COMMUNICATION FACTORS AFFECTING AFRICAN POLICYMAKERS' DECISIONS ABOUT AGRICULTURAL BIOTECHNOLOGY

A Dissertation

by

BELAY EJIGU BEGASHAW

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2009

Major Subject: Agricultural Education

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Approved by:

Chair of Committee,	Gary J. Wingenbach
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	Edward Runge
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ABSTRACT

Communication Factors Affecting African Policymakers' Decisions about Agricultural Biotechnology. (August 2009)

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Chair of Advisory Committee: Dr. Gary J. Wingenbach

The purpose of this study was to develop a model for impacting decisions on agricultural biotechnology practices in food production among African policymakers. The research focused on three African countries, namely, South Africa, Malawi and Ghana. Taking into consideration the different stages and levels of engagement in biotechnology, these countries were assumed to be representative of the current heterogeneous environment of Africa regarding biotechnology adoption. Policymakers, primarily government officials, civil servants and activists, journalists, business leaders, religious leaders, farmers' leaders, and extension workers were involved as respondents and discussants in the study. Of the total number of 174 respondents, 69 were from Ghana, 76 from Malawi, and 29 from South Africa.

The research instrument entitled "Communication Factors Affecting Africa Policymakers' Decisions about Agricultural Biotechnology" was designed to provide scales by which to measure understanding, knowledge, and perceptions of agricultural biotechnology, three important constructs of the overall study. These three constructs were used to design questions for 12 specific scales to measure African policymakers' socio-demographic characteristics (gender, age, education level, occupation, geographic location); worldviews and values (moral values, labeling, regulation, consumers' rights, willingness to pay); information sources (interpersonal, print, and electronic forms); understanding of agricultural biotechnology practices; perceptions of agricultural biotechnology use in food production; and attitudes toward agricultural biotechnology policies.

Significant differences occurred in policymakers' understanding of biotechnology, perceptions about biotechnology, and attitudes when compared by country of origin. Respondents from Malawi had significantly less knowledge about agricultural biotechnology, held significantly lower perceptions about agricultural biotechnology, and held significantly lesser attitudes about agricultural biotechnology than did respondents from Ghana or South Africa. No significant differences existed in policymakers' understanding, perceptions, or attitudes toward biotechnology when compared by gender.

The study revealed that significant moderate positive relationships occurred between the dependent variables worldviews and values, and understanding, and attitudes. These associations suggested the existence of some level of complementarities between worldviews and values, and understanding, and attitudes of African policymakers toward biotechnology for agricultural development. Other findings showed significant moderate associations between the independent variable education level and worldviews and values, and low positive associations between occupation and worldviews and values, understanding, and attitudes toward biotechnology. On the other hand, no significant associations occurred between the dependent variables and gender or country of origin in this study.

In conclusion, the study showed that a critical gap exists in the understanding of biotechnology between policymakers in Africa. Educating the African public in general and those of low educational backgrounds in particular, is strongly recommended. Taking into consideration the differences in understanding agricultural biotechnology, it is further suggested that a need exists to adopt a target group approach in educating Africa policymakers about biotechnology. Another recommendation resulting from this study is the need for close collaboration between university scientists and mass media professionals as a means for raising the public's levels of trust for media, as well as accessing university scientists to the societies which they serve.

DEDICATION

To Sara Gizaw Abay

This is dedicated to you for all of your patience, love, understanding, prayer and support. Indeed you are a great gift from God to me. We are truly two parts that make a whole. Without you my dream to finalize my study wouldn’t have come true.

Thank you for all that you do. I thank god for you everyday.

I love you.

