

X

**ECONOMIC EVALUATION OF ACCEPTANCE OF GENETICALLY MODIFIED  
SEED MAIZE IN EASTERN MOIST TRANSITIONAL ZONE, KENYA**

EGERTON UNIVERSITY LIBRARY

BY

NGIGI OBADIAH HINGA

A Thesis submitted to the Graduate school in partial fulfillment for the requirement of  
the Master of Science Degree in Agricultural and applied Economics of Egerton  
University.

X 2013/9504

X  
EULIB



036 865

EGERTON UNIVERSITY

June 2012



## DECLARATION

I declare that this MSc Thesis is my original work and has not been submitted to any other university for any other award of a degree.

Student: Ngigi Obadiah Hinga

Reg No. KM17/1772/06

  
.....  
Signature

20/06/2012  
.....  
Date

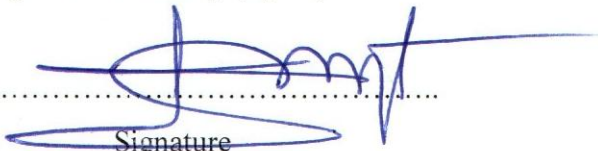
## APPROVAL

This MSc Thesis has been submitted to graduate school with our approval as supervisors,

Dr. Lagat J. K.

Senior lecturer,

Egerton University (Njoro)

  
.....  
Signature

20th June 2012  
.....  
Date

  
Dr. De Groote Hugo

Senior Economist

International Maize and Wheat Improvement Center (CIMMYT) Nairobi

  
.....  
Signature

20/6/2012

20/6/2012  
.....  
Date

EGERTON UNIVERSITY LIBRARY

2013/95024

## ACKNOWLEDGEMENT

Many individuals and institutions have contributed to the success of this report. First and foremost, I wish to sincerely express my gratitude to my supervisors, Dr. Job Lagat and Dr. Hugo De Groote for their tireless efforts that has helped to bring this work this far.

In addition, I wish to acknowledge the contributions of Egerton University through CMAAE programme and CIMMYT-Nairobi for their financial support.

More so, I wish to thank all the interviewed farmers, KARI-Embu staff and more specifically to Mr James Ouma for their valuable co-operation and information during the data collection stage of this study.

Last but not least, I wish to thank all the staff of Agricultural Economics Department of Egerton University, particularly the Chairman Dr. Mutai, and Mr. Simon Kimenju CIMMYT- Nairobi who have been extremely helpful in giving freely their time to advice and comment on the successive drafts of this report.

## **DEDICATION**

To my family and my supervisors for their encouragement and support, and to all small-scale farmers in Kenya who toil day-in day-out to feed this nation.

## ABSTRACT

Stem borers and storage pests are among the major problems maize farmers in Kenya face. Stem borers, in particular, inflict significant yield losses. More than 50% of the losses occur in the eastern moist transitional zone. This area also has a high adoption rate of improved varieties (95%) making it a promising target for insect resistant varieties. This problem can be partly solved by adoption of genetically engineered (*Bt*) maize to help resource-poor farmers combat food insecurity. Successful introduction and adoption of insect-resistant (*Bt*) maize to address this problem will largely depend on farmers' acceptance. Before its introduction, it is important to understand their awareness and acceptance so that the potential benefits of GM maize will be realized. The objectives of the study were: to assess and analyse the farmers' awareness, attitude and perception towards genetically modified technology; to identify and document sources of agricultural information among farmers in Kenya; to determine farmers mean willingness to pay for the insect-resistant seed maize, and to identify and analyse the factors that influences their' willingness to pay for the insect-resistant seed maize. Multistage stratified random sampling technique was used to indentify 107 farmers. Data was collected using a structured questionnaire through personal interview. Double bounded logit model was used to estimate farmers' WTP. Results showed that 8% of the farmers were aware of GM crops. Vernacular radio was the main source of agricultural information to the farmers in the area. Over 79% of farmers believed in the technology's positive impacts that it can reduce the world food problem, though some were concerned about environmental, health risks and ethical and equity issues of the technology. The mean willingness to pay for GM seed maize was Kshs.463 per 2kg pack, with a premium of 56% above their mean seed maize variety's price. Cognitive variables such as benefit, health risk perceptions and perception on government control on seed quality were found to be the main determinants of farmers WTP for the seed maize. The low levels of awareness of GM technology among farmers need to be addressed by the government and other stakeholders using scientific facts about the technology. Farmers' positive attitudes towards genetic modification and their high WTP for GM seed maize shows that there is potential demand for *Bt* maize and market for GM products in the country which can be tapped to play a role in addressing food security in Kenya.

TABLE OF CONTENTS

DECLARATION ..... II

APPROVAL ..... II

ACKNOWLEDGEMENT.....III

DEDICATION ..... IV

ABSTRACT.....V

TABLE OF CONTENTS ..... VI

LIST OF FIGURES AND TABLES..... VIII

LIST OF ABBREVIATIONS AND ACRONYMS ..... IX

CHAPTER ONE ..... 1

INTRODUCTION ..... 1

    1.1. BACKGROUND INFORMATION..... 1

    1.2. STATEMENT OF THE PROBLEM..... 5

    1.3. OBJECTIVES OF THE STUDY ..... 5

    1.4. HYPOTHESES OF THE STUDY..... 5

    1.5. JUSTIFICATION OF THE STUDY ..... 5

CHAPTER TWO ..... 7

LITERATURE REVIEW ..... 7

    2.1. IMPACTS OF GM TECHNOLOGY ON SMALL-SCALE FARMERS’ YIELD, INCOME AND POVERTY  
    REDUCTION ..... 7

    2.2. STUDIES ON ATTITUDES, PERCEPTION AND ACCEPTANCE OF GM PRODUCTS ..... 8

    2.3. STUDIES THAT HAVE USED CVM WITH A FOLLOW-UP QUESTION IN ESTIMATING WTP ..... 10

    2.4 THEORETICAL FRAMEWORK ..... 13

    2.5 CONCEPTUAL FRAMEWORK ..... 16

CHAPTER THREE ..... 17

RESEARH METHODOLOGY ..... 17

    3.1. AREA OF STUDY ..... 17

3.2. SAMPLING TECHNIQUES .....	17
3.3. DATA COLLECTION .....	18
3.4. DATA ANALYSIS.....	18
3.4.1 DESCRIPTIVE ANALYSIS .....	18
3.4.1 Econometric analysis.....	19
<b>CHAPTER FOUR.....</b>	<b>23</b>
<b>RESULTS AND DISCUSION .....</b>	<b>23</b>
4.1 FARMER AND FARM CHARACTERISTICS .....	23
4.1.1 HOUSEHOLD’S SOCIO-ECONOMIC CHARACTERISTICS .....	23
4.1.2 Gender, land ownership, education, employment and agricultural loan access status....	24
4.1.3 Choice of maize varieties to plant .....	25
4.1.4 Household decision making on farm production activities.....	25
4.2 FARMERS’, ATTITUDE, AWARENESS AND SOURCES OF INFORMATION ON GENETICALLY MODIFIED TECHNOLOGY.....	26
4.2.1 Farmers’, attitude towards genetically modified technology.....	26
4.2.2 Farmers awareness on Biotechnology and GM crops.....	28
4.3 Sources of information on biotechnology .....	28
4.4 ECONOMETRIC RESULTS .....	31
4.4.1 Farmers mean willingness to pay for the insect-resistant seed maize.....	31
4.5 FACTORS INFLUENCING FARMERS’ WILLINGNESS TO PAY FOR THE INSECT-RESISTANT SEED MAIZE. ....	31
<b>CHAPTER FIVE.....</b>	<b>34</b>
<b>CONCLUSIONS AND ROMMENDATIONS.....</b>	<b>34</b>
<b>5.1 CONCLUSIONS.....</b>	<b>34</b>
<b>5.2 RECOMMENDATIONS .....</b>	<b>35</b>
<b>REFERENCES.....</b>	<b>36</b>
<b>APPENDICIES .....</b>	<b>41</b>
APPENDIX 1. LOGLIKELIHOOD FUNCTIONS FOR THE DOUBLE BOUNDED LOGIT MODEL .....	41
APPENDIX 2. AREA OF STUDY .....	42
APPENDIX 3: STUDY INSTRUMENT .....	43

## **LIST OF FIGURES AND TABLES**

Figure 1: Interrelationships between factors influencing farmers' willingness to pay for genetically seed maize

Figure 2. Maize varieties planted

Figure 3: Maize agro ecological zones of Kenya showing the area of study

Table 1. Distribution of the sample respondents

Table 2. Description of variables

Table 3. Household's socio-economic characteristics

Table 4. Gender, land ownership, education, employment and agricultural loan access status

Table 5. Household decision making on farm production activities

Table 6. Farmers' attitudes and perceptions on GM technology

Table 7. Farmers' awareness on Biotechnology and GM crops

Table 8. Sources of agricultural information

Table 9. Parameter estimates for WTP model without farmers' characteristics

Table 10. Parameter estimates for WTP model with farmer characteristics

## LIST OF ABBREVIATIONS AND ACRONYMS

ABNETA	-Agricultural Biotechnology Network in Africa
ABSF	-African Biotechnology Stakeholders Forum
<i>Bt</i>	- <i>Bacillus thuringiensis</i>
CBOs	-Community Based Organisations
CIMMYT	-International Maize and Wheat Improvement Centre
CVM	-Contingent Valuation Method
FAO	-Food and Agriculture Organization
GDP	-Gross Domestic Product
GoK	-Government of Kenya
GMO	-Genetically Modified Organisms
ISAAA	-International Service for the Acquisition of Agricultural Biotechnology Application
IRMA	-Insect Resistant Maize for Africa
KARI	-Kenya Agricultural Research Institute
Kshs.	-Kenya Shillings
WTA	-Willing/Willingness To Accept
WTP	-Willing/Willingness To Pay

## CHAPTER ONE

### INTRODUCTION

#### 1.1. Background information

Agriculture dominates Kenya's economy through contribution to income generation, employment creation, food security and raw material for industries (GoK, 2005a). It accounts for 23% of overall economic growth, 24% of GDP directly and 27% indirectly through linkages with other sectors such as manufacturing, distribution and hotels (Gok, 2009). The sector accounts for 80% of total national employment, 75% of industrial raw materials and 57% of total exports (GoK, 2009).

About 80% of the population in Kenya lives in rural areas and derive their livelihood largely from subsistence agriculture (GoK, 2004 and 2005b). In Kenyan, arable land is under pressure due to high population growth (2.9% growth annually) and rising population densities coupled with small proportion of cultivatable land (only 16% of total land area)(GoK, 2009). Agricultural productivity has not been able to cope with population growth, since most suitable land has been brought under production, leading to serious problems in food security (De Groote *et al.*, 2005) and high poverty level of about 56% of the population (GoK, 2007), of which over 80% live in rural areas (GoK, 2004).

Past increases in agricultural productivity resulted from expansion of land under cultivation (Benhin, 2006). Because new arable land is no longer available, intensive techniques provide the best hope for increased production of the principal food crops in Kenya. Agricultural intensification generally leads to higher pest pressure (De Groote *et al.*, 2002).

In Kenya maize is the leading staple food (GoK, 2005a). About 90% of the population depends on it for direct consumption (Nyangito and Nyameino, 2002). It is both a subsistence and commercial crop, grown on an estimated 1.4 million hectares by large-scale farmers (25%) and smallholders (75%). This area represents more than 30% of arable land. Kenya is a deficit producer of maize and has over the years depended on inflows of imports from the regional and international markets to bridge her production-consumption gap (GoK, 2007). The country

produces a mean of 2.4 million tons of maize per year which translates to 79kg per person and yet consumption is estimated at 103 kg per person annually (Nyangito and Nyameino, 2002).

The expected green maize revolution did not take off in Africa and in Kenya specifically because of diverse and complex reasons (De Groote *et al.*, 2005b). Among the reasons are high input cost compared to decreasing maize prices (Mugo *et al.*, 2005). Stem borers and storage pests are among the major problems maize farmers in Kenya face (De Groote *et al.*, 2004 b). Stem borers, in particular, inflict significant yield losses which are estimated at 13.5 % per annum (with estimated value of US\$ 76 million roughly equivalent to annual maize imports (De Groote, 2002). Three quarters of the losses occur in the high-potential zones, and three species are responsible for 98.9% of the losses: *Busseola fusca* (63%, dominant in the highlands), *Chilo partellus* (29%, dominant in the lowlands) and *Sesamia calamistis* (7%) (De Groote *et al.*, 2003). Depending on agro-ecological zones these losses range from 8.5 % in the lowlands to 16.6% in moist transitional zone a mean for three seasons measured in farmers' fields. More than 50% of the losses occur in the moist transitional zone (Mugo *et al.*, 2005). This area also has a high adoption rate of improved varieties (95%) making it a promising target for insect resistant varieties (De Groote *et al.*, 2004a). The use of insect resistant varieties is important since only a small proportion of farmers use insecticides to control stem borers, mainly due to high costs and labor requirements (Mugo *et al.*, 2005).

