the X_j on the probability regression P_i (y = 1|X). The latent variable formulation (5.1) indicates that the probit adoption model is primarily interested in the effect of each X_i (e.g., households had access to extension services and credit) on Y_i^* (whether or not to adopt improved maize or bean varieties)[5].

5.3.Variables Description.

Independent variables are classified into three main groups: 1) farmers' socio-demography characteristics, including household size, and household head's gender, age, and education; 2) institutional factors, including access to price information from markets, extension services and credit, and membership in an agricultural association; and 3) risks and economic attributes, including whether or not crop production had been reduced by drought, flood, or wild animals, household head's salaried employment, whether or not the household grew cotton or tobacco in previous year, and the use of

[5] Gujarati (2004) argues that in the logit model, the marginal effect or the rate of change of an event happening is given by $\beta_j P_i(1 - P_i)$, where β_j is the partial regression coefficient of the *j*th independent variable. In the probit model, the rate of change in the probability is somewhat complicated and is given by $\beta_j f(Z_i)$, where $f(Z_i)$ is the density function of the standard normal variable and $Z_i = \beta_1 + \beta_2 X_{2i} + \cdots + \beta_k X_{ki}$, thus, in the logit and probit models, all independent variables are involved in computing the changes in probability. Wooldridge (2009), argues that for the discrete independent variables (e.g, a binary independent variable), partial effect from changing X_i from zero to one, holding other variable constant is $f(\beta_0 + \beta_1 + \beta_2 x_2 + \ldots + \beta_k x_k) - f(\beta_0 + \beta_2 x_2 + \ldots + \beta_k x_k)$, and for the continuous variables is $f(\beta_0 + \beta x)\beta_j$

animal traction. A detailed description of the dependent and independent variables is provided in the following sections.

5.3.1. Dependent Variables

The dependent variables *(Adop_Imp_Maize* and *Adop_Imp_Bean)* are a 0, 1 dummy variables, which indicates whether or not households planted an improved maize and bean varieties in the 2006/2007 agricultural year. The probability of households' adoption of improved maize and bean varieties is explained and estimated by the sign, the statistically significance, and the magnitude of the parameter of estimates in the probit technology adoption model. The independent variables are classified into three main groups: farmers' socio-demography characteristics, institutional factors, and risks and economic attributes.

5.3.2. Independent Variables

5.3.2.1. Farmers' Socio-Demography Characteristics

The household head's decision whether or not to adopt improved maize and bean varieties is hypothesized to be associated with several independent variables. The household size *(HH_Size)* is a continuous variable that indicates the number of people in the household, including parents, children, and other relatives who live in the same house and share food together. The household head's age *(HH_Age)* is also a continuous variable that may be associated with varietal adoption because old and young farmers may respond differently to new agricultural technologies. Household head's gender *(HH_Sex)* is a dummy variable equals to 0 if the household head is female and 1 if the household head is male. Household head's gender is an independent variable that is commonly used in technology adoption studies in developing countries because in some communities, socio-cultural factors limit females to access to public services. The household head's education *(HH_Educ)* indicates years of formal education that the household head has completed. This variable is included in the probit adoption analysis to assess if household heads with different level of education behave differently toward improved maize and bean varieties.

5.3.2.2. Institutional Factors

Access to extension services *(Acc-Ext),* credit *(Acc_Credit),* and price information from markets *(Acc_Price_Info)*, as well as membership in an agricultural association (Mem_Ass), are dummy variables that take a value of 1 if the household has access to these services and 0 if otherwise. Literature suggests that households may learn about improved varieties and share experience through agricultural associations' programs. Similarly, households may learn about a new agricultural technology from extension agents and other farmers. Therefore, it is frequently argued that households who are active in an agricultural association and have contact with extension agents are more likely to adopt new agricultural technologies.

In deciding whether or not to adopt improved maize and bean varieties, households need cash and price information from markets. Therefore, these variables are included to assess whether these factors are associated with households' adoption of improved maize and bean varieties.

5.3.2.3. Risks and Economic Attributes

Drought *(Risk_Drought),* flood *(Risk_Flood),* and damage from wild animals *(Risk_Wild_Ani)* are included as independent variables because in recent years, drought and flood have reduced households' maize and bean yields. Household head's salaried employment *(HH_Sal_Emp)* is a categorical variable that takes a value of 1 if the household head received payments (e.g., salary) from his/her job and 0 if otherwise. The objective of employing this variable in the probit improved varieties adoption model is to assess whether incomes from off-farm jobs have a positive or negative association with households' decision to adopt improved maize and bean varieties.

"Whether or not households grew cotton or tobacco in previous year" *(Cotton* or *Tobacco)* are included as independent variables to assess whether these factors are positively or negatively associated with households' adoption decision. It is hypothesized that adoption of improved maize and bean varieties is positively associated with mechanization used in the cotton or tobacco farming – both because households need appropriate equipment to plow and weed their farms in a timely manner and the availability of residual fertilizer in the previous year's cotton or tobacco fields reduces households' cash outlays for the maize and bean production. "Use of animal tractions" *(Use_Ani_Traction)* is included as an independent variable to assess whether households' use of animal tractions is associated with households' adoption of improved maize and bean varieties in the 2006/2007 agricultural year.

Table 5.1 presents a detailed description on the definition of the dependent and independent variables, the unit of measurement, and the summary statistic for these variables. The table also presents the independent variables into three different categories: 1) farmers' socio-demography characteristics; 2) institutional factors; and 3) risks and economic attributes.

Table 5.1. Definition and Descriptive Statistics of Dependent and Independent Variables[6]

Variable	Definition	Obs	Unit of Measurement	Mean	Std. Dev.	Min	Max
	Dependent Variables						
Adopt_Imp_Maize	Adoption of Improved Maize Varieties	4,956	1 = adopt & 0 = otherwise	0.2	0.02	0	1
Adopt_Imp_Bean	Adoption of Improved Common Bean Varieties	924	1 = adopt & 0 = otherwise	0.1	0.01	0	1
	Independent Variables						
Farmers' Socio-Demography Characteristics							
HH_Size	Household Size	6,075	Person	5.4	0.11	1	41
HH_Sex	Household Head's Sex	6,075	1 = male & 0 = otherwise	0.8	0.02	0	1
HH_Age	Household Head's Age	6,075	Years	43.1	0.63	14	97
HH_Educ	Household Head's Education	6,075	Years	2.6	0.11	0	13
Institutional Factors							
Acc_Ext	Household had Contact with Extension Services	6,075	1 = yes & 0 = no	0.1	0.02	0	1
Acc_Credit	Household had Access to Credit	6,075	1 = yes & 0 = no	0.1	0.01	0	1
Acc_Price Info	Farmers Received Price Information from Market	6,075	1 = yes & 0 = no	0.2	0.02	0	1
Mem_Ass	Household Belonged to an Agricultural Association	6,075	1 = yes & 0 = no	0.1	0.01	0	1
Risks & Economic Attributes							
Risk_Flood	Household Affected by Flood in the Last 2 Years	6,075	1 = yes & 0 = no	0.3	0.02	0	1
Risk_Drought	Household Affected by Drought in the Last 2 Years	6,075	1 = yes & 0 = no	0.1	0.02	0	1
Risk-Wild_Ani	HH Affected by Wild animal in the Last 2 Years	6,075	1 = yes & 0 = no	0.3	0.02	0	1
HH_Sal_Emp	Off –farm job	6,073	1 = yes & 0 = no	0.3	0.02	0	2
Cotton	Farm Household Grew Cotton	6,075	1 = yes & 0 = no	0.0	0.01	0	1
Tobacco	Farm Household Grew Tobacco	6,075	1 = yes & 0 = no	0.1	0.01	0	1
Use_Ani_Traction	Farm Household Used Animal Traction	6,075	1 = yes & 0 = no	0.2	0.02	0	1

Source: TIA, 2007

[6] The mean values in table 5.1 are weighted.

5.4. Chapter Summary

Descriptive statistics and probit analysis are used to answer the research questions and test the hypothesis described in Chapter I. The descriptive statistical analysis is used to describe the distribution of maize- and bean-producing households in each province and present a summary statistics of the improved maize and bean varietal adoption rates. The dependent variables of the adoption model are a 0, 1 dummy variables, which indicates one if households planted improved maize and bean varieties in the 2006/2007 agricultural year, and zero if otherwise. There are three approaches for the qualitative response of the dummy dependent variables: 1) Linear probability model (LPM); 2) logit model; and 3) probit model.

This study uses a probit model because it is an appropriate econometric model for the limited dependent variable case and the error term is assumed to be normally distributed. In most application of binary regression models (e.g., probit model), the primary goal is to explain the effects of the X_j on the probability regression P_i $(y = 1|X)$.

Independent variables are divided into three main categories: socio-demography characteristics, institutional factors, and risks and economic attributes. Socio-demography characteristics included in the adoption model as independent variables are household size, and household head's gender, age, education. The institutional variables are access to extension services, credit, and price information from markets, as well as membership in an agricultural association. The independent variables that fall into the risks and economic attributes category are crop losses due to drought, flood, or wild animals, household head's salaried employment, and whether or not the household grew cotton or tobacco in previous year, and if it used of animal tractions.

CHAPTER VI: RESULTS AND INTERPRETATION

6.1. Introduction

This chapter presents the results and interpretation of the analysis. The chapter is divided into four sections. The second section describes the improved maize varietal adoption analysis, including the distribution of maize-producing households at the provincial level, improved maize adoption rates, and the results and interpretation of the probit analysis of improved maize variety adoption. The third section presents the improved bean varietal adoption analysis, including the distribution of bean-producing households at the provincial level, improved bean adoption rates, and the results and interpretation of the probit analysis of improved bean variety adoption. The fourth section summarizes the chapter.