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CHAPTER I

INTRODUCTION

Biotechnology relates to the utilization of living organisms such as plants, animals, microorganisms, or their products in the modification of products for use. Broadly speaking biotechnology is the use of biological processes to achieve a specific purpose. "It is application of scientific principles of the development of new forms of biological systems and utilization of living organisms, their parts and derivatives for the intended purposes" (Ministry of Agriculture, 2004, p. 5). Biotechnology is used in agriculture, medicine, industry, and in environmental remediation for combating pollution. Biotechnology refers generally to the application of a wide range of scientific techniques to the modification and improvements of plants, animals, and microorganisms that are of economic importance (Persley & Siedow, 1999). Genetic engineering therefore arises from the artificial movement of genes from one organism to another and the organisms involved may or may not be related.

The need for modern technologies in the economic transformation and sustainable development of African agriculture may not be a debatable issue, although there have been long-standing divergences between the scientific and development communities on the application and appropriateness of agricultural technologies such as chemical fertilizer and improved seeds. The debate can be traced to the late 1980s, but now has renewed interest because of rapid scientific and technological advances, increased commercialization of transgenetic modified foods, increased food insecurity in Africa, and growth in the activities and influence of environmental activists.

Recent famines in parts of sub-Saharan Africa and the decision by some African governments to reject aid in the form of genetically modified foods have moved the debate from the confines of scientific and environmental groups to the center of public policy and politics in Africa. Consequently, two extreme positions polarize the debate: extreme pro- and extreme anti-biotechnology groups. Africa has many problems - a

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This dissertation follows the style of the *Journal of Agricultural Education*.

shortage of skilled people (especially in biotechnology), minimal research funding, lack of appropriate policies, corruption, and civil strife. Government officers and politicians share one common element in managing development; they seek technologies and practices that yield results quickly. The gap between political interests and long-term scientific advances exists in policymakers' reluctance to invest in long-term research. Such reluctance not only deprives Africa's scientific advancements, but also may be the cause for existing dismal capacities in science and technology. Hence, Africa remains skeptical and resistant to most new scientific ideas such as the use of biotechnology because policymakers lack sufficient confidence to examine and confront the issue.

Tension between proponents and opponents of biotechnology has increased over the last decade. While free market, globalization, and property rights are used as a pre-text among proponents, bio-safety, environment, and corporate monopolies are used by opponents. Unlike other new technologies, the issue is not only about adoption or rejection. In many instances, those who reject biotechnology continue fighting against it so others also reject it. Biotechnology is not an ordinary innovation with a quantitative impact; instead it has shown to have great potential for bringing qualitative changes in the role of bio-science in life and in society.

In his comment on the current world food crises in "The Politics of Hunger," Collier (2008) explained the potential science may have and the importance of policy decision for curbing the situation as follows.

> Politicians and policymakers do, in fact have it in their power to bring food price down. But so far their responses have been less than encouraging: beggar-thy-neighbor restrictions, pressure for yet large farm subsides, and a retreat into romanticism. In the first case, never have been beggared by the imposition of export restriction by the government of food-exporting countries. This had the immaculately dysfunctional consequence of further elevating world price while reducing the incentive for the key producers to invest in agriculture sector. In the second case the subsidy hunters have, unsurprisingly turned the crises into an opportunity; for example Michele Bariner the French agriculture minister, took it

> as a chance to urge the European commission to reverse its incipient subsidy – slashes reforms of the Common Agriculture Policy. And finally the romantics have portrayed the food crises as demonstrating the failure of scientific agriculture, which they have long found distasteful. In its place they advocate to return to organic small scale farming – counting on abandoned technologies to feed a prospective world population of nine billion. (Collier, 2008, p. 1)

> The Web site, *Africa: Basic Data*, describes several key facts about the continent as Africa is the world's second-largest and second most-populous continent. It covers 6.0% of the Earth's total surface area, and 20.4% of the total land area. With nearly one billion peoples (as of 2005), it accounts for about 14% of the world's human population and it is the fastest growing region in the world.

