BIOTECHNOLOGY AND FOOD SECURITY IN KENYA - AN ASSESMENT OF PUBLIC PERCEPTION AND ENVIRONMENTAL CONCERNS ON GENETICALLY MODIFIED MAIZE PRODUCTION.

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DECLARATION

This project report is my original work and has not been presented for examination in any other university.

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This project report has been submitted for examination with our approval as university supervisors

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DEDICATION

This project report is dedicated to my parents Mr. David Mbugua and the late Lucy Wairimu Mbugua who remain a great inspiration.

To my beloved husband Robert Gitau and our two lovely daughters Wambui and Wairimu Gitonga, your encouragement has made this possible.

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I wish to express my sincere gratitude to everyone who has been involved in completion of this work. First and foremost I would like to thank the Almighty God for giving me the opportunity to carry out this research in good health.

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LIST OF ABBREVIATIONS

CFT	Confined Field Trials
CBD	Convention on Biodiversity
CSPro	Census and Survey Processing System (Statistical software)
EA	Enumeration Area
EFA	Education for All
FAO	Food and Agriculture Organisation
GMO	Genetically Modified Organisms
HT	Herbicide tolerant
IRMA	Insect Resistant Maize for Africa
ISAAA	International Service for the Acquisition of Agri-Biotech Applications
IUCN	The World Conservation Union
KNBS	Kenya National Bureau of Statistics
KZN	KwaZulu-Natal
LMOs	Living Modified Organisms
MLND	Maize Lethal Necrosis Disease
Mt / ha	Metric tonnes per hectare
NASSEP	National Sample Survey and Evaluation Programme
NBA	The National Biosafety Authority
SPSS	Statistical Program for Social Sciences
USDA	United States Department of Agriculture
WEMA	Water Efficient Maize for Africa

ABSTRACT

According to International Institute of Tropical Agriculture (2009), maize is the most essential cereal crop in sub-Saharan Africa (SSA) and an important staple food for more than 1.2 billion people in SSA and Latin America. Although most maize is used as animal feed, it is a staple food in numerous countries, predominantly in sub-Saharan Africa and South Asia. For instance, the consumption of maize in Kenya has been reported to be 400 g per person per day. The purpose of this study was to establish:- a) the public's perception towards the importance of biotechnology on maize production for food security in Kenya, b) the environmental implications of maize related agro biotechnology on national biodiversity conservation and biosafety and c) the public health concerns on the introduction of maize related agro biotechnology in Kenya.

The study population included two clusters, namely maize farmers and consumers. The farmers were interviewed from two maize farming zones, namely Githunguri Ward (Kiambu County) as a small scale production area and Moiben Ward (Uasin Gishu County) as a large scale production area. .The consumers on the other hand were interviewed from Umoja 1 Ward (Nairobi County). Maize is the principal staple food in Nairobi in terms of kilograms consumed per adult equivalent. Nairobi has several sub-counties including Embakasi where the study was undertaken within the Umoja. Residential Estate which is a middle income residential area.The number of enumeration areas (EAs) was based on planned 10-household interviews per EA, resulting in a total of 12 EAs; 6 from Umoja 1, 3 from Githunguri and 3 from Moiben with a total of 120 respondents including 60 maize producers and 60 consumers. The data analysis was undertaken using descriptive statistics and inferential statistics like Man U Whitney test the initial phase using frequencies and cross tabulations.

The findings showed that majority of Kenyans especially consumers believe that GM maize will solve the problem of food insecurity in the country because there is a critical need to produce more maize in order to meet the increasing food demand. Out of the 120 surveyed respondents 69% agreed that GM maize will play a great role in solving food insecurity in Kenya. Only 34% of the respondents agreed that current maize production methods are sufficient to meet Kenya's food security needs. The respondents portrayed confidence that GM maize will be beneficial to farmers. 65% of the respondents agreed that GM maize will improve the profitability of the growers due to the increased yields per unit area. In addition,

60% of the respondents believed that GM maize will benefit the society because it will allow farmers to produce food more efficiently. 51% believed GMO foods will play a major role in solving malnutrition problem in Kenya. On the flip side, majority of the respondents were concerned about the likely environmental and health risks. 76% of the respondents were concerned that GM maize will contaminate the conventional crops through cross pollination. More than 6 in every 10 respondents believed that GM maize will be harmful to non-target insects, while 49 % believed that some of the GM maize will invade the environment and become uncontrollable. With regards to public health and religious concerns on the introduction GM maize, it was established 90% of the respondents were in favour of food labelling to show the presence of biotech ingredients. In addition, 55% of the respondents believed that GM maize might lead to human sickness and death.

The study concluded that Kenyans would like a more integrated approach to address the food security issue without over relying on any particular technology. There was appreciation of GM technology will play a critical role in addressing the food insecurity issue in Kenya. However there were also concerns that introduction of GM crops will have a negative impact on the environment. In view of the outcome from this study, a national policy on food labelling is recommended to ensure that information is availed to consumers at the point of product purchase. A policy to regulate GM seed distribution in the county will also be critical to minimize the environmental impacts associated with cross-fertilization.

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CHAPTER ONE

INTRODUCTION

1.1. Overview

The recent prediction from the United Nations (2015), projects the population of world will grow from 7.3 billion to 9.7 billion in year 2050. More than half of this growth will occur in Africa, where the population is set to double to 2.5 billion. This projected growth makes food security among the most critical social matter for the next 30 years.

Kenya's population is predictable to double by the year 2050; therefore there is a need to more than double the food production in order to be a food secure country. Several ways exist in which agricultural output can be improved in a sustainable manner. These include but not limited to the reliance on food imports from other countries, expansion of agricultural land including and irrigation in arid areas, use of biological fertilizers, better pest control, soil and water management, and the use of enhanced plant varieties, increased production either by conventional or biotechnological means.

It's imperative to note that the objectives of genetic engineering in food production are the similar those of conventional breeding. They both may aim to progress crop output in the field by enhancing pest and disease resistance, herbicide resistance, or tolerance to environmental strains including climate change (drought or flooding). There is also a focus on enhancing product value like nutritional worth, beneficial health features as well as upgraded post- harvest shelf life. .

Applications of biotechnology in crop production include tissue culture, genetic engineering and molecular transformations. This study was largely focused on genetic engineering, which has over time generated concerns. Confirmation from the study by Kimenju *et al*. (2005) indicates that consumer groups, conservationists and other non-governmental organizations are apprehensive about genetically modified (GM) foods based on food safety, ethical grounds, religious concerns and the possible side effects on the environment.

If consumer acceptance matters are not sufficiently addressed, then the prospective economic and social profits of modern biotechnology may not be achieved (Stenholm& Waggoner, 1992). It is therefore important to institute the level of consumers' consciousness, perception and apprehensions about GM foods since acceptance of GM food is one of the most critical success factor with regards to the future of this technology.

In 2014, the International Service for the Acquisition of Agri-Biotech Applications (ISAAA), abiotech advocacy group based in New York projected the total global area under Genetically Modified crops to have reached 181.5 million hectares, up from 175.2 million hectares in 2013. Since the first year of GM crops commercialization in 1996, GM crop acreage has grown more than a hundredfold from 1.9 million hectare to 181.5 million hectare. According to ISAAA, due to this growth genetically modified crops are deemed as the fastest crop technology to be aggressively taken up in the history of contemporary agriculture.

In Kenya, corn is the staple food crop. And as such, it plays a great part in food security and for any technology to be successfully introduced in maize production, acceptance by the society is key. Currently the government of Kenya is investing in research, development and capacity building on modern biotechnology. There are several on-going biotechnology projects on 5 crops under confined field trials (CFT). The crops include cotton, corn, cassava, sorghum and sweet potatoes. As this development continues, it calls for more studies to be done in order to gauge public's perception on adoption of genetic engineering as a tool towards sustained food security. Understanding the society's perspective will be instrumental in coming up with a proper strategies as the world moves towards genetic engineering. Scientific studies on this issue are necessary in order to establish the degree of public willingness to embrace and adopt biotechnology as an acceptable solution to the problem of food insecurity. This kind of research has not been undertaken because most discussions on the matter are usually undertaken in high levels by upstream experts, technocrats and scientists. The aim of this study is to fill this gap.

1.2. Research Problem

Although numerous studies have analysed consumer reception of GM foods in the industrialized countries and Asia, there is negligible evaluation work done in Sub-Saharan Africa, though this expanse could advance significantly from this technology (De Groote *et al*., 2003). Generally it is agreed that opinions of risks and benefits are a key driver of people's reactions to a specific activity or technology, such as GM food (Slovic, 2000).

A considerable amount of myth and misinformation exists on the biotech crops issue which forces many world governments to be extremely careful on their approach. In November 2012 The Government of Kenya barred the import of GM crops into Kenya and stringent regulations were put in place that requires mandatory labelling and lengthy approval process. This has posed a great challenge on food aid imports as well as trade in GM foods. Violation of the mandatory labelling provisions imposes a fine up to $235,000 and/or imprisonment up to ten years (The Biosafety labelling Regulation 2012). Despite these challenges Kenya continues to invest in research, development and capacity building on biotechnology and as earlier stated there are several biotech crops project that are on-going with the aim meeting the food security agenda.

The journey towards food security in Kenya faces numerous challenges despite increased food demand due to the rapid population growth. The total arable land in Kenya was last measured at 5.5 million hectares in 2011, according to the World Bank. The total arable land under maize production is estimated at 1.9 million hectares which reflects the importance of this crop in the country. However, despite the large acreage dedicated to maize production, Kenya habitually has a shortage in her maize requirement, which is complete by informal cross-border trade from Uganda and Tanzania. During major crisis, imports from the international market have been required. The national consumption per capita is 98kg in Kenya. The country produces 25,000 tons against the national demand of 35,000 tons (GOK, 2012).

Climate change has seen the yield per hectare fluctuate over the years because the rains have been erratic and the seasons are increasingly unpredictable. These challenges can be confronted through the introduction of transgenic maize associated with water efficiency as the traits being tested under the Water Efficient Maize for Africa (WEMA) project. This project is among those approved by the National Biosafety Authority.

In addition to the climate change dilemma, the country faced the Lethal Maize Necrosis Disease (MLND) crisis in 2011 which saw a significant decrease in national maize yield. According to Sicily Kariuki the former Principal Secretary in the Ministry of Agriculture, the total maize acreage in 2014 dropped to 1.1 million from 1.19 million in the year 2013. Approximately 163,450 hectares of maize was affected by MLND in 2014 this caused the country to loose approximately 1,035,420 bags. The disease has placed the entire maize sub-sectors across the country at a greater risk and the hardest hit is its food security role (Wangai *et al*., 2012).

With the outlined challenges above, there is need to embrace available crop technology in modern agriculture in a sustainable way so as to alleviate food insecurity and malnutrition. For this to be possible the general public should be involved through creating awareness and addressing society concerns that arise. This is only possible if we fully understand the public perception on the matter. Public response is a critical influence in developing and introducing biotechnology (Cantley &De Flines, 1987). This study was motivated by the following research questions regarding this matter:-

a) What is the public's perception towards the importance of biotechnology on food security in Kenya in response to the growing food demand or do they prefer other alternatives?
b) Do the public have any fears on the possible negative environmental impact as a result of introduction of maize related agro biotech in Kenya?
c) Do the public have any public health or religious concerns on the introduction of maize related agro biotech in Kenya?

1.3. Research Objectives

a) To establish the public's perception on the introduction of modern biotechnology and GM crops on food security in Kenya in response to the growing food demand.
b) To assess whether the public have any negative environmental concerns as a result of introduction of maize related agro biotech in Kenya?
c) To assess whether the public have any public health or religious concerns on the introduction of maize related agro biotech in Kenya.

1.4. Research Hypotheses

i. H_o: There is a public perception that GM maize may not play a great role in solving the food insecurity issue in Kenya

   H_1: Alternative

ii. H_o: There is a public perception that GM maize may not have adverse effects on the environment

   H_1: Alternative

iii. H_o: There is a public perception that GM maize may not lead to human sickness and death

H_1: Alternative

iv. H_o: There is a public perception that GM maize may not interfere with God's creation of ordinary crops-undermining God

H_1: Alternative

1.5. Justification and Significance of the Study

According to the UN Millennium Project (2005), genetic modification (GM) technology can contribute significantly towards the world food security goals through higher crop yields through the genetic design of hardier and better crop varieties that can withstand drought and disease. The application of biotechnology in food production has generated a wide range of public concerns around the world. A study by Kimenju et al (2005), for example, established that food consumer organizations, environmentalists and civil society are concerned about GM food on the basis of food safety, environmental impacts and religious ethics. Based on these concerns, it is likely that inadequate public confidence on the use of biotechnology for sustainable food production may derail the prospective socio-economic benefits of the technology as already indicated by Stenholm and Waggoner (1992). It is therefore necessary for scientific research to determine the level of education and awareness, public perception and concerns on biotechnology products including GM food in order to identify the key areas of negative myth and misconception and address them in an effective and acceptable way especially for the key food crops.

Maize is the principal food crop in Kenya which contributes in a big way towards food security. The overall consumption is valued at 98-125 kilograms per person per year which converts to about 2700 thousand metric tonnes annually (Nyoro *et al*., 2004). According to the Government of Kenya (2015), maize is the most important staple food crop in the country and contributes significantly to food security. Therefore it is important to focus on this key crop. The role of biotechnology in mitigating the runaway maize demand in Kenya might be inevitable in the long run. Currently the Government of Kenya is investing in research, development and capacity building in modern biotechnology with on-going projects on five crops under Confined Field Trials (CFT). These crops are cotton, maize, cassava, sorghum and sweet potatoes.

The study is important and justifiable to three key stakeholders, namely the policy makers, researchers and seed companies as highlighted below;

- To policy makers, the findings from this research will give more insights on key public concerns. Policy makers performance a pronounced role in the authorization and regulation of any new agricultural technology. Therefore the findings from this study will help in closing any gap between the public's view and the policy makers' view.
- The study will provide more literature and provide a basis for future research through the recommendation that shall be outlined
- The seed companies will benefit from the findings of this study, consumer and growers attitudes and perceptions will shape how the companies will position their products and which areas need campaigns to close the awareness gap.

The study areas were selected as below

- Uasin Gishu County is one of the key large scale maize growing areas in Kenya with average farm size at 2-10 acres and upto 224,890 acres under maize cultivation. The Uasin Gishu County Together With Transnzoia are considered as the bread-basket of Kenya (Republic of Kenya 2013a).
- Kiambu County is one of the high agricultural potential and high population density areas in Kenya with the average farm size below 2 acres. The key crops which are grown in the county include tea, coffee, maize, beans and potatoes. Maize growing in the area is largely for subsistence use. The study was conducted in the Githunguri Sub-County which is a small scale land tenure zone.
- Maize is the primary essential food in Nairobi in terms of the kilograms consumed per adult equivalent. Muyanga *et al*., (2004) established that up to 97% of the middle income people in Nairobi used maize related products (maize meal, dry grain or green maize) on regular basis. Nairobi has several sub-counties including Embakasi where the study was undertaken within the Umoja Residential Estate which is a middle income residential area.

1.6. Scope of the Study

The study was undertaken in three counties Nairobi, Kiambu and Uasin Gishu with a specific focus on one administrative ward within each county, namely, Umoja ward, Githunguri ward and Moiben ward respectively. To assess the perception towards biotechnology's role in handling the food security challenge in Kenya and the perceived environmental concerns. Perception on other aspects of biotechnology like industrial, medical and environmental biotechnology were not assessed in this study

1.7. Research Assumptions

The research assumed that all the respondents that were interviewed had a basic understanding of GMO subject and would present their views freely.

1.8. Operational Definitions

Biotechnology: the use of living systems and organisms to improve or make products, or any technological application that uses biological systems, living organisms or end product thereof, to make or alter products or processes for particular usage.

Food security: a state that occurs when all people, at all times, have physical, social and economic access to adequate, safe and nutritive food that meets their dietary requirements and food first choice for an active and healthy life.

Genetic engineering: direct manipulation of an organism's genome using biotechnology. It is a set of technologies used to alter the genetic characteristic of cells, comprising the transfer of genes within and across species restrictions to come up with upgraded or innovative organisms.

Genetically modified organism: an organism or microorganism whose genetic material has been transformed by means of genetic engineering.

Public perception: a belief or opinion frequently held by many people and based on how a matter or circumstances are regarded or well-thought-out by associates of the community.

1.9. Limitations of the Study

In the initial stages there was a challenge on how to get research assistants that have a good understanding on the biotechnology subject to ensure quality data is collected. This was overcome by engaging University of Nairobi 4th year students from the Centre for Biotechnology Studies, Chiromo campus.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This chapter focuses on the available literature and empirical data concerning food security and GM technology. The major themes considered in the literature review include; population growth and food security outlook in Kenya, maize and food security in Kenya, application of biotechnology, biotechnology in agriculture, worldwide adoption of GM crops, GM crops acceptance in Africa, the GM crops controversy and finally the situation in Kenya with regards to GM technology.

2.2. Population Growth and Food Security Outlook in Kenya

In the Sub Saharan Africa there are Approximately 240 million people that lack satisfactory quantity and quality of food for a healthy and active life whereas high food prices and drought are forcing more people into insufficiency and starvation (FAO, 2010). Surveys conducted on global agricultural commodities reveal that crop yields in Africa have remained stagnant in the past several decades whereas outputs in other areas have surged. In Kenya, for instance, farmers lose approximately 15 per cent of the corn production to stem borers (Glover, 2003), in addition to other yield reducing factors like climate change. The USDA (2015) report reveals that the national maize production average in Kenya was 1.56mt/ha in the 2013/2014 cropping year, compared to USA whose national maize production average stood at 9.93mt/ha in the same year.

The 2009 Kenya Population and housing Survey counted an overall of 38,610,097million people, demonstrating an upsurge of roughly 35% from the 1999 poll. The Kenya population increased from merely 8.6 million people in 1962 to 10.9 million, 15.3 million, 21.4 million, 28.7 million and 38.6 million people in 1969, 1979, 1989, 1999 and 2009 correspondingly (Figure 2.1).

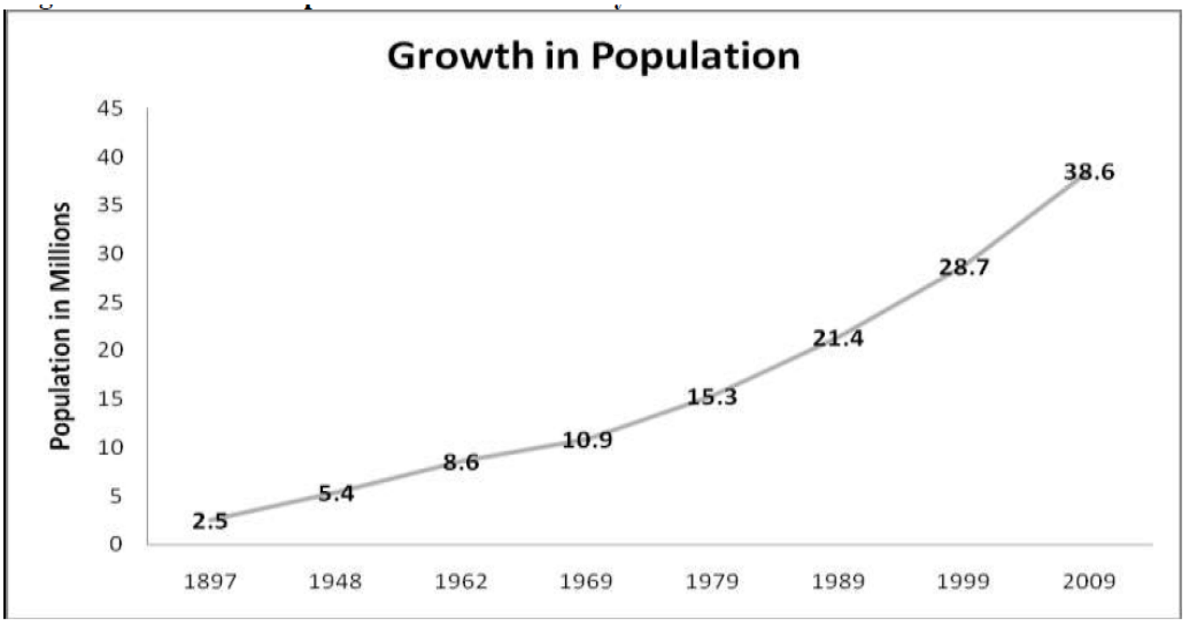


Figure 2.1: Trends in Population Growth in Kenya **(*GOK 2009 Kenya Population and Housing Census Volume 1C pp.2*)**

On the other hand food production has not marched population growth; factors like climate change impact are being experienced with droughts and floods increasing in frequency and intensity over the past decade. The agricultural sector in Kenya is exceedingly exposed to climate change and climate variability, as farming undertakings are directly determined by climatic conditions and weather patterns. This has adverse effects on food security. For example a report by IFAD indicates that severe droughts occurred in Kenya in 2010 and 2011, this necessitated 4 million people to depend on food aid.