6.2. Improved Maize Varietal Adoption Analysis.

6.2.1. Distribution of Maize-Producing Households and Maize Production

6.2.1.1. Distribution of Maize-Producing Households

Maize is the most widely grown staple food crop in Mozambique. Approximately 82% (N = 6,075) of the households who participated in the Mozambique Agricultural Household Survey (TIA 2007) produced maize. The distribution of maize-producing households varied greatly by region and province. At the regional level, 87% of the households in the southern region (Inhambane, Maputo, and Gaza Provinces) produced maize, compared to 86% in the central region's four provinces (Zambezia, Manica, Tete, and Sofala) and 69% in the northern region (Nampula, Cabo Delgado, and Niassa Provinces).[7]

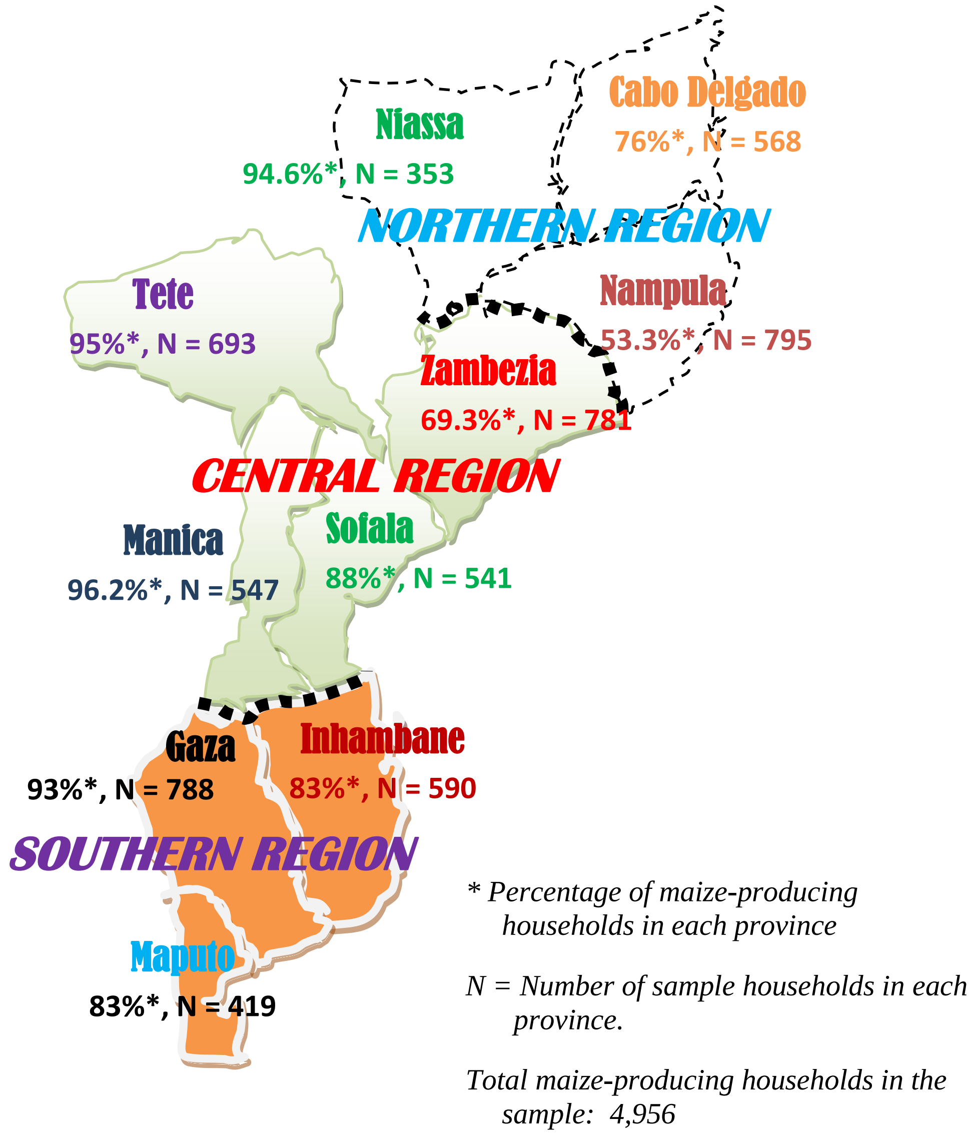
The distribution of maize-producing households also varied greatly by province, ranging from 53 to 96%. The percent of households producing maize was highest in Manica Province (96%), followed by Tete Province (95%). In contrast, the percent of households growing maize was lowest in Nampula (53%) and Zambezia Provinces (69%) (Figure: 6.1). The distribution of maize-producing households by province suggests that maize was an important staple food crop for smallholder households in each province, given that more than 50% of households in all provinces produced maize in the 2006/2007 agricultural year.

6.2.1.2. Maize Production

Household maize production in Mozambique is relatively low. In the 2006/2007 agricultural year, maize production per household averaged 443 kilograms,[8] despite the fact that maize is the most-widely grown staple food crops in Mozambique. Relatively low production of maize suggests that probably most of smallholder households grown maize for subsistence on rainfed land, intercrop maize with other staple crops, use manual cultivation techniques, and apply limited amounts of purchased inputs (e.g., fertilizer).

[7] Total number of households included in the TIA 2007 data sets varied by region: northern region, 1,716; central region, 2,562; and southern region, 1,797.
[8] The weighted average of households' maize production in the 2006/2007 agricultural year

Figure: 6.1. Map of the Maize-Producing Households in Mozambique by Province in the 2006/2007 Agricultural Year[9]



Source: TIA, 2007

6.2.2. Improved Maize Varietal Adoption Rate.

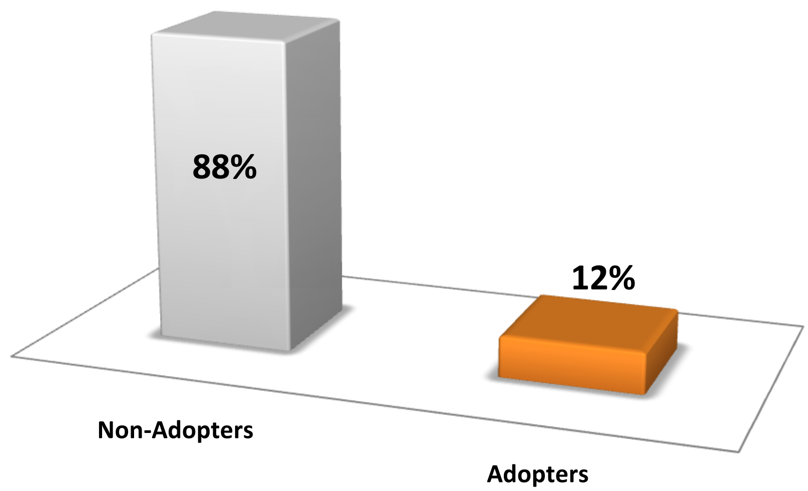
6.2.2.1 Improved Maize Adoption Rate: National and Provincial Levels

Adoption of improved maize variety in Mozambique was relatively low. In the Mozambique Agriculture Household Survey (TIA 2007), improved maize variety was defined as a variety that was commercially packaged and sold. Thus, adopters are limited

[9] Shaded areas in the map represent provinces and regions in Mozambique.

to farm households who planted commercially packaged maize in the 2006/2007 agricultural year.[10] Of the 4,956 maize-producing households, only 12% reported growing an improved maize variety (Figure 6.2). Although this adoption rate is low, it is higher than the adoption rate in the 2004/2005 agricultural year, which was only seven percent.

Figure 6.2. Adoption of Improved Maize Variety in Mozambique in the 2006/2007 Agricultural Year



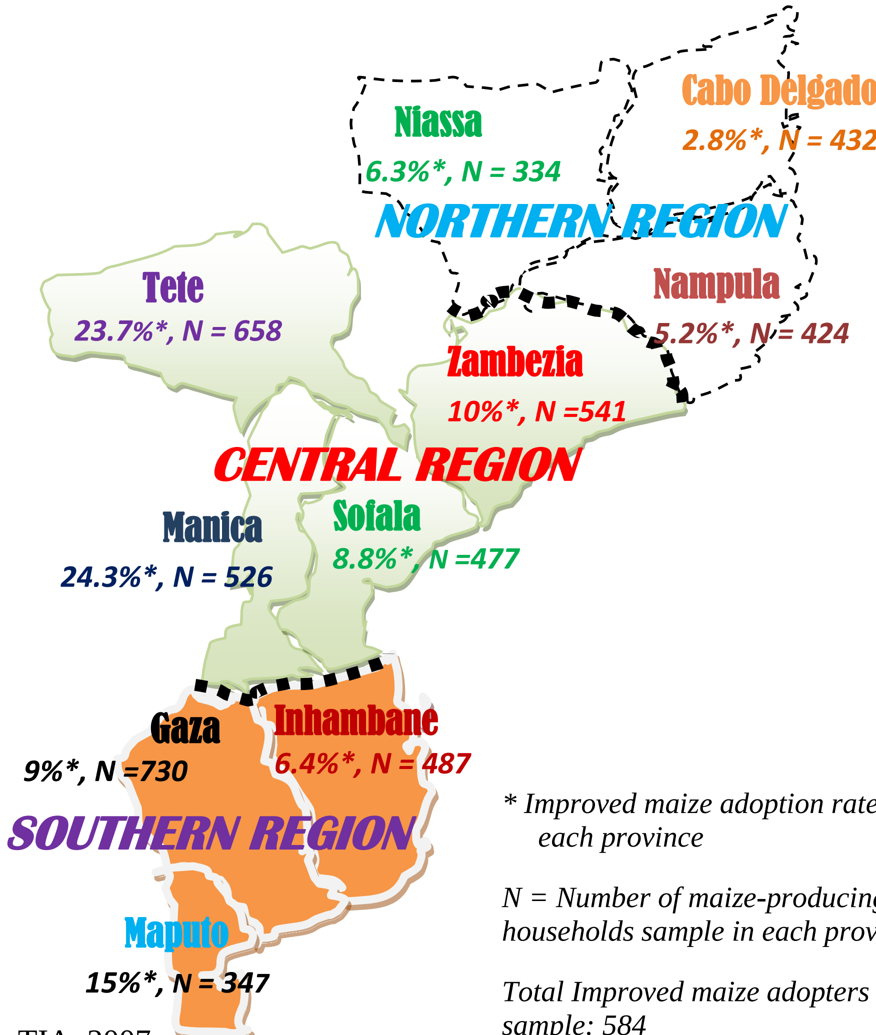
Source: TIA, 2007

Households who adopted improved maize were distributed throughout the regions and provinces of the country. At the regional level, the highest percentage of maize-producing households who planted improved maize in the 2006/2007 agricultural year were in the central region (17%), followed by the southern region (10%), and the northern region (4.6%).

[10] The same definition is applied for the improved bean variety and households who planted an improved bean variety.

The percentage of households who planted improved maize varied greatly by province, ranging from 3% to 24%. The adoption rate was highest in Manica Province (24%), followed by Tete (23.7%) and Maputo Provinces (15%). In contrast, the adoption rate was lowest in Cabo Delgado Province (3%) (Figure 6.3).

Figure: 6.3. Map of the Improved Maize Adoption Rate in Mozambique by Province in the 2006/2007 Agricultural Year



** Improved maize adoption rates for each province*

N = Number of maize-producing households sample in each province

Total Improved maize adopters in the sample: 584

Source: TIA, 2007

6.2.2.2. Improved Maize Adoption Rate: Household Size

Household size is one of the characteristics that has been widely used in studies to explain technology adoption. Households typically had 1 to 8 members, with an average of 4.8 members.[11] To assess the relationship between household size and the adoption rate, households were divided into four groups: households with 1-4 members, 5-8 members, 9-12 members, and more than 12 members. Among maize-producing households, the largest share of the household heads had 5-8 members (46%), followed by those with 1-4 members (39.6%) (Table 6.1).

Improved maize varietal adoption varied by the household size. Households with 9-12 members had the highest adoption rate (15.5%), whereas, households with 1-4 members had the lowest adoption rate (10%). (Table 6.1).

Table 6.1 Improved Maize Adoption in Mozambique by Household Size in the 2006/2007 Agricultural Year

Household Size (Members)	Number of Households	Percent	Number of Adopters	Adoption Rate (%)
1 to 4	1,963	39.6	190	9.7
5 to 8	2,278	46.0	288	12.6
9 to 12	510	10.3	79	15.5
13 & More	205	4.1	27	13.2
Total	**4,956**	**100**	**584**	**12.0**

Source: TIA, 2007

6.2.2.3. Improved Maize Adoption Rate: Age of Household Head

Age of the household head is hypothesized to be associated with technology adoption. Analysis of the TIA 2007 data indicated that the household head's age averaged 42.7 years[12]. To assess the relationship between household head's age and improved maize varietal adoption, households were divided into four different groups. Among maize-producing households, the largest share of the household heads was 21-40 years of age (42%), followed by those 41-60 years of age (40%) (Table 6.2).