A number of studies have suggested that improved technologies in agricultural sector in developing countries can lead to increased production and also help reduce poverty and solve the food crises problem (Guthiga and Mburu, 2006; Benhin, 2006; Ehui and Hertel, 1989; De Groote *et al.*, 2005a). According to Selgeld (1997) and others, biotechnology can be used to achieve the goals of environmental protection, alleviate poverty and address food security by helping promote sustainable agriculture. In Kenya agricultural biotechnology holds the promise for millions of farmers especially small and marginal ones to produce enough maize, and ensure food security, since it provides an alternative to use of inputs such as chemical fertilizer and pesticides. Thus the relevance of genetic modification to produce transgenic crop varieties with resistance to herbicides, pesticides, insects, and diseases cannot be ignored, given the high costs associated with agricultural chemical inputs and yield losses (Mugo *et al.*, 2005).

Genetically modified (GM) crops were commercially introduced in 1996 in United States of America. Although there is intense debate concerning the adoption in many countries, globally they have been accepted and grown on 125 million Ha in 25 countries. The countries with the biggest share are USA (50%), Argentina (17%), Brazil (13%), Canada (6%) and china (6%) among others (James, 2008). In Africa only South Africa, Egypt and Bukina faso are commercially growing GM crops with South Africa leading with 1.8 million Ha (James, 2008). Several other countries including Kenya are at different stages of trials for different GM crops. GM maize is the second-most dominant crop and covered 30% of the global GM area and 24% of total maize production in 2008. Other popular crops are soybeans, and cotton as well as canola, squash, papaya and alfalfa.

GM crops have resulted in significant benefits in countries where they are grown. These benefits include: higher yields that address food shortages, reduced losses from insect pests and diseases, reduced pesticide cost, and reduced pesticide residues in the environment and low food prices for the consumers because of low production cost (James, 2008, Qaim, 2009 ). Specifically *Bt* maize will benefit the poor families in Kenya who spend more than 50% of their available income on maize (De Groote *et al.*, 2005).

There are potential risks and perceived concerns about GM crops such as; the danger of unintentionally introducing allergic substances or toxins to foods, possibility of these genes escaping from cultivated crops into wild relatives, possibility that transgenic crops carrying antibiotic genes will generate antibiotic resistance in livestock and humans after eating food from these crops, the potential for pests to develop resistance to the pesticide produced by GM crops and the risk of substances from these crops affecting non-target and beneficial insects.

According to Feldmann *et al.* (2001), GMOs are living organisms into which foreign genes have been inserted. Other authors have defined GMOs as “organisms in which the genetic material has been altered in a way that does not occur naturally”. This technology of transferring genes is known as genetic engineering. It also referred to as “gene technology”, “modern biotechnology” or “recombinant DNA technology”. It allows selected individual genes to be transferred from one organism into another, between related or non-related species.

In Kenya, six major agro-ecological zones for maize production have been identified. At the coast is the Lowland Tropics (LT). Westwards are the Dry Mid-altitudes (DM) and Dry Transitional (DT) zones. These three zones are characterized by low yields (less than 1.5 t/ha); although they cover 29% of maize area in Kenya, they only produce 11% of the country's maize. In Central and Western Kenya, are the Highland Tropics (HT), bordered on the west and east by the Moist Transitional (MT) zone (transitional between mid-altitudes and highlands). These zones have high yields (more than 2.5 t/ha) and produce 80% of the maize in Kenya on 30% of the area. The Moist Mid-altitude (MM) zone is found around L.Victoria and produces moderate yields (1.44 t/ha), covers 22% of the area and produces 9% of maize in the country (Hassan *et al.*, 1998).

To address the problem of maize stem borers, the Insect Resistant Maize for Africa (IRMA) project is developing maize varieties resistant to stem borers (Mugo *et al.*, 2005). The IRMA project is a collaborative effort between researchers from the Kenya Agricultural Research Institute (KARI) and the International Maize and Wheat Improvement Center (CIMMYT), supported by the Syngenta Foundation for Sustainable Agriculture and the Rockefeller Foundation, to identify sources of stem borer resistance through conventional and biotechnological means. The project was launched in 1999 with a goal to increase maize production and food security through the development and deployment of insect resistant maize, thereby significantly reducing crop losses (De Groote *et al.*, 2005a).

Studies in Kenya have revealed that consumers are willing to accept the *Bt* maize. In Nairobi city, 68% were willing to pay for GM maize meal at same prices as their favorite brands (Kimenju and De Groote, 2008) while 89% of the rural consumers in western Kenya were willing to pay GM maize meal if it was available at the same price as the conventional maize meal (Keter, 2007). Given GM foods' potential to improve Kenya's food security, there is need to better understand the farmers' perception of the GM crops and food especially rural farmers where hunger and malnutrition are most common, and where GM crops are likely to have the greatest contribution to human welfare. Therefore, this study seeks to provide more information that will help public policy makers in resolving the on-going public debates of GM food issues in Kenya.

## **1.2. Statement of the problem**

Though maize varieties resistant to stem borers have been developed for eastern moist zone, their acceptance for growing by farmers has not been evaluated. Further, their attitude towards the new varieties and the sources of related information has not been established. Consequently, their willingness to pay for the type of seed needs to be known. The purpose of this study was to bridge this knowledge gap.

## **1.3. Objectives of the study**

### **General objective**

Economic evaluation of acceptance of genetically modified seed maize in eastern moist transitional zone, Kenya

### **Specific objectives**

1. To analyse the farmers' awareness and attitude towards genetically modified technology.
2. To determine the sources of agricultural information among farmers in eastern moist zone.
3. To determine farmers mean willingness to pay for the *Bt* seed maize.
4. To identify and analyse the factors that influences the farmers' willingness to pay for the *Bt* seed maize.

## **1.4. Hypotheses of the study**

1. Farmers' awareness and attitude does not significantly affect WTP for insect-resistant seed maize.
2. Sources of agricultural information to farmers are not significant.
3. Farmer's willing to pay for insect resistant seed maize is not significant.
4. Socio-economic factors do not explain farmers' WTP for insect-resistant seed maize.

## **1.5. Justification of the study**

Maize is the leading staple food in Kenya, yet production is under threat of maize stem borers which cause a mean of 13.5% yield losses. This problem can be solved by insect-resistant maize but there is little information about acceptability of insect-resistant maize in Kenya and therefore it is not known whether their potential benefits will be realized. Results of this study will contribute to filling knowledge and literature gaps on farmers' acceptance of insect-resistant maize in Kenya; recommendations will be made on biotechnology policy intervention and biotechnology information dissemination. In addition the results will help to promote sustainable

agriculture through environmental protection through use of agricultural biotechnology that eliminates spraying of synthetic chemicals.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1. Impacts of GM technology on small-scale farmers' yield, income and poverty reduction

Poor families spend a large proportion of their income on maize, yet stem borers are a real and serious problem in maize production, especially in the low potential areas. Moreover, small-scale farmers are net buyers of maize. An increase in production on small-scale farms will have a direct effect in increasing the household's available income for other expenditures. Moreover, an increase in national production will reduce the price, benefiting both urban and rural consumers. *Bt* technology has shown very good efficacy against the stem borer species and could boost yields by 20%, substantially improving the livelihood of poor maize farmers (Mugo *et al.*, 2005; De Groot *et al.*, 2005a).

According to Ismael *et al.*, (2001), study of adoption and economic impacts of *Bt* cotton in South Africa showed that 44% of small-holder farmers adopted it because it had direct savings on cost of insecticide, 24% cited increased yield while 10% believed it was labour saving in term of time spent in spraying. For the non-adopters, 90% were willing to adopt the technology in future but cited the cost of seed as the main reason for not adopting. Results of the two years of adoption showed that *Bt* cotton had important implications for livelihood compared to conventional alternatives. Further, analyses by Smale *et al.*, (2009), comparing economic returns per ha between smallholders and large-scale producers in South Africa found that smallholders there are major beneficiaries of *Bt* cotton. These benefits were in terms of increased yield, cost reduction and higher gross margins for small holder farmers and associated environmental and human health benefits.

Almost 80% of cotton planted in South Africa is genetically modified seeds. Among the reasons given by small-scale farmers for adopting the GM cotton were; 58% indicated increased yield, 30% better quality, 15% higher prices, 70% pesticide saving and 35% labour saving.(Gouse *et al.*, 2003). *Bt* cotton had impacted on farm income in South Africa in three ways according to Gouse *et al.*, (2003); decrease in input cost through saving on pesticide chemical application cost, increased yield and increase input cost through higher seed prices and additional technology fee. Further *Bt* technology adopters were more technically efficient than non-adopters.

Gouse *et al.*, (2006) observed yield benefits in the three seasons by small-scale maize farmers in South Africa due to adoption and production of *Bt* white maize as 32%, 16% and 5% more yielding compared to conventional maize. Small-scale farmers rated *Bt* maize grains of superior quality compared to local maize and non-*Bt* maize grains. According to that study, income and food security effects of *Bt* maize revealed that income generated by selling extra grains or in terms of cost saving from not purchasing maize meal are a monetary value of yield advantage from *Bt* maize. Results further indicated that *Bt* maize farmers were marginally better off than conventional hybrid seed planting farmers despite the *Bt* technology fee. Farmers who consumed their additional maize enjoyed a bigger income benefit.

Costa-Font *et al.*, (2007) pointed that although GM crops certainly will not solve all of the poverty and malnutrition issues in the developing world, GM crops do provide certain production advantages, which may provide crops of comparative advantage to developing nations in world markets. Due to the increased productivity of GM crops, one would find it hard to believe that any low-income developing country would refrain from implementing GM crops. They further confirmed that not only are GM crops resulting in increased yields and lower production costs, they also create a safer farming environment. Changes include fewer incidents of farmer poisoning, lower water toxicity and reduced use of herbicides with residual effects. Their review revealed that GM crops have led to increased welfare for European Union producers. According to Quam (2009), *Bt* crops can be suitable for small-scale farmers. Evidence from India and other developing countries shows that they contribute to higher household incomes and poverty reduction, when embedded in a conducive institutional environment. Several studies show that *Bt* technology advantages for small-scale farmers are of a similar magnitude as those of larger-scale producers and, in some cases, the advantages can be even greater. Specifically, *Bt* cotton and maize are produced by many small scale farmers in India (Smale *et al.*, 2009), and South Africa (Gouse *et al.*, 2004),

## **2.2. Studies on attitudes, perception and acceptance of GM products**

Various studies have been carried out to determine the attitudes, perceptions, acceptance and rejection for GM foods particularly the consumers. Moon and Balasubramanian (2004) in determining public attitudes toward agro biotechnology proposed that the impact of trust, awareness, sense of outrage, and socio-demographic variables on attitudes are mediated by risk

perceptions. The survey was administered by mail to a sample of 3,060 U.S. households stratified by geographic regions, household head's age, education and income, and 2,600 U.K. consumers by Internet. They found out that influence of negative attributes dominates attitude formation in both the U.S. and U.K., and this reflects strategic failures on the part of the agro biotechnology industry in that few GM food products present direct tangible benefits like improved nutrition and taste, and the lack of effective information/education programs that promote positive attributes of agro biotechnology. In general, attitudes of U.K consumers were more susceptible to negative attributes when compared with U.S. consumers. Results also showed that trust, awareness, sense of outrage, and socio-demographic factors play an important role in shaping public attitudes toward agro biotechnology, largely via their links to risk perceptions. Their study focussed more on attitude formation on the assumption that the general attitudes for these regions are known. The current study aims at determining such attitudes, as they are not known a priori, and to determine whether they have an influence on WTP for insect resistant maize.

Chern *et al.*, (2003) estimated the consumer willingness to pay for selected GM foods in Japan, Norway, Taiwan, and the US using university students as the respondents. They found that there are notable differences in the attitude and perception on GM foods across these countries. Consumers were willing to pay 55-69%, 50-62%, 33-40%, 17-21% premiums for non-GM foods in order to avoid GM counterparts for the Norwegian, American, Japanese and Taiwanese respectively. By considering only university students as the respondents, the study rules out important determinants of WTP for GM food such as age, income and credit among other variables. This study determined attitudes and perceptions of randomly selected farmers on GM crops in the study area.

Chen and Chern (2002) used contingent valuation method (CVM) to estimate WTP for three selected products: vegetable oil, salmon and cornflakes in the US. They revealed that variables related to attitude, perception, labelling, and price have significant effect on consumers' choices between GM and non-GM food products. Income and number of children in the household were found to have a significant negative effect on respondents' willingness to consume GM food products. The respondents were willing to pay a premium of 5-8% for non-GM vegetable oil, 15-28% for non-GM salmon, and 12-17% for non-GM cornflake breakfast cereal. Female

respondents, middle-aged consumers and non-white respondents were found to be willing to pay a higher premium for non-GM food products. That study contributes to this study in that it uses dichotomous choice questions to determine WTP. However, the current study uses dichotomous choice with a follow-up question which is known to be more efficient.