2.3. Maize and Food Security in Kenya

During the World Food Summit of 1996, food security was well-defined as surviving when all persons, at all times, have physical and economic access to adequate, safe and nourishing food to address their dietary requirements and food preferences for an active and healthy life. Food security has similarly been well-defined as the existence of the essential settings for human beings to have physical and economic access, in socially satisfactory means, safe food, that is nourishing and in accordance with their social inclinations, so as to address their dietary prerequisites and live fruitful and healthy lives. In light of this, Kenya can be considered as being a long way to attain food security.

In Kenya, food security has for a long time, been associated to self-reliance in corn production. This is because maize is the key staple food for a substantial percentage of the

Kenyan population in urban and rural regions. As a food commodity, maize delivers a great percentage of calorie essentials to a bulk of consumers in urban and rural areas (Nyoro 1992). Maize is also significant in Kenya's crop production patterns, contributing approximately 28% of gross farm production from the small-scale farming segment (Jayne *et al*., 2001). Consequently, the government, since independence, has focused on guidelines intended at increasing maize output to enhance the country's food self -reliance.).

Previously, the Millennium Development Goal (MDG) 1, target 2 pursues to decrease chronic hunger by half from the 1990 baseline by 2015. Similarly the Sustainable Development Goal 2 is on ending hunger, attaining food security and improving nutrition and encouraging sustainable agriculture. According to the UNDP (2014) report, there is a slight improvement towards this goal indicator in Kenya. The report further notes that, to keep up this development it is paramount for Kenya to fast track technology adoption and interventions geared towards improving food accessibility via amplified agricultural productivity so as to improvement domestic access to food in adequate quantity and quality as well as excess for sale.

Low food self-reliance has been credited to lack of output improving technologies, higher occurrence of pests and diseases, irregular climatic patterns and complications in credit access (Nyoro *et al.*, 2007). Food self-sufficiency has not been achieved in the past decade because as the population continues to grow exponentially, the demand for maize has been rising without a consistent year on year increase in maize production, as illustrated in figure 2.2. According to Otonge *et al,* (2010), progression in maize output in Kenya has been minimal averaging only about 2% per annum. This is inferior to the population progression speed which stands at about 3%; consequently, if the country is to attain self-reliance, national maize output has to increase at a rate of 4% per year.

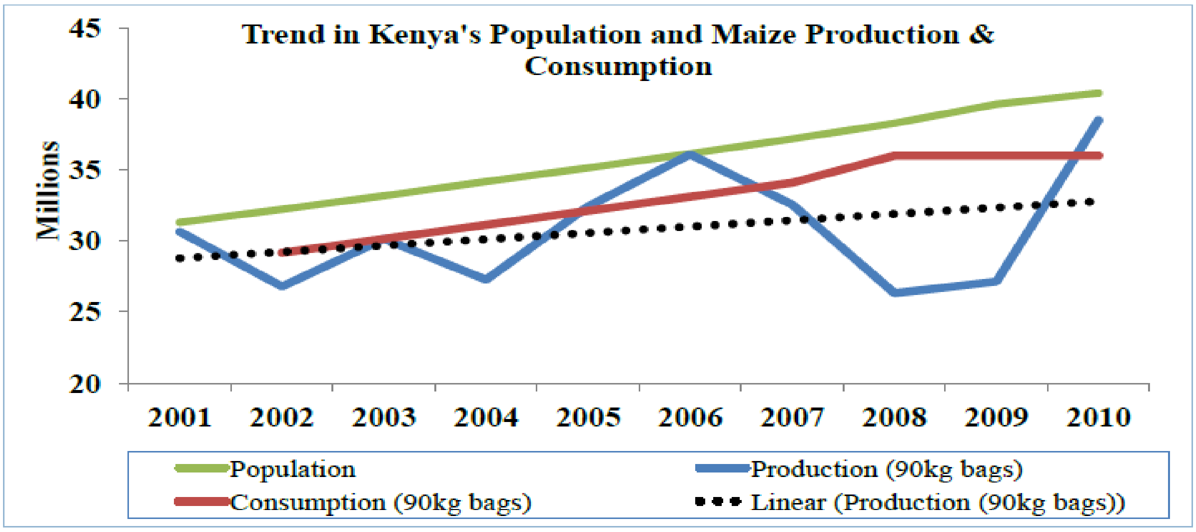


Figure 2.2: Gap between maize production and consumption in the last decade (*Ministry of Agriculture: Economic Review of Agriculture – Various Issues)*

In the recent past, the country has encountered some years of intensified food shortage and reliance on imports and disaster philanthropic assistance. Owing to the shrinking accessibility of arable land, the future progression in maize production would have to rely mostly on yield improvements made possible by wide-spread use of output improving technologies such as use of upgraded farming methods (Kang'ethe, 2008). Technology adoption will play a key role in improving agricultural productive so as to achieve food security in the country.

Genetic alteration tools may back food security objectives through growing crop outputs producing tougher crop varieties that can tolerate heat and drought, improving nutritive and medicinal worth, and improving the shelf life (UN Millennium Project, 2005). Some of the attributes that are critical in improving yield can be acquired via genetic modification. Improving crop resistance to pests and diseases and decreasing weeds could assist decrease crop losses and lessen reliance on expensive fertilizers and herbicides, resulting in substantial savings for resource poor growers (Bernsten, 2004). For instance, if Bt maize can efficaciously cab the corn borer, maize harvests in Africa could rise considerably (Ives *et al*., 2001). Apart from yield enhancing attributes, crops can also be genetically modified to mend their architecture and look, flavour, dietary quality and post-harvest loss reduction. In Kenya the latter two would be of paramount importance.

2.4. Application of Biotechnology

Biotechnology involves any scientific application that uses biological systems, living organisms or by-products thereof, to create or alter products or processes for specific use, (UN Convention on Biological Diversity, Art. 2). The process involves a wide range of techniques and it has been used for centuries for example through fermentation. Modern application has focused in areas including: agriculture, environment, industrials and medicine. Figure 2-3 shows the other various application dimensions for biotechnology in anthropogenic activities.

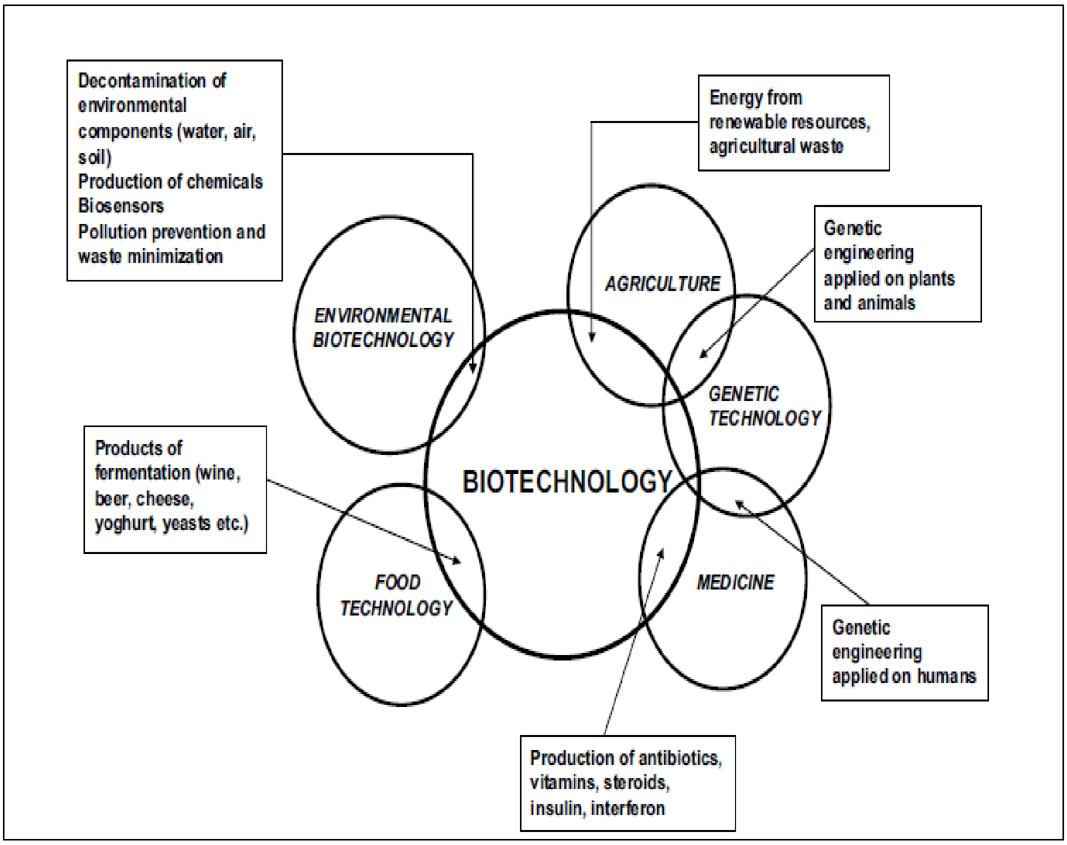


Figure 2.3: Application of biotechnology in anthropogenic activities (Nair 2006)

One of the new and interesting biotech dimensions is environmental biotechnology whose focus is waste treatment and pollution prevention. It uses microorganisms and their products in the inhibition, handling and observing of environmental contamination through solid, liquid and gaseous waste biotreatment, bioremediation of contaminated environments, and biomonitoring of environmental and treatment processes. Environmental biotechnology can impressively decrease our reliance on means for land-based disposal. Environmental engineers use bioremediation, they introduce nutrients to boost the action of bacteria already existing in the soil at a waste position, or introduce new bacteria into the soil. After the bacteria ingest the unwanted materials, they die off or return to their usual population levels in the environment.

2.4.1 Biotechnology in Agriculture

Agricultural biotechnology applies an assortment of scientific techniques used to advance the status of dependable plants, animals and microorganisms. A deeper understanding of the genetic configuration of life forms through their DNA has enabled scientists to come up with solutions to improve agricultural output. Genetic engineering encompasses the use of laboratory tools and precise enzymes in cutting out, insertion, and alteration of pieces of DNA that hold one or more genes of interest. What distinguishes genetic engineering from conventaional plant breeding is the competence to influence precise genes and to transfer genes amid species that would not voluntarily interbreed under regular circumstance. Beginning with the capability to recognize genes that may confer benefits on given crops, and the capability to work with such features very accurately, biotech improves breeders' ability to create enhancements in crops and livestock. In agriculture there are several important biotechnology tools which include:

- Conservative plant breeding
- Tissue culture and micro propagation
- Molecular breeding or marker assisted selection
- GM crops and Genetic engineering
- Molecular diagnostic tools

The focus of this study was on genetic engineering and GM crops with a bias on maize. Genetic engineering permits the direct relocation of one or just a few genes, between any closely or distantly related organisms. It is imperative to note that not all genetic engineering techniques encompass implanting DNA from other organisms. Plants can also be altered by eliminating or swapping off specific genes and genetic controls (promoters). On the other hand, with conservative plant breeding, there is minute or no assurance of gaining any specific gene arrangement from the millions of crosses bred. Unwanted genes can be moved together with needed genes or while one wanted gene is gained, another is lost since the genes of both parents are mixed together and re-assorted more or less indiscriminately in the progenies. Figure 2-4 shows the difference between conventional and genetic engineering.

Figure 2-5 shows the process flowchart in the combination of conservative and current biotechnology methods in plant breeding.

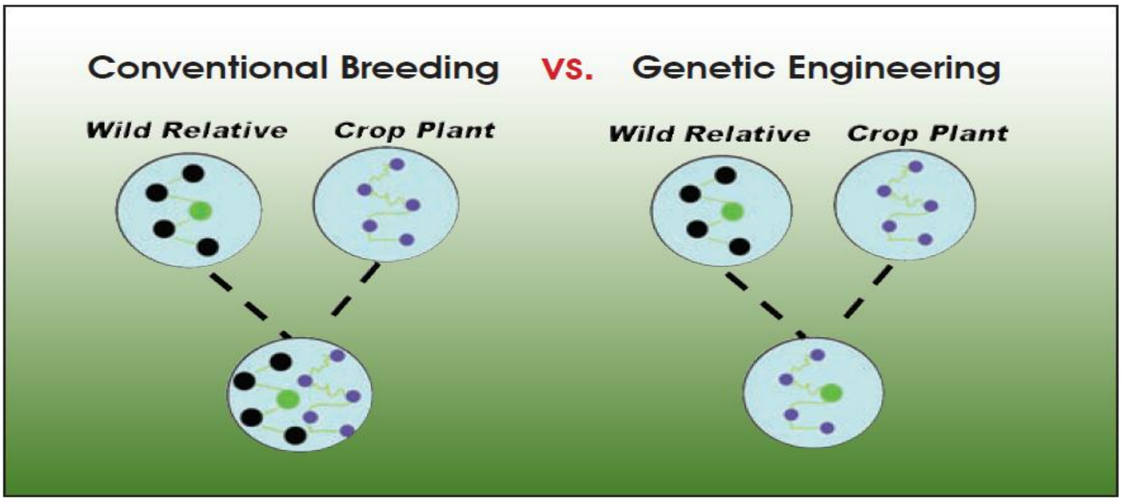


Figure 2.4: Conventional vs. genetic engineering (Biotech Mentor's Kit, 2003)

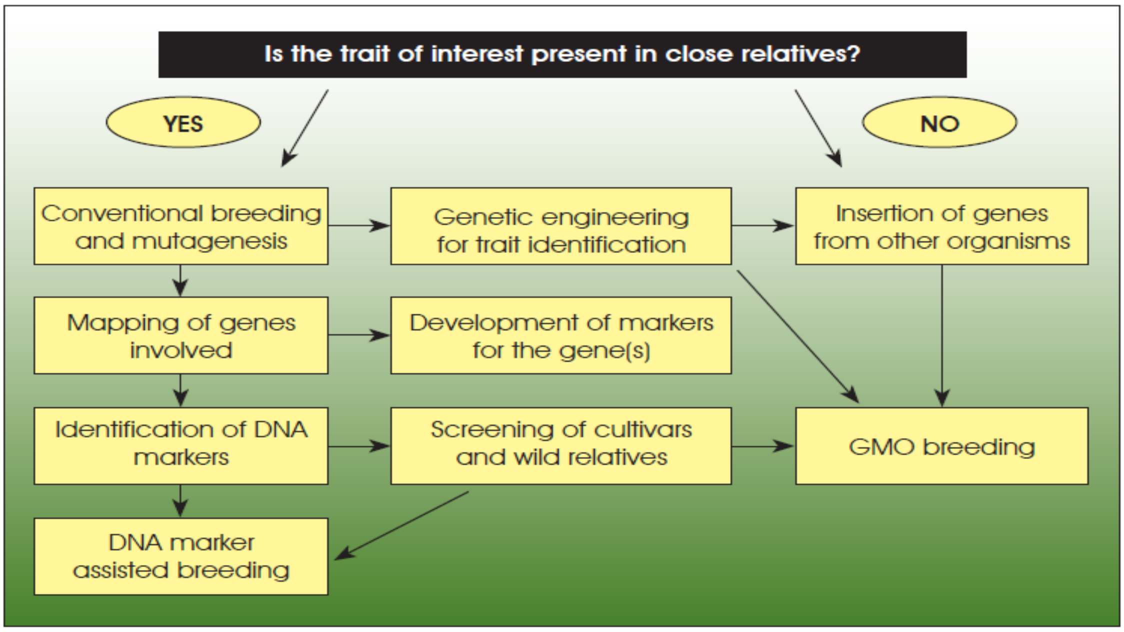


Figure 2.5: Process flowchart in the integration of conventional and modern biotechnology methods in crop breeding (DANIDA, 2002)

2.5. Global Adoption of GM Crops

According to ISAAA, so far, upto 27 transgenic crops, are commercially cultivated in the world including alfalfa, Argentine canola, bean, carnation, chicory, cotton, creeping bent grass, eggplant, flax, corn, melon, papaya, petunia, plum, Polish canola, poplar, potato, rice, rose, soya bean, squash, sugar beet, sugarcane, sweet pepper, tobacco, tomato, and wheat. These crops have been adopted in 28 countries around the world, with a record of 181.5 million hectares of GM crops grown in 2014. Over half of the global population (~60% or ~4 billion people) in the 28 countries are said to be cultivating biotech crops (Clives, 2014). Table 1 and Figure 2-6 provides the details on the 28 countries that grow GM crops commercially.

Table 2.1: Global Area of Biotech Crops in 2014: by Country (Million Hectares) **

Rank	Country	Area (million hectares)	Biotech Crops
1	USA*	73.1	Maize, soybean, cotton, canola, sugar beet, alfalfa, papaya, squash
2	Brazil*	42.2	Soybean, maize, cotton
3	Argentina*	24.3	Soybean, maize, cotton
4	India*	11.6	Cotton
5	Canada*	11.6	Canola, maize, soybean, sugar beet
6	China*	3.9	Cotton, papaya, poplar, tomato, sweet pepper
7	Paraguay*	3.9	Soybean, maize, cotton
8	Pakistan*	2.9	Cotton
9	South Africa *	2.7	Maize, soybean, cotton
10	Uruguay*	1.6	Soybean, maize
11	Bolivia*	1.0	Soybean
12	Philippines*	0.8	Maize
13	Australia*	0.5	Cotton, canola
14	Burkina Faso*	0.5	Cotton
15	Myanmar*	0.3	Cotton
16	Mexico*	0.2	Cotton, soybean
17	Spain *	0.1	Maize
18	Colombia*	0.1	Cotton, maize
19	Sudan*	0.1	Cotton
20	Honduras	<0.05	Maize
21	Chile	<0.05	Maize, soybean, canola

Rank	Country	Area (million hectares)	Biotech Crops
22	Portugal	<0.05	Maize
23	Cuba	<0.05	Maize
24	Czech Republic	<0.05	Maize
25	Romania	<0.05	Maize
26	Slovakia	<0.05	Maize
27	Costa Rica	<0.05	Cotton, soybean
28	Bangladesh	<0.05	Brinjal/Eggplant
	Total	181.5	

* 19 biotech mega-countries growing 50,000 hectares, or more, of biotech crops ** Rounded off to the nearest hundred thousand (Clive, 2014)

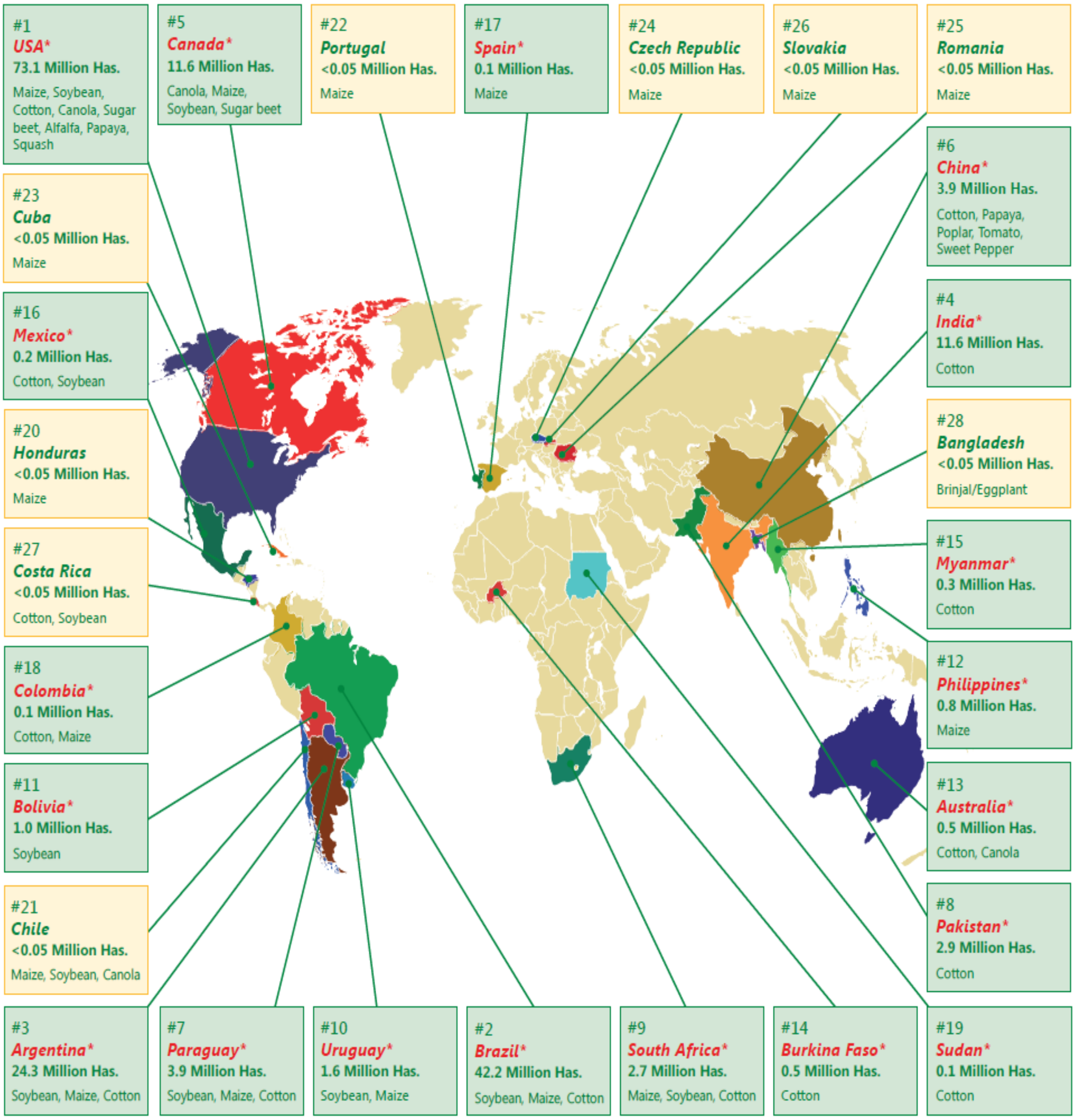


Figure 2.6: The world GM crop growing countries in 2014 (Clives, 2014)

Based on the current cultivation acreages, the leading crops are soybeans, maize, cotton and canola. Transgenic maize is grown commercially by 17 countries around the world which accounts for 30% of the total acreage under maize in the world.