[11] The weighted average household size of the households who participated in the 2007 TIA survey
[12] The weighted average of the age of household head

Households who planted improved maize varied by household head's age (Table 6.2). Households whose head was 41-60 years of age had the highest adoption rate (13%), whereas, households whose head was 20 years of age or younger had the lowest adoption rate (4%). The relationship between household head's age and the adoption of improved maize indicates that the adoption rate is higher among mid-aged heads (21-60), compared to households with a very young or very old household head.

Table 6.2 Improved Maize Adoption in Mozambique by Household Head's Age in the 2006/2007 Agricultural Year

Household Head's Age	Number of Households	Percent	Number of Adopters	Adoption Rate (%)
20 or younger	93	1.9	4	4.3
21 to 40	2,073	41.8	249	12
41 to 60	1,967	39.7	250	12.7
61 & older	823	16.6	81	9.8
Total	**4,956**	**100**	**584**	**12.0**

Source: TIA, 2007

6.2.2.4 Improved Maize Adoption Rate: Education of Household Head

In Mozambique, the education level of household heads is quite low. Approximately 42.6% of household heads in the sample never attended formal education, 47.4% attended primary school, 9.7% attended high school, and less than one percent had a college (13 years) education (Table 6.3). On average the household heads had 2.8 years of schooling.[13]

The adoption of improved maize with respect to the education of household head varied greatly (Table 6.3). To assess the relationship between education and adoption, household heads were divided into four categories: no education refers to household

[13] The weighted average of household head's education.

heads who had no formal education, one to six years is equal to a primary school education, seven to 12 years is equal to pre-secondary school (Junior High School) and secondary (High School) education, and 13 years or more is equal to a college education. The adoption rate was highest among households whose head had a college education (38.5%), whereas, it was lowest among households whose head had no formal education (9%). This suggests that adoption of improved maize varieties is positively associated with the household head's education.

Table 6.3 Improved Maize Adoption in Mozambique by Household Head's Education in the 2006/2007 Agricultural Year

Education of the Household Head	Number of Households	Percent	Number of Adopters	Adoption Rate (%)
No Education	2,110	42.6	187	8.9
1 to 6	2,351	47.4	288	12.3
7 to 12	482	9.7	104	21.6
13 & more	13	0.3	5	38.5
Total	**4,956**	**100**	**584**	**12.0**

Source: TIA, 2007

6.2.3. Probit Analysis: Improved Maize Varieties

This study uses probit analysis to estimate the likelihood of improved maize adoption and to assess the statistical significance, as well as to assess socio-demography characteristics, institutional factors, and risks and economic attributes associated with the households' adoption decision at both the national and regional (north, central, and south) levels.[14]

[14] As shown in Table 6.4 and Table 6.8, the estimated coefficients and the marginal effects estimate the effect of each variable on the households' probability of adopting improved maize and bean varieties at the national and regional (north, central, and south) levels. These tables also show the statistically significant of the coefficients and the marginal effects.

The national level probit analysis uses data from all sample households (N= 4,919) to estimate the likelihood of the households' adoption decision. On the other hand, the regional-level probit analysis only uses sample households from the respective regions (e.g., only information from sample households in the northern region) to estimate the likelihood of the households' adoption decision.[15]

Table 6.4 presents the estimated coefficients and the marginal effects of the probit regression for improved maize varietal adoption at both the national and the regional levels. Furthermore, it also shows the statistical significance of the coefficients at 1%, 5%, and 10% levels. The statistical significance of the estimated coefficients and the marginal effects are indicated with stars and parentheses, respectively.

[15] The national and the regional level probit analysis is conducted to better understand the adoption likelihood at the national and/or the regional levels.

Table 6.4 Coefficient and Marginal Effect Estimates for Improved Maize Variety at the National and Regional Levels[16]

Variables	National Level			Northern Region			Central Region			Southern Region		
	Coef.		Marginal Effect	Coef.		Marginal Effect	Coef.		Marginal Effect	Coef.		Marginal Effect
Constant	-7.275	***		-8.177	***		-0.937	**		-1.830	***	
Farmers' Socio-Demography Characteristics												
HH_Size	0.011		0.002	0.038		0.001	0.023		0.005	-0.029		-0.003
HH_Sex	-0.011		-0.002	-0.017		-0.001	-0.139		-0.032	0.257		0.027
HH_Age	0.004	*	0.001	0.012	*	0.0004	0.004		0.001	0.001		0.0001
HH_Educ	0.063	***	(0.009)	0.149	***	(0.005)	0.045	***	(0.010)	0.023		0.003
Institutional Factors												
Acc_Ext	0.420	***	(0.075)	0.421	*	0.023	0.362	***	(0.091)	0.706	***	(0.120)
Acc_Credit	0.205		0.033	0.699	**	0.052	0.024		0.005	0.140		0.017
Acc_Price_info	0.070		0.010	0.065		0.003	0.064		0.014	-0.007		-0.001
Mem_Ass	-0.059		-0.008	0.019		0.001	-0.076		-0.016	0.164		0.020
Risks & Economic Attributes												
Risk_Drought	-0.144	**	(-0.020)	-0.485	*	(-0.013)	-0.234	***	(-0.050)	-0.099		-0.012
Risk_Flood	0.385	***	(0.068)	-0.373		-0.010	0.320	***	(0.077)	-0.292		-0.026
Risk_Wild_Ani	0.069		0.010	-0.182		-0.006	0.160		0.037	0.272	*	0.034
HH_Sal_Emp	0.244	***	(0.038)	-0.103		-0.004	0.374	***	(0.088)	0.047		0.005
Cotton	0.037		0.005	-0.329		-0.009	0.120		0.028	a		a
Tobacco	0.027		0.004	-0.942		(-0.015)	0.104		0.024	0.589		0.102
Use_Ani_Traction	0.259	***	(0.042)	a		a	0.464	***	(0.122)	-0.090		-0.010
Log p likelihood	*-1471.1*			*-168.9*			*-868.5*			*-340.4*		
Pseudo R^2	*0.085*			*0.225*			*0.081*			*0.083*		
Observations	*4919*			*1111*			*2183*			*1469*		

***Statistically significant at 1% level; ** Statistically significant at 5% level; *Statistically significant at 10% level. The marginal effects for significant variables (significant at five and one percent levels) are in parentheses. a) The coefficients and marginal effects on animal traction in the northern region and cotton in the southern region were dropped due to collinearity.

[16] The pseudo R^2 is low because of dummy dependent variable. Gujarati (2004) argues that R^2 in the dichotomous response model is much lower compared to the linear model because of dummy or binary dependent variable.

6.2.3.1. Probit Analysis: Farmers' Socio-Demography Characteristics Associated with the Adoption of Improved Maize Varieties.

The explanatory variables included in the category "farmers' socio-demography characteristics" are household size *(HH_Size)*, household head's gender *(HH_Sex)*, household head's age *(HH_Age)*, and household head's education *(HH-Educ).*

"Household size" *(HH_Size)* is hypothesized to be positively associated with the households' improved maize adoption decision.[17] The effect of this variable is positively associated with the households' adoption decision at both the national and regional levels (except for households in the southern region), but it was not statistically significant (Table 6.4).

Similarly, the effect of the "household head's gender" *(HH_Sex)* is not statistically significant at all levels, is but positively associated with the likelihood of maize-producing households in the southern region to plant an improved maize variety, and negatively associated with the household adoption decision at the national level and in the northern and the central regions (Table 6.4).

The effect of the household head's experience, as measured by the "age of the household head" *(HH_Age)*, on its decision to adopt an improved maize variety is only statistically significant (10% level) at the national and in the northern region. However, the effect is positive at all levels of analysis (Table 6.4). This implies that the likelihood of adoption is higher among older household heads, relative to younger ones. Across the country, an additional one year of the household head age increases the likelihood of the household to adopt an improved maize variety by 0.1% -- older farmers are more likely

[17] While adults/adult equivalents is a better indicator of labor availability, data were not available to use adult equivalents as an independent variable.

to adopt improved maize than young farmers. Adesina and Forson (1995) suggest that old farmers may have a higher likelihood of adoption, relative to young farmers because old farmers may have accumulated capital or have greater access to credit, due to their age.

The estimated coefficient for "household head's education" *(HH_Educ)* is statistically significant (1% level) at the national level and in the northern and the central regions, but not for households in the southern region. Furthermore, the coefficient is positively associated with the adoption of improved maize at both the national and the regional levels (Table 6.4). This suggests that household heads who spent more years attending formal school programs are more likely to adopt an improved maize variety than less educated household heads. Across the country, an additional one year of education increases the likelihood of the household to adopt an improved maize variety by 0.9%. This is consistent with other technology adoption studies (e.g., Adegbola and Gardebroek, 2007), which argue that educated farmers are better able than uneducated farmers to process information, allocate inputs efficiently, and assess the profitability of new technologies -- thereby increasing their likelihood of adopting new agricultural technologies.

While variables such as available land/farm size and value of farm assets may be associated with households' adoption decision, data were not available to include these items as independent variables in the adoption model.

6.2.3.2. Probit Analysis: Institutional Factors Associated With the Adoption of Improved Maize Varieties.

Independent dummy variables that are included in the category "institutional factors" are whether or not households had access to 1) extension services, 2) credit, 3) price information from markets, and 4) association membership. This study uses these variables in the probit adoption model to measure the extent to which households had access to information and capital. Some technology adoption studies (e.g., Pattanayak et al., 2003; Feder et al., 1985; and Bandeira and Rasul, 2005) suggest that these variables are positively associated with households' decision to adopt new agricultural technologies.

As expected, "access to extension services" *(Acc_Ext)* is statistically significant (1% level) at the national level and in the central and southern regions, but is also statistically significant at the 10% level in the northern region. Furthermore, the effect is positively associated with the adoption of an improved maize variety at both the national and the regional levels (Table 6.4). This suggests that households who had access to extension programs from the government, NGOs, and other extension providers are more likely to adopt an improved maize variety. Across the country, the likelihood of adopting an improved maize variety for households who had access to extension programs is 7.5% higher, relative to households who did not have access to extension programs. At the regional level, access to extension programs increases the likelihood of adoption for households in the northern region by 2.3%, in the central region by 9.1%, and in the southern region by 12%. This is consistent with the hypothesis that extension programs help households to understand the potential benefits of improved maize -- thereby increasing the likelihood of adoption.

This study hypothesizes that "access to credit" *(Acc_Credit)* is associated with the households' adoption decision. Feder et al. (1985) argue that capital in the form of either accumulated saving or access to capital markets is necessary for households to purchase or finance new agricultural technologies. Furthermore, they suggest that access to credit and farmers' new technological adoption decision are positively associated. Access to credit is positively and statistically significant (5% level) in the northern region (Table 6.4). In the northern region, the likelihood of planting an improved maize variety is 5.2% higher for household who had access to credit, relative to households who did not have access to credits from banks, microfinance institutions, or other credit providers. However, improved seed is relatively inexpensive-compared to a capital investment like a tractor. This may explain why access to credit is not significant at the national level and in other regions.