Africa constitutes 58 countries of which 47 are located in the sub Saharan region. Out of the total estimated population of 820 million, over 81% are living in the sub Saharan region. Africa, particularly eastern Africa, is widely believed within the historian and scientific community, to be the origin of humans. Africa is also known to be home for several flora and fauna which can be utilized as potential sources of breeding. The domestication of cattle in Africa precedes agriculture and seems to have existed alongside hunter-gathering cultures. It is speculated that by 6000 BC, cattle were already domesticated in North Africa. Agriculturally, the first case of domestication of plants for agricultural purposes occurred in the Sahel region circa 5000 BC, when sorghum and African rice began to be cultivated. Around this time and in the same region, the small guinea fowl became domesticated. Despite all these potential and old time wisdom, Africa is a continent that poorly feeds its people. As it described by Sachs (2005), the essence of Africa's crisis is basically its extreme poverty and therefore its inability to mobilize out of its own resources. Agriculture is the mainstay of the economy for most African nations. It also provides the sole means of living for hundreds of millions of people on the continent. This implies that without sound agriculture development, it is not possible to address the broad-based poverty situation in Africa.

The failure in farm productivity in Africa is not because of science and a lack of natural resources, but incorrect policy and misguided direction of African leaders for investment in education and science. Paarlbrerg (2008) described this fact as

> Between 1981 and 2000, while per capita public spending on agriculture science was increasing by 30 percent in developing world as a whole, it actually fell by 27 percent in Africa (Pardey et al., 2006). On top of this in many African countries policy makers have recently denying their own farmers access to agricultural science through official disapprovals or stifling regulation placed on modern agricultural biotechnology. (p. 10)

Science is a method for transitioning from one life stage to another, supported by a conscious move to advanced stages. It is essentially a way of thinking, understanding and knowing the world. Modern science is very destructive of traditional modes of thinking, and related values and cultures. In the African context, attachment to traditions and resistance to modern science is fierce. On the other hand, science for agricultural development has a good track-record of delivering real benefits to poor farmers and consumers through new crop, livestock, fish, forest and farming technologies that improve both productivity and farmers' incomes, thereby contributing to poverty reduction (Paarlberg, 2008; Sachs, 2008). Such technologies are also helping to protect the environment by enabling land and other natural resources to be used more prudently. These and other studies provide overwhelming evidence that science-based sustainable agriculture can allow millions of farmers to escape poverty, which is essential if the MDGs are to be achieved.

The need for a systematic approach to improving the productivity of agriculture labor at all levels is of paramount importance to change the current low input low output systems of African agriculture. By a systematic approach is meant a comprehensive reform that encompasses farmers, extension agents, scientists and policy makers who play direct and indirect roles in agriculture production. More importantly, it includes reforming the training and institutional capacities of the private and public sectors that are meant to provide support to the sector.

Cognizant of the fact that subsistence agriculture offers a bright future to no one, in sustaining ever-increasing population pressures and the rapid decline of the natural resource base, most African countries have adopted a market driven agriculture development strategy for ensuring sustainable growth. This implies agriculture needs to be productive enough to go beyond meeting domestic consumption to produce standard products for markets. Agriculture should earn the foreign exchange to finance the inputs it needs. On the other hand, the world has turned rapidly into a single economic and political space and ruled by laws that are set internationally. These rules and laws not only have set high standards for compliance, but are dynamic and sophisticated to the extent that they are difficult to achieve. Requirements for standards, qualities, and costs are no longer easily conquered. The fact that the new market has given paramount importance to newly emerging social values such as tracing labor to its source, consciousness of producers' share of profits, etc., adds additional challenges that need to be confronted.

Adaptive Structuration Theory

Adaptive structuration theory (AST) is based on Giddens' (1984) structuration theory, stated as "the production and reproduction of the social systems through members' use of rules and resources in interaction" (p. 25). AST presents the need for emphasizing social aspects, as opposed to exclusive emphasis on techno-centric views. Instead, AST examines change processes from two vantage points: 1) the types of structures provided by advanced technologies; and 2) the structures that actually emerge in human actions as people interact with these technologies.