2.5.1 Adoption of GM Crops in Africa

In the developing world there are 20 countries commercially growing GM crops. Out of these only 3 countries are based in Africa, namely, South Africa, Burkina Faso and Sudan. However, there 11 African countries that are piloting confined field trials and are testing various GM crops. The key biotechnology techniques which are currently employed in Africa include tissue culture, molecular characterization, marker assisted selection, molecular diagnostics and genetic modification (GM). Presently tissue culture is useful in numerous countries including Kenya for quick reproduction of propagation materials for vegetatively reproduced crops for example pineapple, coffee, banana, and root crops. Nonetheless, few countries have accepted GM for crop production enhancement, and for agricultural research and development (Table 2.2).

Table 2.2: Status of Genetically Modified (GM) Crops in Africa **(Modified from absafrica.org)**

Application stage	**No. of Countries**	**Country Names**
Commercial production	3	Burkina Faso; Sudan ; South Africa
Confined field testing	7	Burkina Faso; Egypt; Kenya; South Africa; Uganda; Nigeria; Malawi
Contained research	At least 14	Burkina Faso; Cameroon; Egypt; Ghana; Kenya; Mali; Mauritius; Namibia; Nigeria; South Africa; Tanzania; Tunisia; Uganda; Zimbabwe; Malawi

Application stage	No. of Countries	Country Names
Developing capacity for research and development	At least 27	South Africa; Burkina Faso; Egypt; Kenya; Morocco; Senegal; Tanzania; Uganda; Zambia; Zimbabwe; Benin; Cameroon; Ghana; Malawi; Mali; Mauritius; Namibia; Niger; Nigeria; Tunisia; Algeria; Botswana; Ethiopia; Madagascar; Rwanda, Burundi, Sudan

With regards to developing regulatory framework, several African countries have established or are in the course of establishing the frameworks to be used for fresh biotechnology application (Figure 2.7).

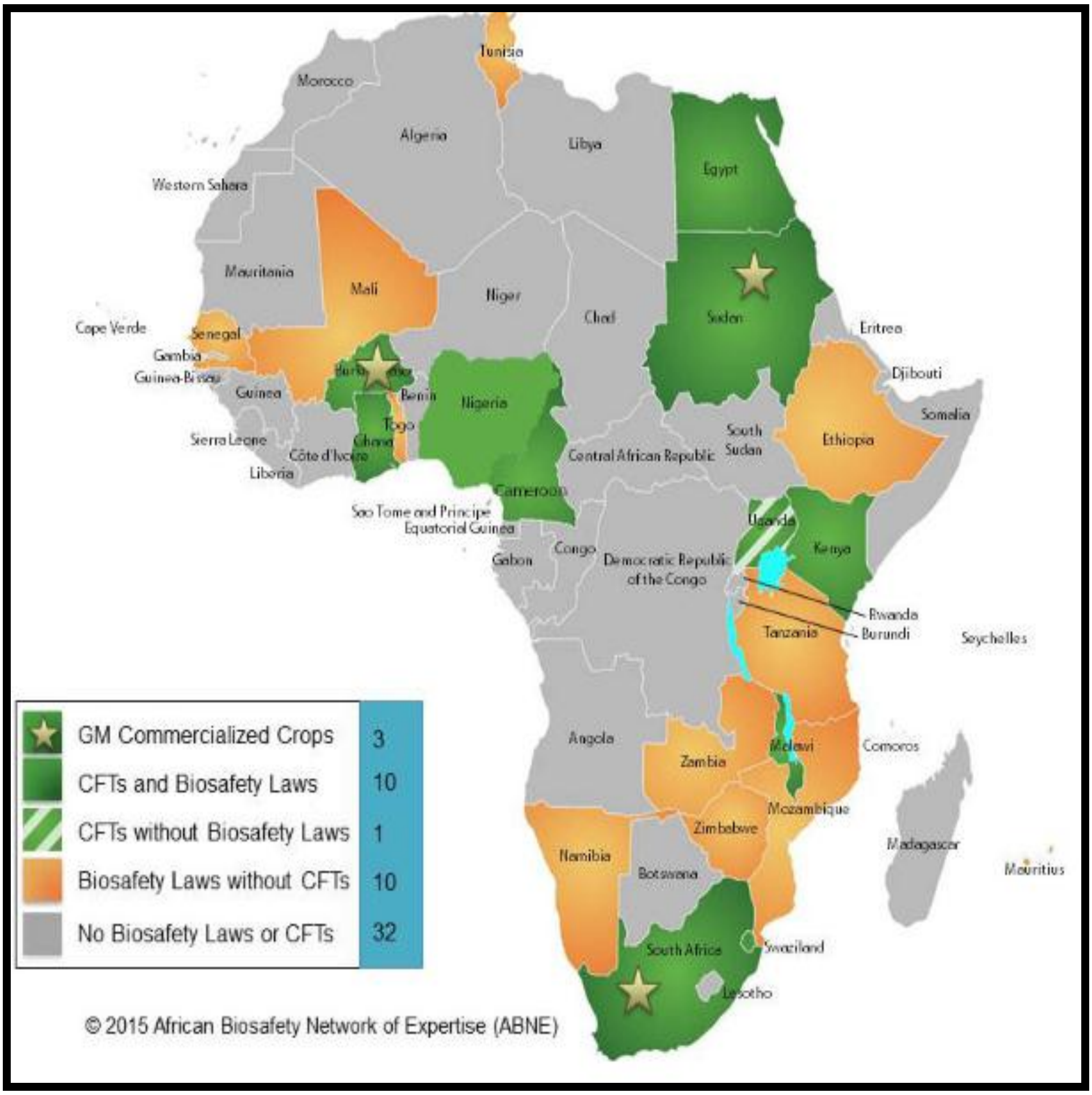


Figure 2.7: Status of Biosafety Regulation in Africa (ABNE, 2015)

2.5.1.1 GM Crops Adoption in South Africa

South Africa has become a regional lone ranger and a springboard for western biotechnology in Southern Africa. Most of the other SADC countries have preferred the precautionary approach on GM food production and consumption. Zambia, through the government of the late Mr. Levy Mwanawasa cited a number of explanations for their unwillingness to accept any GM food including an lack of decisive scientific confirmation that GM food is harmless for human and animal consumption, absence of sufficient capability to identify and accomplish the transmission of GM crop into the extensive environment, and the fear that GM crops might eventually pollute the non-GM varieties if both are grown by farmers in Zambia.

South Africa was the pioneer African country to adopt and commercialize GM crops in 1997. They began this through commercial production of Bt cotton in 1997 trailed by Bt maize (Monsanto 810) in 1998 and herbicide tolerant (HT) cotton and soya bean in 2000. Commercial farmers in South Africa produce over 90% of the total maize crop and nearly all GM maize is produced by the commercial growers . (Gouse *et al.*, 2009). However, there are also smallholder farmers who grow GM maize in joint zones of KwaZulu-Natal (KZN), Mpumalanga, and the Eastern Cape. Since institution of GM maize in South Africa in 1998, there has been a general rise in the output per hectare whereas the area under cultivation has dropped as illustrated in Figure 2.8, with the exclusion of severe drought years in 1991/92, 1994/95 and 2006/07.

The introduction of GM crops in South Africa have demonstrated that the technology has resulted in substantial saving of arable land for other uses which has also been observed globally. According to Brookes & Barfoot (2013) in the first 16 years of GM introduction globally between 1996 -2011, a total of 108.9 million hectares became available for other uses due to considerable yield increament, an extra 328 million tonnes of GM crops. Empirical indication from numerous studies submits that there has been a positive economic benefit of GM crop approval in South Africa. According to Gouse (2005), GM maize output per unit of area yielded 22% more than conventional corn in 2005/06 season. In addition to this, there was some significant cost savings on pesticides. From a study conducted by Brookes & Barfoot (2012), the estimated economic gains at farm level due to biotech crop acceptance in South Africa from commencement in 1998 to 2010 was US$809 million.

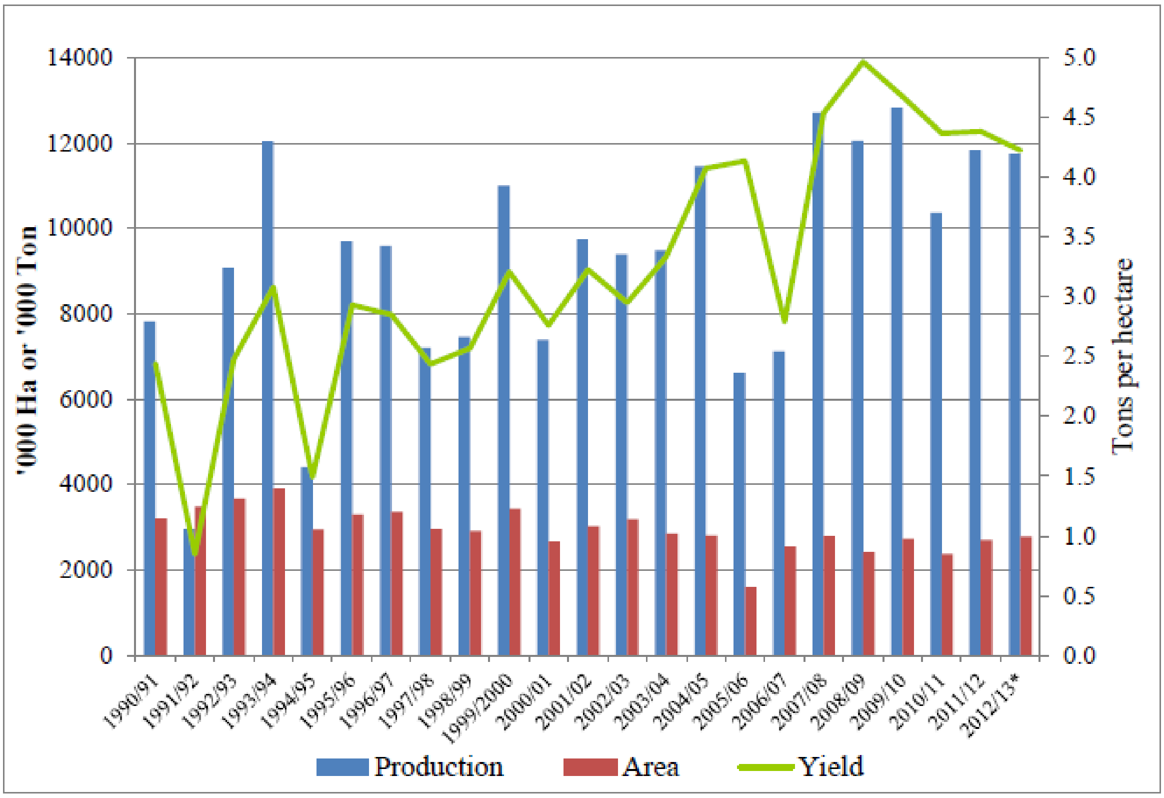


Figure 2.8: Maize production in South Africa (Grains, 2013)

2.6. The GM Crop Controversy

Any choices in Agriculture are usually about food amount as well as about nutritive requirements, livelihoods, culture, poverty, trade and sustainability in any advancement. GM technology might be beneficial in tackling some of these facets but it is also linked with controversies. There are considerable concerns and ambiguity about the effect on human beings and environmental well-being, and moreover if these foodstuffs will offer a sustainable result to food problems. The public opinion on GM crops has been equivocal across the globe. Whereas the European Union (EU) is very critical of GM crops, most of the other countries are either uninterested or support GM and associated products (products resulting from GM components) (Stein & Rodriguez-Cerezo, 2010). However, public acceptance of GM food has remained very poor in the USA with widespread outcry for product labelling. US GM food exports have also faced widespread resistance especially in Europe. Just like in the case of the Kyoto Protocol on greenhouse emissions and climate change, the USA and its biotech industry were among those adamantly opposed to the UN Biosafety Protocol which received widespread international support. The majority of public outlook in Europe remains steadfastly opposed to GM food. Previous European surveys have showed that 70% of the public do not want to eat GM food, and about 95% mandate labelling so that they can make a knowledgeable choice. It is known that upto 300 European food retail out lets were some of the pioneers globally to introduce and market GM foods in Europe in the mid-nineties. By 1999, public unrest obligated most of the key manufacturers and retailers to eradicate GM ingredients from the shelves.

In Africa, the key public apprehensions have rotated around moral concerns, food self-sufficiency and livelihood disquiets, farmers' and consumer human rights, and non-inclusive policy practices. For example, farmers' societies in West African countries have, in asserting their protest to the introduction of GM crops, focused on a variety of aspects that undercut the industrious agricultural sector, including European Union (EU) and US cotton subsidizations. The public in that region are starting to look more keenly at the overriding prototypical of cotton production, interrogative the necessity for chemical inputs and considering other ways to diminish their dependency on cotton (GRAIN 2004).

In numerous cases, public opposition to and apprehensions about GMOs have played a role in limitations to GM crop research and ultimate commercialization of GM products. There has been poor dissemination and communication of available information. This has played a role in the unending high ranks of concern and ambiguity around effects and threats. Universally, these concerns emphasis on health and environmental repercussions. An IUCN – The World Conservation Union (IUCN) report discovered that the disputes are principally in three areas (Young 2004) including

- The understanding of science and in detail if GMOs are essentially safe or essentially hazardous from a people and environmental outlook;
- Economic scrutiny and in specific how to assess the cost-benefit analysis allied to GMOs;
- Socio-cultural effects and biosafety consequences rotating around matters of food production and self-sufficiency, livelihoods, and people and environmental wellbeing.

Kenya is not an exception as far as these three areas are concerned, in addition to these, other challenges to GMO acceptance consist of: defiant opinions and outlooks, access to and use of patented technology, uncertain biotechnology application policy and the cost implications of biotechnology research. Transgenic research is very costly when paralleled to more conventional biotechnology procedures. For instance, the Insect Resistant Maize for Africa (IRMA) project is projected to have cost US$6 million over 5 years whereas the transgenic sweet potato research cost a total of US$2 million, paralleled to the typical funding of tissue culture and marker technology projects estimated on average to cost US$300 000 (Odame e *et al*, 2003)

Studies on public perception towards GM crops have been conducted globally. For instance in India which is the fourth largest GM crop growing country, a three year research study was undertaken by Gene Campaign and the University of Hyderabad to assess the level of awareness as well as public attitudes and perceptions to GM technology and GMOs among farmers, consumers and other stakeholders. The study established that the farmers were keener to grow cash crops like cotton with modified seed than they are to promote food crops (which are consumed by humans) with modified seed. Public attitude towards food crops is unadventurous, because of the sacredness attached to food. Neither are growers eager to grow food crops with seeds they do not perceive as unnatural, nor are they willing to eat food derived thereof. Approximately 40% of the growers involved in the survey said they would be willing to produce cash crops with modified seed. However, 80% of the growers pointed out that they would not be willing to grow food crops from seeds containing a poison to control pests.

In the USA a study carried out by Hallman *et al*. (2003) on consumer perceptions of GM food revealed that Americans demonstrate greater support for the genetic modification of plants than they do for animals. More and more consumers in the USA are embracing the GM crop technology. In Ghana a study by Deffor (2014) on consumer reception of GM foods in the Greater Accra exposed that public belief and assurance in regulatory organizations on the part of consumers can impact the reception of GM foods. This indicates that more information should be availed to the public with regards to pros and cons of the GM crop technology.

2.7. GM Technology in Kenya

Although there are no commercially produced GM crops in Kenya, several steps have been made towards preparation for the possible commercial entry of GM crops in the future as highlighted below.

- In 2000, Kenya ratified the Cartagena Protocol which is a subsidiary agreement to the UN Convention on Biological Diversity (CBD). It targets to warrant the safe handling, transport and use of living modified organisms (LMOs) ensuing from contemporary biotechnology that might have severe side effects on biological diversity, risks to human wellbeing is also taken into consideration. This protocol was established in Montreal in 2000 and came into force in 2003. So far, this has been ratified by 166 countries.

  The Biosafety Act, 2009 was passed into law by the Kenyan parliament in December 2008. It received Presidential Approval on 12 February 2009. The formulation of the biosafety Act, 2009 was an important achievement towards the domestication of the obligations to the UN Cartagena Protocol on biosafety which seeks to address the negative impacts of biotechnology on society and environment. The legislation has endeavoured to implement the Cartagena Protocol and the African Model Law on Biosafety in Biotechnology. The formulation of the Biosafety Act in Kenya was heavily backed by the USA both openly and quietly because the USA has been a lead champion on the introduction of genetically modified organisms (GMOs) in the world.

- The National Biosafety Authority (NBA) was established by an Act of Parliament. The authority is to implement overall management and regulate the transfer, handling and use of genetically modified organisms (GMO). However, additional mechanisms may still be necessary through other institutions like NEMA and KEPHIS in order to adequately safeguard Kenyan society and environment from some unconsidered threats of biotechnology especially the introduction of GMOs. Since inception, NBA has approved several GMO projects under 3 categories, namely:-
  - Contained use trials: these are trials conducted in laboratories, greenhouses, growth chambers and animal facilities. Some of the projects approved comprise bacterial-wilt-disease-resistant banana, insect-resistant pigeon pea, stress tolerant cassava, nematode-resistant and virus-resistant yam, trypanosome resistance model studies on mice, trypanosome resistance in cow and enhanced vaccines against livestock infections.
  - Confined field trials: these are trials done in restricted fields with on-going projects including: a) water-efficient/drought tolerant transgenic maize at KALRO Kiboko, b) virus- resistant transgenic Cassava at KALRO Alupe, c)

vitamin-A-enhanced cassava at KALRO Alupe, d) Bio-fortified sorghum at KALRO Kiboko and e) virus- resistant cassava at KALRO Mtwapa

- Genetically modified foodstuffs for importation and trans boundary movement through Kenya for charitable assistance and relief supplies. This was however suspended in November, 2012 following the government's ban on importation of GM foods.