The independent variable "household had access to price information from markets" *(Acc_Price_Info)* is employed as a proxy variable for households who had access to markets. The effect of this variable is not statistically significant[18], but it is positively associated with the households' adoption decision (except in the southern region) (Table 6.4).

The likelihood of adopting an improved maize variety is hypothesized to be high among "agricultural association members" *(Mem_Ass)* because they receive and share information on the potential benefits of the improved maize variety with other members. Surprisingly, the effect of this variable is not statistically significant at the national and the regional levels. Furthermore, it is not statistically significant and negatively

[18] The effect of "whether farm households sell their maize and beans in the market" is also not statistically significant when this variable is included in the adoption models.

associated with households' adoption decision at the national level and in the central region (Table 6.4).

6.2.3.3. Probit Analysis: Risks and Economic Attributes Associated With the Adoption of Improved Maize Varieties.

The independent dummy variables included in the category "risks and economic attributes" are whether or not: 1) the household experienced crop losses in the last two years due to drought, flood, or wild animals; 2) household head earned income from salaried employment; and 3) the household grew cotton and/or tobacco in previous year; and 4) the household used animal traction during the 2006/2007 agricultural year.

This study hypothesizes that "having experienced drought in the last two years" *(Risk_Drought)* is negatively associated with the households' adoption decision. As expected, the effect of this variable is statistically significant (5% level) at the national level, (10% level) in the northern region, and (1% level) in the central region. In addition, this variable is negatively associated with the households' adoption decision at both the national level and in all three regions (Table 6.4). This suggests that having experienced drought decreases the likelihood of households adopting an improved maize variety. Across the country and in the central region, drought reduces the likelihood of the household adopting an improved maize variety by 2% and 5%, respectively. Uaiene et al. (2009) report that Mozambique's farm households experienced drought in several previous agricultural years. They suggest that farmers will be less likely to adopt improved varieties, if the risk of drought is high.

The independent dummy variable "flood" *(Risk_Flood)* is hypothesized to be negatively associated with the households' adoption decision. Surprisingly, the effects of this variable are statistically significant (1% level) and are positively associated with adoption at both the national level and in the central region (Table 6.4). The positive association suggests that the occurrence of floods in the last two years increases households' likelihood of adopting an improved maize variety. Across the country and in the central region, maize-producing households who had experienced flooding are 6.8% and 7.7% more likely to plant an improved maize variety. The positive association between flood and improved maize adoption could be because farmers received improved seeds as part of a post-flood disaster relief program. As expected, households' response to the impact of droughts and floods on the adoption of improved varieties differs across regions due to the wide diversity in the climate and the ecology of Mozambique[19].

Threats of "wild animals" *(Risk_Wild_Ani)* on households' crops farming is expected to decrease the likelihood of adopting an improved maize variety. Surprisingly, the effect is only statistically significant (10% level) in the southern region (Table 6.4). The positive association suggests that threats of wild animals increase the likelihood of adoption. In the southern region, threats from wild animal increase the likelihood of the household to adopt an improved maize variety by 3.4%.

This study includes the independent dummy variable "household head's salaried employment" *(HH_Sal_Emp)* in the probit adoption model to estimate if households who earned off-farm income are more likely to plant improved maize. The effect of this variable is statistically significant (1% level) at both the national level and in the central region. Furthermore, the estimated coefficient is only negative for maize-producing households in the northern region (Table 6.4). The positive association implies that

---

[19] While access to irrigation may be associated with households' adoption behaviors, data were not available to use irrigation as an independent variable.

households who earned off-farm income are more likely to plant an improved maize variety. Across the country and in the central region, the likelihood of households who earned off-farm income to plant an improved maize variety is 3.8% and 8.8% greater, respectively, compared to households who did not earned off-farm income.

Both cotton and tobacco are cash crops for households in Mozambique. This study hypothesizes that the estimated coefficients on these two variables are positively associated with the households' adoption decision. However, neither coefficient is statistically significant at any level (Table 6.4).

Households who "used animal traction" *(Use_Ani_Traction)* are expected to plant an improved maize variety. The effect of using animal traction is statistically significant (1% level) and positively associated with the households' adoption decision at both the national level and in the central region (Table 6.4). This suggests that households who reported using animal traction are more likely to adopt an improved maize variety. Across the country and in the central region, households who reported using animal traction are more likely to adopt an improved maize variety by 4.2% and 12.2%, respectively.

6.3. Improved Bean Varietal Adoption Analysis.

6.3.1. Distribution of Bean-Producing Households and Bean Production

6.3.1.1. Bean-Producing Households

Beans are grown by many households throughout Mozambique. However, beans were not as widely grown as maize in the 2006/2007 agricultural year -- only 15% (N = 6,073) of the sampled households produced beans. Analysis of the TIA 2007 survey data indicated that the central region had 18% of households produced bean, compared to the southern region (17%) and the northern region (10%).

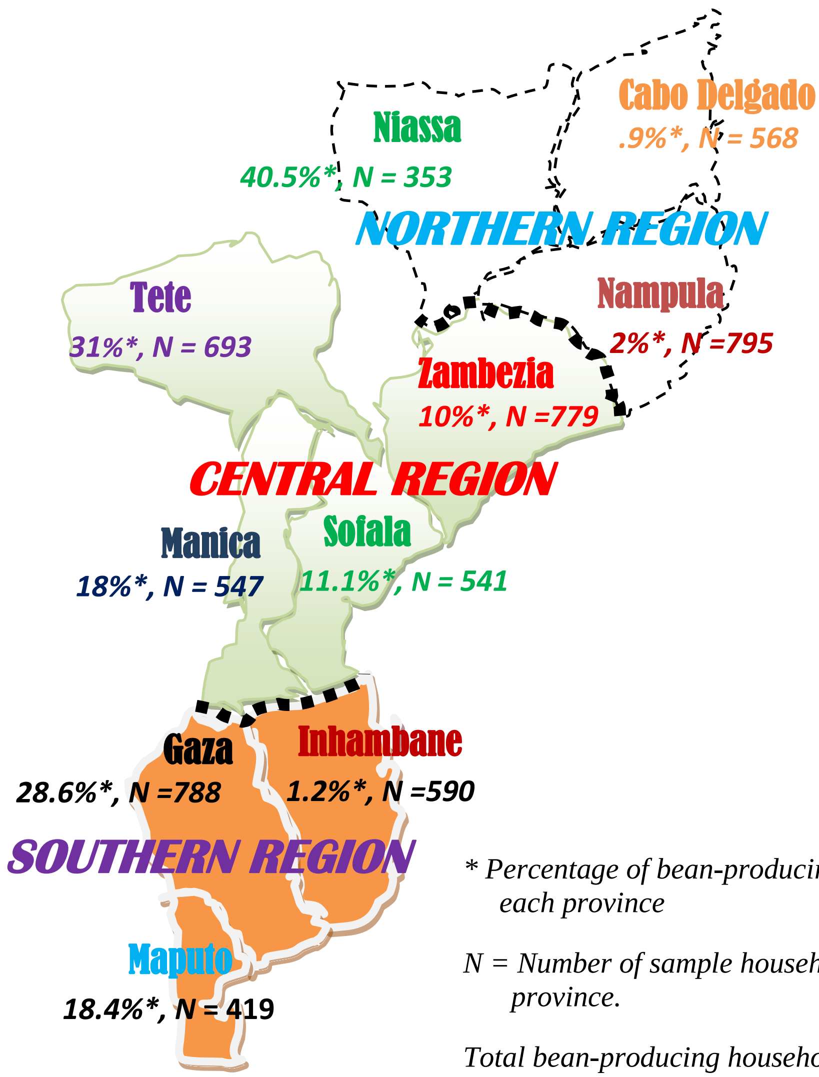
The distribution of bean-producing households varied greatly by province, ranging from 0.9% to 40.5%. The percent of households planting bean was highest in Niassa Province (40.5%), followed by Tete (31%), and Gaza Provinces (29%) In contrast, the percent of households planting bean was lowest in Cabo Delgado (0.9%) and Inhambane Provinces (1.2%) (Figure 6.4).

6.3.1.2 Beans Production

Household bean production in Mozambique in the 2006/2007 agricultural year was very low, ranging from 1 to 4,106 kilograms and averaging 143 kilograms[20] per household. These results suggest that beans were likely planted together with other staple food crops. Bias and Donovan (2003) reported that many smallholder households in Mozambique grow staple food crops (e.g., maize and cassava) in an intercrop system.

[20] The weighted average of households' bean production.

Figure: 6.4. Map of the Bean-Producing Households in Mozambique by Province in 2006/2007 Agricultural Year



** Percentage of bean-producing households in each province*

N = Number of sample households in each province.

Total bean-producing households in the sample: 924

Source: TIA, 2007

6.3.2. Improved Bean Varietal Adoption Rate

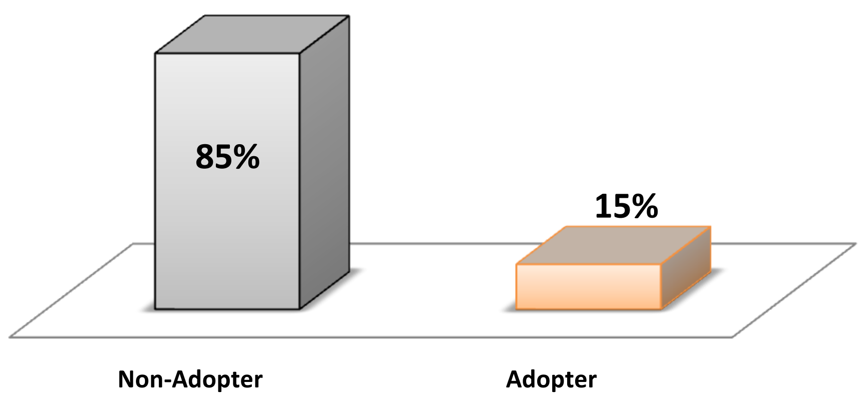
6.3.2.1. Improved Bean Adoption Rate: National and Provincial Levels

To assess the distribution of bean-producing households who planted an improved bean variety in Mozambique, this study analyzes the adoption rate at the national, the regional, and the provincial levels. Analysis of the TIA 2007 survey data indicated that in the 2006/2007 agricultural year, the number of household who planted improved bean varieties was very small -- only 15%[21] (N = 924) of bean-producing households reported planting an improved bean variety (Figure 6.5).

Adoption of an improved bean variety varied greatly by region. At the regional level, the highest percentage of bean-producing households who planted an improved bean variety were in the central region (20%), followed by the southern (15%) and the northern regions (2%).

At the provincial level, the improved bean variety adoption rate varied greatly, ranging from 1.4% to 28.6%. The highest percentage of households who planted an improved bean variety lived in Inhambane Province (28.6%), followed by Tete Province (27%). In contrast, the lowest percentage of households who planted an improved bean variety lived in Niassa Province (1.4%) and Zambezia Provinces (4%). In the southern region's three provinces and provinces in the central region (except Zambezia Province), the adoption rate was greater than 10% (Figure 6.6).