Moon and Balasubramanian (2001) determined public perception and WTP a premium for non-GM foods in the UK and the US using the probit model. They found that while UK consumers had significantly more WTP a premium to avoid GM foods than the US consumers, risks and benefits clearly translated into behavioural intentions as measured with WTP in both countries. More importantly, they established that risk perception exerts a greater impact on WTP than benefit perception. Unlike the current study, that study used the single-bounded dichotomous choice CV, where only one bid was used. This leads to loss of information, as it is not possible to place the bound on the respondent's true WTP. To avoid that, this study used double-bounded CV. Logit model was used and double bounded dichotomous choice instead of single-bounded dichotomous choice.

Qaim (2009) pointed that there has been partial acceptance of GM crops because most of them involve agronomic traits with limited direct benefits to consumers. He argues that consumers acceptance may increase when second generation, quality enhanced GM foods and crops with combined agronomic and quality traits are introduced.

### **2.3. Studies that have used CVM with a follow-up question in estimating WTP**

Contingent valuation method (CVM) is a survey-based method to elicit individual's valuation of goods and services not sold in the market place, by calculating their willingness to pay (WTP). Contingent valuation method was pioneered by Bishop and Heberlein (1979). The method has extensively been used in the valuation of non-marketed resources such as recreation, wildlife and environmental quality. In this method, the researcher creates a hypothetical market in a non-market or new good, invites a group of subjects (survey respondents or experimental subjects) to operate in that market, and records the results. The values generated through use of the hypothetical market are treated as estimates of the value of the non-market good or service, contingent upon the existence of the hypothetical market.

Contingent valuation method with dichotomous choice studies with a follow-up question has recently been used. This is because of the generally accepted view that the method gives more efficient results (Hanemann *et al.*, 1991). Li *et al.*, (2003) conducted a survey in Beijing, China to determine consumer attitudes towards GM foods. They found that although the majority of surveyed consumers reported that they had little or no knowledge of biotechnology, their attitudes toward GM foods was generally positive. Using dichotomous choice CVM, they found that Chinese consumer's willingness to pay for GM rice and GM soybean oil were positively affected by respondents' positive opinion, and by higher levels of self-reported knowledge for soybean oil. Willingness to pay was negatively affected by the respondent's age. Their results indicated that unlike Europe or Japan, there is a potential market for GM foods in China. Consumers were WTP a 38.0% premium for GM rice and 16.3% premium for GM soybean over their non-GM counterparts. That is similar to the current study in that they both use the double-bounded logit model. The difference is that the current study focused on farmers' awareness and acceptance of insect resistant maize.

McCluskey *et al.*, (2001) sought to estimate willingness to pay for GM-free food products and analyse the factors that induce Japanese consumers to choose GM-free food products. They built a double-bounded logit model, and from it developed a "semi-double-bounded" logit model, in that those individuals who responded with a yes to the first question, implying that they were willing to purchase the GM food product at no discount, were not asked a follow-up question because of the nature of the product. The results indicate that customers in Seikyuu, Japan, are willing to purchase GM noodles with a 60% discount and GM tofu with a 62% discount. They further found out that consumers who are less concerned about food safety, less knowledgeable about biotechnology in food production, and less concerned about labelling of GM foods are more willing to choose GM food products when they are offered more discounts on the foods. Also, female consumers with larger families were more willing to pay for GM foods. In avoiding asking whether consumers could buy the GM product at a premium, the methodology leads to loss of information as one can not place the WTP of those people particularly supportive of the technology.

Kaneko and Chern (2003) used dichotomous choice based CV to determine willingness to pay for non-GM vegetable oil, salmon fillets and cornflakes. To counter the problem of awareness,

they provided a basic definition of genetic modification along with pros and concerns. They found that consumers do care about the price even when the choice involves such controversial products as GM foods. Among the determinants of choice, risk perception stands out. The mean willingness to pay to avoid the GM alternative were 41.2%, 31.4%, 40.9% and 52.5% for GM vegetable oil, GM cornflake cereal, GM-fed salmon and GM salmon respectively. The WTP for GM salmon is the highest and significantly different from that of GM-fed salmon, implying that respondents feel a weaker aversion to GM foods involving only modification of plant genes as opposed to animal genes or a combination of plant and animal genes. That study is similar to the current one because it uses a follow-up question on the dichotomous choice question, and that it offers information to the respondent on genetic modification. However, this study used a double bounded logit model to estimate WTP unlike the binomial logit that was used in that study, as the latter is better placed to capture the advantage of using a follow-up question.

Hanemann *et al.*, (1991) conducted a survey on WTP for protecting wildlife and wetland habitat in California's San Joaquin Valley. They used mail-out questionnaires to collect the responses to the initial bids, and a telephone interview to collect the responses to the follow-up bids. Estimation of the WTP was done using both the single and double bounded logit models, yielding a mean WTP of US\$257 and US\$152 respectively, for the wetland and wildlife protection. Comparing the two, they observed that coefficients from double-bounded model were asymptotically more efficient than those from single bounded model and yields tighter confidence intervals and lower point estimates for mean WTP.

Kimenju and De Groote (2008) conducted a survey in Nairobi, Kenya to gauge consumers' awareness of GM crops, their WTP for GM foods and factors that influence their WTP. The results revealed that 38% of consumers were aware of GM crops, 68% were willing to pay for GM maize meal at same price as their favourite brand. They also found that consumers with higher education and income groups were however concerned about side effects especially on environment and biodiversity. They estimated willingness to pay using double bound logit dichotomous choice model based on CV method similar to this study. The difference arises in that, (i); data was collected from farmers in a rural set-up rather than urban consumers.(ii); education variable is a continuous variable measured by number of years of schooling rather than a categorical variable, income is a continuous variable measured by the level of income through

expenditure approach rather than a categorical variable used in that study. (iii); availability of credit is included as an additional variable in the current study.

Keter (2007) assessed rural consumer's awareness, attitude and willingness to pay for genetically modified food in western Kenya and found that 13.2% were aware of GM crops. The awareness differed by gender, education and occupation. Results revealed that 89% of the rural consumers were willing to pay GM maize meal if it was at the same price as the conventional maize meal. Benefit perception had a strong positive effect on WTP while health and environment risk perception had negative effect on WTP. Most of the consumers (85.9%) revealed that they had just learnt of GM technology with radio as the main source of information. The current study utilizes the same approach but focus on rural farmers' awareness and acceptance of insect-resistant maize rather than consumers since in the rural areas, large population are farmers

This method of obtaining farmers willingness to pay using contingent valuation where farmers state their preferences as applied in this and other studies has an advantage in that data obtained is representative. The disadvantage, however, is the potential hypothetical bias, as respondents state their preferences without any direct financial implications (Qaim, 2009). This bias can be avoided through experimental auctions, although samples are usually smaller and not representative of the total population. The experiments are often designed such that participants bid with real money or are presented with opportunities to exchange a given GM product for a corresponding GM-free product or vice versa (Lusk *et al* 2004b).

## **2.4 Theoretical framework**

Generally there are two approaches for assessing demand or WTP. The first is the demand curve approach, which entails making observations on prices and quantities in a market. A demand curve is then estimated and WTP can be inferred. The other approach is CV, a more direct assessment of preference. This survey-based method uses responses to some questions posed to an individual to infer WTP for a hypothetical product or service. This is the method employed in this study since GM seed maize is not available in the market. According to theory, if demand for a good or service exists, then this must be reflected by WTP. A high WTP is logically a

proxy for its demand. Thus the value placed by an individual on a good or service can be expressed as WTP to obtain it.

A rational person will, due to the constrained maximization facing him, give preference to alternatives that give him higher utility. A good or service associated with highest WTP would be the one that yields highest utility to the individual and vice versa. Subsequently, a high willingness to pay indicates high utility derived from the commodity and hence such a good would be given preference, implying its high demand. Logically, a good that satisfies one most is also highly valued. The value of a good would be expressed through WTP for the good.

The random utility model is the basic model for analyzing dichotomous choice CV responses. This model arises from the assumption that while the individual knows her preferences with certainty and does not consider them stochastic, they contain some components that are unobservable to the econometric investigator and are treated by the investigator as random (Hanemann and Kanninen, 1998). These components are captured by the random term. In this case individuals are expected to maximize their utility. The indirect utility function for an individual may be expressed as;

$$U = f(y, z, e)$$

Where:

$U$  represents individual's utility

$y$  is the individual's income

$z$  is a vector of respondent's characteristics and other demographic variables

$e$  is the random term

Given this utility function, the individual answers "yes" to the offered price if the utility with the proposed change is greater than the utility without the change.

Since, however,  $U$  is observable to the respondent but not to the researchers, one can make only the probabilistic statements about the response.

The probability that the respondent will answer yes and hence be willing to pay is the probability that their utility with the proposed change is greater than that without the change, represented by the equation:

$$P_j = P\{U_{ji}(y_j - b, z, e_{ji}) > U_{jo}(y_j, z_j, e_{jo})\}$$

Where:

$P_j$  is the probability that the  $j^{th}$  respondent will answer “yes” to an offered price of  $b$

$U_{ji}$  is the respondent’s utility with the change

$U_{jo}$  is the respondent’s total utility without the change

$y_j$  is respondent’s income

$z_j$  is a vector of the respondent’s characteristics and other demographic variables

$e_{ji}$  and  $e_{jo}$  are random components with and without change, respectively.

In dichotomous choice CVM, the respondents are offered specific dollar amounts,  $B$ , and asked whether they are willing to pay that amount or not, to secure some given improvement (change).

This format can either use a single-bounded design (where only one bid is presented) or the double-bounded design (where two bid values are tested- an initial and a follow-up one). The respondent answers with a “no” or a “yes”. The yes-no answers are then used along with the required payment to estimate a discrete model from which expected WTP is calculated

The probability of obtaining a “no” or a “yes” response can be represented, respectively, by

$$(1) \quad \pi^n(B) = G(B;\theta),$$

$$(2) \quad \pi^y(B) = 1 - G(B;\theta),$$

Where  $G(\cdot; \theta)$  is some statistical distribution function with parameter vector  $\theta$

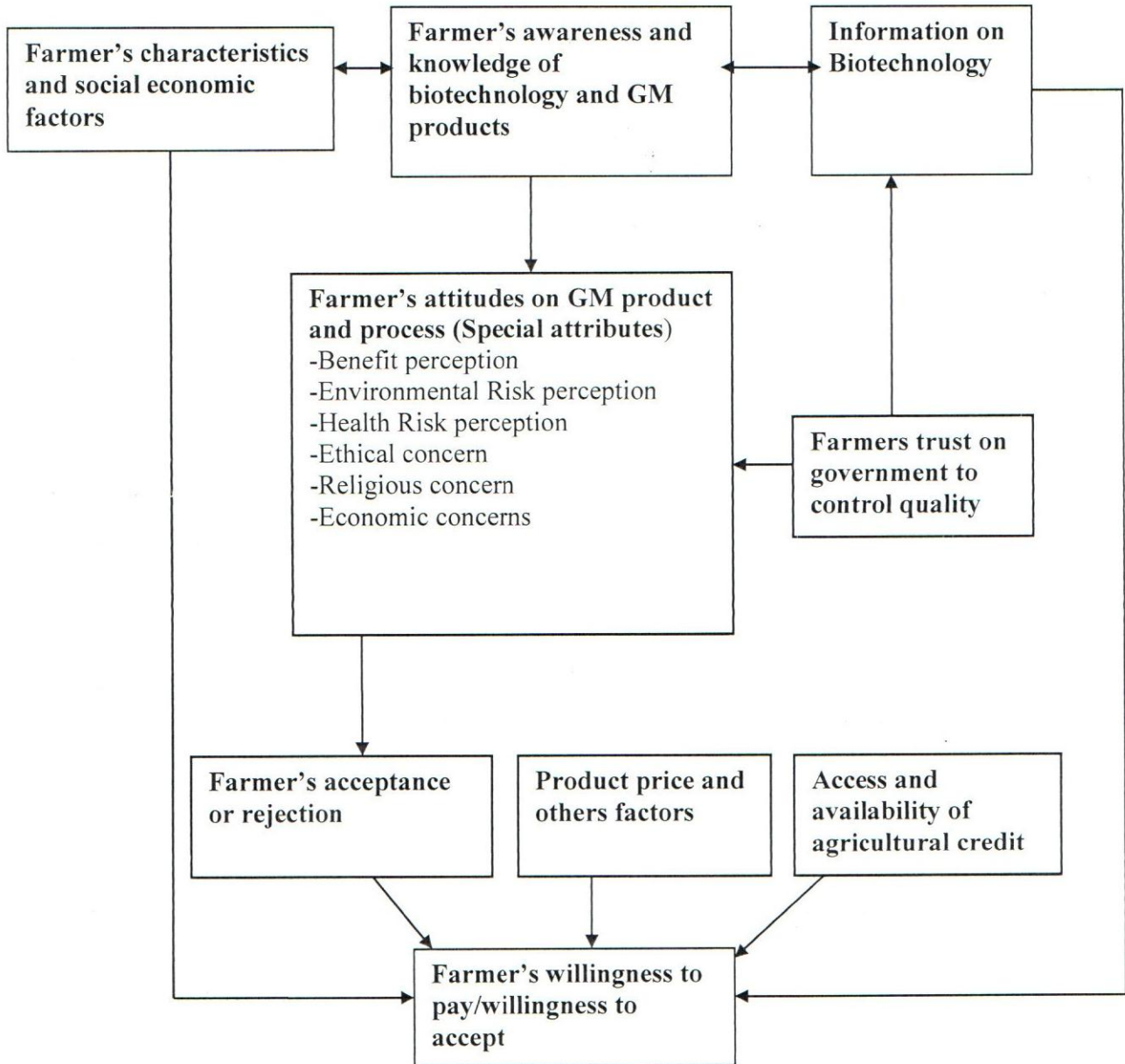
(Hanemann *et al.*, 1991). This statistical model can be interpreted as utility-maximization response with a random utility context, where  $G(\cdot; \theta)$  is the cumulative density function (cdf) of the individual’s true maximum WTP since utility maximization implies

$$\Pr \{\text{No to } B\} = \Pr \{B > \text{maximum } WTP\},$$

$$\Pr \{\text{Yes to } B\} = \Pr \{B \leq \text{maximum } WTP\},$$

## 2.5 Conceptual Framework

Figure 1. Interrelationships between factors influencing farmer's willingness to pay for GM seed maize



The model above shows the interrelationships between factors influencing the farmer's willingness to pay for insect resistant seed maize. The farmers WTP is directly influenced by social-economic characteristics, awareness of Biotechnology, attitude and the GM products attributes, product prices and access and availability of agricultural credit. Indirectly Farmers awareness is influenced by the information they have on the products in question. Farmers trust in the government to control product's quality influence their attitudes and perception.