With the progress made by the government towards adoption of this technology, the question is whether the public is ready to embrace GM foods? This study was aimed at addressing this issue.

2.8. Research Gap

Many studies have been undertaken to gauge the level of consumer reception for GM foods in the industrialized countries (Lucht, 2015) but such studies are limited in Sub-Saharan Africa (De Groote et al 2003). This research gap must be addressed because public confidence is a critical factor in the adoption of biotechnology in the developing countries as emphasized by (Cantley ,1987).It is clear from the above review that different countries and communities within the same country could have varied views and perspectives on the adoption of GM crop. Therefore, there must be an understanding that all technology has its pros and cons. According to CBD and UNEP (2003), no technology or human activity is totally risk-free. People generally receive novel technologies because they have faith that the prospective benefits offset the possible risks. The critical issue is to ensure factual and relevant information is made available to the consumers and the general public to ensure that the consumers make informed decisions. One of the key challenges for legislators is how to react to the ambiguity about the comparative prospects and threats posed by GM technologies. Their key predicament is whether to approve this new technology and face blame for lack of precaution, or to necessitate exhaustive study of possible risks and face criticism for failing to act in a timely way (Young 2004).

Karembu *et al* (2010) have indicated that among the reasons for low uptake of crop biotechnology in Africa, including Kenya, is because the governments, due to influence by negative perceptions, inadequate awareness and mis-information on the technology, adopted stringent regulations and policies that makes it harder for the adoption of trade in crop biotechnology. Paarlberg (2008) and Juma & Serageldin (2007) concluded that negative perceptions, low awareness and opposition to biotechnology are major factors contributing to the low adoption of crop biotechnology in Africa.

Anunda *et al.* (2009) conducted an assessment of biotechnology awareness and perceptions in Kenya and concluded that there is a low level of awareness of modern biotechnology among the Kenyan public. Anunda *et al.* (2009) therefore recommended that a well-designed program be implemented in Kenya to create more awareness of biotechnology among the public.

The study conducted by Anunda *et al* (2009) on public perception towards GM crops and foods in Kenya focused on factors that influence perception. The study revealed that 58% of the respondents had a positive attitude towards GM crops. From the findings of the study, it was observed male had a positive perception compared to their female counterparts. The younger people were also found to be more receptive than the elderly. In the same study, agro-ecological zones and perception towards GM crops and foods were found to be significantly associated, with those from low and medium agro-ecological zones having a favourable perception towards GM crops and foods than their counterparts from high agro ecological regions of the country. The aim of this study was to compare the findings Anunda *et al* (2009) with regard to maize as the staple food crop in Kenya.

A study was conducted by Otonge 2012 to evaluate the level of awareness of and perceptions towards crop biotechnology by members of STAK (Seed Traders Association of Kenya). The study further aimed to establish the sources of crop biotechnology information among STAK members. Overall, majority of respondents agreed that they are aware of policies, laws, bodies and regulations governing crop biotechnology research and trade in Kenya. On GMO Labeling Regulation, 69.6 % were aware while 30.4 %were not. On the environmental safety regulation awareness 43.5% were aware while 56.5 % were not. On whether respondents were aware of Biosafety regulations on Trade, 87 % agreed while 13% disagreed. 100 % of the respondents were aware of Cartagena Protocol on Biosafety. Otonge also found out that 100 % of respondents get information on crop biotechnology from the mass media, friends and STAK. This shows that the mass media as a tool is very effective in the spread of biotechnology information.

The above literature review reveals that there has been an attempt to assess the general perception towards GM foods. Most of the previous studies focused on factors affecting public perception towards GM crops this study assessed the general public's perception towards GM technology as a vital tool to tackle the food security problem. However this study focused on establishing if the consumers and the producers (farmers) have any differences in perception towards GM foods. It is assumed that the adoption of the GM technology will greatly depend on the growers' perception and willingness to grow GM crop as much as it is hinged on the consumer's views. It is therefore important to gauge and understand the society's perspective specifically on the application of biotechnology in boosting maize production in Kenya in order to establish the degree of public willingness to embrace this as a solution to the problem of food insecurity. This matter is usually revolving among the upstream experts, technocrats and scientists without adequate participation and consideration of the public views in the downstream. However, if scientists can identify the fears which people have towards biotechnology including GM food products it will then be easier to demystify such concerns using the available scientific evidence.

2.9 Theoretical framework

According to Slovic (1979), risk was defined in terms of benefit to humanity, extent of risk and acceptability of risk, and evaluated relative to proportions of risk comprising: voluntariness, dread, perceived control, severity, personal and social concerns and familiarity.

Consumer behaviour and perception concerning food has been widely analysed over time. Nonetheless, technology variations convey new behavioural scopes that change decision making processes. There are few theories have been proposed to unveil the formation process of behaviour. Among the most cited work stands the "Theory of Reasoned Action" (TRA) (Fishbein and Ajzen, 1975). The TRA focuses on the determinants of behavioural intentions to objects of choice where individuals have adequate control over their choices when they have perfect information. With the assumption in the TRA theory that the consumer has sufficient information makes this theory not suitable for GM technology and any other new technology where sufficient info is not available both to the general public as well as the experts.

There is a need to expand the TRA to technology decision making concerning the choice scenarios where information is far from perfect is in the case of GM technology, which has been developed through the "Theory of Planned Behaviour" (TPB) (Ajzen, 1991). Indeed, the latter implies the introduction of an "incomplete volitional control" parameter as a determinant for consumers' behaviour. Therefore, individuals make a choice with regard to future consequences, based on the available information despite the adequacy or inadequacy thereof. In addition, it states that either intentions or behaviour are a function of personal attitudes towards the behaviour; individual opinion of social pressure; and independently apparent behavioural control of the matching intent (Ajzen, 2005).

Risk awareness is qualified as a significant concept to appreciating decision making when individuals do not have complete information (Fischhoff et al., 1993). This last element of control, which very much depends on the available information that people receive, is hypothesised to be a fundamental component for GM food consumer objectives as well as for other consumer food choices. "Perceived behavioural control" is defined by Ajzen (2005), as a function of views regarding the occurrence or lack of factors that aid or frustrate the execution of behaviour. Interestingly, perceived possible hazards related to behaviour, specifically risk perceptions, have been revealed to be significant elements of this control matter.

Fischoff et al. (1993) claim that people need to not only comprehend the costs and benefits of behavioural selections but also the limitations to their understanding and that of experts. The way in which the mind interprets intuitive feelings varies depending on the type and availability of information about the risk at the time of decision-making (Slovic et al., 2004).

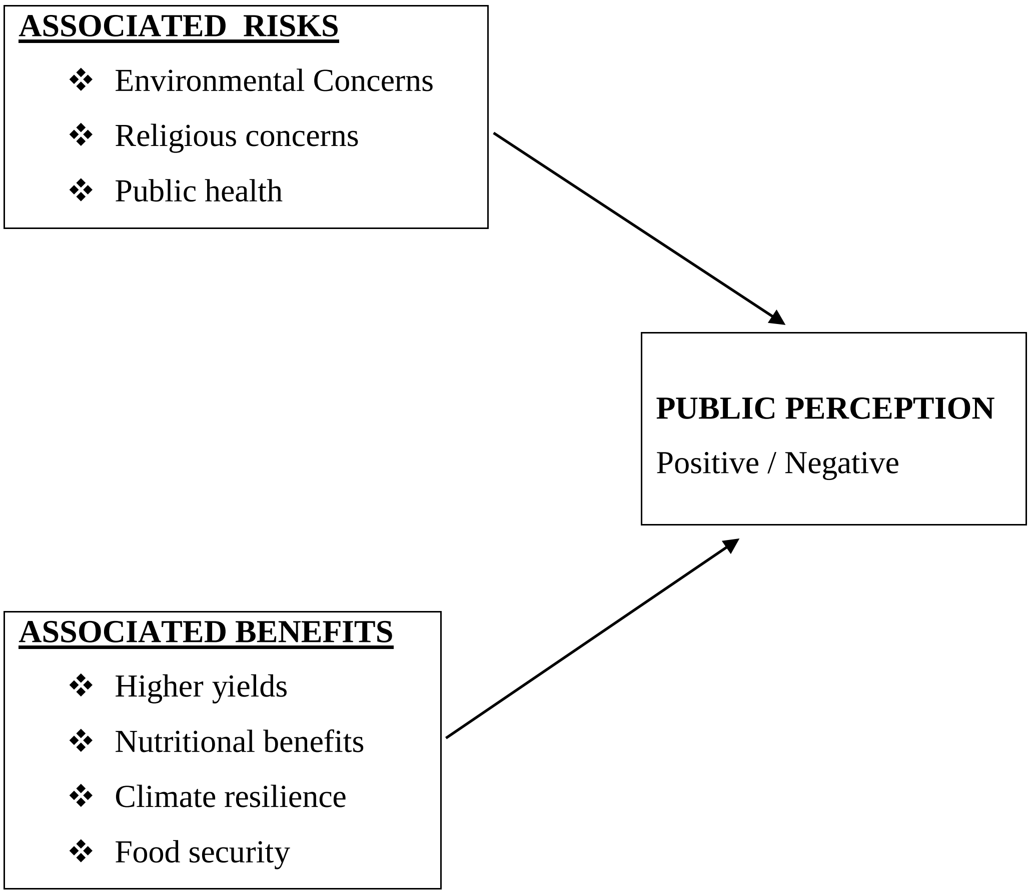
A wide range of literature has concluded that people overrate low risks and underrate high likelihood risks (Kahneman and Tversky, 1979; Viscusi, 1992; and Hurley and Shogren, 2005). The risks of GM food are of particular importance due to its technical nature that determine a set of behavioural processes that need to be disentangled and better understood. Hence the association between risk consumer perceptions regarding GM food consumption is of particular importance, especially when intermediate risk attitudes influence the decision making process. The sufficiency of conservative risk models, which assume full awareness of consequences and likelihoods, has been questioned by studies, including Yeung and Morris (2006), in the context of consumer behaviour when potential hazards that threaten food safety. This is because consumers are subject to great intensities of "uncertainty" regarding the outcomes of their behaviour. In that case, neither identities nor relative probabilities of possible consequences are known by consumers and consequently an ambiguity situation exists.

The definition of ambiguity according to Frisch and Baron (1988) is "the subjective experience of lacking information important to a prediction". Once this ambiguity state occurs, consumers do not recognise control over the situation and hence perceptions of risk surge due to the presence of ambiguity dislike described in several studies (Slovic and Tversky, 1974; Saring and Weber, 1993; and CostaFont and Mossialos, 2007).

The subjective extents touching the intensity of risks perceptions in the case of GM food consist of the involuntariness of some aspects of risk-taking behaviour, the non-existence of knowledge about a certain risks and particularly the presence of dread associated with the risk, the immediacy, irreversibility and magnitude of effects, the probability to control or decrease the risk, and others (Kasperson et al., 1988).

2.10 Conceptual Frame Work

The conceptual framework of this study is summed up in Figure below, which illustrates the relationship between the outcome and independent variables associated with perceptions of GM crops. It is commonly agreed that perceptions of risks and benefits are a key driver of individual's reactions to a particular activity or technology, like GM food (Slovic, 2000). The associated benefits and risks are the independent variables which in turn shape the general public perception as the dependent variable.



Independent Variables ***Dependent Variable***

Figure 2.9: Conceptual Framework *(The Researcher, 2016)*

CHAPTER THREE

STUDY AREA

3.1. Introduction

This chapter describes the study area by highlighting a number of aspects including; the location, climatic condition and socio-economic activities of the study area.

3.2. Study Area

The study was conducted in three areas including two potential GM maize production areas, namely, and Kiambu and one potential GM maize consumption area, namely Nairobi.

3.2.1. Uasin Gishu

Uasin Gishu County is a highland plateau whose altitudes extending from 2,700 m to about 1,500 m above sea level. Uasin Gishu County lies between longitudes 34 degrees 5’’ East and 35 degrees 3’’ West and latitudes 0 degrees 0’’ South and 0 degrees 5’’ North (Figure 3-1). The county shares common boundaries with Trans Nzoia County to the North, Elgeyo Marakwet County to the East, Baringo County to the South East, Kericho County to the South, Nandi County to the South West and Kakamega County to the North West. It occupies an overall area of 3,345.2 km^2. The county is one of the vital large scale maize growing zones in Kenya with typical farm size at 2-10 acres and upto 224,890 acres under maize farming. The study was restricted to the Moiben Sub-County which located in the northern part of the County (Figure 3-1).

The soils vary across the county. They include: red loam soils, red clay soils, brown clay soils and brown loam soils which mainly support maize, sunflower, wheat, pyrethrum, potatoes and barley farming. This also supports livestock rearing and forestry. Uasin Gishu experiences high and dependable precipitation that is uniformly spread throughout the year. The regular rainfall ranges between 624.9 mm to 1,560.4 mm with two separate peaks happening between March and September; and May and August.

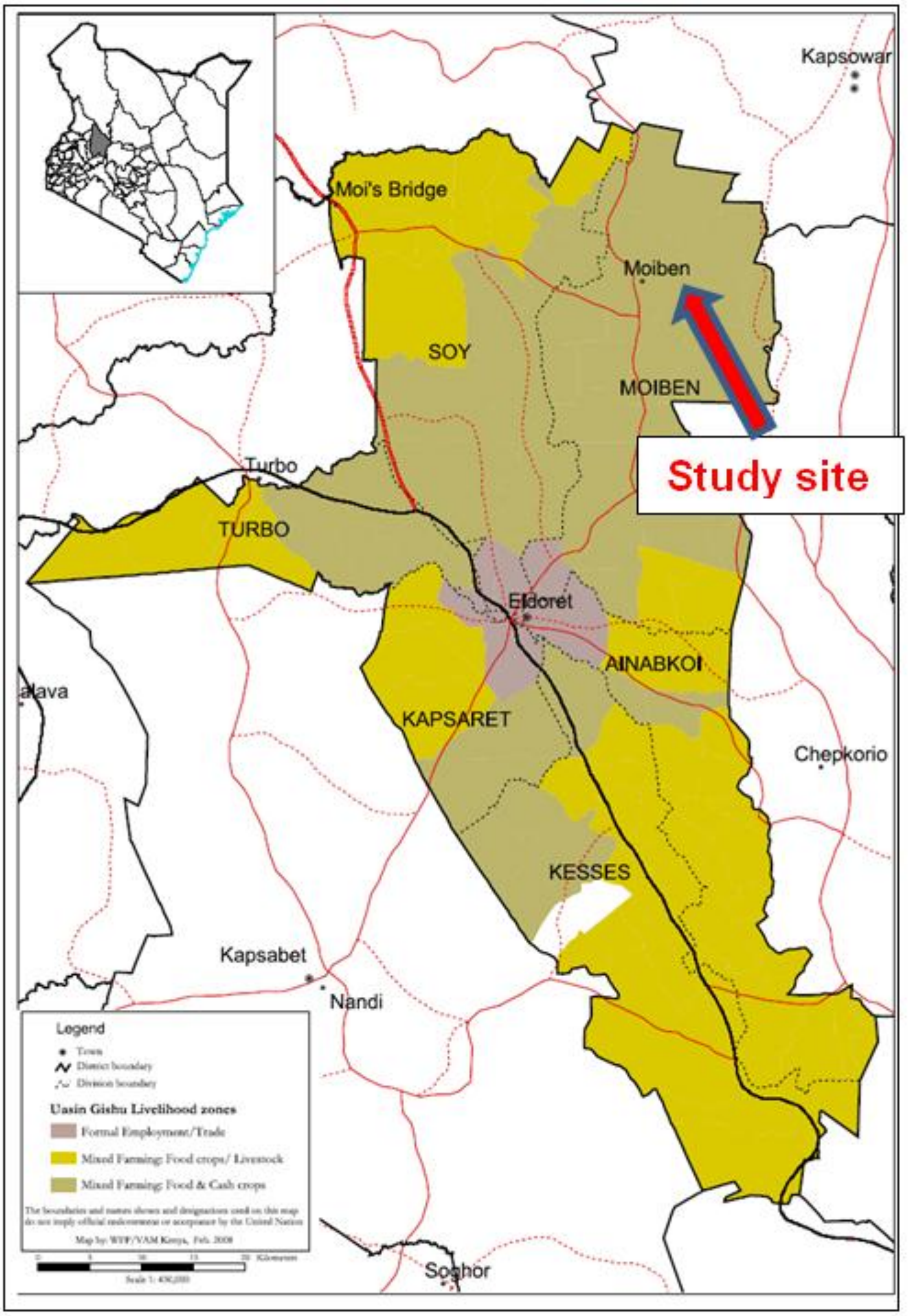


Figure 3.1: Map of Uasin Gishu County (Yego 2013)

The dry season occurs between November and February. The temperatures range between 7^0C and 29^0C. Normally these settings are suitable for livestock raring, crop and fish farming. The Uasin Gishu County has an average land holding of 5 hectares in rural regions, and 0.25 of hectares inside Eldoret Municipality.

3.2.2 Kiambu

Kiambu County is situated in central Kenya. It borders Murang'a County to the North and North East, Machakos County to the East, Nairobi and Kajiado counties to the South, Nakuru County to the West, and Nyandarua County to the North West (Figure 3-2). The county lies between latitudes 00 25'and 10 20'South of the Equator and Longitude 360 31'and 370 15'East. According to 2009 census, Kiambu County has a population of 1,623,282, with a total area of 2,543 $km^{2.}$ Upto 60.8% of Kiambu's population lives in urban areas. The study was conducted in the Githunguri Sub-County (Figure 3-2).

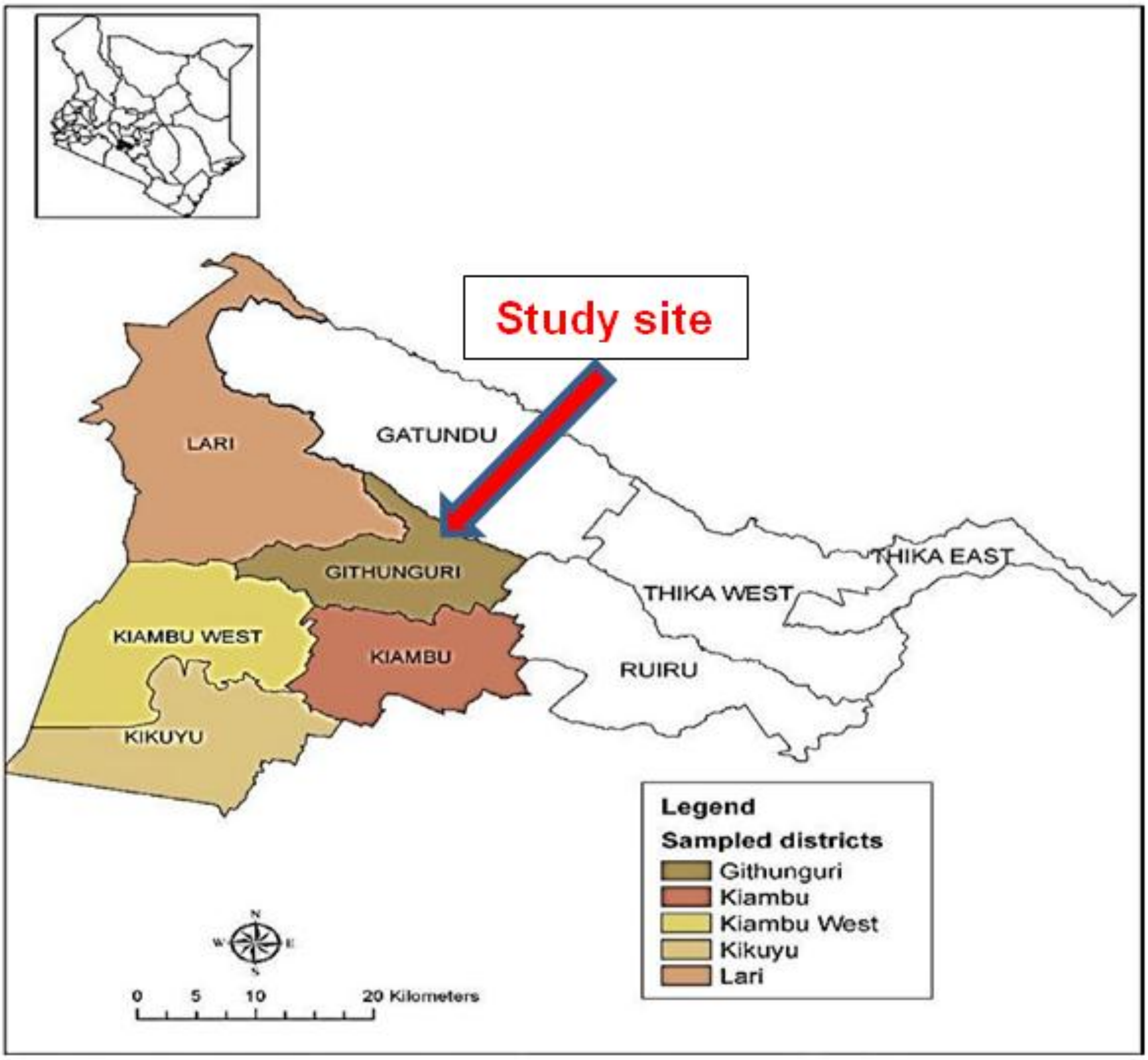


Figure 3.2: Map of Kiambu County **(**Omwenga *et al* 2016)

The county normally has bi-modal kind of rainfall with the long rains occuring between Mid-March to May thereafter, there is a cold season typically with drizzles and frostiness in June to August and the short rains between Mid-October to November. The yearly precipitation fluctuates with altitude, with higher zones getting as high as 2,000 mm and lower zones of Thika Town constituency getting as low as 600 mm. The average rainfall received by the county is 1,200 mm.