Though, it was used originally for studying the role of advanced information technologies in organizational changes, AST could be used to analyze the advent of various innovations such as the printed press, electricity, telegraph, mass transpirations' radio, TV, the internet etc., and show how the structure of these innovations penetrated societies, influencing them, and the social structures of those societies influenced and modified innovations original intent (*Adaptive structuration theory*).

Structuration Theory

As explained by Giddens' (1984), Structuration theory views group or organizations as systems with observable patterns of relationships and communicative interactions among people. Systems are produced by action of people creating structure (sets of rule and resources). The theory further expands the relationship between systems and structures, by defining that they exist in a dual relationship with each other in an ongoing cycle, referred to as a "structuration" process. Such a process can be stable or change substantially over time.

A structuration process needs to be defined in biotechnology. The current extreme stances supporting and opposing this science need to be equalized through scientific reason and fact. The ever-growing debate, which may be for the sake of debate only, should be focused on issues and facts. The debate should be focused on how to find compatibility with structural changes in society with the existing rules and regulations of biotechnology and to make use of the innovation for the sake of the users.

Agricultural Biotechnology

The introduction of biotechnology has introduced new structures different from what has been perceived by society in the past. According to Juma and Mugabe (1989), the history of breeding goes back to Stone Age where hunting of wild animals and crops were the main means to sustain. For thousands of years, human beings driven by instinct have gone through various ways of selecting hybrids with better yields. They have been breeding crops and animals and their parts for more production. The breakthrough in the field however has not been achieved until 1900, when Mendel's theory came to light. Though it was not recognized until 1900, Mendel published his theory of heredity in 1866. Though his research was focused on plants, the basic underlining principles of heredity that Mendel discovered was also applied to people and animals as the basic mechanism of hereditary are essentially the same for all complex life forms (O'Neil, 2009).

New structures began with the discovery of DNA, which brought extraordinary capacities to scientific research because it enabled scientific research at an individual gene level to characterize traits and manipulate genes for an intended purpose. Working with the level of capacity that DNA provides would not only expanded the horizon for exploring these resources, but also provided an opportunity for creating new form of biological system that fits the intended purpose through the process of fully or partially modifying the existing one.

To date, this process illustrates itself in different forms of biotechnology research such as medicine, agriculture, natural resources, and the environment. With regard to products such as Genetically Modified (GM) seed, biotechnology-type products such as Soya bean, cotton, and maize are new products which would otherwise be non-existent without biotechnology. Likewise, new medicines such as insulin and new vaccines and serums for humans and animals, are among those that have been developed because the invention of biotechnology. The ability to alter the genome of animals by introducing DNA is a major technological advance in biotechnology and animal agriculture (Etherton et al., 2003).

Opponents are concerned that biotechnology encourages monoculture and only lends itself to a large-scale, industrialized agriculture, which is uncommon in Africa. Opponents further argue that biotechnology may break apart traditional, sustainable agriculture that diversifies risk, and forces producers to shift to incompatible cultures and mindsets. Another concern is with the need to invest in main agricultural inputs such as seeds by small farmers, unlike the current practice of using their home-grown seeds. Many observers also worry that promoters of genetic engineering seek to eliminate any possible competition from non-GM crops. In particular, non-GM crops affect traditional crops that are suited to a country's capacity to control its own future, and more appropriate to its technological developments and know-how.

The adoption, commercialization, and popularization of technology on one hand, and the fight against it on the other, have led to the introduction of several new structures in society. These new structures include the emergence of new networks, and relationships between and among countries; for example there is collaboration between developing countries and the European countries, which can be defined by the Cartagena protocol. Intellectual property rights, bio-safety and other regulatory arrangements created as a result of international pressures are evidence of new societal structures. New structures in human interactions embrace changes in productivity, income, and shifts in resource use that can be attributed to the onset of technological advancements.