## CHAPTER THREE

### RESEARH METHODOLOGY

#### 3.1. Area of study

The study area was purposively selected to cover Eastern Moist Transitional (MT) zone. The moist transitional zone has considerably high yields of about 80% of maize produced in Kenya (Hassan *et al.*, 1998). It has the highest maize losses caused by maize stem borers measured at 16.6% on mean for long and short rain seasons (De Groote *et al.*, 2004a). This zone also accounts for an enormous 59% of all losses attributed to maize stem borers in Kenya, yet has the highest adoption rate of high yielding varieties estimated at 95 % (De Groote *et al.*, 2004a). The zone has ten administrative districts namely Embu, Mbeere, Meru Central, Meru South, Meru North, Tharaka, Kirinyaga, Maragua, Murang'a and Nyeri Districts (Figure 1). Data was collected in five districts within the zone namely: Embu, Kirinyaga, Maragua, Murang'a and Nyeri.

#### 3.2. Sampling techniques

Multi stage stratified random sampling procedure was used to select households. Administrative districts and locations formed the strata. Locations within divisions in each district were established within the zone and locations selected randomly, 22 households in each location were also selected randomly. A total of 110 households were randomly selected from five districts; Embu, Kirinyaga, Maragua, Murang'a and Nyeri. In each selected household, the household head was interviewed to determine the effectiveness of the research instrument the interview schedule was pre-tested among respondents exhibiting similar research conditions as those of research area but not included in the sample frame. A total of 107 respondents were included in the analysis since 3 cases were dropped due to non response in many areas in the questionnaire.

**Table 1: Distribution of the sampled respondents**

District	Division	Location	No of respondents
Kirinyaga	Mwea	Mutithi	11
Kirinyaga	Guchugu	Ngariama	11
Embu	Manyatta	Ngandori	22
Nyeri	Mukurwe-ini	Githi	22
Murang'a	Kiharu	Mbiri	22
Maragua	Kigumo	Kirere	22

### **3.3. Data Collection**

Primary data was collected using structured questionnaires by enumerators through personal interview. To achieve objective 1, awareness about GM crops was first sought; the farmers' attitudes on five types of perceptions on genetic modification were obtained: benefits, health risks, environmental risks, and ethical and equity concerns. For each type, several statements were read, and farmers were asked their opinion, on a 5 – point Likert scale. These answers were then analyzed. To achieve objective 2, different sources of media, medical and other professional sources were presented to the farmers. They were asked whether they sort agricultural information from those sources. The frequencies of the answers were determined in percentages.

To determine farmers mean willingness to pay for the *Bt* seed maize and to identify and analyse the factors that influences the farmers' willingness to pay for the for the *Bt* seed maize, respondents were first asked if they were willing to purchase insect-resistant *Bt* seed maize if it were offered at the same price as their preferred variety in a hypothetical situation where insect-resistant seed maize was assumed to be available in the market. The two products are exactly the same except that the former is produced through genetic modification. If the respondent's answer to this question was a "no", a follow-up question was asked, where the respondent was offered a percentage discount on the GM product relative to the non-GM product. If the respondent's answer to the first question was a "yes," a follow-up question was asked where the respondent was offered a percentage premium on the GM product relative to the non-GM product. The discount and premium levels were, 10%, 25%, 50% and 75%. These were presented to all respondents in the sample depending on the first response.

### **3.4. Data analysis.**

#### **3.4.1 Descriptive analysis**

The unit of analysis was the household head. To achieve objective 1; to assess and analyse the farmers' awareness, attitude and perception towards genetically modified technology and 2; to identify and document sources of agricultural information among farmers in eastern moist transitional zone, descriptive analysis was used. This was done in order to summarize the variables of interest and determine interrelationships among them. It entailed computation of measures of central tendency and frequencies.

### 3.4.2 Econometric analysis

In order to achieve objective 3 and 4; the double-bounded logit model was used. This approach was first proposed by Hanemann and Carson in 1985 and first implemented by Carson, Hanemann, and Mitchell in 1986. The questions asked in this survey elicited discrete choice responses, “yes” or “no” hence a dichotomous choice format, which is also known as the referendum approach, or take-it-or-leave-it approach. The appropriate models for analyzing discrete response are the logit and the probit models. Both are non-linear and use the principle of maximum likelihood to estimate the parameters.

In the double-bounded model there are four possible outcomes:

- (a) the respondent is not willing to purchase the GM product at the same price as non-GM product, nor at a discount relative to the non-GM product ( "no" to both bids, NN);
- (b) the respondent is not willing to purchase the GM product at the same price as the non-GM product, but is willing to purchase the GM product at the random discount offered ("no" followed by "yes", NY);
- (c) the respondent is willing to purchase the GM product at the same price as non-GM product, but is not willing to purchase it at a premium ( "yes" followed by a "no", YN);
- (d) the respondent is willing to purchase the GM product at the same price as non-GM product and also willing to purchase the GM product at a random premium offered relative to the non-GM product ("yes" to both bids, YY).

These four possible outcomes can be denoted as NN, NY, YN and YY, where Y represents an affirmative answer and N a negative one. The model most applicable to examine the outcomes of such a survey is the standard double-bounded logit model (Hanemann et al., 1991). This is based on the assumption that the first and second responses are consistent.

The second bid allows the researcher to place both an upper and a lower bound on the respondents true WTP when the outcome is either NY or YN. When the outcomes are either NN or YY, the second bid sharpens the single bound – it raises the lower bound or lowers the upper bound.

If we represent the applicable bid to the  $i^{\text{th}}$  respondent as  $B_i$  for the initial bid,  $B_i^d$  for the lower bid after an initial “no” response, and  $B_i^u$  for the upper bound after an initial “yes” response, then the relationships between the bids may be expressed as follows

$$B_i^u > B_i \text{ for YY and YN} \tag{1}$$

$$B_i^d < B_i \text{ for NY and NN} \quad (2)$$

If we represent the likelihoods of the respective outcomes as  $\pi^{yy}$ ,  $\pi^{yn}$ ,  $\pi^{ny}$  and  $\pi^{nn}$  then the formulas for these likelihoods may be expressed as:

$$\pi^{yy}(B_i, B_i^u) = \Pr\{B_i \leq \max \text{ WTP and } B_i^u \leq \max \text{ WTP}\} \quad (3)$$

Information on a wider range of values, different amounts for the bids are assigned randomly between respondents  $i$ . The probability of receiving a “yes” answer to both questions equals the probability that the respondent’s WTP is higher than the highest bid offered:

$$\pi^{yy}(B_i, B_i^u) = \Pr(B_i^u < \text{WTP}_i) = 1 - G(B_i^u) \quad (4)$$

Similarly, the probability of receiving a “yes” followed by a “no” equals the probability that the WTP of respondent  $i$  lies between the initial bid and the second, higher bid offered:

$$\begin{aligned} \pi^{yn}(B_i, B_i^u) &= \Pr(B_i < \text{WTP}_i < B_i^u) \\ &= G(B_i^u) - G(B_i) \end{aligned} \quad (5)$$

The probability of receiving a “no” followed by a “yes” is again the probability that  $\text{WTP}_i$  lies between the initial and the second, now lower, bid offered:

$$\begin{aligned} \pi^{ny}(B_i, B_i^u) &= \Pr(B_i^u < \text{WTP}_i) = 1 - G(B_i^u) \\ &= G(B_i) - G(B_i^d) \end{aligned} \quad (6)$$

Finally, the probability of receiving two “no” an answer is equal to the probability that  $\text{WTP}_i$  lies below the second, lowest bid offered:

$$\pi^{nn}(B_i, B_i^d) = \Pr(B_i^d < \text{WTP}_i) = G(B_i^d) \quad (7)$$

Where  $G(\bullet)$  is some statistical distribution function with parameter vector  $Z_i$ . It is the of the individual’s true maximum WTP. Logistic cumulative density function (cdf) will apply in this case, represented as:

$$G(B) = [1 + e^{a-b(B)}]^{-1} \quad (8)$$

Combining the probabilities of the four outcomes, where  $B_i$ ,  $B_i^u$  and  $B_i^d$  are the bids used for the  $i^{\text{th}}$  respondent, the log-likelihood function for a sample of  $N$  farmers takes the form:

$$\ln L^D(\theta) = \sum_{i=1}^N \{d_i^{yy} \ln \pi^{yy}(B_i, B_i^u) + d_i^{nn} \ln \pi^{nn}(B_i, B_i^d) + d_i^{yn} \ln \pi^{yn}(B_i, B_i^u) + d_i^{ny} \ln \pi^{ny}(B_i, B_i^d)\} \quad (9)$$

where,  $d_i^{yy}$ ,  $d_i^{nn}$ ,  $d_i^{yn}$  and  $d_i^{ny}$  are binary-valued indicator variables with 1 denoting

the occurrence of that particular outcome, and 0 otherwise.

The maximum likelihood estimator for the double-bounded model,  $\hat{\theta}^D$  is the solution to the

$$\text{equation: } \partial \ln L^D(\hat{\theta}^D) / \partial \theta = 0 \quad (10)$$

The above model is used to estimate the predictive model for WTP. The regressors are the bid values and the farmers' characteristics.

The WTP function for insect-resistant seed maize is specified as:

$$WTP_i = \alpha - \rho B_i + \lambda Z_i + \varepsilon_i \quad (11)$$

Where  $B_i$  is the ultimate bid individual  $i$  faces,  $Z_i$  is a column vector of observable and cognitive characteristics of the individual, and  $\varepsilon_i$  is a random term. The empirical representation of this is

$$WTP = f(\text{BID, AWR, KS, BP, ERP, HRP, EREC, AGE, GDR, EDUC, INCM, CRDT, GOVT})$$

Where:

**Table 2: Description of Variables**

Variable	Description
Bid	Random bid value offered to the respondents
AWR	Dummy variable for awareness about GM crops; 1 if aware of GM crops, 0 otherwise
KS	knowledge score
BP	Benefit perception score
ERP	Environment risk perception
HRP	Health risk perception
EREC	Ethical/ religious/ economic concerns
AGE	Age of the respondent in years
GRD	Dummy for gender of the respondent; 1 for female, 0 otherwise
EDUC	Number of year of schooling
INCM	Respondents level of monthly income
CRDT	Availability of agricultural credit; 1 if yes, 0 otherwise
GOVT	Dummy for trust in government to ensure seed quality; 1 if the respondent trusts the government to ensure seed quality, 0 otherwise

The model was estimated using LIMDEP software. According to Hanemann et al. (1991); Hanemann and Kanninen (1998), the mean and median WTP is given by  $\alpha/\rho$ , obtained from the restricted model without farmers characteristics, that is, by restricting  $\lambda_i = 0$ . The full model was further used to estimate the mean WTP including farmers' characteristics by adjusting the  $\alpha$  to include the estimated parameters and the average values for the vector of factors  $Z$  thereby the mean WTP was calculated as  $WTP = (\alpha + \lambda \bar{Z}) / \rho$ , Where  $\alpha$  is the constant,  $\lambda$  is the respective parameter's coefficient,  $\bar{Z}$  is the variable mean value and the  $\rho$  is the bid coefficient. The mean WTP was found by dividing the resultants of the summation of the constant plus the sum of the products of the variables mean and variable coefficient by the bid coefficient. (Kimenju and De Groot, 2008).