The average temperature in the county is 26^{o} C with temperatures oscillating between 7^{o}C in the higher regions Limuru and certain parts of Gatundu North, Gatundu South, Githunguri and Kabete constituencies, and 34^{0}C in the lower midland zone occurring partially in Thika Town constituency (Gatuanyaga), Kikuyu, Limuru and Kabete constituencies (Ndeiya and Karai). The average land size is around 0.36 Ha on smallholding and 69.5 Ha on largeholding. Agriculture is the principal source of income in the county and contributes 17.4% of the county's population revenue. Coffee and tea are the main cash crops in the county. The leading food crops cultivated in the county include: maize, beans, pineapples and irish potatoes, which are predominantly grown by smallholder growers.

3.2.3 Nairobi

Nairobi County borders Kiambu County to the North and West, Kajiado to the South and Machakos to the East. The County has an overall area of 696.1 km^2 and is situated between longitudes 36^{o} 45' East and latitudes 1^{o} 18' South (Figure 3-3). It lies at an altitude of 1,798 metres above sea level. Nairobi County has a generally cool climate owing to its high altitude. Temperature fluctuate from a low of 10^{0}C to a high of 29^{0}C. It has a bi-modal precipitation pattern. The long rains season occurs between March and May having an average rainfall of 899 mm on the other hand the short rains season occur between October and December with an average rainfall of 638 mm. The mean annual rainfall is 786.5 mm. Based on 2009 census Nairobi has a total population of 3,134,265. The study was restricted to Embakasi Sub-County within the Umoja Residential Estate (Figure 3.3).

Umoja estate is a middle income residential area. Many of the houses were at the beginning owner-occupied, but this has shifted as most resorted to letting them out. Others demolished the houses and built flats. The average asking rental price is about Sh20, 000 per month for the standalone houses. The servant's quarters go for about Sh5, 000. One bedroom apartments are about Ksh10,000 and Ksh15,000 for two bedroom apartments.

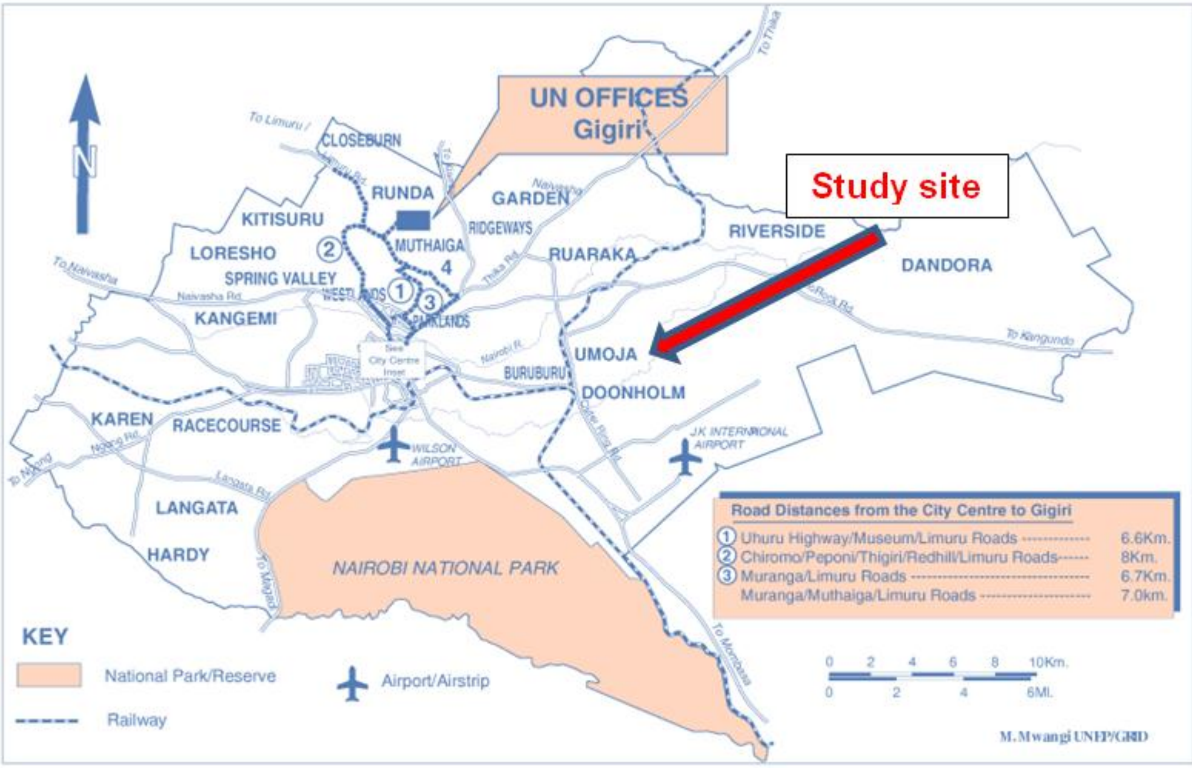


Figure 3.3: Map of Nairobi County (UN-Habitat – www. unhabitat.org)

There are about 150,000 people residing in Umoja I alone according to the National Population Census of the year 2009. Maize remains to be the key staple food in Nairobi based on the kilograms consumed per adult equivalent. Muyanga *et al* (2004) established that upto 97% of the middle income people in Nairobi used maize related products (maize meal, grain or green maize) on regular basis.

CHAPTER 4

RESEARCH METHODOLOGY

4.1. Research Design

A household survey design was used in this study. The respondents (N= 120) were drawn from 3 counties: Kiambu, Moiben & Nairobi. Data on individual perceptions towards GM maize was generated from self – completion questionnaires that were administered.

4.2. Study Population

In order to provide sub-national assessment of public perception about the production and consumption of GM maize, the study population included two clusters: farmers and consumers. The farmers were interviewed from two maize farming zones, Githunguri ward (Kiambu County) and Moiben ward (Uasin Gishu County). The population of Githunguri ward and Moiben ward is 36,378 and 25,774 people respectively.(2009 Housing and population census) The former represented small scale maize growers while the latter represented the large scale producers. The consumers on the other hand were interviewed from a stand-alone livelihood cluster zone in Umoja 1 ward (Nairobi County). The population in Umoja 1 ward is 50,739 people.(2009 Housing and population census).

3.5. Sampling strategy

In an ideal situation one would like to study the whole population. However, in most cases it is not possible or not feasible to do this and therefore one is necessitated to go for a sample. According to Black and Champion (1976), a sample is a portion of elements taken from a population that is deliberated to be representative of the population. Cochran (1977) tackled this subject of representation by affirming that "One method of defining sample size is to stipulate margins of error for the items that are regarded as most critical to the study. An estimate of the sample size required is first made separately for each of these key items. When these calculations are finalised, researchers will have a range of n's, typically ranging from smaller n's for scaled, continuous variables, to larger n's for dichotomous or categorical variables. More frequently, there is an adequate variation among the n's so that we are hesitant to choose the largest, either from budgetary concerns or because this will give an over-all standard of precision significantly higher than originally intended. In this event, the preferred standard of precision may be relaxed for some of the items, so as to allow the use of a smaller value of n (Cochran, 1977).

To determine the correct sample size for continuous data (unknown population) at 95% confidence, with value of the selected $\underline{\alpha}$=.025 being 1.96 and margin of error of .03, Cochran's sample table for population size more than 10,000 yielded a sample size of 119; rounded off to 120 for purposes of convenience in allocation.

Since the study involved household survey, determining the households to be selected was informed by the 2009 Population and Housing Census in Kenya (KNBS NASSEP IV Sampling Manual, 2009). In each strata, representative enumeration areas (EAs) were randomly selected from a list of all EAs using a simple random sampling method. Each enumeration area has 150 households (KNBS NASSEP IV Sampling Manual, 2009). In order to reduce the sample ratio to population, 10 households were selected for interviews in each EA. This is important because it reduces cluster variability (United Nations Statistics Manual, 2005). According to KNBS Housing and Population Census (2009), Umoja 1 has approximately 15,000 households which is about 100 EAs. Githunguri and Moiben each has approximately 7000 households which is about 47 households whereas. Therefore, the sample was distributed according to the ratio of the number of enumeration areas. In Umoja 1, 6 EAs were randomly selected, while in both Githunguri and Moiben, 3 EAs each were selected. The distribution of the sample size is presented in Table 3.1.

Table 3.1: Sample distribution across regions (clusters)

Region	Sample size	Clusters of the respondents
Umoja 1 (Nairobi County)	60	Maize consumers
Moiben (Uasin Gishu County)	30	Maize farmers
Githunguri (Kiambu County)	30	Maize farmers
Total	**120**	

3.6. Data collection

Data collection was commenced by the use of a semi-structured questionnaire administered through informed adult consent with the household as the basic sampling unit. The standard questionnaire was structured in accordance with the Likert Scale whereby the respondents were given a choice of five pre-coded answers with the neutral point being neither agree nor disagree (Joshi *et al* 2015). The questionnaire was structured to enable the assessment of the level of public acceptance and public views on maize related biotechnology including GM maize in relation to biodiversity conservation and biosafety, public health and religious ethics.

i) Interviews

Five field interviewers were selected and they were trained on the objectives of the project and the methodology of fieldwork. It was a directive that during fieldwork, each interviewer was to identify a land mark from the sampling point and skip 10 households in urban and 5 households in the rural as directed by KNBS NASSEP IV methodology. Since the questionnaire was short, each interviewer was expected to conduct 10 interviews daily. With the help of an additional hand, the supervision was very strict to ensure that the interviewers observed all research ethics as required. Every evening, the questionnaires were collected from the interviewers and challenges discussed. One of the key challenges that came out was that majority of the respondents did not have strong prior knowledge of GM maize. However, the interviewers made sufficient effort to explain the GM concept before the field questionnaire was administered. However, the state of ignorance resulted to several skip routines in search of relevant respondents. A total of 120 questionnaires were collected from the field which translated to a 100% response rate.

ii) Questionnaire

The primary data collection was undertaken through the use of a self-administered questionnaire in accordance with Orodho (2004). The general configuration of the questionnaire included a preliminary section on the respondents profile (Appendix 1). The other three sections focused on assessing the respondents' views and perception on:-

- The role / importance of biotechnology on food security
- Environmental implication of biotechnology
- Public health and religious concerns on the introduction of maize related agro biotech in Kenya

The questionnaire was structures in accordance with the Likert Scale whereby the respondents were given a choice of five pre-coded answers with the neutral point being neither agree nor disagree. The Likert Scale is a psychometric response scale which is predominantly used in questionnaires to acquire participant's inclinations or level of agreement with a statement or set of statements. Likert scales are a non-comparative scaling technique and are unidimensional (only measure a single trait) in nature. Respondents are asked to specify their degree of agreement with a specified statement by way of an ordinal scale. The Likert Scale was used in the study in order to allow the individual to demonstrate the level of agreement or disagreement with various statements concerning the adoption of GM maize.

3.8. Data analysis

Once the questionnaires were collected from field, they were cross-checked and screened for missing information especially on the demographics section. Data coding then followed on certain sections of the demographics (occupation, religion, Home County) and the additional comments on food security, environmental implications and public health. Here, responses were allotted certain numerical codes to be entered into the statistical software and also for purposes of uniformity and time saving during data entry. All the data were entered using CSPro software which is best for data entry because it allows for skips and lock of certain values outside the scope of coding. The data was then exported to SPSS for ease of data cleaning and analysis. Data cleaning was done through checking of missing information, wrongly entered codes and joining similar responses. The scales that were used for food security, environment and health were then tested for validity and internal consistency (reliability) using Cronbach's alpha. The Cronbach's alpha (α) generated from IBM SPSS 20 for the overall scale was 0.759 while the Cronbach's alpha for various subscales for the following perceptions were also measured; food security (0.750), environmental concerns & biodiversity (0.731) and public health concerns (0.760). This indicated a good internal consistency of the data collection instrument. According to Cronbach (1951), an alpha (α) in the range $0.7 \leq \alpha < 0.9$ indicates good internal consistency of the data collection instrument.

The data analysis was undertaken using basic summary statistics means, frequencies, and standard deviation. Descriptive data was analysed in the initial phase using frequencies and cross tabulations.

Non-parametric tests - Mann U Whitney test was used to test the hypotheses. Non parametric tests assume that data do not follow normal distribution. The dependent variable was subjected to Shapiro- Wilk tests to check the normality. The results at 95% confidence showed that the data did not follow a normal distribution. Therefore to compare the differences of any two of the independent variable (consumers, small scale and large-scale growers), a non-parametric test was most appropriate. A Mann – Whitney U test employed to compare differences between two independent groups when the dependent variable is ordinal or continuous but not normally distributed. For this study, the data was continuous but not normally distributed. As such, only median could be used as a central tendency measure statistic; which made Mann-Whitney U test most appropriate for testing the difference in any two of the three independent variable.

CHAPTER 5

RESULTS AND DISCUSSION

5.1. Introduction

This chapter presents the study findings whose main objective was to establish the public's perception towards the application of biotechnology for food security in Kenya in response to the growing food demand. The study also sought to assess whether the public have any fears on the negative environmental implications on national biodiversity conservation and biosafety. The third objective of the study was to evaluate whether the public have any religious or public health concerns on the introduction of maize related agro biotech in Kenya.

5.1.1 Response rate

The study targeted a sample of 120 respondents and a total of 120 questionnaires were filled giving a response rate of 100%. This response rate was quite representative, since it adapts to Mugenda and Mugenda (1999) view that a response rate of 50% is satisfactory for analysis and reporting; a 60% response is rated as good, while a response rate of 70% and above is rated as excellent.

5.1.2 Data reliability

Cronbach's alpha was used to measure internal consistency of the data collected. Since each participant was viewed as independent from all others, Cronbach's alpha was calculated for the overall scale and the sub scales. The Cronbach's alpha (α) generated for the overall scale was 0.759 while the Cronbach's alpha for various subscales for the various perception were also measured as follows; food security (0.750), environmental concerns & biodiversity (0.731) and public health concerns (0.760). This statistics indicated a good internal consistency of the data collection instrument. According to Cronbach (1951), an alpha (α) in the range $0.7 \leq \alpha < 0.9$ indicates good internal consistency of the data collection instrument.

5.2. Respondents Demographic Profile

The demographic profiles of the respondents were analysed using descriptive methods including frequencies and cross tabulations. The profiles were segmented as shown in Table 5.1. The specific characteristics for the respondents are highlighted below.

Table 5.1: Breakdown of key demographic characteristics of the respondents

		Study area		
		Moiben	**Githunguri**	**Umoja 1**
Sample size (n)		**30**	**30**	**60**
Age	18-24	0%	7%	20%
	25-34	7%	20%	45%
	35-44	27%	33%	23%
	45-54	30%	20%	8%
	55-64	13%	13%	3%
	65+	23%	7%	%
Gender	Male	60%	70%	53%
	Female	40%	30%	47%
Level of education	Informal	7%		
	Primary		20%	
	Secondary	40%	60%	25%
	Tertiary	53%	20%	75%

5.2.1 Age and Gender

Table 5.1 below shows the breakdown of the key demographic characteristics; age, gender and highest level of education. The sample consisted of 59.2% of the males and 40.8% females. Majority of the respondents consisted of the youth between the ages 25-34 years (29%; 35/120) followed by those between the ages 35-44 years (27%; 32/120). The study results of Table 4.1 indicates that there is a slight similarity in the distribution of respondents' ages across the respondents surveyed in Moiben and Githunguri, perhaps due to the fact that these regions consisted many farmers. The respondents surveyed in Umoja 1 however, consisted of those below 65 years old with an overwhelming majority (45%; 27/60) indicating that they were between 25-34 years. According to the 2009 housing and census data, about 63% of the population in Umoja 1 are between the ages 18-64 years, with only 2% having 65 years and above (KNHBS, 2010). This age variation in composition is perhaps due to low income and the compelling high cost of living around the urban area which only favours young and energetic population.

5.2.2 Education

The Government of Kenya is devoted to the delivery of quality education and training for all Kenyans in harmony with the constitution and international conventions such as the Education for All (EFA) goal, and is developing policies for moving the country in the direction of the realization of this objective. Approximations from Kenya's 2009 Housing and Population Census show that over 85% of Kenyans aged over 15 years can read and write with over 90% of men being literate as paralleled to 80% of women. Illiteracy was established to be more common among the underprivileged, predominantly poor women who constitute 61% of the total illiterate population.

The present research findings indicate that only 2% (2/120) of the total respondents had informal education. Table 5.1 above indicates that these respondents were interviewed in Moiben ward. Majority of those surveyed in Githunguri, however, consisted those with secondary education levels. In Umoja 1, 3 in every 4 respondents surveyed indicated that they had tertiary education. This may be because a bigger portion of the population is engaged in white collar job.

5.2.3 Occupational analysis

Table 5.2 shows that there is a mix of occupations among the respondents. Majority (53%) of the urban respondents in Umoja I was dominated by respondents engaged in small and medium enterprises In the case of the rural areas 50% of the respondents associated themselves with agriculture as their primary occupation with 20% indicating that they also engaged in small and medium enterprises (Table 5.2).

Table 5.2: Respondents' occupational analysis

Primary occupation	**Overall**	**Farmers [Githunguri & Moiben]**	**Non farmers [Umoja 1]**
Agriculture	**26%**	**50%**	2%
Road transport	1%	2%	-
Administrative services	5%	2%	8%
Auxiliary finance and insurance services	2%	-	3%
Student	3%	2%	5%
Teaching	6%	8%	3%
Medical and health care services	3%	2%	5%
Social assistance services	2%	2%	2%
Artistic activities	1%	-	2%
Defense	2%	3%	-
Public services	3%	3%	3%
Computer system design and related services	1%	-	2%
Engineering (Civic, chemical and mechanical)	6%	2%	10%
Religious services	2%	3%	-
Sales and marketing	1%	-	2%
Small and medium enterprises	**37%**	20%	**53%**
Retiree	1%	2%	-
Sample size (n)	**120**	**60**	**60**

5.2.4 Rural Farm size and urban household size

Table 5.3 shows the findings on rural farm size and urban household size respondent characteristics. In Moiben and Githunguri, since all the respondents were farmers, the key point of interest was to determine the farm size as principal maize production factor whereas in Umoja 1, the key focus was on household size as a key maize consumption factor. The large scale farmers in Moiben were found to own very large tracks of land (Mean=211.33 acres, SD=524.76) compared to Githunguri small scale farmers (Mean=1.67 acres, SD=2.07).

Table 5.3: Farm size and household size characteristics

	Area	Mean	Std Dev.	Minimum	Maximum
Farm size (Acres)	Moiben	211.33	524.76	4.0	2,000.0
	Githunguri	1.67	2.07	0.25	8.0
Household size	Umoja 1	3.22	1.52	1	7

The average household size of occupants of Umoja 1 was approximately 3 people per household which is an approximate value of the 2009 housing and population census results. The difference among the maize producers was considered suitable for perception comparative analysis.