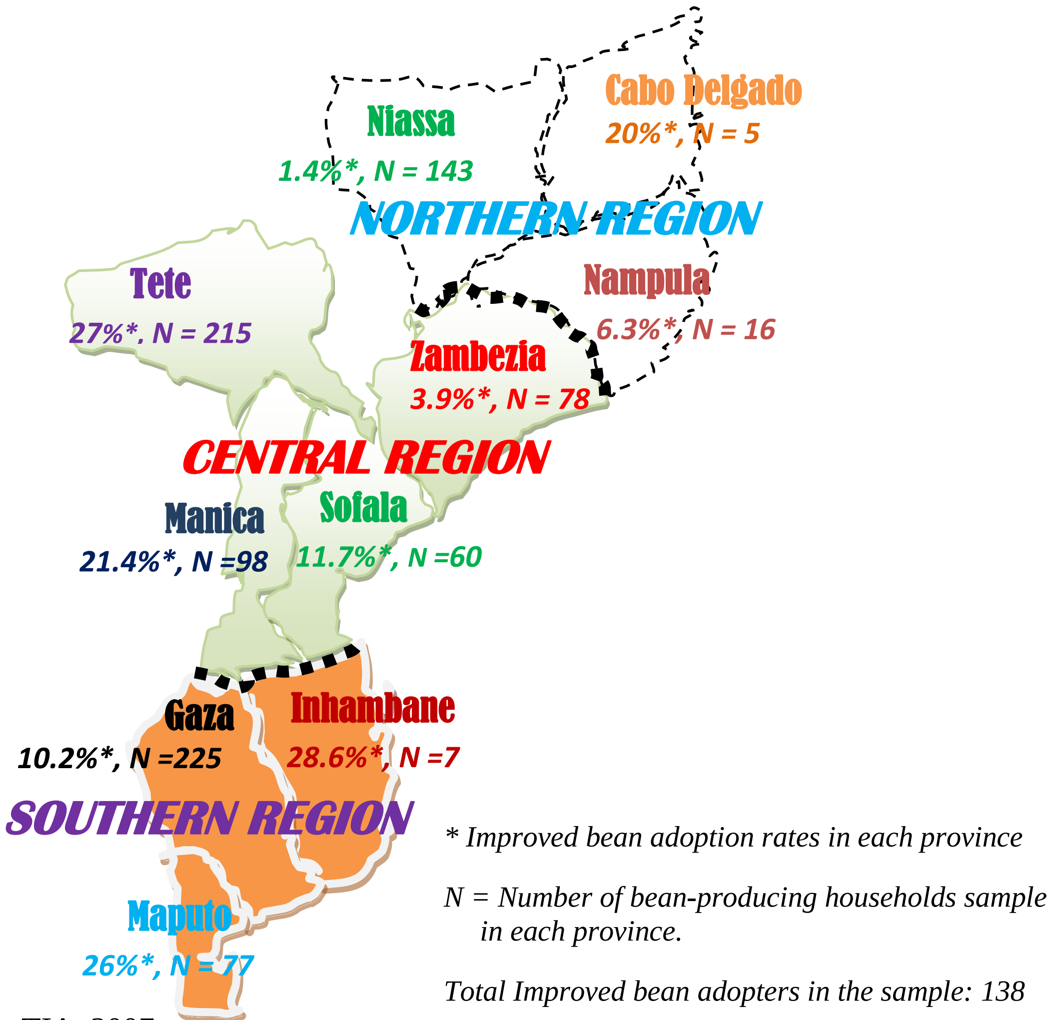
Figure 6.5: Improved Bean Adoption in Mozambique in the 2006/2007 Agricultural Year



Source: TIA, 2007

[21] The total number of bean-producing household who adopted and did not adopt an improved bean variety was 924.

Figure: 6.6. Map of the Improved Bean Adoption Rates in Mozambique by Province in the 2006/2007 Agricultural Year



Source: TIA, 2007

6.3.2.1. Improved Bean Adoption Rate: Household Size

Improved bean variety adoption varied by household size. To assess the relationship between the adoption of an improved bean variety and household size, households were divided into four groups (Table 6.5). Among bean-producing households, the largest share of the households was 5-8 members (47%), followed by those with 1-4 members (33%). Households who had 9-12 members had the highest adoption rate (21%), whereas, households with more than 12 members had the lowest adoption rate (13%).

Table 6.5 Improved Bean Adoption in Mozambique by Household Size in the 2006/2007 Agricultural Year

Household Size (Members)	Number of Households	Percent	Number of Adopters	Adoption Rate (%)
1 to 4	306	33.1	44	14.4
5 to 8	431	46.7	59	13.7
9 to 12	133	14.4	28	21.1
13 & More	54	5.8	7	13.0
Total	**924**	**100**	**138**	**15.0**

Source: TIA, 2007

6.3.2.2. Improved Bean Adoption Rate: Age of the Household Head

This study hypothesizes that the household head's age is associated with the households' adoption of an improved bean variety. Analysis of the TIA 2007 data suggests that in the largest share of the household, the head was 21-40 years of age (41.5%), followed by households whose head was 41-60 years of age (40%). In contrast, the smallest share of the households had a head who was 20 years of age or younger (2%) (Table 6.6).

Analysis of the relationship between adoption of an improved bean variety and the household head's age suggests that households whose head was 41-60 years of age had the highest adoption rate (16%), followed by those whose head was 21-40 years of age (15.%). In contrast, households whose heads was 20 years of age or younger had the lowest adoption rate (7%). This suggest that the adoption rate is higher among mid-aged heads (21-60), compared to households with a very young or a very old household head.

Table 6.6 Improved Bean Adoption in Mozambique by Household Heads' Age in the 2006/2007 Agricultural Year

Household Head's Age	Number of Households	Percent	Number of Adopters	Adoption Rate (%)
20 or younger	15	1.6	1	6.7
21 to 40	383	41.5	59	15.4
41 to 60	370	40.0	59	16.0
61 & older	156	16.9	19	12.2
Total	**924**	**100**	**138**	**15.0**

Source: TIA, 2007

6.3.2.3. Improved Bean Adoption Rate: Education of the Household Head

Adoption of an improved bean variety with respect to the education of the household head varied greatly (Table 6.7). The largest share of the household heads had 1-6 years of schooling (52%), followed by those with no education (39%). In contrast, the smallest share of household heads had a college education (0.3%).

Household head's education is hypothesized to be positively associated with the adoption of an improved bean variety. Households whose head had a college education had the highest adoption rate (67%), whereas, households whose head had no formal education had the lowest adoption rate (13%) (Table 6.7).

Education had a positive impact on households' adoption of an improved bean variety. However, the impact of education on adoption is ambiguous because the adoption rate among households with 1-6 years of education is slightly higher, relative to households with 7-12 years of education. Furthermore, the number of household heads with a college education is very small.

Table 6.7 Improved Bean Adoption in Mozambique by Household Head's Education in the 2006/2007 Agricultural Year

Education of the Household Head	Number of Households	Percent	Number of Adopters	Adoption Rate (%)
No Education	360	39.0	48	13.3
1 to 6	482	52.2	77	16.0
7 to 12	79	8.6	11	13.9
13 & more	3	0.3	2	66.7
Total	**924**	**100**	**138**	**15.0**

Source: TIA, 2007

6.3.3. Probit Analysis: Improved Bean Varietal Adoption.

There are similarities and the differences between the probit analysis for the adoption of improved maize and bean varieties. The same independent variables are employed in analyzing the adoption of improved maize and bean varieties. Both maize and bean analyses control for 21 dummy district variables in the model and use population weight to take into account the survey. Regarding the differences, for the improved bean adoption analysis, the valid sample size is smaller (N= 4,919 vs 910)[22] due to missing values. Also, the coefficients and the marginal effects for the northern region are not reported because many independent variables were dropped due to collinearity.[23]

Table 6.8 presents the estimated coefficients and the marginal effects of the probit regression for improved bean varietal adoption at both the national and regional levels. Furthermore, it also shows the statistical significance of the coefficients at 1%, 5%, and 10% levels.

[22] N = 4,919 and 910 are the valid sample at the national level of improved maize and bean varieties, respectively.

[23] Stata software version 10 did not report results of the bean adoption analysis for the northern region because of collinearity .

Table 6.8 Coefficient and Marginal Effect Estimates for Improved Bean Variety at the National and Regional Levels[24]

Variables	National Level			Central Region			Southern Region		
	Coefficient		Marginal Effect	Coefficient		Marginal Effect	Coefficient		Marginal Effect
Constant	-6.000	***		-0.963			-0.205		
Farmers' Socio-Demography Characteristics									
HH_Size	0.011		0.002	0.022		0.005	-0.029		-0.002
HH_Sex	-0.111		-0.019	-0.127		-0.031	0.463		0.028
HH_Age	-0.004		-0.001	-0.003		-0.001	-0.028	**	(-0.002)
HH_Educ	0.007		0.001	0.007		0.002	-0.071		-0.005
Institutional Factors									
Acc_Ext	0.214		0.039	0.197		0.049	0.076		0.006
Acc_Credit	0.426		0.088	0.248		0.064	2.254	***	(0.607)
Acc_Price_Info	-0.265		-0.04	-0.131		-0.03	-1.407	***	(-0.053)
Mem_Ass	-0.153		-0.023	-0.234		-0.049	0.543		0.057
Risks & Economic Attributes									
Risk_Drought	-0.182		-0.029	-0.259		-0.056	0.377		0.019
Risk_Flood	0.309		0.059	0.235		0.059	-0.174		-0.011
Risk_Wild_Ani	0.225		0.04	0.09		0.021	1.304	***	(0.232)
HH_Sal_Emp	0.368	**	(0.067)	0.429	**	(0.109)	0.637	*	0.054
Cotton	-0.873	***	(-0.081)	-0.962	***	(-0.134)	a		a
Tobacco	0.088		0.015	0.087		0.021	a		a
Use_Ani_Traction	0.345	**	0.064	0.538	**	(0.147)	-0.591	*	-0.053
Log p likelihood	*-314.6*			*-187.4*			*-66.3*		
Pseudo R^2	*0.14*			*0.12*			*0.37*		
Observations	*910*			*447*			*290*		

***Statistically significant at 1% level; ** Statistically significant at 5% level; *Statistically significant at 10% level. The marginal effects for significant variables (significant at five and one percent levels) are in parentheses. The coefficients and marginal effects for northern region are not reported because many independent variables are dropped due to collinearity. a) The coefficients on cotton and tobacco for the southern region are not reported due to collinearity.

[24] See Appendix I for detailed probit regression results (estimated coefficients, marginal effects, standard error, and p-value) of improved bean varieties.

6.3.3.1. Probit Analysis: Farmers' Socio-Demography Characteristics Associated with the Adoption of Improved Bean Varieties.

The study hypothesizes that "household size" *(HH_Size)* and "household head gender" *(HH_Sex)* are associated with the adoption of the improved bean variety. However, while the effect of "household size" *(HH_Size)* on the households' adoption decision is not statistically significant, it is positively associated with adoption (except in the southern region). On the other hand, while the effect of the "household head's gender" *(HH_Sex)* is not statistically significant, it is negatively associated with the households' adoption decision at both in the national level and in the central regional (Table 6.8).

While "Household head's age" *(HH_Age)* is statistically significant (5% level) in the southern region, it is negatively associated with the households' adoption decision at the national and in all regions. This suggests that younger household heads are more likely to adopt an improved bean variety, relative to the older household heads. In the southern region, an additional one year of the household head's age decreases the likelihood of the household head to adopt an improved bean variety by 0.2%.