Technology should not be considered only for good or bad actions, but for a social construct that configures social relationships. Ruivenkamp, Hisano, and Jongerden (2008) concentrated on the social shaping of society by biotechnology. The authors especially focused on three types of social relations: (1) Commercialization, “commoditization” of genetic resources into market products and change of agriculture producers into entrepreneurs; (2) new relationships formed between the north and south, emerging from the interchangeability and compatibility of products, producers, and markets; and (3) new divisions of labor between private and public sectors (p. 45). In this transformation process, genetic resources are turned to seed as a commodity for sale, through hybridization technology. This process moves seed beyond technical routes, passes through legal routes, complies with property rule (IP) regulations, and is enforced and protected by the public sector (Ruivenkamp et al., 2008).

A recent report by the World Bank “World Development Report 2008,” offers an important reminder that three out of four people in developing countries live in rural areas and most of them depend directly or indirectly on agriculture for their livelihoods. It recognized that overcoming abject poverty cannot be achieved in sub-Saharan Africa without a revolution in agricultural productivity for the millions of subsistence farmers, most of whom are women. The report further underscores the importance of agriculture in the fight against poverty as “Agriculture is a vital development tool for achieving the

Millennium Development Goals that calls for halving by 2015 the share of people suffering from poverty and hunger" (The World Bank, 2008, p. 15).

As a result of consistent and substantial benefit during the first dozen years of commercialization from 1996 to 2007, farmers have continued to plant more of biotech crops every single year (James, 2007). In 2007, for 12 consecutive years, the global area of biotechnology continued to grow at sustained double-digit growth rates of 12% or 12.3 millions hectares—the second highest increase in global biotech crop areas in the last five years—reaching 114.3 million hectares (James, 2007, p. iii).

According to International Service For the Acquisition of Agri-Biotech Applications Briefs, (ISAAA) In 2007, the number of countries planting biotech crops increased to 23, and comprised 12 developing countries and 11 industrial countries; they were in order of hectares planted: US, Argentina, Brazil, Canada, India, China, Paraguay, South Africa, Uruguay, Philippines, Australia, Spain, Mexico, Colombia, Chile, France, Honduras, Czech Republic, Portugal, Germany, Slovakia, Romania, and Poland. The report further elaborated on the importance of this technology for poverty reduction as "Biotech crops achieved a very important milestone in 2007 with humanitarian implications-the number of small and resource-poor farmers benefiting from biotech crops in developing countries exceeded 10 million for the first time" (James, 2007, p. iii).

Biotechnology Communications

The stark contrast between extremist groups (pro- and anti-biotechnology groups) has confused many African policymakers and the public because reliable information and guidance is lacking. Increasing uncertainty and confusion is evident in the responses of many African governments to a wide range of social, ethical, environmental, trade, and economic issues associated with the development and application of modern agricultural biotechnology. Such confusion likely denies African countries the opportunities to benefit from such agricultural biotechnologies, no matter where they were invented.

The following hypothetical exchange between alternative viewpoints on the risks posed by GM technologies demonstrates the deep epistemological divergences on the issue.

> *Modernist:* There is far too much wooly, antiscientific thinking flying around. Prove to me that GM technologies pose any more risk than do traveling in a car or flying in a plane. The risks posed by GM crops are dwarfed by the risks we face every day, using conventional technologies. Just think about the risk of *not* taking advantage of the benefits promised by GM technology. Isn't that risk pretty clear? Isn't it continued hunger and poverty around the world? Isn't that outcome would fully be avoidable? Why not give Nature a nudge toward greater efficiency? Who are we to deny millions of poor, starving people the opportunity to live better, longer more rewarding lives? What kind of leaders would allow their citizens to suffer in that way?
>
> *Post modernists*: Not even the greater scientist on this earth could "prove" that to you. You are enamored with science, yet you misapply it. You are blinded by it. The fact is that genetic engineering unleash forces more powerful than even atomic energy, which unparalleled potential to harm life as we know it –and for all future generations. We also have responsibilities to these future generations. And those leaders you condemn out of hand – how can you begin to pass judgment on them when you have no idea about the political pressure you are facing? Who are you to impose your priorities and values on them? (Omamo, & Grebmer, 2004, p. 5)