5.3. Public perception on GM maize and food security

The respondents were requested to show the extent to which they agree or disagree with statements of public perception on GM and food security items on a 5-point Likert scale. The overall findings by all the respondents considered GM maize as a possible solution to the food insecurity problems in Kenya (Figure 5.1). 69% of the respondents were in agreement that GM maize will play a great role in solving food insecurity in Kenya (Figure 5.1). The respondents were in agreement on need to produce sufficient maize for the increasingly growing population. These respondents viewed the sole cause of food insecurity in the country as associated to the domination of the country by arid and semi-arid areas which are unproductive hence produces insufficient food. However, some of the respondents attributed the food insecurity problem with widespread laziness and believed that GM maize will not be the sole solution. Others believed that the youth’s overreliance on white collar job affects innovation in agricultural sector. The respondents suggested that the government needs to advise farmers on the best modern farming methods while also searching for other safer ways of curbing the issue of food insecurity without necessarily relying on GM maize. Figure 4.1 shows that 65% of all the respondents agreed with the Likert Scale statement that GM maize could improve the profitability of the growers. Up to 60% believed that GM maize will benefit the society by permitting growers to produce food more efficiently.

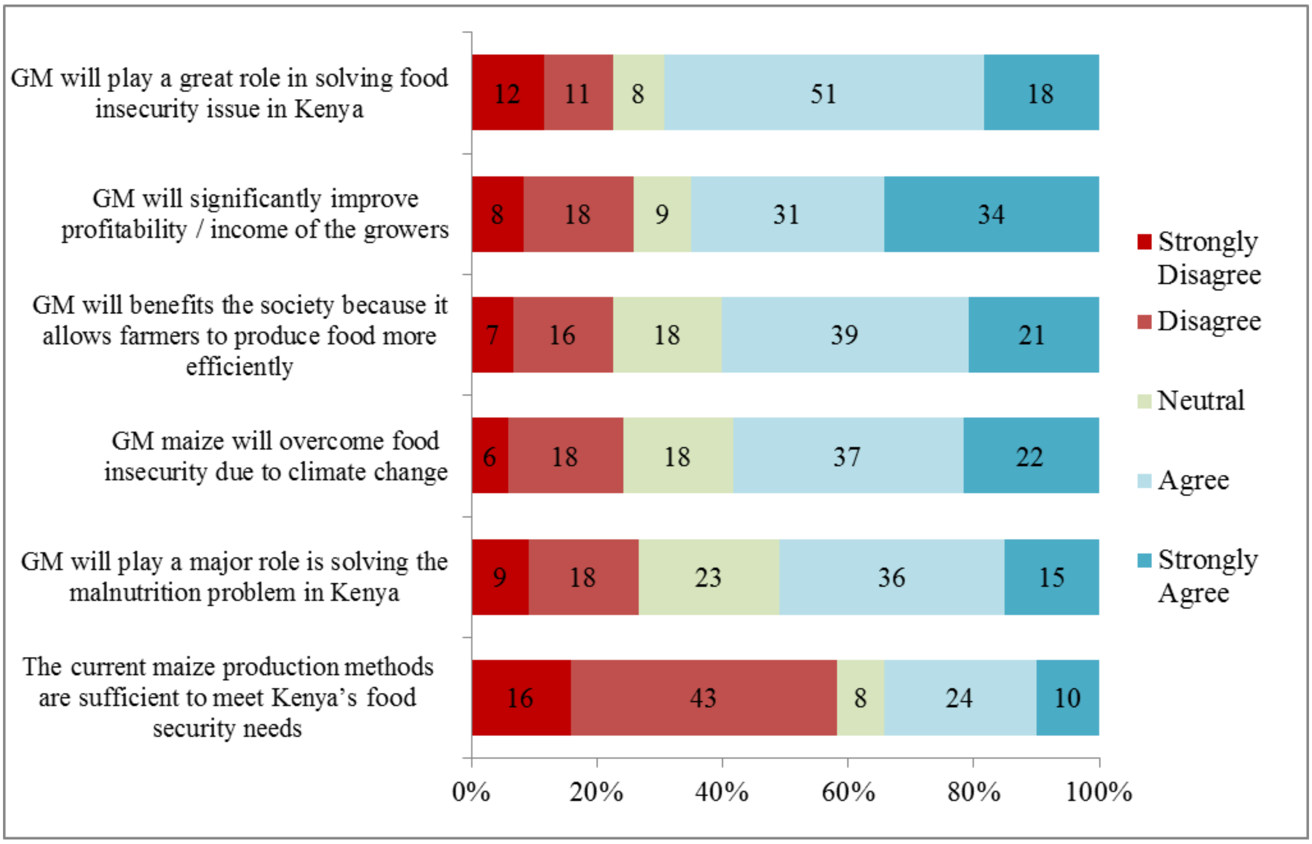


Figure 5.1: Perception towards the role of biotechnology on food security

The statements met mixed reactions from various stakeholders (consumers, small and large holder farmers) surveyed. For instance, the small scale maize farmers from Githunguri believed that GM food campaigns have only focussed on the benefits without unearthing and disclosing the side effects. At the same time, these farmers are optimistic that GM maize will solve the problem of food insecurity stated by more than 73% of the surveyed farmers from the region. The small scale farmers also believe that with GM maize, problems of malnutrition will be solved citing that farmers will greatly improve profitability from growing GM maize as state by 60% and 70% of the respondents respectively. This cluster of farmers is a little hesitant that the current maize production methods are sufficient to meet Kenya's food insecurity needs. However, they warn that in the event that farmers rely on GM maize and it fails, more hunger is more likely to be experienced.

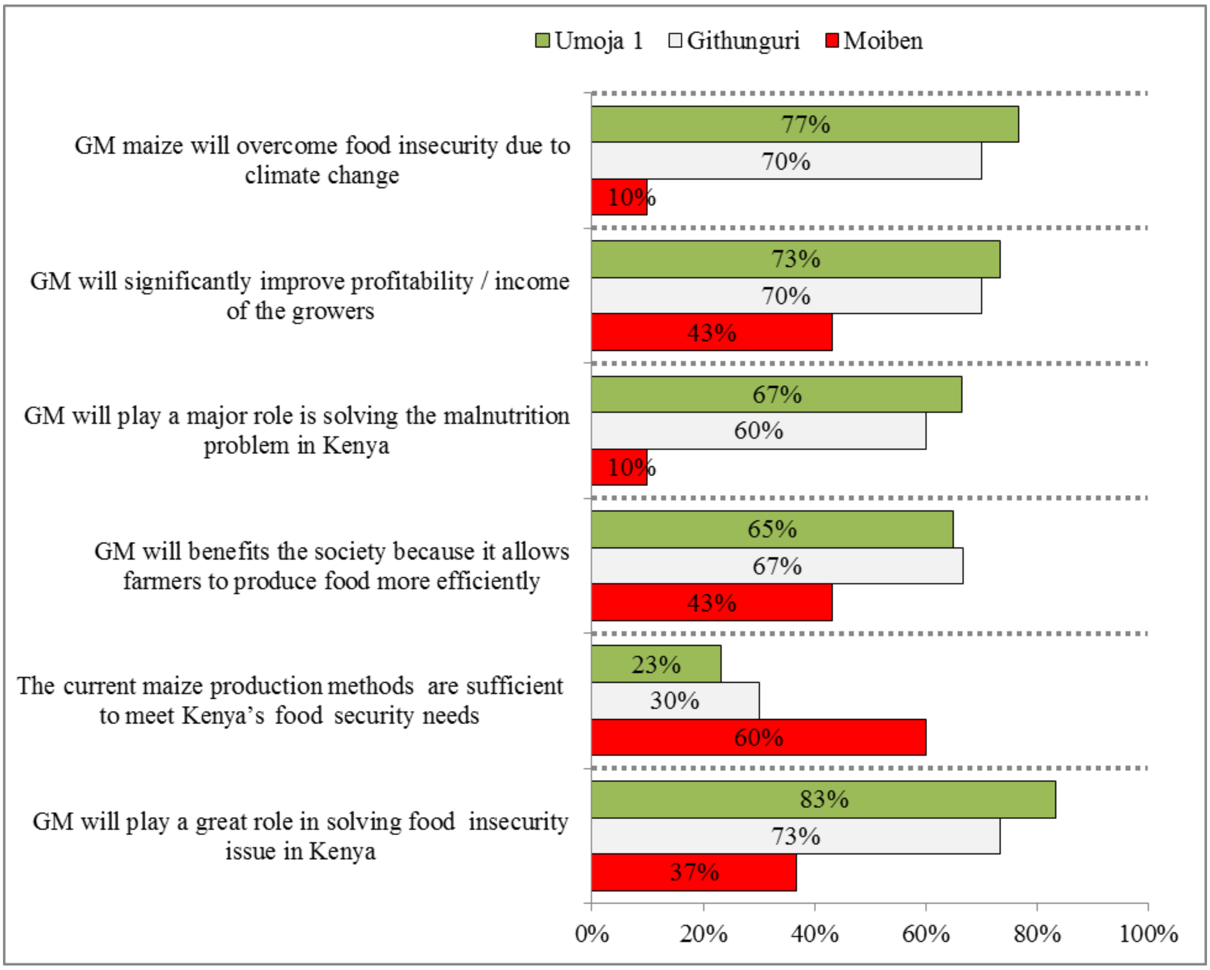


Figure 5.2: Regional analysis of perception towards the role of biotechnology on food security (Agree + Agree strongly)

On the flipside, large scale maize farmers from Moiben who are large scale growers believed that the current maize production approach and technology are sufficient to meet Kenya's food security needs as indicated by 60% of the farmers surveyed from the region. Many of them were hesitant of the fact that GM maize will solve food insecurity and malnutrition problems in Kenya. However, 43% appreciate the fact that GM maize will benefit the society by allowing farmers to produce more and definitely to a certain level solve food insecurity level in the country.

Maize consumers from Umoja 1 showed their optimism and trust in the GM maize. More than 80% indicated that GM maize will help solve food insecurity in Kenya as shown in Figure 5.2. Similarly, more than 60% of the consumers surveyed believe that GM maize allow farmers to produce food more efficiently, improve farmers profitability/income and solve the problem of malnutrition in the country.

Analysing further comments from the consumers revealed that majority of these consumers feel that GM maize is superior and would grow quickly and provide quick earnings thereby resolving the issue of food insecurity in the long run. Some of them also cited that GM maize would require less fertilizer and biocides thereby reducing the production costs which would probably also reduce the cost of maize related products. Some of the consumer respondents however had the view that GM maize will create unnecessary competition with the traditional maize.

5.4. Environmental implications on national biodiversity conservation and biosafety

The respondents were asked to rank the extent they agree or disagree whether GM maize affects the environment especially on national biodiversity conservation and biosafety. The results indicated that 76% of the respondents feared that that the introduction of the GM maize will contaminate the conventional crops through uncontrollable cross-pollination. Similarly, more than 50% of the respondents also agree that introduction of GM maize will cause increased pesticide use which would contaminate the environment.

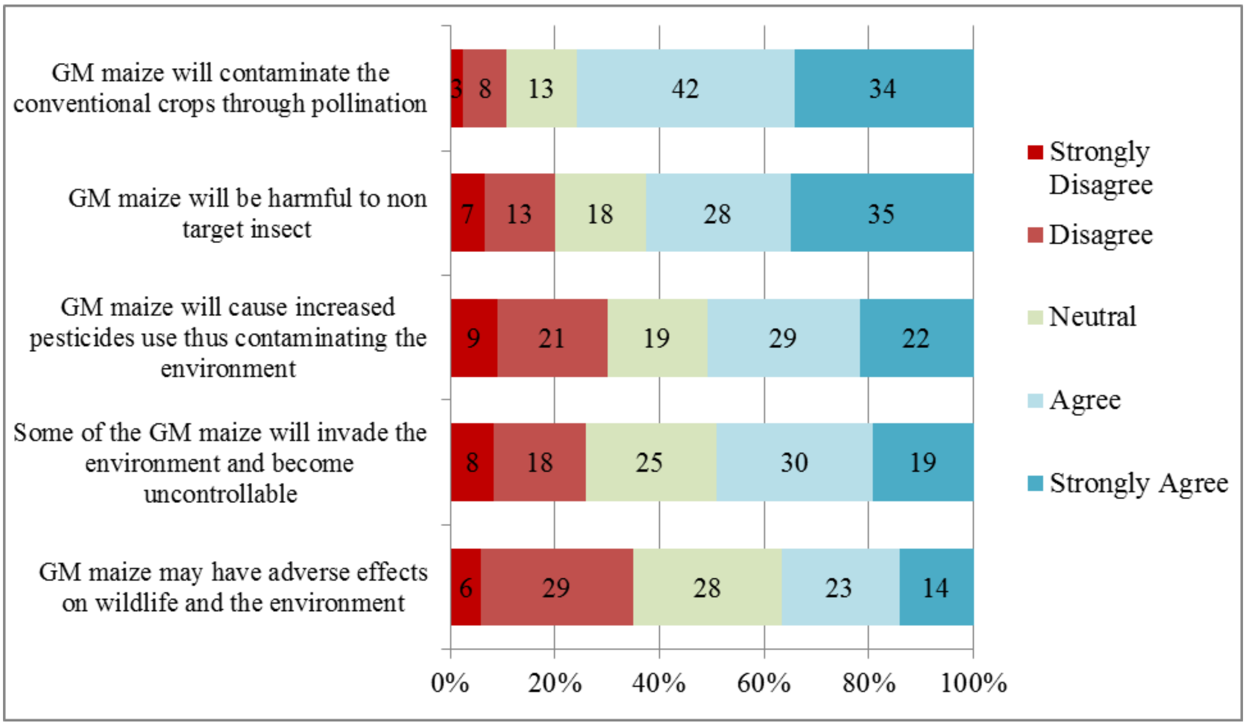


Figure 5.3: Public perception on the environmental implications of GM maize on national biodiversity conservation and biosafety

Small scale farmers from Githunguri believe that in spite of the positive attributes expected from the introduction of GM maize, more than 60% of the GM maize would invade the environment and become uncontrollable with majority (73%) of the surveyed small scale farmers citing GM maize will contaminate the conventional maize through cross pollination.

Just as small holder growers, more than 50% of the large scale growers from Moiben stated that they agree with the fact that GM maize is likely to affect the environment stating that the introduction of GM maize is likely to contaminate the conventional maize through cross pollination. These farmers added their concerns that harmful herbicides sprayed to control GM related maize weeds would kill beneficial insects like bees and decomposers. As such, large scale farmers suggest that additional research on the environmental impact of GM maize is required because this is not known in Kenya. These large scale farmers from Moiben felt that since maize farms will always be fenced, GM maize is likely to have significant effects on wildlife. As majority of the farmers demand for a thorough scientific proof to unearth the real side effects of GM maize on wildlife, some claim that research findings found out that GM maize causes animal ulcers (to livestock).

In equal measure of magnitude of their optimism with GM maize, consumers were open to the expected negative effects of GM maize especially on the fact that GM maize would contaminate the conventional maize through pollination, cited by 83% of the surveyed consumers. Similarly, more than 70% of the consumers are deeply concerned that GM maize may be harmful to non-target insects since they believe that GM maize would increase the use of pesticides which will then be harmful to the environment. The consumers also added other expected effects of GM maize. Some believe that after consuming GM maize, some animals become ill or die adding that since GM maize is artificially made, it has some genes that affect plants, animals and even humans. Some of the consumers surveyed from Umoja 1, who claim that GM maize would create unnecessary competition for water and nutrients with other crops, fear that traditional maize varieties may be lost forever.

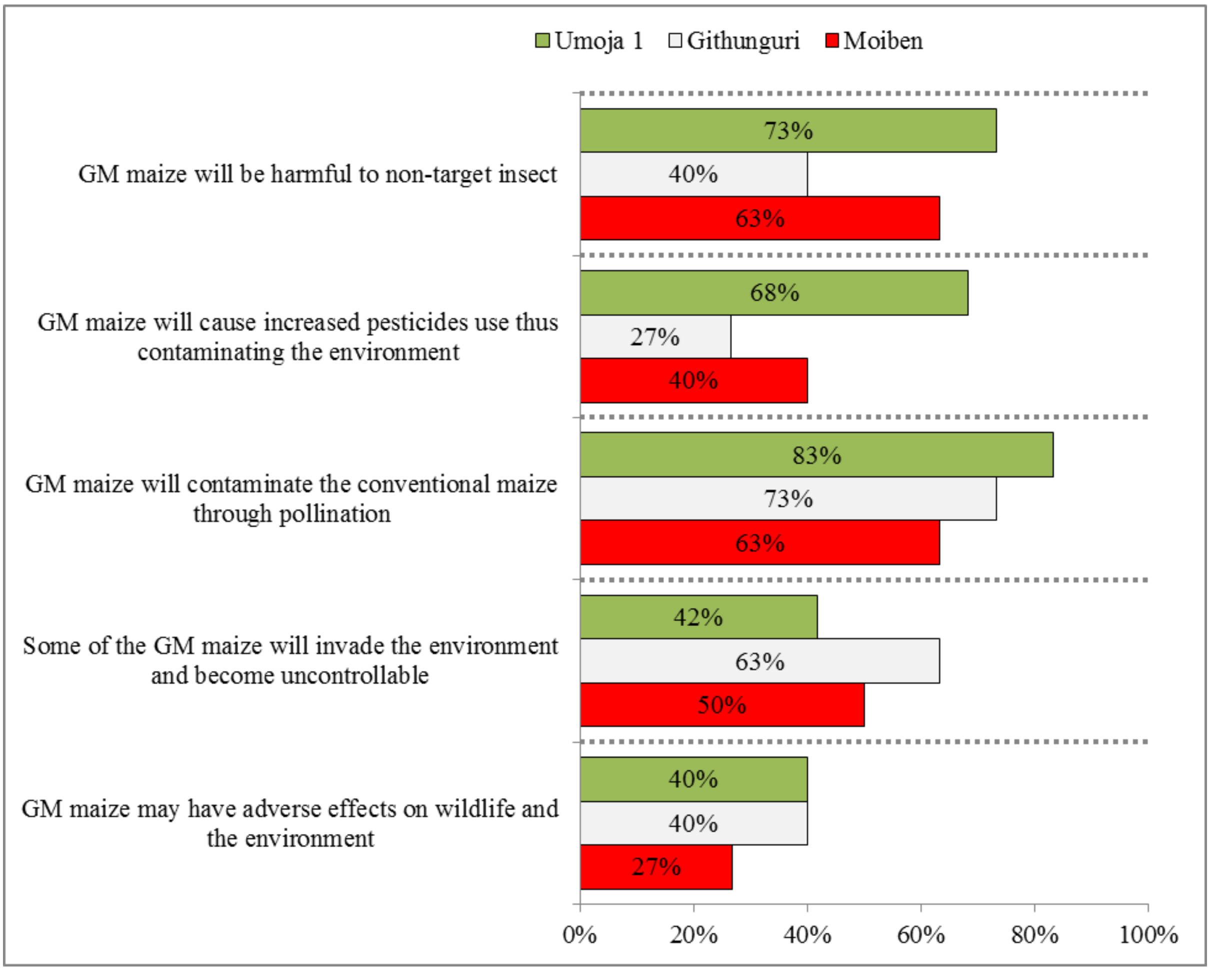


Figure 5.4: Regional analysis of public perception on the environmental implications of GM maize on national biodiversity conservation and biosafety (Agree + Agree Strongly)

Additional probing revealed the following public environmental concerns:-

a) The GM maize will lead to increased invasion of pests such as weevils.

b) The GM maize is likely to affect the quality of dairy milk and bee honey.

c) The GM maize will cause increased use of pesticides thus contaminating the environment. However, some of the consumers believe that GM maize is pest resistant and will require limited use of pesticides which is good for the environment.

d) The GM maize will change the soil structure and mineral composition thereby affecting the production of traditional indigenous maize.

e) The excessive spraying of the GM maize will contaminate rivers

f) The GM maize may lead to desertification.

g) The GM maize may have adverse effects on wildlife.

h) The GM maize will invade the environment and become uncontrollable.