## CHAPTER FOUR

### RESULTS AND DISCUSION

#### 4.1 Farmer and farm characteristics

##### 4.1.1 Household's socio-economic characteristics

The results in Table 1 show that the respondents' mean age was 46.6 years. This is an indication that majority of the farmers were middle aged. The mean farm size was 1.2 hectares and on average half of it was allocated to maize farming. The mean household maize production was 3.7, (90 kg) bags in the year 2008 both in the long and short rain season. This maize was expected to feed a mean of 5 persons per household (Table 1). The mean annual household income was Ksh 144,806 derived from aggregation of crops, livestock, and off-farm income. This mean annual income was confirmed through the expenditure approach in the same households on food, non food and durables over the same period and obtained as Ksh 142,143. The mean price (initial bid) of the preferred seed maize was found to be Ksh 297.6 for 2kg seed pack.

**Table 3. Household's socio-economic characteristics**

Variable	Mean	Std. Deviation	Minimum	Maximum
Respondent's age (Years)	46.6	14.9	17.0	79.0
Farm size (Ha)	1.2	1.4	0.0	10.1
Area allocated to maize farming (Ha)	0.6	0.9	0.12	7.3
Quantity of maize produced by the household in 2008 (90kg bags)	3.7	11.5	0	115.0
Number of members living in the household	4.8	2.6	1	16.0
Total household annual income (year 2008 in Ksh)	144,806.0	326,782.3	0	2,931,300.0
Total household expenditure (year 2008 in Ksh)	142,142.7	235,611.5	0	2,270,650.0
Price of the preferred seed maize variety	297.6	76.7	160.0	816.0
<b>N=107</b>				

**Source: Author's compilation 2010**

#### 4.1.2 Gender, land ownership, education, employment and agricultural loan access status

Table (2) shows that almost each gender was equally represented 49% men and 51% women. About three quarters (72%) of the farms were owned with title deeds while 25% were owned but had no title deeds. Very few households (2.8%) in the area of study rented land. About half (54.2%) of the respondents had attained primary education while 34.6% had attained secondary education. Few respondents had tertiary (6.5%) and 4.7% had no education.

**Table 4: Gender, land ownership, education, employment and agricultural loan access status**

Variable	Category	% respondents	Frequency
Gender	Male	48.6	52
	Female	51.4	55
land ownership	freehold with title	72.0	77
	free hold without title	25.2	27
	rented from other individual	2.8	3
Respondent's highest level of education	none	4.7	5
	primary	54.2	58
	secondary	34.6	37
	Tertiary/ college	6.5	7
Employment status	Formally employed	6.5	7
	Self employed	49.5	53
	Unemployed	41.1	44
	Student	1.9	2
	Other	0.9	1
Reason for lack of access to agricultural loan	no collateral	6.5	7
	no lenders	19.6	21
	high interest rates	43.9	47
	other reasons	15.0	16
	not applicable	10.3	11
	Missing variable	4.7	5
		<b>N=107</b>	

Source: Author's compilation 2010

Half (49.5%) of the respondents considered their farming activity as self employment while a good number of them considered themselves unemployed (41.1%). Few respondents (6.5%) were formally employed while the rest (1.9%) were students.

The main reason revealed by farmers in the area of study for lack of access to agricultural loan was high interest rates (43%) among the lending institutions. About 20% of the respondents were

willing to get agricultural loan but there were no lenders to extend this facility. Only few 6.5% were willing to get agricultural loan but had no collateral (table 2).

#### 4.1.3 Choice of maize varieties to plant

Figure 2. Maize varieties planted

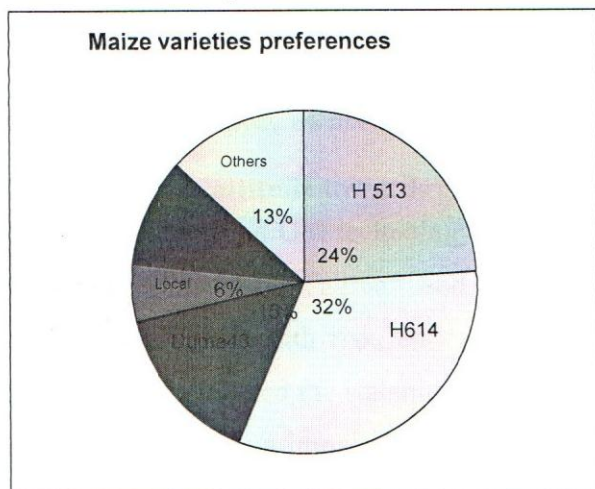


Figure 2. Shows that 32% of farmers preferred hybrid H614 maize variety especially during the long rains season. This is mainly because it was considered to be high yielding. The local variety was also common but with few farmers (6%) both for long and short rains season with the argument that it has good eating quality as well as the farmers didn't want to lose their traditional maize variety.

Source: Author's compilation 2010

For short rains, 24% preferred hybrid H513 maize variety for its fast maturity and resistance to pest and diseases. Other preferred short rains varieties were Duma 43 and Pioneer variety with 15% and 10% respectively. Other varieties which included H516, H625, H627, H628, DH 04, DK831, Simba and Pannar accounted for 13% for both short and long rains seasons with diverse preference reasons.

#### 4.1.4 Household decision making on farm production activities

Table 5: Household decision making on farm production activities

Household decision making ( %)	Husband	Wife	Joint decision	Children	Whole family
Purchasing farm input	33.6	23.4	40.2	0.9	1.9
Planting food and cash crop	18.7	34.6	41.1	2.8	2.8
Purchase of type of food consumed	15.9	49.5	29.9	1.9	2.8
Harvesting farm produce	15.9	37.4	37.4	2.8	6.5
Sales of farm produce	17.8	33.6	43.9	2.8	1.9

N=107

Source: Author's compilation 2010

The results in Table 3 show that most decisions are jointly made though women in most households dominated the decision making on farm production activities over men except on the purchase of farm inputs. Children contributed very little in the households' decision making especially on purchase of farm inputs and the type of food to be consumed. Whole family decision making according to the results was only significant during harvesting of farm produce where all family members are involved.

## **4.2 Farmers attitude, awareness and source of information on GM technology**

### **4.2.1 Farmers', attitude towards genetically modified technology.**

Farmer's attitudes on GM technology were determined using five variables; "strongly disagree", "disagree", "neutral", "agree" and "strongly agree" representing perception on benefits, environment risk, health risk, ethical and equity concerns. Table 4 shows the percentage of farmers that completed the statements and their perceptions. Most farmers (89%) believed in the technology's positive impacts that it can offer a solution to the world's food problem with a quarter (26%) of them strongly agreeing with the statement, 81% that it can reduce pesticides on food and 79% that it has the potential of creating foods with enhanced nutritional value as well as the potential of reducing pesticide residues in the environment.

About half of the farmers (56%) had the perception that the use of the technology to produce food is safe to the environment. Almost a third in each opinion category believed that the use of GM technology could lead to loss of original plant variety and insect resistant GM crops may cause death of untargeted insects. Similar results were shown on health risk perception where about half (56%) disagreed with the statement that consuming GM foods can damage ones health and 55% also disagreed that people could suffer allergic reactions after consuming GM foods. On ethical issues 60% of farmers believed that genetic modification does not tamper with nature, while 29% thought it does. Almost a third (30%) thought that GM technology makers are imitating God while 58% argued that God provides knowledge to modify the creation. Over half (56%) of the respondents did not support the argument that GM products only benefit multinational company but benefits small scale farmers according to 62% of farmers. Few farmers (11%) agreed with the statement that GM products are being forced on developing Countries by developed countries while 56% disagreed.

**Table 6: Farmers' attitudes on GM technology (%)**

Type of perception	Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
<b>Benefit</b>	Use of GM technology increases food productivity and offers a solution to the world food problem	3	1	7	63	26
	GM technology has the potential of creating foods with enhanced nutritional value	1	4	16	62	18
	GM technology has potential of reducing pesticide residues on food	1	5	13	64	18
	GM technology has potential of reducing pesticide residues in the environment	1	4	16	64	16
<b>Environmental risk</b>	The use of GM technology in food production threatens the environment	8	48	28	15	1
	Genetic modification can lead to a loss of original plant varieties	7	26	27	32	8
<b>Health risk</b>	Insect resistant GM crops may cause death of untargeted insects	7	35	34	21	4
	Consuming GM foods can damage ones health	10	46	23	18	3
<b>Ethical concerns</b>	People could suffer allergic reactions after consuming GM foods	7	49	25	18	2
	Genetic modification is tampering with nature	14	46	11	23	6
	GM technology-makers are imitating God	15	43	12	24	6
<b>Equity concerns</b>	GM products only benefit multinational companies	8	48	25	16	3
	GM products do not benefit small-scale farmers	9	52	12	21	6
	GM products are being forced on developing countries by developed countries	11	45	33	7	4
	GM food is artificial	7	26	26	30	11

**N=107**

Source: Author's compilation 2010

Slightly less than half of the interviewed farmers (41%) agreed that GM food is artificial while a third (33%) disagreed. Comparing these results with those of Moon and Balasubramanian (2004), the Kenyan farmers have higher benefit perceptions than both US and UK consumers. In UK, 61% and 47% of US consumers agreed that GM technology increases yields while 63% UK and 42% US agreed that it leads to reduced chemical use in farming. For health risks, the UK consumers had the higher (40%), compared to 21% found in this study while the US consumers had less than ones found in this study. Consumers' perception on the image of multinationals as the beneficiaries of biotechnology, 71% of UK and 53% of US consumers agreed. These results are significantly higher compared to the results in this study which were 11%.

#### 4.2.2 Farmers awareness on Biotechnology and GM crops

**Table 7: Farmers awareness on Biotechnology and GM crops**

<b>Farmers' awareness of biotechnology and GM crops</b>	<b>% Yes</b>	<b>% No</b>
Biotechnology	38	62
Genetically modified (GM) crops	33	67
Insect resistant ( <i>Bt</i> )maize	11	89
Insect resistant ( <i>Bt</i> )cotton	6	94
Virus resistant sweet potato	7	93
<b>N=107</b>		

Source: Author's compilation 2010

Results in Table 5 show that the awareness on biotechnology and GM crops was low among the farmers. It was 38 % of farmers who had heard or were aware of biotechnology and 33% had heard or were aware of genetically modified crops in general. The same results reveal that the awareness of specific GM crops was also low. Few farmers (11%) were aware or ever heard of either insect resistant (*Bt*) maize, while only 6% were aware of the insect resistant (*Bt*) cotton while 7% of the respondents were aware of the virus resistant sweet potatoes. The cumulative mean proportion of farmers aware of the specific GM crops was 8%. The results were consistent with the previous studies in Kenya by Keter (2007) who found that awareness of GM crops among consumers in rural western Kenya was as low 13% while Kimenju (2005) found that the awareness was higher in urban areas at 38% among Nairobi consumers.

#### 4.3 Sources of information on biotechnology

The results in Table 6 show that the most popular source of agricultural information was vernacular radio station with 65% of farmers accessing information almost daily. Agricultural

extension officers reached almost half (47%) of the respondents though the access was occasional. Family and friends met almost daily and shared agricultural information among 36% of the interviewed farmers. None of the respondents (0%) accessed internet for information. Apart from Kiswahili news paper which is not commonly used (7%) and vernacular radio the most popular source of information in the area, all the other media sources were almost equally preferred with about a quarter of the farmers getting agricultural information from these sources though at different frequencies. Qaim, (2009) has also shown that in other studies public media play an important role, especially in Europe where media reports about GM crops have been predominantly negative.

Other sources were unpopular with less than 10% of the respondents using them to get agricultural information such as posters and billboards, brochures, magazines and books medical professionals, teachers, food industries and non governmental organizations. Community based organizations (CBOs) and churches were also revealed to contribute to agricultural information in the area of study where 24% of respondents in CBOs meeting monthly and 25% of church members meeting weekly.

The results have revealed that the respondents relied mostly on media, agricultural extension officers, family and friends and local organization for agricultural information. None of the respondents relied on internet. This is not surprising especially with farmers having low education levels as show by the results earlier. Printed material such as books, magazine and brochures were not also common among the respondents.