One of the great challenges facing Africans in the 21st century will be a renewal and broadening of scientific education at all levels. Nowhere is it more important for knowledge to confront fear born of ignorance than in the production of food, still a basic human activity. In particular, a need exists to close biological science knowledge gaps in affluent societies, now thoroughly urban and removed from any tangible relationship to the land. The needless confrontation of consumers against the use of transgenic crop technology in Europe and elsewhere might have been avoided had more people been better educated about genetic diversity and variation. Privileged societies have the luxury of adopting a very low-risk position on the genetically modified crop issue, even if this action later turns out to be unnecessary development (Borlaug, 2000).

A study (Torres, Suva, Cleofe, Carpio, & Dagli, 2006) conducted by ISAAA, SEAMEO, SEARCA and CDC-UPLB sought to determine stakeholders' socio-demographic characteristics, worldviews and values, information sources, and stakeholders' levels of understanding, perceptions, and attitudes toward biotechnology in the Philippines and Indonesia. Results showed that policymakers were among those stakeholders who had below average levels of understanding and a negative perception of the potential biotechnology has for agricultural development. The study (Torres et al., 2006) summarized its findings in the Philippines as

> In terms of worldviews and values, the religion leaders exhibited a more conservative stand. The use of biotechnology in food production is against my moral values [the majority of the stakeholders thought otherwise. Policymakers and religious leaders strongly supported the statement] until we know genetically altered foods are totally safe, those products should be banned. [Stakeholders generally disagreed with the statements] we have no business meddling with nature, and that regulation of modern biotechnology should be left mainly to the industry. (p. vi)

Similarly, in the case of Indonesia (Torres et al., 2006) some of the findings included:

> In terms of frames used when making judgments on biotechnology Indonesian policymakers and scientists are not strongly inclined toward biotechnology application that would improve food quality, make crop more resistant, or cure diseases.
>
> The worldviews and values of stakeholders impinge greatly on their application of and attitude toward agricultural biotechnology. Conservatives worldviews and values such as the application of agricultural biotechnology

> being against their moral values consistently lead to a negative perception and attitude toward the use of biotechnology for food production. (p. vii)

Torres et al. (2006) study was of great importance to the envisaged study in Africa, as it conforms to the very hypotheses of this study and its importance of targeting policymakers. What are African stakeholders' levels of understanding, perceptions, and attitudes toward biotechnology, in comparison to those in the Philippines and Indonesia, where policymakers had better access to media and information sources? Moreover, both studies (Torres et al., 2006) indicated that almost all stakeholders confirmed an interest in the biotechnology debate. Should such an outcome be evident among African stakeholders?

Understanding biotechnology in Africa requires recognizing agriculture as a system with social, economic, and ecological components. The effects and fate of agricultural biotechnology in the developing world depends not on simple performances, but also on incorporation of new technologies into such systems. Particularly important is the social component in indigenous skills. “Skill” refers not simply to the farmer's knowledge of plants and agronomic processes, or proficiency in agricultural tasks, but more generally to the farmer's ability to execute performance based on agronomic knowledge, economic strategy, prediction of a range of factors, and manipulation of socially-mediated resources (Richards, 1989).

Africa missed most of the green revolution, which helped Asia and Latin America achieve self-sufficiency in food production. Africa cannot afford to be excluded or to miss another major global technological revolution. Africa faces a risk in ignoring advanced agricultural technologies because its populations are projected to increase to 1.3 billion in the next 25 years. The continent's 3.1% growth rate is the highest population growth rate in the world (Ndiritu, n.d.).