While the effect of "household head's education" *(HH_educ)* is not statistically significant, it is positively associated with the households' adoption decision at the national level and in the central region. In contrast, the regional analysis indicates that the effect of education is not significant and negatively associated with the households' adoption decision in the southern region (Table 6.8).

6.3.3.2. Probit Analysis: Institutional Factors Associated With the Adoption of Improved Bean Varieties.

The policy parameter "household had access to extension services" *(Acc_Ext)* is hypothesized to facilitate improved varieties adoption. While it is not statistically significant, it is positively associated with the households' adoption decision at the national level and in all regions (Table 6.8).

While the variable "households had access to credit" *(Acc_Credit)* from banks, microfinance institutions, or other credit providers is not statistically significant at the national level, but it is statistically significant (1% level) in the southern region. Furthermore, it is also positively associated at both the national and the regional levels (Table 6.8). This is consistent with the hypothesis that households who had access to credit are more likely to adopt an improved bean variety. In the southern region, households who had access to credit are 60.7% more likely to adopt an improved bean variety, relative to household who did not have access to credit.

The effect of the independent dummy variable "household had access to price information from markets" *(Acc-Price_Info)* is inconsistent with the hypothesis that access to price information is positively associated with adoption. The variable is statistically significant (1% level) in the southern region and also negatively associated with the households' adoption decision at both the national and regional levels (Table 6.8). This suggests that households who had access to price information from markets are less likely to adopt an improved bean variety. In the southern region, the likelihood of a household who had access to price information from markets to adopt an improved bean variety is 5.3% lower, relative to a household who did not have access to price information from markets. Zavale et al. (2005) and Uaiene et al. (2009) report that in developing countries, poor road networks between rural and urban areas make it difficult for households in rural areas to access to markets, including access to price information. Furthermore, they argue that in Mozambique, most rural farm households are subsistence producers with very little access to markets.

Similarly, the negative effect of “association membership” *(Mem-Ass)* is also inconsistent with the hypothesis that association membership facilitates adoption. While association membership is not statistically significant, it is only positively associated with the households’ adoption decision in the southern region (Table 6.8). This is an unexpected finding because association membership was expected to help households to receive and share information on the benefits of improved bean -- thereby increasing their likelihood of adopting an improved bean variety and other technologies.

6.3.3.3. Probit Analysis: Risks and Economic Attributes Associated With the Adoption of Improved Bean Varieties.

While not statistically significant, the estimated coefficient for “having experience on incidence of drought” *(Risk_Drought)* is only positive in the southern region. On the other hand, an unexpected result was found for variable “impacts of flood on the households’ crops farming in the last two years” *(Risk_Flood).* The estimated coefficient is not statistically significant, and it also has a positive effect at both the national level and in the central regional (except in the southern region) (Table 6.8).

Similarly, households’ response to “damage caused by wild animals” *(Risk_Wild_Ani)* is inconsistent with the hypothesis that having experienced animal-related crop damage decreases households’ likelihood of adopting an improved variety.

While the effect is only statistically significant in the southern region (1% level), it is positively associated with the households' adoption decision at both the national and the regional level (Table 6.8). This suggests that in the southern region, households who had experienced wild animal damage are 23.2% more likely to adopt an improved bean variety.

The effect of the independent variable "household head's salaried employment" *(HH_Sal_Emp)* is consistent with the hypothesis. The effect is statistically significant (5% level) at the national level and in the central region, and at 10% level in the southern region. Furthermore, it also has a positive association at both the national and the regional levels (Table 8.6). This suggests that, across the country and in the central region, households with access to off-farm income are 6.7% and 10.9% respectively, more likely to plant an improved bean variety, compared to household without off-farm jobs.

The effect of the independent variable "whether households grew cotton in previous year" *(Cotton)* on the households' adoption of an improved bean variety is inconsistent with the hypothesis that having grown cotton is associated with adoption. While the effect is statistically significant (1% level) at the national level and in the central region, it is negatively associated with adoption at both the national and the regional level (Table 6.3). This implies that households who grew cotton in the previous year are less likely to adopt an improved bean variety. At the national and in the central region, households who grew cotton in the previous year are 8.1% and 13.4% less likely to adopt an improved bean variety.

The effect of "growing tobacco in the previous year" *(Tobacco)* is hypothesized to be positively associated with adoption. While not statistically significant, this variable has a positive association with adoption at the national level and in the central region (Table 6.8).

The effect of "using animal traction"*(Use_Ani_ Traction)* on the households' adoption decision varied at the national and the regional levels. The effect is positive and statistically significant at the national level (5% level). However, at the regional level, while it is statistically significant at 5% level in the central region and 10% level in the southern region, it is also negatively associated with adoption in the southern region and positively associated in the central region (Table 6.8). The positive association at the national level suggests that households who use animal traction are 6.4% more likely to adopt an improved bean variety, relative to households who did not use animal tractions.

6.3.3.4. Adoption Rates of Improved Beans

Some independent variables included in improved bean varietal adoption model are not statistically significant. This may suggest that these variables did not affect households' decision whether or not to adopt an improved bean variety in the 2006/2007 agricultural year. However, the sample size and number of households who planted improved bean varieties are smaller, compared to the sample size and number of adopters in the improved maize adoption. Thus, it is likely that some of the variables were non-statistically significant, due to small sample size.

Also, descriptive statistics between dummy dependent and independent variables suggest that several variables in the northern region and the variable *"Cotton"* and *"Tobacco"* in the southern region were correlated (collinearity) (Table 6.9). Therefore, estimated coefficients and marginal effects of the northern region improved bean adoption analysis are not reported in Table 6.8.

Table 6.9. Adoption rates of Improved Bean Varieties Given Independent Variables.

Dependent and Independent Dummy Variables	Type of Response	National Level			Regions: North			Central			South		
		No H	Adop	%	No H	Adop	%	No H	Adop	%	No H	Adop	%
Adop_Imp_ Bean		924	138	15.0	164	4	2.4	451	89	19.7	309	45	14.6
HH_Size	Person	924	138	15.0	164	4	2.4	451	89	19.7	309	45	14.6
Acc_Sex	Male	754	116	14.4	123	4	3.3	389	78	20.0	242	34	14.0
	Female	170	22	13.0	41	0	0.0	62	11	17.7	67	11	16.4
HH_Age	Year	924	138	15.0	164	4	2.4	451	89	19.7	309	45	14.6
HH_Educ	Year	924	138	15.0	164	4	2.4	451	89	19.7	309	45	14.6
Acc_Ext	Yes	171	39	22.8	25	1	4.0	88	20	22.7	58	18	31.0
	No	753	99	13.2	139	3	2.2	363	69	19.0	251	27	10.8
Acc_Credit	Yes	65	16	24.6	7	0	0.0	50	10	20.0	8	6	75.0
	No	859	122	14.2	157	4	2.6	401	79	20.0	301	39	13.0
Acc_Price_Info	Yes	179	18	10.1	23	0	0.0	110	13	12.0	46	5	10.9
	No	745	120	16.1	141	4	2.8	341	76	22.3	263	40	15.2
Mem_Ass	Yes	107	26	24.3	17	0	0.0	39	8	20.5	51	18	35.3
	No	817	112	13.7	147	4	2.7	412	81	20.0	258	27	10.5
Risk_Drought	Yes	440	64	14.6	16	0	0.0	131	21	16.0	293	43	14.7
	No	484	74	15.3	148	4	2.7	320	68	21.3	16	2	12.5
Risk_Flood	Yes	126	29	23.0	13	0	0.0	106	27	25.5	7	2	28.6
	No	798	109	13.7	151	4	2.6	345	62	18.0	302	43	14.2
Risk_Wild_Ani	Yes	245	44	18.0	71	1	1.4	125	27	22.0	49	16	32.6
	No	679	94	13.8	93	3	3.2	326	62	19.0	260	29	11.2
HH_Sal_Emp	Yes	268	50	18.7	38	0	0.0	121	32	26.5	109	18	16.5
	No	656	88	13.4	126	4	3.2	330	57	17.3	200	27	13.5
Cotton	Yes	39	5	12.8	3	0	0.0	35	5	14.3	1	0	0.0
	No	885	113	15.0	161	4	2.5	416	84	20.2	308	45	14.6
Tobacco	Ys	54	12	22.2	7	0	0.0	47	12	25.5	0	0	0.0
	No	870	126	14.5	157	4	2.5	404	77	19.1	309	45	14.6
Use_Ani_Traction	Yes	337	61	18.1	1	0	0.0	109	32	29.4	227	29	12.8
	No	587	77	13.1	163	4	2.5	342	57	16.7	82	16	19.5

No H: Number of Household; Adop: Adopters of Improved Bean Varieties.
Source: TIA 2007

6.4. Chapter Summary

Descriptive statistics and probit regressions were estimated to evaluate factors associated with adoption and the likelihood of adopting improved maize and bean varieties. Analysis of the TIA 2007 survey data indicated that the adoption rate for improved maize and bean varieties in the 2006/2007 agricultural year was 12% and 15%, respectively. In addition to the national level adoption analysis, the adoption rates of these two crops were also estimated at the regional and provincial levels, by households' size, and by household heads' age and education level. Adoption rates for improved maize and bean varieties and factors associated with adoption varied across regions and provinces.

Also, adoption likelihood varied greatly at the national and the regional level. To estimate the likelihood of adopting improved maize and bean varieties, the probit adoption model employed independent variables that measured farmers' socio-demography characteristic, institutional factors, and risk and economic attributes.

Results of the national level improved maize adoption analysis identified several statistically significant variables: "household head's education" *(HH_Educ)*, "household had access to extension services" *(Acc_Ext)*, "flood in the last two years" *(Risk_Flood)*, "household head's salaried employment" *(HH_Sal_Emp)*, and "whether household used animal tractions" *(Use_Ani_Traction)* are statistically significant at 1% level; "drought in the last two years" *(Risk_Drought)* is statistically significant at 5% level; and "household head's age" *(HH_Age)* is statistically significant at 10% level. On the other hand, the national level improved bean adoption analysis identified the following statistically significant independent variables: "whether household grew cotton in the previous year"

(Cotton) is statistically significant at 1% level; and "household head's salaried employment" *(HH_Sal_Emp)* and "whether households used animal traction" *(Use_Ani_Traction)* are statistically significant at 5% level. Also, several variables had unexpected signs – the effect of "flood" *(Risk_Flood)* was positive and "association membership" *(Mem_Ass)* was negative at both improved maize and bean adoption. Moreover, the negative sign on the coefficient of "access to price information from markets" and "cotton" in the improved bean adoption analysis are inconsistent with the hypothesis that access to price information and "growing cotton" are positively associated with adoption of improved bean varieties.

CHAPTER VII: CONCLUSION AND POLICY IMPLICATION

7.1. Introduction

This chapter is divided into four sections. The second section summarizes the main findings of the study, including the association and significant of the policy parameters. The third section presents policy implications. The fourth section describes the limitations of this study and provides recommendations for future research.