**Table 8: Sources of Agricultural information**

	Source	Frequency (%)								N/A
		%Yes	Daily	Weekly	Monthly	Occasionally	Often	Yearly	Rarely	
1	English newspaper	21	3	2	2	<b>11</b>	0	0	3	79
2	Television	25	<b>15</b>	1	5	3	0	0	2	75
3	Kiswahili newspaper	7	1	1	1	<b>4</b>	0	0	0	94
4	English radio	24	<b>20</b>	0	0	6	0	0	0	75
5	Kiswahili radio	12	<b>8</b>	0	0	3	1	0	0	88
6	Vernacular radio	65	<b>40</b>	9	0	10	5	0	1	35
7	Internet	0	0	0	0	0	0	0	0	0
8	Posters and billboards	6	0	0	0	2	1	0	2	94
9	Brochures	1	0	0	0	1	0	0	1	98
10	Magazines and books	4	0	0	0	<b>4</b>	0	0	0	96
11	Medical professionals	7	0	0	1	<b>5</b>	1	0	0	93
12	Teachers	6	0	0	0	<b>5</b>	1	0	0	94
13	Government officials	26	0	2	4	<b>15</b>	2	1	3	74
14	Food industry	7	0	0	0	2	1	1	<b>3</b>	93
15	Non Governmental Organizations	3	0	0	0	<b>2</b>	0	0	0	98
16	Family and friends	36	<b>11</b>	0	4	<b>8</b>	9	0	3	64
17	Agriculture extension officers	47	3	5	3	<b>20</b>	2	6	8	54
18	Community Based Organizations	24	0	2	<b>13</b>	5	4	0	1	76
19	Church	25	0	<b>13</b>	1	8	1	0	2	75
20	Other sources	3	0	0	1	0	0	1	0	97
<b>N=107</b>										

Source: Author's compilation 2010

## 4.4 Econometric Results

### 4.4.1 Farmers mean willingness to pay for the insect-resistant seed maize.

Following Hanemann *et al.*, (1991), the mean WTP is given by  $\alpha/\rho$ , obtained from the restricted model without farmers' characteristics. The restriction is placed on  $\lambda_i$  (coefficient for vector of farmers' characteristics to zero), where  $\alpha$  and  $\rho$  are the coefficients for the constant and the bid respectively. Farmers' mean WTP for GM seed maize was Kshs.494 for a 2 kg pack. Therefore, these farmers were willing to pay a 66% premium over non-GM seed maize since the mean price for the preferred variety (initial bid) was Kshs.297.6 per 2kg pack.

**Table 9. Parameter estimates for WTP model without farmers' characteristics**

Parameter	Variable	Coefficient	Standard error	t-value	p-value
$\alpha$	Constant	2.42	.49	4.927	.0000
$\rho$	Bid	.49E-02	.81E-03	5.977	.0000
		WTP = $\alpha/\rho = 494$			
		N=107			

Source: Author's compilation, 2010

This is not surprising, given that over 79% respondents had strong benefit perceptions about genetic modification technology. At the same time, health and environmental risk perception, ethical and equity concerns were not high among the respondents. These results significantly differed with results found by Kimenju (2005) in which he found that urban consumers in Kenya were willing to pay 13.9% premium for GM maize meal compared to farmer's willingness to pay 76.9% premium for GM seed maize in this study. Results by Kaneko and Chern (2004) showed similar high premium in developed countries for non-GM products to avoid GM products.

### 4.5 Factors influencing farmers' willingness to pay for the insect-resistant seed maize.

In order to determine the factors that influence farmers' WTP for insect resistant seed maize, the double bounded logit model was estimated with farmer's characteristics hypothesized to influence WTP. However, to avoid multicollinearity, variable for knowledge was omitted in the regression as it is correlated with awareness variable. Environment perception variable was also omitted as it is correlated to both health risk perception and ethical/religious and economic

concerns variables. Other studies have found the same high correlation between health risk and environment risk perception. Moon and Balasubramanian (2001), found a high correlation between health and environment hazards, which may indicate that if respondents perceive health hazards from eating GM products, they are also likely to perceive biotechnology as posing environmental risks.

The results in Table 8 show that the mean farmers' WTP for the seed maize with considerations of their characteristics was KShs. 463. This differs with the mean WTP without farmers' characteristics which was found to be Kshs.494. The difference can be attributed to the fact that most of the factors negatively influence farmers WTP. This is an indication that with considerations of their characteristics, the farmers were willing to pay a premium of KShs 165 (56%) per 2kg packet for GM seed maize.

Awareness of the GM technology negatively affects the farmers WTP for insect resistant (*Bt*) seed maize. Similarly, health risk perception, Ethical/religious/economic concern, gender, age, education and farmer's perception for government control of seed quality variables negatively influenced farmers WTP for the GM seed maize.

**Table 10. Parameter estimates for WTP model with farmer characteristics**

Variable	Coefficient	Standard error	t-value	p-value	Mean Z
Constant	6.1715584	3.6591980	1.687	0.0917	1
Bid	0.0123304	0.0015956	7.728	0	297.58
Gm awareness	-1.1528537	1.0649927	-1.082	0.279	0.19
Benefit	1.1036955	0.4572204	2.414	0.0158	3.97
Health	-0.4500999	0.3609028	-1.247	0.2123	2.64
Ethical	-0.0178523	0.3398493	-0.053	0.9581	2.62
Gender	-0.4304385	0.4785997	-0.899	0.3685	1.51
Age	-0.0124039	0.0187589	-0.661	0.5085	46.60
Education	-0.6540558	0.3938919	-1.660	0.0968	2.43
Income	0.0000020	0.0000020	0.981	0.3265	144,806.00
Seed quality	-1.4827561	0.7576578	-1.957	0.0503	0.75
Agricultural Loan	1.3815907	0.8181099	1.689	0.0913	0.18
<b>Mean WTP</b>	$WTP = (\alpha + \lambda \bar{Z}) / \rho = 462.8$				

**N=107**

Source: Author's compilation, 2010 (Limdep 8 software)

These results are consistent with other studies in rural areas in Kenya. Keter (2007) found that benefit perception variable, farmer's income and access to credit positively influenced consumers' WTP for GM maize meal in western Kenya.

Benefit perception and income variables and dummy for agricultural loan exhibit positive signs as expected. The variables for health risk perception and ethical/religious/economic concerns show the expected negative sign. Contrary to expectations, variable for education level and perception for government control for seed quality has a negative sign, implying a negative influence on WTP. There was no expected sign for awareness about GM crops, age, and gender variables, as research has shown that they can assume either sign depending on particular situations.

Like in other studies, cognitive variable are the main determinants of WTP. Benefit perception significantly increases WTP at 5% significant level while health risk perception decreases the WTP. This is similar to the results by Kaneko and Chern (2004). Ethical/equity/Economic concern is not significant. Farmers' perception of government control of seed quality significantly influences their WTP. This is consistent with results of Curtis *et al* (2004) who found that WTP in developing countries especially in China and Columbia depended on trusting the government delegations of food supply. The two socio-economic significant variables are education and access to agricultural loan/credit. Income was revealed insignificant.

Although several economic literature indicate that WTP is influenced by socio-demographic factors, such as income and education this study did not find the same influence among farmers in Kenya. Similar findings were obtained by Keter (2007) and (Kimenju 2005). In addition Nayga *et al.*,(2004) found that respondent's information on genetically engineered products also affects their WTP. He found that providing more information on genetic engineering to respondents increased the number of strong buyers and reduced the number of doubters.

## CHAPTER FIVE

### CONCLUSIONS AND ROMMENDATIONS

#### 5.1 Conclusions

The study revealed the farmers' awareness and knowledge on biotechnology in general and GM crops in particular were determined. The survey revealed that 8% of the respondents were aware of GM crops and that the media was the major source of information. Generally, farmers are appreciative of the positive benefits of the technology, as more than 79% agree with the benefit statements. However some farmers are worried about the potential negative effects relating to health, environmental, ethical/equity and economic concerns. Thus, farmers have perception that the technology can benefit them greatly, but there are issues that they may want addressed. These are the issues that are mostly in the core of the controversy about GM foods in the world.

The other objective was to identify and document sources of agricultural information among farmers. It was revealed that the most popular source of agricultural information was vernacular radio with 65% of farmers accessing agricultural information almost daily. It was also revealed that non of the farmers sort agricultural information from internet.

The double bounded logit was used to determine farmers' mean WTP for GM seed maize. The, farmers' WTP was Kshs 463 (56% premium) per 2kg pack for *Bt* seed maize over the ordinary seed maize varieties, hence there is high potential demand for GM seed maize provided the issues of concern are addressed. This corresponds to the farmers' benefit perception of the technology, as most farmers had strong benefit perception. The potential demand is high, and hence biotechnology can play a big role in addressing food insecurity in the country.

Cognitive variables are the main determinants of farmers WTP. Benefit perception, health risk perception and perception on government control on seed quality are the cognitive variable significantly influencing the WTP while socio-economic variables such as education level, and access to agricultural loan significantly influence the WTP. Ethical/equity/ economic age, gender and income does not influence the farmers WTP.

## 5.2 Recommendations

The study has revealed that awareness about GM crops is low. The government and other stakeholders have a task of increasing these levels and giving scientific facts about the technology. This can be done through an educative campaign, which can effectively be carried out through the revealed main sources of agricultural information established; radio, newspapers and government extension officers. In such a campaign, vernacular radio should be the main focus. The media should also be encouraged to be balanced in its reporting about this technology, as it is a major route through which people develop attitudes. This can be ensured by having seminars for media people hosted by scientists.

Farmers have concerns about the environment, their health, equity and ethical issues brought about by the technology. Promoters and other stakeholders should give scientific facts about these technologies so as to address wrong beliefs, and dispel myths that have come about through misinformation by the media and other groups. In particular, they should aim to inform the public of the generally accepted safety of GM products to the community.

The fact that farmers have positive attitudes towards genetic modification, and that farmers are willing to pay a premium for GM seed maize suggest that the potential demand for *Bt* maize in Kenya is high, which further signifies acceptance of the technology. It also signifies that there is a potential market for GM products in the country. Therefore, the technology can be tapped to play a role in food security in Kenya. The government can spend more on biotechnology research, but at the same time educate the community on the technology, and regulate the playground to ensure that this research is done within biosafety regulations. The government should also address the negative community perception on its failure of ensuring seed quality in the Kenyan markets if this technology is adopted.

## REFERENCES

- ABNETA (2007). *Agricultural Biotechnology Network in Africa News*, July and August 2007.
- ABSF (2005). "Linking Gene to Economic Growth". *Africa Biotechnology Stakeholders Forum (ABSF) News*.
- Benhin, J.K.A. (2006). "Agriculture and deforestation in the tropics: A critical theoretical and empirical review." *Royal Swedish Academy of Sciences. Ambio* Vol. 35 No.1, February 2006.
- Beuzekom B, Arundel A. (2006). *Organization for Economic Cooperation and Development (OECD) "Biotechnology statistics"*.
- Bishop, Richard and Heberlein (1979). "Measuring values of Extra-Market Goods; Are Indirect Measures Biased" *American Journal of Agricultural Economics* 61 (1979) 926-30.
- Carson et al (1986). "Determining the demand for public goods by simulating Referendums at different Tax Prices. " *Department of Economics Working Paper, University of California, San Diego* 1986.
- Chen Hsin-Yi and Chern, W.S. (2002). "Consumer Acceptance of Genetically Modified Foods." *Paper presented at the American Agricultural Economics Association (AAEA) Annual Meeting, Long Beach, California, July 28-31, 2002.*
- Chern, W.S., Rickertsen, K., Tsuboi, N., and Fu, T. (2003). "Consumer acceptance and willingness to pay for genetically modified vegetable oil and salmon": A multiple-country assessment. *AgBioForum*, 5(3), 105-112. Available on the World Wide Web: <http://www.agbioforum.org/>.
- Costa-font M, Gill Jose'M and Trail W. Bruce. (2008). "Consumer acceptance, valuation of attitudes towards genetically modified food: Review and implication for food policy." *Science direct, food policy* 33(2008) 99-111 Available on the World Wide Web: [www.elsevier.com/locate/foodpol](http://www.elsevier.com/locate/foodpol)
- Curtis, K.R., McCluskey, J.J., Wahl, T.I. (2004). "Consumer Acceptance of Genetically Modified Food Products in the Developing World". *AgBioForum* 7 (1/2), 70-75.
- De Groote, H. (2002). "Maize yield losses from stem borers in Kenya." *Insect Sci. Applic.* 22, 89- 96.
- De Groote, Charles Bett, James Ouma Okuro, Martins Odendo, Lawrence Mose, and Elizabeth Wekesa. (2003). "Direct estimation of maize crop losses due to stem borers in Kenya, preliminary results from 2000 and 2001." In: Friesen, D. K., Palmer, A. F. E. (Eds.),