Statement of the Problem

As Africa continues to struggle with civil wars, poverty, and HIV-AIDS, hunger remains the continent's most critical problem. Promoters of GM foods believe that agricultural biotechnology is the answer to eradicating starvation. Opponents question the safety and nutritional value of GM foods. Proponents argue that if Africa gives GM foods a chance, it will curtail hunger in every country, especially in countries where crops fail to grow because of drought, pests, or other natural causes (AllAfrica, n.d.). Research shows that acceptance and use of agricultural biotechnology practices can be affected by societal knowledge and perception of this science. Minimal research exists to determine what African policymakers know and/or believe about agricultural biotechnology practices in food production.

Purpose and Objectives

The purpose of this research was to empirically verify communication factors affecting African policymakers' decisions toward adopting agricultural biotechnology to alleviate food insecurity. The purpose was achieved through the following research objectives, which included determining African policymakers'

(k) Worldviews and values,

(l) Information sources used to understand agricultural biotechnology,

(m) Levels of understanding about agricultural biotechnology,

(n) Attitudes toward agricultural biotechnology, and

(o) Socio-demographic characteristics.

Additional objectives included studying the

(p) Effects of independent variables on decisions for agricultural biotechnology policies,

(q) Effects of dependent variables on decisions on agricultural biotechnology policies,

(r) Significant relationships between independent and dependent variables, and

(s) Model for impacting decisions on agricultural biotechnology practices in food production.

The research focused on three African countries, namely South Africa, Malawi and Ghana (see Figure 1). These countries were assumed to be representative of the current African situation with regard to the adoption of biotechnology, as they were at three different stages of adoption. Whereas South Africa is using biotechnology at commercial levels, Ghana was in the last stages of preparation, research, and verification of major products; however Malawi was just starting to develop critical mass to examine the situation.

Malawi

The issue of biotechnology has never been taken seriously until 2002, when Malawi and other countries in the southern part of Africa were hit by widespread draught and famine as a consequence. In response to the crisis, these countries had to import food from overseas, mainly in the form of aid that included genetically modified maize. It was then that Malawi and other African countries in the region raised an outcry about such genetically modified maize. This predicament caught many of these countries leaders' unaware since they did not have country legislation on GMOs and biotechnology products in general, except for the African Union (AU) model law on GMOs. In this regard, Malawi, concerned with the bio-safety of these products drafted its bio-safety law, which had a strong GM regulatory base and also ratified its biotechnology policy. As is stipulated in the Malawi national policy document,

> The policy aims to strengthen existing research and training institutions and improve the country's legal and regulatory framework in order to facilitate the safe acquisition, development and application of biotechnology, and the structured generation of innovations and intellectual property rights. The policy also provides for the establishment of the implementing agency to ensure that it fulfills it's commitment through a well coordinated National Biotechnology Program and the developed implementation plan. (National Research Council of Malawi, 2007, p. 3)

Figure 1. Map of selected African research sites (The University of Texas at Austin, 1998).

With regard to the consultation process in formulating the policy it was known that broad base community consultations led by civil societies in Malawi had been taken place between 2005 and 2007 with the objective of impacting the process.

> CISANET recognized that the biotechnology issues were critical in the development of agriculture in Malawi, and it could impact both positively and negatively the lives of people in Malawi. In this regard it was essential to conduct consolations' with Malawian people on what they wanted the policy draft should regulate in order to avoid facing adverse effects of biotechnology (Musopole, Gondwe, & Mhoni, 2005, p. 4).

South Africa

With regard to the status of development and implementation of biotechnology, South Africa has had a legally binding GMO Act since 1997; also it has the institutional framework to administer the act. The country has a number of both public and private laboratories adequately equipped to do Genetic Engineering (GE) work, having more than 110 plant biotech groups, more than 160 plant biotech projects, and more than 150 trials. Regarding use of the bio-safety system, already a number of GE researches work projects and products are on the ground, including commercial cultivation of GM horticultural crops, cotton and maize by smallholder farmers (Omamo, & Grebmer, 2004, p. 22).