7.2. Main Findings

7.2.1. Maize-Producing Households and Adoption of Improved Maize

Maize is an important staple food crop in Mozambique. Analysis of the TIA 2007 survey data demonstrated that maize is the most-widely grown staple food crop in Mozambique – 82% of sample households produced maize in the 2006/2007 agricultural year. At the regional level, Of the 6,075 sample households, the percentage of household producing maize was highest (87%) in the southern region's three provinces (Gaza, Inhambane, and Maputo), while only 69% households in the northern region (Nampula, Cabo Delgado, and Niassa Provinces) produced maize. At the provincial level, the highest percent households who planted maize from Manica Province (96%), while the lowest percentage lived in Nampula Province (53%). Maize production per household was quite low – averaging only 443 kilograms per household in the 2006/2007 agricultural year. The high percentage of maize-producing households in all provinces suggests that maize was an important staple food crop for smallholder households in each province – in all provinces, more than 50 percent of households sample grew maize. However, very few planted improved maize varieties.

The adoption rate for improved maize in the 2006/2007 agricultural year was relatively low. At the national level, only 12% of the maize-producing households planted improved maize. Furthermore, the improved maize adoption rate varied greatly by region and province. The central region had the highest adoption rate (17%), while the lowest adoption rate was in the northern region (4.6%). At the provincial level, Manica Province had the highest adoption rate (24%), while Cabo Delgado Province had the lowest adoption rate (3%). Differences in adoption rates among provinces/regions may be partly due to the local availability of improved maize seed. Also, the low adoption rate of improved maize varieties in the northern region may be partly due to farm households in this region giving priority to growing cash crops (i.e., cotton and tobacco).

7.2.2. Bean-Producing Households and the Adoption of Improved Beans

Beans are grown by many households throughout Mozambique. However, beans were not as widely grown as maize in the 2006/2007 agricultural year – only 15 percent of the households sample produced beans. At the regional level, the highest percent of household who grew beans was in the central region (18%) and the lowest in the northern region (10%). At the provincial level, the percentage of households who grew beans was highest in Niassa Province (40.5%) and the lowest in Cabo Delgado Provinces (0.9%). Bean production was very low – averaging only 143 kilograms per household in the 2006/2007 agricultural year. The difference in the importance of beans across provinces/regions is largely due to varying agro-climatic conditions—beans are a more appropriate crop to grow in some regions than in other regions.

The adoption rate for improved bean in the 2006/2007 agricultural year was low, only 15% of the bean-producing households planted improved bean. Adoption of improved bean varied greatly by region and province. At the regional level, the central region had the highest adoption rate (20%), while the lowest rate was in the northern region (2%). At the provincial level, Inhambane Province had the highest adoption rate (29%), while the lowest rate was in Niassa Province (1%). Differences in adoption rates among provinces/regions may be partly due to the local availability of improved bean seed.[25]

7.2.3. Factors Associated With the Adoption of Improved Maize and Bean Varieties

This study employed independent variables which reflected households' socio-demography characteristics, institutional factors, and risks and economic attributes to estimate the effect of these variables on households' adoption decision. Each variable, including policy parameters (e.g., household head's education, access to extension services and credit, and association membership) have different effects on the adoption of improved maize and bean varieties across both the national and regional levels.

In the maize adoption analysis, as expected, "household head's education" *(HH_Educ)* is statistically significant (1% level) at the national level and in the northern and central regions of the maize adoption analysis, but it is not statistically significant in the improved bean adoption model. Furthermore, the effect is positive for maize producers, but negative for bean producers in the southern region. This suggests that, across the country, an increase in household head's years of schooling increases the likelihood of the household to adopt an improved maize variety by 0.9%.

"Household had access to extension services" *(Acc_Ext)* is consistent with the hypothesis. For the improved maize adoption analysis, as expected, access to extension

---

[25] See Appendix II for detailed information of the difference adoption rates of improved maize and bean varieties among provinces/regions.

services is statistically significant (1% level) at the national level and in the central and southern regions and also (10% level) in the northern region, but it is not statistically significant in the improved bean analysis. In addition, the effect is positively associated for both maize and bean adoption. This indicates that households who had access to extension programs from the government, NGOs, or other extension providers are more likely to adopt improved maize. Across the country, the likelihood of adopting an improved maize variety for household who had access to extension programs is 7.5% higher, relative to households who did not have access to extension programs.

In the maize adoption analysis, the effect of "households had access to credit" *(Acc_Credit)* is statistically significant (5% level) in the northern region and statistically significant (1% level) in the southern region for bean adoption. Furthermore, the estimated coefficients are positively associated with households' adoption decision. The national and the regional level of the maize and bean adoption analyses demonstrated that with access to credit, households are more likely to adopt improved varieties. Households in the northern region are 5.2% more likely to plant an improved maize variety, and households in the southern region are 60.7% more likely to plant an improved bean variety, if they had access to credits. In the maize and bean adoption analysis, "association membership" *(Mem_Ass)* is not statistically significant.

Along with the main policy parameter described above, Table 6.4 and 6.8 summarizes the following variables that are statistically significant at the national level: household head's salaried employment "*HH_Sal_Emp"* (1% level, maize; 5% level, beans), drought in the last two years *"Risk_Drought"* (5% level, only for maize), flood in the last two years *"Risk_Flood"* (1% level, only for maize), whether or not households planted cotton in previous year "*Cotton"* (1% level, only for bean), household used animal tractions in the 2006/2007 agricultural year "*Use_Ani_Traction"* (1% level, maize; 5% level, beans), and household head's age *"HH_Age"* (10% level, only for maize). In addition, for the bean analysis, variable "*Risk_ Flood*" and *"Acc_Price_Info"* have positive and negative associations, respectively. These are not consistent with the hypothesis that flood reduces adoption likelihood and access to price information facilitates adoption.

7.3. Policy Implication

This study examined the underlying factors that are associated with the households' decision to adopt improved maize and bean varieties. The major findings described in the section 7.2 provide information for suggesting policies and making recommendations to stakeholders involved in the maize and bean development in Mozambique:

First, the Ministry of Agriculture's extension service is widely recognized as understaffed and underfunded (Gemo, 2006; Uaiene et al., 2009). However, the result indicates that the existing extension services have had a positive and significant effect on the adoption of improved maize[26]. This finding suggests a strong rationale for extension providers from both the government and NGOs to improve quality of their services and expand extension services to more households in underserved geographical zones. In short, research and extension programs should be one of the fundamental cores of the

[26] However, extension was not statistically significant in the bean analysis.

government, NGOs, and private sector efforts to strengthen agriculture sector in Mozambique.

Second, household head's education *(HH_Educ)* appears to have a positive effect and a very strong and robust impact on improved maize adoption across all analysis, except in the southern region. On the other hand, it is not statistically significant in the beans adoption model. On average, Mozambican household heads had very low years of attending formal education (only 2.8 years). Drawing from this result, policies that emphasize improving the household heads' knowledge are required (e.g., improve household heads' knowledge through various training activities). Also, household heads' formal educational background (e.g. household heads' ability to read and write) should be taken into account when developing training materials. Greater attention should be placed on practical training in order to more effectively communicate results of agricultural research to the typical household with minimal formal education.

Third, while the variable "household had access to credit" *(Acc_Credit)* is positively associated with the household's adoption decision, it is only statistically significant in the northern region in the improved maize model and in the southern region in the improved bean model. This suggests that credit accessibility is vital in influencing households' adoption decision in these regions. Because the difficulty in accessing credit appears to be a major constraint to technology adoption in Mozambique, considerable attention should be given to designing policies that strengthen financial markets, especially creating an environment where financial institutions grow and thereby better provide financial services to households in rural areas. It is expected that improvement in access to financial markets could help households to access sufficient capital to buy agricultural inputs (e.g., improved varieties), and thereby increase agricultural productivity and households' income and standard of living.

Fourth, while the variable "association membership" *(Mem_Ass)* is not statistically significant, it is also negatively associated with the households' adoption decision. This suggests that association membership does not have an influence on household decisions. The government may therefore need to evaluate the existing policies that are associated with development of agricultural associations and monitor current associations' programs to identify challenges facing by assocation members. This may help both the government and assocation members to understand why association membership does not have any effect on households' adoption decisions.

Taking into account the empirical results of this study and from other technologies adoption studies regarding factors affecting households' adoption decisions, research institutions need to continue to give priority to developing new agricultural technologies that respond to the need of households, and agricultural input providers need to develop dynamic market plans that improve households' satisfaction and awareness of the benefits of improved maize and bean varieties and other new agricultural technologies. Furthermore, farmers' maize and bean yields are very low—likely due to their limited use of purchased inputs such as fertilizer. Thus, the government and NGOs must place priority on developing strategies to increase farmers' use of fertilizer.

Finally, the local availability of seed of improved maize and bean varieties may to be a major constraint to farmer adoption. Thus, there is a need to give priority to insuring that seed of improved varieties is locally available in the country's major maize and bean-growing regions.

7.4. Limitation of the Study and Recommendations for Future Research

7.4.1. Limitation of the Study

The main objective of this study was to identify factors that are associated with households' adoption of improved maize and bean varieties. In trying to achieve this objective, this study faces several limitations. Therefore, it is important to understand limitations of this study, which include:

1) The TIA 2007 survey collected data at the household and the community levels. However, this study only used the household level data. Therefore, some potentially important variables at the community level (e.g., household have access to roads and electricity) are not considered in this study.

2) The probit regression models on the adoption of improved maize and bean varieties only employed 15 explanatory variables plus controlling for district variables. Some potentially important variables (e.g., farm size, and access to market) were not included in the models due to a large number of missing values for these variables and/or they were measured at the community level.

3) Endogeneity problems could affect the estimates of some explanatory variables (e.g., access to extension services and credits) due to selection bias – households make decision whether or not to receive services or participate in a program. Therefore, it could create endogeneity problems because households who get benefits from services or programs are more likely to participate than those who did not. This study does not correct the potential endogenuous variables because of the difficulty to find appropriate instrumental variables.

7.4.2. Recommendations for Future Research and Revisions to the TIA Survey

1) Since this study only employed 15 variables and excluded some potentially important variables (e.g., access to road and electricity), further research should include more explanatory variables and use information from the TIA 2007 community level data sets to better evaluate technology adoption at the household and community levels in Mozambique.

2) While this study demonstrated factors associated with varieties adoption, it also found that maize is an important source of food for farm households. Further economic analysis on the role of maize in the households' portfolio is needed to assess the economic opportunities available to maize-producing households. Future research should include estimating whole-farm budgets which would help to better understand the relative profitability of maize compared to other crops and off-farm activities, and thereby generate information required to assess the likelihood to invest in maize enterprise and other economic opportunities. Also, a key factor that affects households' adoption of a new technology is its profitability. Thus, future research should focus on assessing the profitability (benefit/cost analysis) of adopting improved maize and bean varieties.

3) Empirical evidence from this study suggests that the difference in the adoption rate among provinces/regions may be partly due to difference the distribution (local availability) of improved maize and bean seed. Thus, future researches is needed that focuses on analyzing the distribution of improved seeds and options for providing greater access to seed of improved varieties to farmers in the country's main maize- and bean-growing regions.

4) To better understand farm household behaviors towards improved maize and bean varieties, it is important for the future research to estimate capital and land that farm households allocated for improved maize and bean varieties.

5) The government needs to continue to fund research to increase the productivity of maize and beans, given that they are major food staples in many regions/provinces in Mozambique.