- Integrated Approaches to Higher Maize Productivity in the New Millennium.  
*Proceedings of the 7th Eastern and Southern Africa Regional Maize Conference.*  
 CIMMYT, Mexico, D.F., pp. 401–406.
- De Groote Hugo, J. Okuro, C. Bett, L. Mose, M. Odendo, E. Wekesa. (2004) “Assessing the demand for insect resistant maize varieties in Kenya combining Participatory Rural Appraisal into a Geographic Information System.” In *Participatory Plant Breeding and Participatory Plant Genetic Resource Enhancement: An Africa-wide Exchange of Experiences*, edited by L. Sperling, J. Lancon and M. Loosvelt. Cali, Colombia: CGIAR System wide Program on Participatory Research and Gender Analysis.
- De Groote Hugo, Stephen Mugo, David Bergvinson and James Ouma. (2005a). “Can *Bt* maize alleviate poverty in Africa? Evidence from *Bt* maize research in Kenya.” *Paper presented at the 9th ICABR International Conference on Agricultural Biotechnology: Ten Years Later Ravello (Italy)*, July 6 to July 10, 2005.
- De Groote Hugo, George Owuor, Cheryl Doss, James Ouma, Lutta Muhammad and K. Danda (2005b). “The maize green revolution in Kenya revisited”, *electronic Journal of Agricultural and Development Economics*. Vol.2 No.1 2005 pp32-49.
- Ehui; K.S. and Hertel W. T (1989). “Deforestation and Agricultural Productivity in the Côte d'Ivoire”. *American Journal of Agricultural Economics*, Vol. 71, No. 3. (Aug., 1989),
- Feldmann, M. P., Morris, M.L. and Hoisington, D. (2001). “Genetically Modified Organisms: Why All the Controversy?” In: Paul W. Barkley. Ed. *Choices: The magazine of food, farm and resource issues. First Quarter 2000*, pp 8-12. *The American Agricultural Economics Association*. 415 S. Duff Ave., Suite C Ames, IA
- GoK (2004). “Strategy for Revitalizing Agriculture 2004-2014”. *Ministry of Agriculture and Ministry of Livestock and Fisheries Development*
- GoK (2005a). “Economic Review of Agriculture”. *Ministry of Agriculture*. Government printers, Nairobi, Kenya.
- GoK (2005b). “Achieving millennium development goals in Kenya.” *A Need Assessment and costing report*. Government printers, Nairobi, Kenya.
- GoK (2007). “Basic report on well-being in Kenya 2005/06 Household budget survey”. *Kenya National Bureau of Statistics*, Nairobi
- GoK (2009). “Strategic plan 2008-2012”. *Ministry of Agriculture*

- Gouse M, Kirsten J and Jenkins L. (2004). *Bt* cotton in South Africa: Adoption and the impact on income amongst small-scale and Large-scale farmers. *Agrekon*, Vol. 42, No. 1 (March 2003)
- Gouse M, Pray Carl, Schimmelpennig D and Kirsten J. (2006). "Three seasons of subsistence Insect-resistant maize in South Africa: Have small scale holders benefited". *Ag Bio forum* Vol.9 Number 1, article 2.
- Guthiga, P.; J. Mburu (2006). "Local Communities Incentives for Forest Conservation: Case of Kakamega Forest in Kenya"; *Paper presented at the 11th Biannual Conference of the International Association for the Study of Common Property; Bali, Indonesia, June 2006.*
- Hanemann Michael, John Loomis and Kannien Barbara. (1991). "Statistical efficiency of double bounded dichotomous choice contingent valuation". *American journal of Agricultural Economics*. Vol.73, No 4 (Nov.1991) Pp1255-1263.
- Hanemann, W.M. and Kanninen, B. (1998). "The Statistical Analysis of Discrete-Response CV Data". *Working Paper No. 798. Department of Agricultural and resource Economics and Policy.* University of Californian, Berkeley.
- Hassan R.M., Njoroge K., Njore M., Otsyula R and Laboso A.(1998). "Adoption patterns and performance of improved maize." In: Hassan (Ed.), *Kenya in Maize Technology Development and Transfer: A GIS Application for research planning in Kenya*, CABI Publishing, Wallingford. United Kingdom.
- House L, Jayson Lusk, Sara Jaeger, W. Bruce Traill, Melissa Moore, Carlotta Valli, Bert Morrow and Wallace M S Yee (2004b). "Objective and Subjective Knowledge: Impacts on Consumer Demand for Genetically Modified Foods in the United States and the European Union." *Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, 1-4 August, Denver, Colorado.*
- Ismael Y., Bennett R and Morse S. (2001). "The adoption and Economic Impacts of *Bt* cotton in Makhathini Flats". Republic of South Africa. *Paper presented for Africa Bio conference. Biotechnology Conference for Sub-Saharan Africa 26<sup>th</sup> and 27<sup>th</sup> September 2001, Johannesburg, South Africa.*
- James, C. (2008). Global Status of Commercialized Biotech/GM Crops: 2007. *ISAAA Briefs No. 37-2007.* International Service for the Acquisition of Agri-Biotech Applications (ISAAA), Ithaca NY, New York.

- Kaneko, N., Chern, W.S. (2003). "Consumer Acceptance of Genetically Modified Foods:" A Telephone Survey. *Consumer Interests Annual* 49, 1-13.
- Keter, (2007). "Estimaing consumer awareness, attitude and willingness to pay for genetically modified foods. The case of rural maize meal consumers". *Masters thesis*, Department of Agriculture, University of Maryland Eastern Shore.
- Kimenju, S.C., De Groot, H. (2008). "Consumers' willingness to pay for genetically modified food in Kenya." *Journal of Agricultural Economics* 38 (1), 35-46.
- Kimenju, S.C., De Groot, H., Karugia, J., Mbogoh, S., Poland, D. (2005). "Consumer awareness and attitudes toward GM foods in Kenya." *African Journal of Biotechnology* 4 (10), 1066- 1075.
- Leisinger, K.M., Schmitt, K. M., and Pandya-Lorch, R. (2002). "Six billion and still counting: Population growth and food security in the 21<sup>st</sup> century". *IFPRI*, Washington, D.C. The John Hopkins University Press, 155 pp.
- Li, Q., Curtis, K.R., McCluskey, J.J., and Wahl, T.I. (2003). "Consumer attitudes toward genetically modified foods in Beijing, China." *AgBioForum*, 5(4), 145-152. Available on the World Wide Web: <http://www.agbioforum.org/>.
- Lusk, J.L. and Hudson, D. (2004a). "Willingness-to-Pay Estimates and Their Relevance to Agribusiness Decision Making." *Review of Agricultural Economics*. 26:2:152-169
- Lusk, J.L., Feldkamp, TY and Schroeder C.T (2004b). "Experimental Auction Procedure: Impact on valuation of quality differentiated goods," *African Journal of Agricultural Economics*, 2004.
- McCluskey, J.J., Grimsrud, K.M., Ouchi, H., Wahl, T.I. (2003). "Consumer Response to Genetically Modified Food Products in Japan." *Agricultural and Resource Economics Review* 32 (2), 222-231.
- Mitchell, R. C., Carson, R. T. (1989). "Using Surveys to Value Public Goods: The Contingent Valuation Method." *Resources for the Future*, Washington, DC.
- Moon, W. and Balasubramania, S.K.(2004). "Public Attitudes toward Agro biotechnology: The Mediating Role of Risk Perceptions on the Impact of Trust, Awareness and Outrage." *Review of Agricultural Economics*. 26 (2) 186-208.
- Moon, W., Rimal, A., Balasubramanian, S.K.(2004). "Willingness-to-Accept and Willingness-to-Pay for GM and Non-GM Food: UK Consumers." *Paper presented at the American Agricultural Economics Association Annual Meeting, Denver, Colorado, August 1-4,*

2004.

- Mugo Stephen, Hugo De Groote, David Bergvinson, Margaret Mulaa, Josephine Songa and Simon Gichuki.( 2005). “Developing *Bt* maize for resource-poor farmers –Recent advances in the IRMA project.” *African Journal of Biotechnology Vol. 4 (13), pp. 1490-1504*
- Nayga M Rodolfo, Jr., Wipon Aiew, John P. Nicholas. (2004) “Information effects on Consumers’ willingness to purchase irradiated food products.” *Review of Agricultural Economics-Volume 27, Number 1, pages 37-48.*
- Nicholson W. (2004). *Microeconomic theory. Basic principles and Extensions.* Ninth Edition.
- Nyameino D, Kagira B and Njukia.S. (2003). “*Maize Market Assessment and Baseline Study for Kenya*”
- Nyangito, H.O. and Nyameino D.M. (2002). “*Maize Production and Marketing in Kenya.*”
- Perman R. (2003). *Natural Resources and Environmental Economics.* 3<sup>rd</sup> Edition.
- Pinstrup-Andersen, P., Pandya-Lorch, R. and Rosegrant, M.W. (2001). “Global food security: A review of the challenges”. In: *The unfinished agenda: perspectives for overcoming hunger, poverty, and environmental degradation*, eds. Pinstrup-Andersen, P. and Pandya-Lorch, R. IFPRI, Washington, D.C. 301 pp.
- Qaim, M. (2009). The Economics of Genetically Modified Crops. *Annual Review of Resource Economics* 1:665-694.
- Smale, M., P. Zambrano, G. Gruerè, J. Falck-Zepeda, I. Matuschke, D. horna, L. Nagarajan, I. Yerramareddy and H. Jones. (2009). Measuring the economic Impacts of Transgenic Crops in Developing Agriculture during the First Decade. Approaches, Findings, and Future Directions. *Food Policy Review 10* IFPRI, Washington DC.
- Verdurme, A. and Viaene, J. (2002). “Consumer Beliefs and Attitudes Towards Genetically Modified Food: Basis for Segmentation and Implications for Communication.” Ghent University, Belgium.

## APPENDICIES

### Appendix 1. Loglikelihood functions for the double bounded logit model

(a) Without farmer characteristics

```
MINIMIZE; LABELS=A, C;  
START=-10, 0.001;  
FCN=-(YES_YES*LOG(1/(1+EXP(-A+C*PREMSEED))))  
+ NO_NO*LOG(1/(1+EXP(A-C*DISCSEED)))  
+ YES_NO*LOG(1/(1+EXP(A-C*PREMSEED))  
-(1/(1+EXP(A-C*SEEDPRIC))))  
+ NO_YES*LOG(1/(1+EXP(A-C*SEEDPRIC))  
-(1/(1+EXP(A-C*DISCSEED))))))$
```

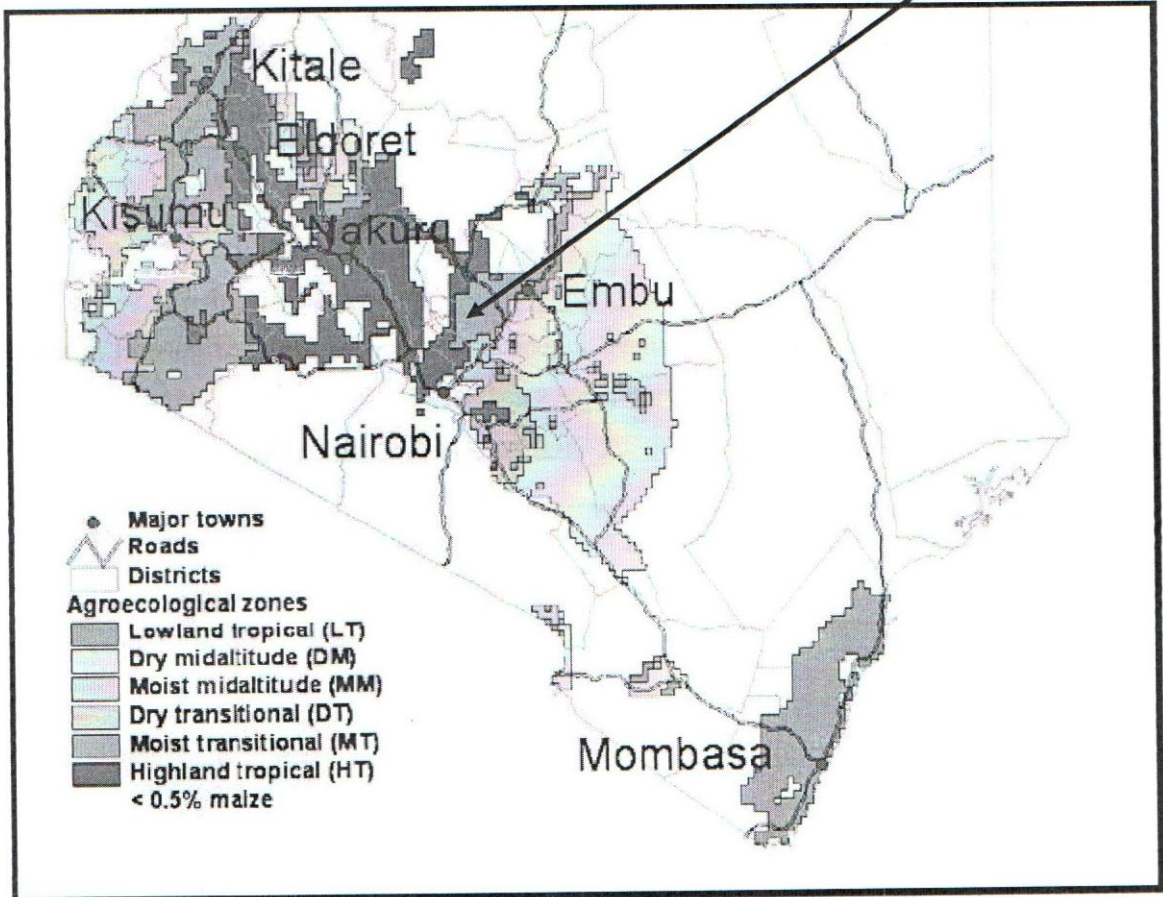
(b) With farmer characteristics

```
MINIMIZE; LABELS=A, C, d, e, g, h, i, j, l, m, o, t;  
START=-10, 0.001, 0, 0, 0, 0, 0, 0, 0, 0, 0;  
FCN=list=d*AWARE+e*BENEFIT+  
+g*HEALTH+h*ETHICAL+i*GENDER+j*AGE+l*EDUC+m*TOTAINCO+o*SEEDQL  
TY+t*OBTLOAN  
|-(YES_YES*LOG(1/(1+EXP(-A+C*PREMSEED-list))))  
+ NO_NO*LOG(1/(1+EXP(A-C*DISCSEED+list)))  
+ YES_NO*LOG(1/(1+EXP(A-C*PREMSEED+list))  
-(1/(1+EXP(A-C*SEEDPRIC+list))))  
+ NO_YES*LOG(1/(1+EXP(A-C*SEEDPRIC+list))  
-(1/(1+EXP(A-C*DISCSEED+list))))))$
```

## Appendix 2. Area of study

Figure 3. Maize agro ecological zones of Kenya showing the area of study.