5.5. Public health and religious concerns on GM maize

The key take-out from the survey findings was that GM maize labels need to show the presence of biotech ingredients owing to the fact that consumers need to understand the health risks associated with these maize. On the contrary, about half of the surveyed respondents feel that GM maize has promising benefits, one of which is its high nutritional value even as others feel that GM maize risks undermining God by modifying the ordinary crops.

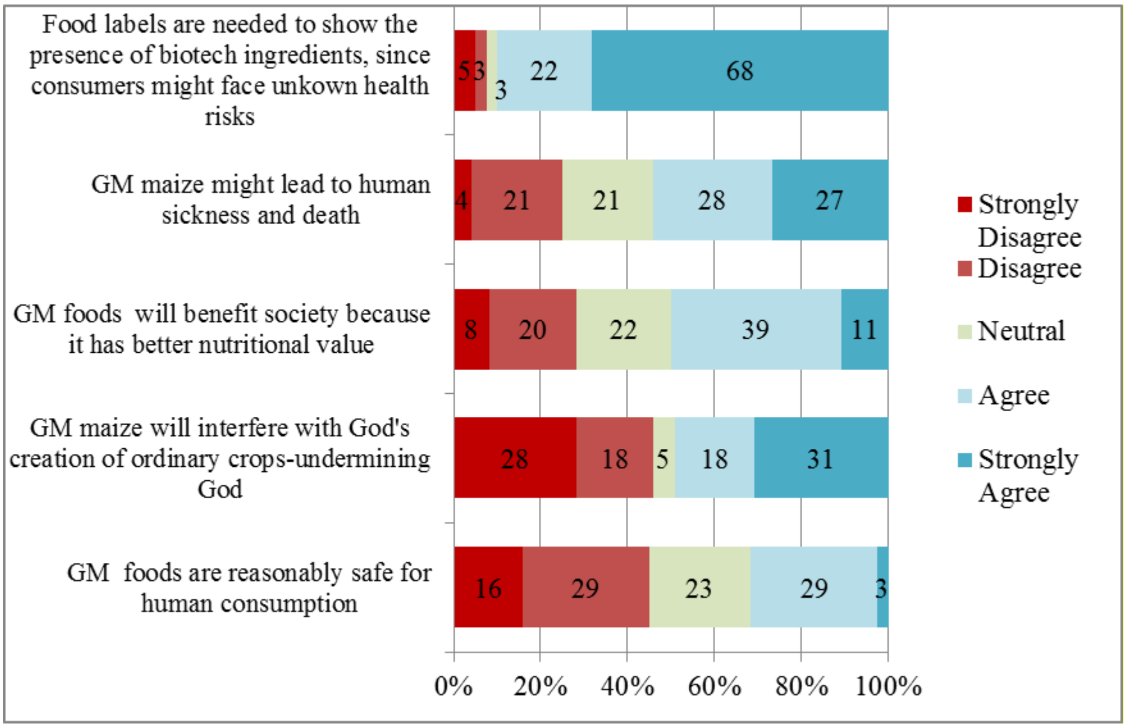


Figure 5.5: Perceived public health concerns on the introduction of maize related agro biotech

Small scale farmers from Githunguri yet again showed their propagating advocate for GM maize stating that GM maize will benefit the society due to its high nutritional values while also stating that GM maize are reasonably safe for human consumption. However, these small scale farmers are part of those campaigning for labelling of GM foods to show the presence of biotech ingredients to expose the level of health risks that these foods have on their consumers.

More than 90% of the consumers posed their concerns about labelling every GM food to show the contents. While many are optimistic that GM maize will solve malnutrition problems due to its nutritional value, 60% of the consumers fear that GM maize might be harmful for human consumption. Above all the, consumers fear that GM food might lead interfere with God's ordinary creation of the crops.

Just as the other respondents, large scale farmers from Moiben expressed their wish for labelling GM foods. Moreover, majority of these farmers (50%) feel that GM foods aren't good for human consumption. The most outstanding negative perception towards GM maize in the large scale growers sector is that GM maize is likely to interfere with God's creation of ordinary crops cited by 67% of the respondents. Only 23% of large scale growers believe that GM foods will benefit the society due to better nutritional value.

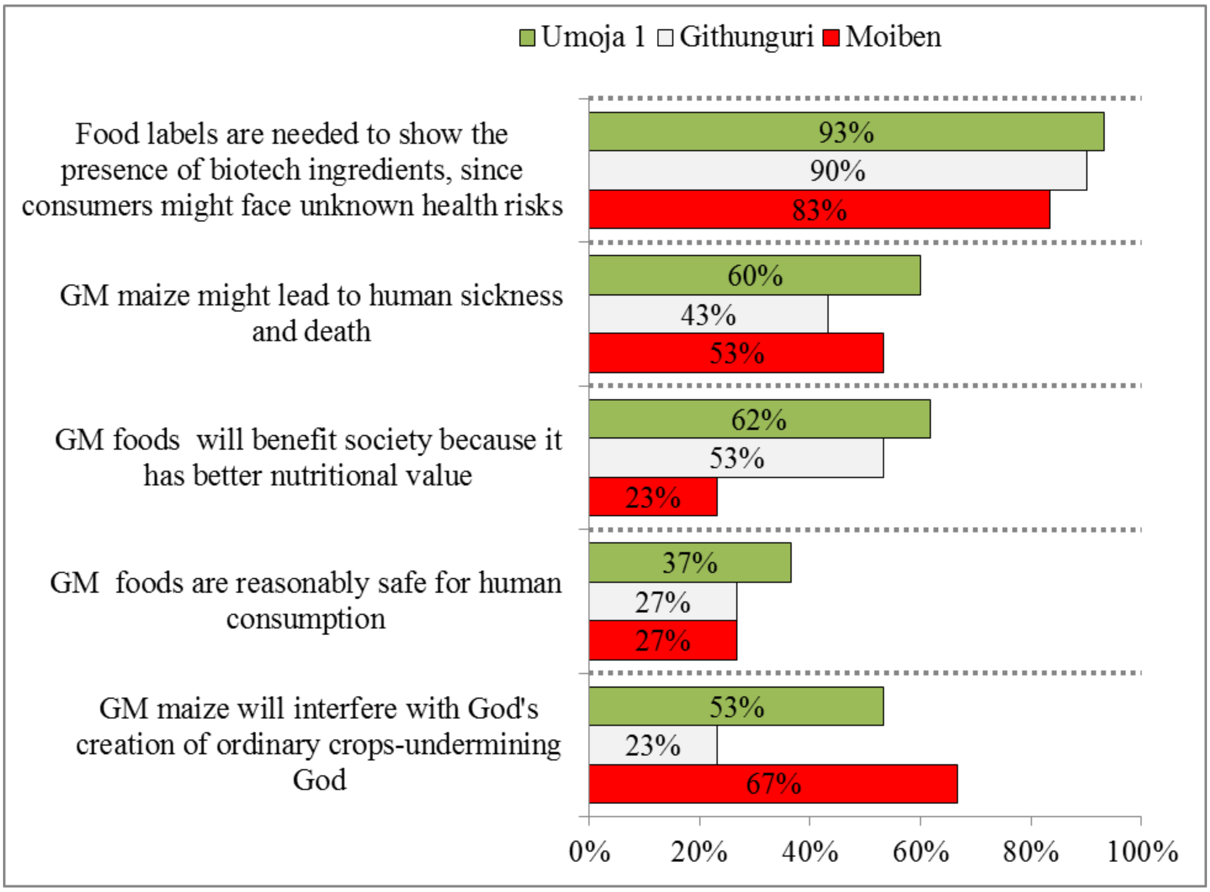


Figure 5.6: Regional analysis of perceived public health concerns on the introduction of maize related agro biotech (Agree +Agree Strongly)

Additional probing revealed the following public environmental concerns:

a) There is need to increase health awareness campaign on GM maize with some calling for in-depth research on the impact of GM maize on human health.
b) GM maize has a lot of nutrients that lack in traditional maize. On the flipside, some of the consumers raised deep concerns about GM foods stating that GM food accelerates aging of individuals, it may lead to a physically weak generation and that GM maize may cause allergic reactions to some people.
c) There were claims that GM maize may make people to be resistant to drugs with others suggesting that due to many demerits than merits, we
d) While others feel that GM interferes with God's creation, some consumers believe that GM is just human improvements of what God already created and as such does not interfere with God's creation at all.
e) Other respondents believe that GM maize being hybrid maize is not harmful to humans at all with others claiming that no reports of serious effects have been received from other countries that use GM maize.

5.6. Preferred alternative instead of introduction of GM foods

The respondents were asked to give out alternative to be resorted to instead of introducing GM foods. They were presented with 7 alternatives in the order of inclination with 1 being the most favoured and 7 the least preferred. The results of figure 5.6 indicates that the option with the highest number of 1 is the most preferred while the one with highest number of 7 considered as the least preferred. The respondents felt that key focus points should be expansion of agricultural lands including irrigating arid areas, advocating for soil and water preservation, use of better-quality plant varieties and the use of biological fertilizers as measures replacing GM foods.

However, on the flipside, due to great concerns about the side effects of GM foods, most respondents felt that the use of biotechnology on other crops and not maize would solve the problem of replacing GM maize. The other method that respondents felt least comfortable with was the option of importing food from other countries. Lastly, the respondents showed that another option that would be considered is the use of improved pest control methods but it is not a method that many would prefer. The ranking of options that would replace GM foods is shown in Figure

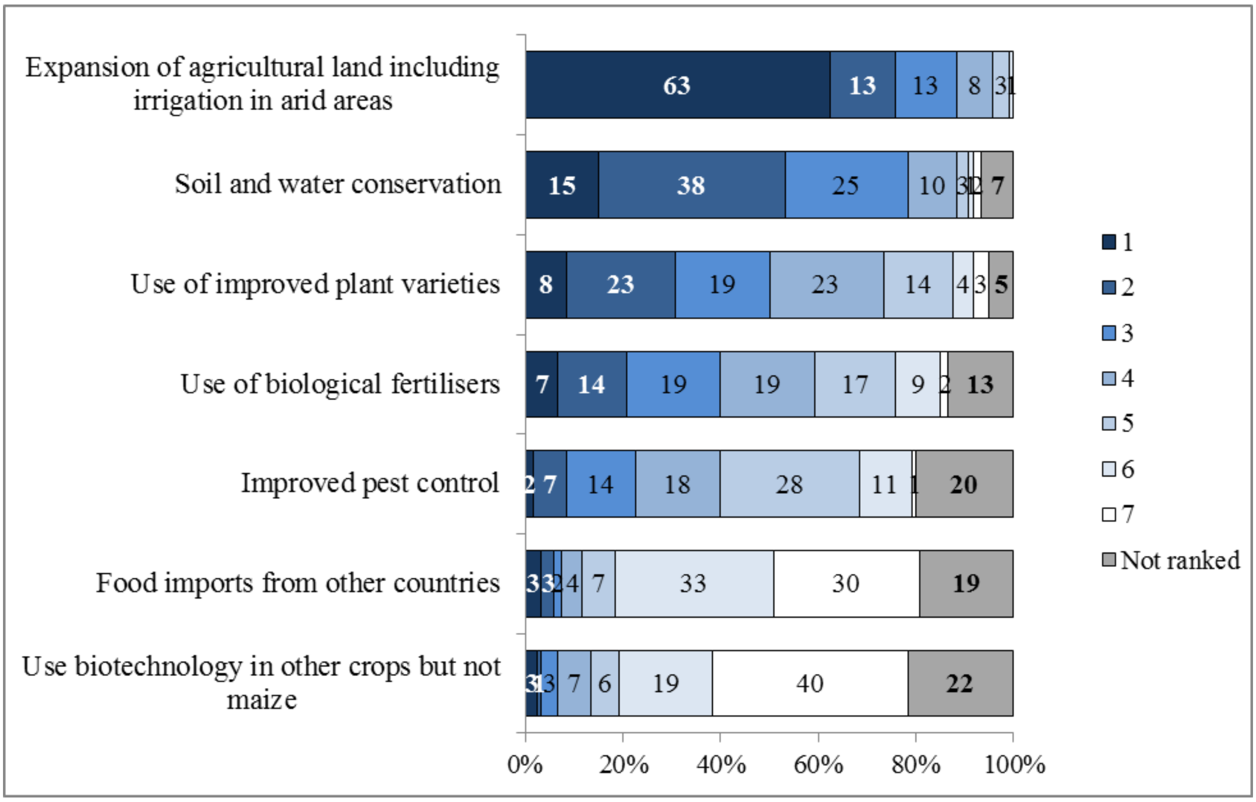


Figure 5.7: Rank of suggested alternatives to GM foods

5.7. Test of hypotheses

The four hypotheses that were to be test included:

i. There is a public perception that GM maize may not play a great role in solving the food insecurity issue in Kenya

ii. There is a public perception that GM maize may not have adverse effects on the environment

iii. There is a public perception that GM maize may not lead to human sickness and death

iv. There is a public perception that GM maize may not interfere with God's creation of ordinary crops-undermining God

To understand the hypotheses above, non-parametric test using Mann U Whitney test was used. This is because the test variables were ordinal in nature.

Hypothesis 1: *There is a public perception that GM maize will not play a great role in solving food insecurity issue in Kenya*

The results of Table 5.1 indicates that there is a statistically significant difference in perception that GM maize will solve food insecurity between small scale farmers and large scale farmers at 95% confidence (W=712.5, Z=-3.12, p<.005). Similarly, there was a significant difference in perception of the same between large scale farmers and consumers

(W=939, Z=-3.921, p<.005). Finally, the difference between small scale farmers and consumers over the fact that GM maize would help in solving food insecurity in the country was not significant at 95% confidence. This implies that while both small scale farmers and consumers are optimistic that GM maize will solve food insecurity in the country, their counterpart large scale maize producers warn that introducing GM maize would not solve food insecurity in Kenya. Since the 69% agree and 23% disagree that introduction of GM GM maize into the country will improve food security, the hypothesis that there is public perception that GM maize will not play a great role in solving food insecurity issue in Kenya is rejected at 95% confidence. It can therefore be concluded that there is sufficient evidence that the introduction of GM maize will help solve food insecurity in the country.

Table 5.4: Mann Whitney U test on perception differences between groups (small scale farmers, large scale farmers and consumers) on the public perception that GM maize will solve food insecurity in the country

Test variable 1	Test variable 2	Mann-Whitney U	Wilcoxon W	Z	p-value
Small scale farmers	Large scale farmers	247.5	712.5	-3.12	0.002
Large scale farmers	Consumers	474	939	-3.921	0.001
Small scale farmers	Consumers	828	1293	-0.695	0.487

Hypothesis 2: *There is a public perception that GM maize may not have adverse effects on the environment*

The results of Table 5.2 indicates that there is no statistically significant difference in perception that GM maize will solve food insecurity between: small scale farmers and large scale farmers (W=907, Z=-.122, p>.005), large scale farmers and consumers (W=1304.5, Z=-.538, p>.005) and small scale farmers and consumers (W=1308.5, Z=-.497, p>.005) at 95% confidence. Since only about 37% of the respondents agree while 35% disagree that GM maize may have adverse effects on wildlife and the environment, a difference of 2% which is insignificant (within the margin of error of 3%). The hypothesis that there is a public perception that GM maize may not have severe effects on wildlife and the environment is therefore accepted at 95% confidence. The results therefore indicate that there is no sufficient proof to conclude that there is a public perception that GM maize may have adverse effects on the environment.

Table 5.5: Mann Whitney U test on perception differences between groups (small scale farmers, large scale farmers and consumers) on the public perception that GM maize may have adverse effects on the environment

Test variable 1	Test variable 2	Mann-Whitney U	Wilcoxon W	Z	p-value
Small scale farmers	Large scale farmers	442	907	-0.122	0.903
Large scale farmers	Consumers	839.5	1304.5	-0.538	0.591
Small scale farmers	Consumers	843.5	1308.5	-0.497	0.619

Hypothesis 3: *There is a public perception that GM maize might not lead to human sickness and death*

The results of Table 5.3 indicates that there is no statistically significant difference in perception that GM maize might lead to human sickness and death between: small scale farmers and large scale farmers (W=866, Z=-.746, p>.005), large scale farmers and consumers (W=1235, Z=-1.151, p>.005) and small scale farmers and consumers (W=1181, Z=-1.624, p>.005) at 95% confidence. Since 56% of the respondents agree while only 25% disagree that GM maize might not lead to human sickness and death, a difference of 31% which is very significant (far much more than the margin of error of 3%). The hypothesis that GM maize might not lead to human sickness and death is therefore accepted at 95% confidence. The results therefore indicate that there is sufficient proof to conclude that there is a public perception that GM maize might lead to human sickness and death.

Table 5.6: Mann Whitney U test on perception differences between groups (small scale farmers, large scale farmers and consumers) on the public perception that GM maize might not lead to human sickness and death

Test variable 1	Test variable 2	Mann-Whitney U	Wilcoxon W	Z	p-value

Test variable 1	Test variable 2	Mann-Whitney U	Wilcoxon W	Z	p-value
Small scale farmers	Large scale farmers	401	866	-0.746	0.456
Large scale farmers	Consumers	770	1235	-1.151	0.25
Small scale farmers	Consumers	716	1181	-1.624	0.104

Hypothesis 4: *There is a public perception that GM maize may not interfere with God's creation of ordinary crops-undermining God*

The results of Table 5.4 indicates that there is a statistically significant difference in perception that GM maize will interfere with God's creation of ordinary crops-undermining God between: small scale farmers and large scale farmers (W=661, Z=-.3.928, p<.005), large scale farmers and consumers (W=2527, Z=-1.794, p>.005) and small scale farmers and consumers (W=1014.5, Z=-3.113, p<.005) at 95% confidence. Due to mixed perceptions among the respondent groups it is necessary to check the actual descriptive scores. It is realised that 49% agree while 46% disagree that GM maize will interfere with God's creation of ordinary crops-undermining God, which is a difference of 3%, insignificant. Therefore, the hypothesis that GM maize will not interfere with God's creation of ordinary crops-undermining God is accepted at 95% confidence. The results therefore indicate that there is no sufficient proof to conclude that there is a public perception that GM maize will interfere with God's creation of ordinary crops-undermining God between.

Table 5.7: Mann Whitney U test on perception differences between groups (small scale farmers, large scale farmers and consumers) on the public perception that GM maize may not interfere with God's creation of ordinary crops-undermining God

Test variable 1	Test variable 2	Mann-Whitney U	Wilcoxon W	Z	p-value
Small scale farmers	Large scale farmers	196.0	661.0	-3.928	0.001

Test variable 1	Test variable 2	Mann-Whitney U	Wilcoxon W	Z	p-value
Large scale farmers	Consumers	697.5	2527.5	-1.794	0.073
Small scale farmers	Consumers	549.5	1014.5	-3.113	0.002

5.8. Discussion

5.8.1. Public perception on GM maize and food security

The findings in this study showed that majority (69%) of the respondents considered the introduction of GM maize as a possible solution to the food insecurity problems in Kenya. This finding is similar to the study conducted in Kenya by Kimenju *et al* (2005), in which most people believed that the adoption of the GM technology would have positive impacts, with above than 80% approving that it can offer an answer to the world's food production hitches. Similarly, the study conducted by Anunda (2009) showed that majority (79%) of the respondents from all the four clusters (consumers, farmers, academia and scientists) believed that the introduction of GM drought tolerant beans in arid areas of Kenya was desirable.

Anunda (2009) asked the respondents if genetically modified crops (GMCs) will improve yields and offer an answer to Kenya's food issue, 50% of the respondents felt that GMCs could improve yields which portrayed some level of public confidence with GM crops performance. In this study when we asked respondents if they believe growing GM maize will significantly improve profitability / income of growers , 65% of them were positive about it which was quite similar to the findings by Anunda (2009).

In an opinion survey conducted by Ombewa and Otunge (2012) on awareness and perceptions of agricultural biotechnology by the Seed Traders Association of Kenya (STAK) members, the study sought to know whether the respondents would be willing to produce, package and sell genetically modified crops. 100% of the respondents indicated that they would be willing, implying that they are aware of the benefits of biotechnology crops.

In the 2010 Eurobarometer which is a sequence of public opinion surveys carried out frequently on behalf of the European Commission, 53% of respondents in Europe expected biotechnology and genetic engineering to have a positive effect in twenty years, while 11% expected no effect, and only 20% expected a negative effect. Although this is not directly linked to food security there is an overall agreement that biotechnology will have a positive impact.