6) In the 2007 TIA survey, the definition of improved seeds is limited to seeds that were commercially packaged and sold. However, many farmers likely planted commercially packaged seed that they had saved from a previous planting season. Thus, the narrow definition of an adopter may explain low adoption rate of improved maize and bean varieties in the 2006/2007 agricultural year. Taking into account a broader definition for improved seeds (e.g., open pollinated, hybrids, and improved seeds that have been recycled) in the subsequent TIA survey would generate more accurate data to better estimate household adoption of improved seeds in Mozambique. However, key informants report that many farmers do not knew the correct name of the varieties they plant. Thus, it may be difficult to determine if recycled seed is a local or improved variety.

Finally, the TIA survey only asked if the household purchased an improved maize or bean variety. As the survey did not ask what percentage of the households' fields were planted to an improved variety, in the adoption analysis it was assumed that the farmer planted only an improved variety—which is unlikely. In order to provide more accurate estimates of adoption, future TIA surveys should ask a follow up question, regarding the percent of the area planted to an improved variety.

APPENDICES

Appendix I. Probit Analysis: Coefficient and Marginal Effect Estimates for Bean Variety at the National and Regional Levels

	National Level					Central Region					Southern Region				
Variables	**Coef.**		**Std. Err.**	**P>|z|**	**Mar. Effect**	**Coef.**		**Std. Err.**	**P>|z|**	**Mar. Effect**	**Coef.**		**Std. Err.**	**P>|z|**	**Mar. Effect**
Constant	-6.000	***	0.437	0.000		-0.963		0.717	0.179		-0.205		0.956	0.83	
Farmers' Socio-Demography Characteristics															
HH_Size	0.011		0.023	0.614	0.002	0.022		0.038	0.554	0.005	-0.029		0.038	0.436	-0.002
HH_Sex	-0.111		0.181	0.539	-0.019	-0.127		0.251	0.613	-0.031	0.463		0.376	0.218	0.028
HH_Age	-0.004		0.005	0.429	-0.001	-0.003		0.006	0.654	-0.001	-0.028	**	0.014	0.044	-0.002
HH_Educ	0.007		0.026	0.797	0.001	0.007		0.032	0.825	0.002	-0.071		0.048	0.134	-0.005
Institutional Factors															
Acc_Ext	0.214		0.217	0.325	0.039	0.197		0.266	0.459	0.049	0.076		0.423	0.858	0.006
Acc_Credit	0.426		0.271	0.116	0.088	0.248		0.34	0.466	0.064	2.254	***	0.603	0	0.607
Acc_Price_Info	-0.265		0.205	0.196	-0.04	-0.131		0.236	0.579	-0.03	-1.407	***	0.417	0.001	-0.053
Mem_Ass	-0.153		0.247	0.536	-0.023	-0.234		0.361	0.516	-0.049	0.543		0.401	0.176	0.057
Risks and Economic Attributes															
Risk_Drought	-0.182		0.174	0.294	-0.029	-0.259		0.226	0.251	-0.056	0.377		0.471	0.423	0.019
Risk_Flood	0.309		0.202	0.125	0.059	0.235		0.223	0.291	0.059	-0.174		0.766	0.821	-0.011
Risk_Wild_Ani	0.225		0.156	0.148	0.04	0.09		0.186	0.629	0.021	1.304	***	0.397	0.001	0.232
HH-Sal_Emp	0.368	**	0.159	0.021	0.067	0.429	**	0.203	0.034	0.109	0.637	*	0.354	0.071	0.054
Cotton	-0.873	***	0.279	0.002	-0.081	-0.962	***	0.293	0.001	-0.134	a		a	a	a
Tobacco	0.088		0.293	0.763	0.015	0.087		0.326	0.789	0.021	a		a	a	a
Use_Ani_Traction	0.345	**	0.166	0.038	0.064	0.538	**	0.217	0.013	0.147	-0.591	*	0.35	0.091	-0.053
Log likelihood	*-314.6*					*-187.4*					*-66.3*				
Pseudo R^2	*0.14*					*0.12*					*0.37*				
Observations	*910*					*447*					*290*				

***Statistically significant at 1% level; ** Statistically significant at 5% level; *Statistically significant at 10% level. The coefficients and marginal effects for northern region are not reported because many independent variables are dropped due to collinearity. a) The coefficients on cotton and tobacco for the southern region are not reported due to collinearity. Standard error is a "robust standard error"

Appendix II: Adoption of Improved Maize and Bean Varieties in Mozambique by Region and Province, 2007

Region and Province	*Adoption of IMV (%)*	*Maize-Producing Households*	*Adoption of IBV (%)*	*Bean-Producing Households*
Northern Region				
Niassa	6.3	334	1.4	143
Cabo Delgado	2.8	432	20.0	5
Nampula	5.2	424	6.3	16
Central Region				
Zambezia	10.0	541	3.9	78
Tete	23.7	658	27.0	215
Manica	24.3	526	21.4	98
Sofala	8.8	477	11.7	60
Southern Region				
Inhambane	6.4	487	28.6	7
Gaza	9.0	730	10.2	225
Maputo	15.0	347	26.0	77
Total		**4,956**		**924**

Note: IMV: Improved Maize Varieties; IBV: Common Bean Varieties

Source: TIA, 2007

REFERENCES

Adegbola, P., and C. Gardebroek. 2007. “The Effect of Information Sources on Technology Adoption and Modification Decisions”. Agricultural Economics 37: 55-65.

Adesina, A. A., and J. B. Forson. 1995. “Farmers' Perceptions and Adoption of New Agricultural Technology: Evidence from Analysis in Burkina Faso and Guinea, West Africa.” Agricultural Economics 13: 1-9.

Bandiera, O., and I, Rasul. 2005. “Social Networks and Technology Adoption in Northern Mozambique.” *The Economic Journal* 116(514): 869-902.

Besley, T., and A., Case 1993. “Modeling Technology Adoption in Developing Countries.” *American Economic Review,* 83: 396-402.

Bias, C., and C. Donovan. 2003. “Gaps and Opportunities for Agricultural Sector Development in Mozambique.”Ministry of Agriculture and Rural Development, Directorate of Economy, Research Report No.54E, Maputo, Mozambique.

Boughton, D., D. Mather., C.B. Barrett., R. Benfica., D. Abdula., D. Tschirley., and B. Cunguara. 2007. “Market Participation by Rural Households in a Low-Income Country: An Asset-Based Approach Applied to Mozambique.” Vol 50, 64-101, Department of Agricultural Economics, Michigan State University, East Lansing, MI.

Cornejo, J. F., and W. D. McBridge. 2002 “Adoption of Bioengineered Crops.” Agricultural Economic Report No. 810. Washington, DC 20036-583.

Cornelibe, T. (2005). “Standard Error of Marginal Effects in the Heteroskedastic Probit Model.” Discussion Paper. 320.

Corzine, N. M. 2008. “An Analysis of Import Tariff Escalation: A Case of Maize Trade between South Africa and Mozambique.” Master Thesis, Department of Agricultural Economics, Michigan State University, East Lansing MI.

Doss, C. R, M.Wangi, H. Verkuijl, and H. de Groote. 2003. “Adoption of Maize and Wheat Technologies in Eastern Africa: A Synthesis of the Findings of 22 Case Studies.” CIMMYT Economics Working Paper 03-06. Mexico, D.F.: CIMMYT.

Doss, C.R. 2003. “Understanding Farm Level Technology Adoption: Lessons Learned from CIMMYT’s Micro Surveys in Eastern Africa.” CIMMYT Economics Working Paper 03-07. Mexico. D.F.: CIMMYT.

Feder, G., R. Just, and D. Zilberman. 1985. "Adoption of Agricultural Innovations in Developing Countries: A Survey." Economic Development and Cultural Change 33 : 255-298. The University of Chicago Press.

Fews Net. 2009. http://www.fews.net/docs/Publications/Mozambique_200604en.pdf

Food and Agriculture Organization. 2009. http://www.fao.org/corp/statistics/en/

Gemo, H. (2006). Recursos Humanos na Extensão Agrária Pública em Moçambique (1987- 2006): Estudos sobre Investigação e Extensão Agrária. Volume I. IIAM, DNEA, MINAG- Maputo.

Gonzales-Ramirez, H. 2003. "Economic Evaluation of Bean Research Investment in Mexico." Phd Dissertation, Department of Agricultural Economics, Michigan State University, East Lansing MI.

Green, H. William. (1996). "Marginal Effects in the Bivariate Probit Model." Department of Economics, Stern School of Business, New York University, New York.

Gujarati, (2004), *Basic Econometrics*, Fourth Edition, McGraw−Hill.

INE. 2009. http://www.ine.gov.mz

Martel, P. V, R.H. Bernsten, and M. T. Weber. 2000. "Food Markets, Policy, and Technology: The Case of Honduran Dry Beans." MSU International Development Working Paper No. 79, Department of Agricultural Economics, Michigan State University, East Lansing MI.

Martel-Lagos, P. V. 1995. "A Socio-Economic Study of the Honduran Bean Subsector: Production Characteristics, Adoption of Improved Varieties, and Policy Implication." Phd Dissertation, Department of Agricultural Economics, Michigan State University, East Lansing MI.

Nation Master. 2009. http://www.nationmaster.com/country/mz-mozambique/agr-agriculture.

Neil, S. P, and D.R. Lee. 2001. "Explaining the Adoption and Disadoption of Sustainable Agriculture: The Case of Cover Crops in Northern Honduras." Economic Development and Cultural Change, 59 (4): 793-820.

Pandey, S. 1999. "Adoption of Nutrient Management Technologies for Rice Production: Economic and Institutional Constraints and Opportunities." Nutrient Cycling in Agro ecosystems, 53: 103-111.

PARPAII (2006). http://www.mpd.gov.mz/documents/parpa/parpa.html

Pattanayak, S. K., D. E. Mercer., E, Sills., and J. C. Yang. 2003 “Taking Stock of Agroforestry Adoption Studies.” Agroforestry Systems 57: 173–186. Kluwer Academic Publishers, Netherlands.

Shampine, A. 1998. “Compensating for information externalities in technology diffusion Models”. *Amer. J. of Agric. Econ*. 80(3): 337-346.

The World Bank Group. 2008. "Promoting Shared Growth through Empowerment of Citizens and Institutions: Mozambqiue Country Partnership Strategy 2008-2011." Maputo, World Bank**:** 1-12.

Tomo, A. A., 2009. “Economic Impact of Newcastle Disease control in Village Chickens: A Case Study in Mozambique.” Master Thesis, Department of Agriculture Economics, Michigan State University, East Lansing MI.

Uaiene, R.N, Arndt. C, Masters,W.A. 2009“ Determinant of Agricultural Technology Adoption in Mozambique.” Ministry of Planning and Development Republic of Mozambique. Discussion papers No. 67E.

Uaiene, R. N., 2004. “Maize and Sorghum Technologies and the Effect of Marketing Strategies on Farmers’ Income in Mozambique.” A Thesis, Purdue University.

Wooldridge, J. M, (2009), *Introductory Econometrics: A modern Approach*, Michigan, South-Western Cengage Learning.

World Bank. 2009. http://www.worldbank.org/

Zavale, H., E. Mabaya, and R. Christy. 2005. “Adoption of Improved Maize Seed by Smallholder Farmers in Mozambique.” SP 2005-03, Department of Applied Economic and Management, Cornell University, Ithaca, New York.