Eastern Moist Transitional Zone



Source: IRMA Project (CIMMYT) 2002

### Appendix 3: Study instrument

#### QUESTIONNAIRE

#### ECONOMIC EVALUATION OF ACCEPTANCE OF GENETICALLY MODIFIED SEED MAIZE VARIETY IN EASTERN MOIST TRANSITIONAL ZONE, KENYA

Place \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_

Questionnaire number \_\_\_\_\_

Enumerator's name \_\_\_\_\_

Percentage of discount or premium \_\_\_\_\_

#### Introduction

*(Appropriate greetings)* My name is \_\_\_\_\_ and i am carrying out a survey on behalf of a student at Egerton University (Njoro) on Economic evaluation of acceptance of GM crops (specifically insect- resistant maize). I would like to ask you some questions that will take few minutes.

#### Part 1: Maize Production and Consumption

1. How important is maize in your daily diet? \_\_\_\_\_

1. Not important 2. Slightly Important 3. Medium 4. Important 5. Very important

2. How do you normally eat maize during these meals?

1. Ugalii 2. Githeri 3. Porridge 4. Not applicable 5. Other \_\_\_\_\_)

Breakfast \_\_\_\_\_ or \_\_\_\_\_, \_\_\_\_\_

Lunch \_\_\_\_\_ or \_\_\_\_\_, \_\_\_\_\_

Dinner \_\_\_\_\_ or \_\_\_\_\_, \_\_\_\_\_

3. Where do you usually obtain your maize from?

(1) From own farm (2) Buying (3) Other \_\_\_\_\_

4. How many acres is your farm? \_\_\_\_\_ Acres

5. Which form of tenure is your land ownership?

1. Freehold with certificate/title deed 2. Freehold without certificate/title deed

3. Rented from another individual 4. Informal and not paying rent (e.g. roadside/public land held informally 5. Communal 6= other (specify) \_\_\_\_\_)

6. What area of your farm is allocated to maize farming \_\_\_\_\_ acres?

7. Which maize variety do you plant \_\_\_\_\_

8. Why do you prefer this variety?

(a) High yielding (b) Early maturing. (c) Pest and disease resistant (d) Cheap (e) readily available (f) Drought resistant (*Circle the response*)

If more than one rank from the most preferred to least preferred.

1.....2.....3.....

9. Who is the decision maker in carrying out the following tasks in this household?

Task	Husband (man)	wife (woman)	joint decision	Children	Whole family
Purchases of farm inputs					
Planting food and cash crops					
Harvesting farm produce					
Sales of farm produce					
Purchase of and type of food consumed					

10. Do you think the government controls are in place to ensure seed quality?

\_\_\_\_\_ (Y/N)

If No, why: .....

11. How much maize (quantity) do you produce on mean per year?

a) Bags \_\_\_\_\_ (b) Debes \_\_\_\_\_ (c) Gorogoros (Tins) \_\_\_\_\_

12. How much of it is sold?

a) Bags \_\_\_\_\_ (b) Debes \_\_\_\_\_ (c) Gorogoros (Tins) \_\_\_\_\_

13 How much of that is consumed?

a) Bags \_\_\_\_\_ (b) Debes \_\_\_\_\_ (c) Gorogoros (Tins) \_\_\_\_\_

14. Do you or any member of this household obtain agricultural credit/loan during planting season? 1. Yes 2.No

*If No what are the reasons why you don't obtain agricultural credit/ loan*

1. No collateral 2.No lenders 3. High interest rates 4. Other (specify) \_\_\_\_\_

**Part 2: Awareness and knowledge about biotechnology and GMOs.**

1. Have you ever heard or read something about biotechnology?

(1) Yes (2) No (circle the response)

2. Have you ever heard or read something about genetically modified (GM) crops?

(1) Yes (2) No (circle the response)

*(If yes go to question 3 below. If no, tell the person; I will explain to you what GM crops are and then ask you some questions about them, which may take extra few minutes.(Then give the information text in the appendix and continue with the rest of the questionnaire.*

3. Where did you hear or read from? \_\_\_\_\_

4. Indicate whether you have heard/read of the following and where you heard/read them from:

a) Insect resistant (*Bt*) maize \_\_\_\_\_ (Y/N) Source \_\_\_\_\_

b) Insect resistant (*Bt*) cotton \_\_\_\_\_ (Y/N) Source \_\_\_\_\_

c) Virus resistant sweet potato \_\_\_\_\_ (Y/N) Source \_\_\_\_\_

**Part 3: Attitudes toward GM crops**

Indicate your agreement or disagreement to the following statements:

(1) Strongly disagree (2) Disagree (3) Neutral (don't know) (4) Agree (5) Strongly Agree

**Benefit Perception (BP)**

- 1. Use of GM technology in food production increases productivity and offers a solution to the world food problem \_\_\_\_\_
- 2. GM technology has the potential of creating foods with enhanced nutritional value \_\_\_\_\_
- 3. GM technology has potential of reducing pesticide residues on food \_\_\_\_\_
- 4. GM technology has potential of reducing pesticide residues in the environment \_\_\_\_\_

**Environment Risk Perception (ERP)**

- 5. The use of GM technology in food production threatens the environment \_\_\_\_\_
- 6. Genetic modification can lead to a loss of original plant varieties \_\_\_\_\_
- 7. Insect resistant GM crops may cause death of untargeted insects \_\_\_\_\_

**Health Risk Perception (HRP)**

- 8. Consuming GM foods can damage one's health \_\_\_\_\_
- 9. People could suffer allergic reactions after consuming GM foods \_\_\_\_\_
- 10. Consuming GM foods might lead to an increase in antibiotic-resistant diseases in human beings \_\_\_\_\_

**Ethical/Religious/Economic Concerns (EREC)**

- 11. Genetic modification is tampering with nature \_\_\_\_\_
- 12. GM technology-makers are imitating God \_\_\_\_\_
- 13. GM products only benefit multinational companies \_\_\_\_\_
- 14. GM products do not benefit small-scale farmers \_\_\_\_\_
- 15. GM products are being forced on developing countries by developed countries \_\_\_\_\_
- 16. GM food is artificial \_\_\_\_\_

#### Part 4: Stated Choice Experiments

##### GM seed maize

Discount or premium % \_\_\_\_\_

*(Price of respondent's preferred seed maizes variety in Kshs \_\_\_\_\_)*

a) Scientists in Kenya are doing research to develop insect resistant maize that is resistant to maize stem borer. Would you be willing to purchase these seed maizes for planting if they were offered at the same price as your preferred variety?

1. Yes (go to b)    2. No (go to c)

*(For b and c below, obtain the correct percentage and tell respondent in terms of Kshs)*

b) Would you be willing to buy these seed maizes if they were offered at a price of Kshs \_\_\_\_\_ (% premium) (1) Yes (2) No *(circle response)*

c) Would you be willing to buy these seed maizes if they were offered at a price of Kshs \_\_\_\_\_ (% discount) (1) Yes (2) No (go to d) *(circle response)*

d) Why aren't you willing to buy insect resistant seed maizes at a lower price?

---

#### Part 5: Demographic/Socio-economic information

1. Gender: (1) Male (2) Female *(circle the response)*

2. Age in years/Date of birth \_\_\_\_\_

3. Highest level of education attained: (No. of years in school)

1. None (0yrs) 2. Primary (7/8yrs) 3. Secondary (12yrs) 4. Tertiary college (16yrs)

5. University (17yrs)

4. Number of people in the household you are living in \_\_\_\_\_

5. Presence of children below 18 years at home living with you 1. Yes 2. No

6. Employment status:

1. Formally employed 2. Self employed 3. Unemployed 4. Student 5. Other \_\_\_\_

7. Profession \_\_\_\_\_

8. Household's income

**Crop production**

Production of the most important crops main season of last year (2007)

	Crop name	Production		Qty sold		Selling price	Total value
		Qty	Unit	Qty	Unit	(Kshs)	(kshs)

**Animal production**

1. How many animals did you sell or slaughter in the last 12 months?

Type of animal	Number of animals sold	Number of animals slaughtered	Unit value of animal (KShs/head)	Total value	Proportion consumed (for slaughtered animals only) <sup>a</sup>

<sup>a</sup>1. None or very little 2. Small part (around a quarter) 3. About half 4. the larger part 5. most or all

2. Milk production last year: \_\_\_\_\_ liters

3. Amount of milk sold: \_\_\_\_\_ liters

**Off-farm income**

1. Over the last 12 months has any one in your household operated any of the following enterprises?

Activity	Income last month (KShs)	Income last 12 months (Kshs)
Labour (including on other farms)		
Salary		
Bodaboda		
Brick making		
Carpentry		
Construction		
Mechanics		
Production and selling local brew		
Trade		
Other (specify _____)		

## Household Food and Non-food Expenditures

### 1. Last month's expenditures

Item	Expenditures over the last month (KShs/month)
Food	
Medical	
Transport	
Rent	
Labor in household	
Labor on farm	
Other (specify _____)	

### 2. Last year's major expenditures

Item	Expenditures over the last 12 months (KShs)
Clothing	
School fees and other educational expenses	
Housing improvements	
Durable expenses (furniture, bicycle, ...)	
Social events (weddings, funerals, harambee, ...)	
Labor on farm	
Savings	

**Part 6: Sources of general information sought and frequency**

Indicate whether you seek the following for general information and how often

Source of information	Is this a source of information to you?(Y/N)	Frequency(Daily, weekly,monthly, yearly, occasionally, rarely, often)
<b>Media sources</b>		
Newspapers - English		
- Kiswahili		
Television		
Radio - English		
- Kiswahili		
- Vernacular		
Internet		
Posters and billboards		
Brochures		
Libraries		
<b>People/ Institutional sources</b>		
Medical professionals		
Teachers		
Government officials such as the assistant chief		
Food industry		
Family and friends		
Community organizations		
Church		
Others		

(Give appropriate thanks to the respondent),

#### **Appendix 4: Information text (*Only for respondents unaware of GM crops*)**

Genetically modified crops contain genes that have been artificially inserted by scientists. The inserted gene may come from plants of the same species, another unrelated plant, or from other organisms such as bacteria. Characteristics targeted by plant breeders for genetic modification include increased yields, disease resistance and pest resistance, consumption traits such as food colour, size, shape, nutrition and taste.

Kenya Agricultural Research Institute (KARI) together with international research organizations are undertaking research to develop pest resistant crops to protect themselves against the pest by producing its own insecticide. These crops are maize resistant to stem borer, cotton resistant to pest and virus resistant sweet potato resistant to virus disease.

Some of the benefits of GM crops are; 1.High yields reducing food shortages and lower food prices.2. Reduced losses from pest and diseases and therefore reduced pesticide costs and residues in the environment.

The potential risks and perceived concerns about Gm crops include; introduced genes through genetic modification might cross to wild relatives and weeds making them stronger, pests might develop resistance to the pesticide produced by GM crops, substances from these crops might affect non-target and beneficial insects and might also be allergic substances or toxins in Gm foods.

To ensure the safe use of Gm crops, the Kenya government has passed biosafety bill. Plants are tested in a special biosafety green house to check their effectiveness such as insect resistance. If these trials proceed without problems, the authorities may give permission for trials on test plots in quarantine stations. If these trials go well, scientists may seek permission to try the varieties on the farm. After successful trials for several years, authorities can grant permission to commercialize and sell these varieties to farmers.

Most Gm crops are grown in developed countries especially the United States of America and Canada, some developing countries such as China, India and Brazil grow Gm cotton. Kenya is not growing them commercially but is doing research in order to develop insect-resistant maize, cotton and virus-resistant sweet potato

HERIOT-WATT UNIVERSITY LIBRARY