5.8.2. Environmental implications of biotechnology on national biodiversity conservation and biosafety

Findings from this study established there are various public environmental concerns that the introduction of GM maize is likely to contaminate the conventional crops through pollination as suggested by 76% of the surveyed respondents. The study by Kimenju *et al* (2005), established that 51% of the respondents were of the opinion that the introduction of GM crops would lead to loss of original plant varieties while 40% were of a contrary opinion.

More than 6 in every 10 respondents in this study believed that the introduction of GM maize will be harmful to non-target insects. The level of public environmental concern in this study was therefore is slightly above a study conducted by Anunda (2009), where respondents were asked if ‘Genetically Modified crops that are insect resistant might lead to death of beneficial insects/non-pests and other non-targeted insects such as bee’s or even birds.’ The responses showed that a significant number (47%) of respondents disagreed that GMCs that are insect resistant may be detrimental to birds and bees with only 38% agreeing while 15% were undecided.

There was substantial public environmental concern in this study about the possible contamination of traditional crops through cross-pollination with GM maize. Scientific studies have shown that best way of preventing cross-pollination between adjacent non-GM and GM crop fields is probably by maintaining sufficient distance between the two or engaging in human-pollination of GM crop under controlled conditions which is feasible. The application of GM buffer zones might be difficult in Kenya where small scale farmers' seldom have any land to spare. There is a significant likelihood that the risks of non-GM contamination by GM crop will obviously come with numerous controversies and court cases in Kenya and the Biosafety Act does not appear to have adequate legal mechanisms to deal with these issues especially the livelihood damages on the emerging organic farmers whose model will almost be rendered impossible.

5.8.3. Public health and religious concerns on the introduction GM maize

In this study, 32% of the respondents agreed that GM foods are reasonably safe for human consumption. This was similar to the study conducted in USA on public perceptions of labeling genetically modified foods by Hallman *et al* (2013), in which 45% of the respondents agreed that GM food was safe for human consumption with 8% strongly agreeing that such food was safe. However, 63% of the respondents in the study indicated that they would be distraught if they were served GM food without disclosure. In addition, 54% of the respondents indicated that they would be enthusiastic to pay more for non-GM food.

One of the issues raised by the opponents of the GM technology was that GM maize may cause allergic reactions to some people and that GM maize may make people to be resistant to medical drugs. These public health concerns are similar with the results of the study conducted by Centre for Disease Control and Prevention (2001) which suggested that there is potential for the unintentional transfer of allergens to formerly hypoallergenic foods.

Upto 68 % of the respondents in this study strongly agreed that food labels are required to confirmation the presence of biotech ingredients, in order to avoid the likelihood of consumers facing undisclosed health risks in the future. This finding concurs with the findings of the study by Hallman *et al,* (2013) where upto 59% of the respondents felt that it was tremendously important to inform the consumers whether food products has GM ingredients on a label. An almost similar percentage indicated that it was necessary to disclose information on whether a food product was cultivated while using hormones (63%), pesticides (62%), or antibiotics (61%).

Finally, the findings in this study established that majority of the respondents believed that the development and introduction of GM crops would interfere with God's creation of ordinary crops thereby undermining God as the Creator of the Universe and all the crops in the world as indicated in the Book of Genesis. Upto 49% of the respondents were concerned while 46 % were not and 5% were non-committal on this matter. From a study conducted by Anunda (2006), most of the consumers (64%) disagreed that genetic modification of crop plants can be considered as an act of an act of "Playing God”. In the study by Kimenju *et al* (2005), it was established that 23% of the respondents were concerned that of the adoption of GM foods was tantamount to “playing God”. This indicated a significant similarity with this study. Elsewhere in the world, a study was conducted in India by Gene Campaign and the University of Hyderabad to assess the level of public awareness, attitudes and perceptions on the adoption of GM technology and GMOs among farmers, consumers and other stakeholders. The findings showed that farmers across all ages and education levels felt that they would never offer ‘genetically modified’ food in temples or use it in religious ceremonies and festivals and were also unwilling to serve such food in weddings.

CHAPTER SIX

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

6.1. Summary of Findings

6.1.1 Public's perception on the introduction of modern biotechnology and GM crops on food security in Kenya

The study established that majority (69%) of the people believe that GM maize would play a great role in resolving the problem of food insecurity in Kenya. 65% of the people believed that GM maize could significantly improve grower profitability and income while 60% believed that GM could benefit the society by enabling the farmers to grow crops more efficiently. With regards to the risk of increasing food insecurity due to climate change 59% of the people believed that that the introduction of GM maize would help to overcome this challenge. It was observed that, the consumers and the small scale growers had an almost similar opinion as far as the role of GM technology in helping to achieve food security in Kenya is concerned. 77% of consumers and 70% of small scale growers believe that GM maize will help overcome food insecurity due to climate change. However, only 10% of the large scale growers hold a similar opinion. Majority of the large scale growers also believe that the current maize production methods are sufficient to meet Kenya's food security needs. On the contrary only 23 % of consumers and 30% of small scale growers have faith in the current maize production methods.

6.1.2. Public environmental concerns on the implications of GM crops on national biodiversity conservation and biosafety

The findings identified several public fears and environmental concerns with relation to the introduction of GM maize in Kenya:-

a) Contamination of conventional crops through accidental cross pollination.

b) The second major concern on GM maize was that it was likely to become harmful to non-target insects in the maize fields and the surrounding environments.

c) The third concern was that the introduction of GM maize is likely to cause an increase in pesticide use which in turn will contaminate the environment.

d) The other public environmental concerns were:-

- The likelihood of increased invasion of pests such as weevils.
- The likely to affect the quality of dairy milk and bee honey.

- The likelihood of causing long term changes on the soil structure and mineral composition.
- The likely contaminate rivers
- The likely adverse effects on wildlife especially insects and birds.

It was established more than 60% of the respondents across the three clusters believe that GM maize will contaminate the conventional maize through cross pollination. However less than 50 % (40% consumers, 40% small scale growers, 27% large scale growers) across all clusters believe that GM maize may have adverse consequence on wildlife and the environment.

6.1.3 Public health and religious concerns on the introduction of GM maize in Kenya

The majority (55%) of the people believed that the consumption of GM maize might lead to human sickness and death. A high number of respondents indicated that there was need to ensure the use of food labels to disclose the presence of biotech ingredients in food in order for the consumers to be aware of the unknown health risks associated with such consumptions. On divinity, there was almost an equal divide in opinion with 49% of the respondents believing that the introduction of GM maize will interfere with God's creation of ordinary crops and thus undermining God.

Consumers had the highest score (60%) in believing that consumption of GM maize might lead to human sickness and health, this was followed by large scale growers at 53% and lastly small scale growers at 43%. The large scale growers had a strong opinion with 67% believing that GM maize will interfere with God's creation of ordinary and thus undermining God, this was followed by consumers at 53%. The small scale growers are on the extreme end with only 23% having an issue on divinity and GM maize introduction.

6.2. Conclusion

6.2.1. Public's perception on the introduction of modern biotechnology and GM crops on food security in Kenya

There is substantial public willingness on the introduction of GM maize in Kenya in order to deal with recurrent food insecurity which might increase under the expected impacts of climate change. Kenya's vulnerability to climate change is predominantly acute due to its geographic exposure, low incomes, and more dependence on climate sensitive sectors like agriculture, tourism, health and energy. The agricultural sector in Kenya is already under pressure from climate change. It is anticipated that climate change will lead to a temperature rise of about 4^{o}C and a rainfall variability of upto 20% by the year 2100. This will seriously affect many economic sectors especially agriculture where a production decline of between 1-22% is expected within the humid and dry land zones. The climate change is likely to increase challenges in the economic and social fabric of society. The government should therefore explore ways of enhancing the application of environmentally sustainable ways biotechnology for food security in the country as an intervention against increasing food demand, shrinking available arable land and the looming climate change.

6.2.2. Public perception on environmental implications on the introduction of GM maize in Kenya

There is substantial public fear and concerns on the likely environmental impacts of GM technology in the country. However, much of this is associated with inadequate public awareness and mis-information on biotechnology. This might also stem from inadequate scientific knowledge on the environmental impacts of biotechnology in the world with most of the studies so far having been conducted in the developed world which also controls the technology.

6.2.3. Public perception on public health and religious concerns on the introduction of GM maize in Kenya

There was apperception that introduction of GM maize might lead to human sickness and eventual death after consumption and almost a similar weight was given to GM foods having better nutrition and eventually benefitting the society. This shows that there is fear and admiration of GM technology adoption in almost equal measure. The society is split between the possible benefits as well as the possible down side of GM technology. However, there is no doubt that there is a strong preference to have food labels indicating presence of biotech ingredients. This is an indication that people still want to have liberty to make a choice and have free will as far as consumption of bio engineered foods is concerned. There is also a strong indication that the introduction of GM maize in Kenya like in other parts of the world could result in some resistance from some religious circles.

6.3. Recommendations

5.3.1. Policy

a) Kenya still lacks a clear national policy on biotechnology although the legal framework is in place through the National Biosafety Act; 2009.There is also a biotechnology development policy in place which seeks to guide research, development and commercialisation of modern biotechnology products. This was approved in September 2006. However, there is a need for an improvement on accurate and transparent dissemination of information on the development and use of the bio-technology to the public and industry.

b) There is need for the development of clear national guidelines on the implementation of biotechnology in Kenya. The guidelines should clearly cater for the needs of all grower segments including large-scale and small holder farmers.

c) Clear guidelines should be put in place to regulate to GM seed distribution in the county.

d) A feasible GM labelling requirement should be put in place. This should be able to accommodate food producers' needs as well as consumers' needs.

NBA should take a lead in making the above recommendations on policy issues.

6.3.2: Public awareness

a) There is need for concerted effort by the government through the NBA to ensure adequate public awareness in order to allay public fear and social concerns associated with biotechnology which is largely due to inadequate awareness and mis-information. Knowledge gaps were identified during the study, to the extent some respondents were confusing hybrids with GM crops.

b) There is need for concerted effort by the government through the NBA to ensure adequate public awareness among the religious institutions in order to allay public fear and social concerns that biotechnology is contrary to religious norms and beliefs. There are myths that need to be demystified by arming the general public with facts about GM crops.

The government and the private sector should be keen to upgrade the public awareness level on the GM technology.

6.3.3 Further research

a) Contamination of traditional maize through accidental cross fertilization with biotech crops including the identification of the minimum distance for non-cross pollination.

b) Impact of biotech crops on insect biodiversity and birdlife.

c) Relationship between biotech crops, pesticide use trends and impact on the environment.

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APPENDICES

APPENDIX 1: QUESTIONNAIRE

UNIVERSITY OF NAIROBI

COLLEGE OF HUMANITIES AND SOCIAL SCIENCES

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

MASTER OF ARTS IN ENVIRONMENTAL PLANNING AND MANAGEMENT

INTRODUCTION

Hello, my name is Agnes Wambui Mbugua;I am undertaking research as part of Master in Arts degree in Environmental Planning and Management. The purpose of this questionnaire is to generate information for my study entitled

"**Biotechnology and food security in Kenya - An assessment of public perception and environmental concerns**"

The information you will disclose in this questionnaire will be strictly confidential and shall be used only for the purpose of this research.

PART I

Respondents Profile (Tick Consumer/Producer)

Moiben ….. Githunguri….. Umoja ……

1. Age of the respondent
    1. 18- 24
    2. 25- 34
    3. 35- 44
    4. 45 – 54
    5. 55 – 64
    6. 64 or older

2. Level of education
    1. Informal
    2. Primary
    3. Secondary
    4. Tertiary

3. Gender. Male… Female ….
4. Occupation………………………………………………………………………
5. Religion………………………………………………………………………..

6. Home county…………………………………………………………………………..

7. Farm size (Moiben & Githunguri only)………………………………………………

8. Household size (Umoja only)………………………………………………………..

PART II

On a scale of 1-5 where 1 means strongly disagree and 5 means strongly agree, please indicate the level to which you agree with the following statements. [CIRCLE THE NUMBERS]

Perception towards the role / importance of biotechnology on food security

	Question	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
11	GM maize play a great role in solving food insecurity issue in Kenya	1	2	3	4	5
12	Current maize production methods are sufficient to meet Kenya's food security needs	1	2	3	4	5
13	GM will benefits the society because it allows maize farmers to produce food more efficiently	1	2	3	4	5
14	GM maize will play a major role is solving the malnutrition problem in Kenya	1	2	3	4	5
15	GM maize will significantly improve profitability / income of the growers	1	2	3	4	5
16	GM maize will overcome food insecurity due to climate change					

Any additional comments on food security……………..

PART III

Environmental implications on national biodiversity conservation and biosafety

	Question	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
17	GM maize may have adverse effects on wildlife in the environment (Ask which ones)	1	2	3	4	5
18	Some of the GM maize will invade the environment and become uncontrollable	1	2	3	4	5
19	GM maize will contaminate the traditional maize through pollination	1	2	3	4	5
20	GM maize will cause increased pesticides use and contaminate the environment	1	2	3	4	5
21	GM maize will be harmful to non-target insect	1	2	3	4	5

Additional comments on environmental concerns……………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………..

Which adverse effects will GM maize have on the wildlife……………………………….

……………………………………………………………………………………………..

PART IV

<u>Public health concerns on the introduction of maize related agro biotech in Kenya</u>

	Question	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
22	GM maize will interfere with God's creation of ordinary crops – Undermining God	1	2	3	4	5
23	GM maize is reasonably safe for human consumption	1	2	3	4	5
24	GM maize will benefit society because it has better nutritional value	1	2	3	4	5
25	GM maize might lead to human sickness and death	1	2	3	4	5
26	Food labels are needed to show the presence of biotech ingredients, since consumers could face unknown health risks	1	2	3	4	5

Any additional comments on public health concerns……..

…………………………………………………………………………………………………….

27. Instead of introduction of GM foods I would prefer the following alternatives (Pleaserank them in order of preference)

Alternatives	**Rank**
Food imports from other countries	
Expansion of agricultural land including irrigation in arid areas	
Use of biological fertilisers	
Improved pest control	
Soil and water conservation	
Use of improved plant varieties	
Use biotechnology in other crops but not maize (please specify the crops)	

Table 2.1: Comments on perception of GM maize as a solution to food insecurity

	Place of survey			
	Moiben	**Githunguri**	**Umoja 1**	**Total**
The GM food campaigns give more emphasis on its benefits and not the side effects	1	1	2	4
The government should focus on irrigation of the dry areas in the country	2	**5**	**6**	13
Need for farmers education on the best farming methods	1	1	***3***	5
Government should give farmers more farming facilities	0	***1***	***1***	2
Government should help farmers market their produce	0	***1***	***1***	2
More research should be done on the type of maize seeds farmers need in various localities	0	1	0	1
Farmers need to be advised on the best pesticides to use across different weather conditions	0	**2**	0	2
Government should solve the poor storage methods that destroy surplus food produces	0	1	0	1
Since GM maize are high grade seeds, they provide quicker solutions to food insecurity	**4**	1	**5**	10
There is a serious need to produce more food to sustain the rapidly growing population	0	**2**	0	2
Farmers need to adopt modern technology in arid and semi-arid areas	2	1	**4**	7
Government should search for safer ways of solving food insecurity issues not necessarily relying on GM maize	2	2	**4**	8
GM maize should be tested first before consumption	0	0	1	1

Youth’s overreliance on white collar jobs affects innovation in the agricultural sector	0	1	0	1
Need for government to provide more land or open up underutilized land in the country	0	**4**	**4**	8
Some parts of the country are unproductive therefore the insufficient food production	0	**2**	**2**	4
Serious need for the government to address corruption and greed that makes resource mobilization unfairly distributed	**4**	1	2	7
GM maize has created unnecessary completion with traditional maize	0	0	1	1
GM maize uses less fertilizers	0	0	1	1
No clarity on the nutrient composition of GM maize	0	0	1	1
Laziness is the cause of food insecurity not GM maize	0	0	1	1
GM maize is mostly used by the rich not ordinary farmers	0	0	2	2
Nutritional value of GM maize is not known	0	0	1	1
First priority needs to be given to traditional maize	0	0	1	1
Government should stop importing maize and buy from local farmers	1	0	0	1
Government should encourage local research on different maize varieties	**3**	0	0	3
Government should encourage planting of traditional food like sweet potatoes	**7**	0	0	7
We have failed to utilize the resources that God gave us	1	0	0	1
Laziness	1	0	0	1
Farmers who plant GM maize spend less on weed and pest control	2	0	0	2
Comment not clear	0	5	8	13
Sample size (n)	**28**	**29**	**46**	**103**

Table 2.2: Comments on perception of the effect of GM maize on the environment

	Place of survey			Total
	Moiben	**Githunguri**	**Umoja 1**	
GM maize changes the soil structure	6	2	6	14
Through crop pollination, other crops are also modified	0	9	2	11
Fear that GM maize may overtake indigenous maize breeds	0	1	1	2
If GM maize is good, then it should be encouraged on other crops	0	1	0	1
GM maize should be tested before consumption	0	1	0	1
Increased use of pesticides may increase contamination of the environment	6	2	14	22
GM maize requires a lot of rainfall/water	0	0	1	1
GM maize is disadvantageous to small scale farmers in areas with short rains	0	0	2	2
GM maize has led to invasion of certain pests e.g. weevils in Nairobi	0	0	1	1

GM maize is pest resistant hence reduced pesticides sprayed thus clean environment	0	0	1	1
There is need for strong research and public awareness on the environmental impact of GM maize	3	1	1	5
Strong herbicides may be harmful to certain organisms	1	0	1	2
Chemicals may pollute rivers	1	0	0	1
Due to continuous pre-emerging weed control, planting GM maize may lead to desertification	1	0	0	1
Much about GM maize is not known since it was developed in other countries	2	0	0	2
Comment not clear	3	4	5	12
	23	**21**	**34**	**78**

Table 2.3: Comments on perception of the effect of GM maize on environmental implication on wildlife

	Place of survey			Total
	Moiben	Githunguri	Umoja 1	
May affect the quality of animal products like honey and milk	1	3	2	6
Since GM maize is artificially made, it has some genes that affect plants, animals and even humans	0	4	3	7
Some animals become ill or die after consuming GM maize	3	5	13	21
GM maize makes some insects to be resistant to insecticides	0	1	0	1
GM maize may fail to produce as expected hence extended hunger	0	1	0	1
GM maize creates unnecessary competition for water and nutrients with other crops	0	0	1	1
Fear that traditional maize varieties may be lost forever	0	0	1	1
Maize farms are always fenced hence GM maize has no effect on wildlife	1	0	0	1
Research findings found that GM maize causes animal ulcers	2	0	0	2
Scientific proof is needed so as to unearth the real side effects of GM maize	1	0	0	1
Comment not clear	1	1	7	9
	9	**14**	**27**	**50**

Table 2.4: Comments on perception of the effect of GM maize on public health concerns

	Place of survey			Total
	Moiben	Githunguri	Umoja 1	
Fears that GM maize causes cancer and obesity	8	14	18	40
GM maize causes body weaknesses	0	1	1	2
There is need to label GM maize for consumers' prior knowledge	0	0	2	2
Need to test GM maize before giving to animals and humans	0	1	4	5
GM maize like hybrid are not harmful to humans	0	1	1	2
GM is just human improvements of what God already created	1	0	5	6
GM food does not reduce life expectancy	0	1	2	3
There is serious need to increase health awareness campaign on GM maize	2	0	10	12

GM maize has a lot of nutrients that lack in traditional maize	0	0	1	1
GM food accelerates aging of individuals	0	0	3	3
Traditional maize are more resistant to diseases than GM maize	0	0	2	2
GM maize has resulted to physically weak generation	0	0	1	1
GM maize may cause allergic reactions to some people	0	0	1	1
GM maize may make people to be resistant to drugs	2	0	0	2
Need for serious research on the impact of GM maize on 'human	5	0	0	5
It is against God's original will	1	0	0	1
No reports of serious effects have been received from other countries using GM maize	2	0	0	2
Since GM maize has many disadvantages than advantages, we should avoid them as much as we can	1	0	0	1
The problem is not with GM maize but rather with us who do not know how to balance food	1	0	0	1
It is better to adopt traditional foods for good health	1	0	0	1
Comment not clear	1	1	1	3
Sample size (n)	**25**	**18**	**48**	**91**