Four GM crops are cultivated in South Africa: insect resistant cotton (since 1997), insect resistant maize (since 1998), herbicide tolerant cotton (since 2000), and herbicide tolerant soybeans (since 2001). The latest statistics from 2007 indicated that 51% of yellow maize, 62% of white maize, 80% soybeans, and 90% of cotton produced were GM crops (Department of Science & Technology, 2007).

Ghana

The Bio-safety Regulation (management of biotechnology) 2007 paved the way for the establishment and operation of a National Bio-safety Committee to coordinate activities of biotechnology diversity under the Cartagena Protocol on Bio-safety, regulate conduct of research into GMOs, and provide rules for the protection of scientists researching the subject matter. The regulations on the institutional arrangements provide for the establishments of a national Bio-safety Committee as a national focal point on Bio-safety and a liaison for the purpose of giving effects to the provisions of the Cartagena Protocol of Biodiversity.

The regulation also empowers the Bio-safety Committee to provide field trials as well as monitor levels of classified risks. It also empowered the Bio-safety Committee to coordinate activities of relevant government agencies and private organizations with a view of maintaining safety levels in biotechnology research. Despite these regulations, Ghana continuously is being criticized by scientists and farmer leaders for the absence of cost effective legislative.

Significance of the Study

The research is devoted to evaluating policymakers' decision-making processes, based on the use of scientific and technological information, and developing recommendations for policymakers to make informed decisions. The recommendations anticipated include defining possible sources of information and networks, identifying appropriate communication mechanisms that allow continuous flow of balanced information from credible and traceable sources, and designing efficient and economical communication methods that enable policymakers' information access.

Raising public awareness of agricultural biotechnology practices, mobilizing political support and commitment to strengthen Africa's capacity in biotechnology, bio-safety, food safety, intellectual property rights, and mounting long-term training programs for the next generation of African plant breeders and crop specialists, are among other factors to be assessed. By doing so, African policymakers will not only ensure advancement in agricultural biotechnology for growth and development, but also will involve them proactively in the current debate of using science and technology for the well-being of humankind.

This study dwelt on experiences of International livestock Research Institute (ILRI) as a case, for strengthening the existing relationships between national agriculture research (NARS) and international research centers, particularly the CGIAR systems. ILRI is known to for its active role in the area of capacity building in biotechnology, congruent with the strategy of the African Union for promoting science and technologies. ILRI's hosting the African Biotechnology Center (BECA) provides an opportunity to understand the challenges of addressing the research issues. ILRI also is known for its demand-driven interventions in the region, focusing on national capacity-building activities.

The investigator has had very constructive discussions with the staff and leadership on one of the prominent regional net working in southern and eastern Africa, Food Agriculture and Natural resource Policy Analysis Network (FANRPAN). FANRPAN is an emerging networking in the region that proved facilitating professional policy dialogs on the area of biotechnology, environment, food security and related issues central to this study.

Assumptions

This study hinges upon four assumptions; 1) world trends forecast increasing pressures on human well-being and sustainable agriculture; 2) science can contribute to human well-being and sustainable agriculture; 3) informed and knowledgeable people will make sound decisions regarding human well-being and sustainable agriculture; and 4) participants in this study responded to all data collection with honest replies.

Acronyms

ASARECA	Association for Strengthening Agricultural Research for Eastern and Central Africa
CDC-UPLB	Collage of Development Communication University Philippines Los Baños
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
EU	European Union
FAO	United Nation Food and Agriculture Organization
FANPAN	Food and Agriculture and Natural Resources Policy Analysis Network
FARA	Forum for African Agriculture Research
ICRISAT	International Crop Research Institute for the Semi-arid Tropics
ILRI	International Livestock Research Institute
IRB	Institutional Review Board
ISAAA	International Services for the Acquisition of Agriculture biotechnology
MDG	Millennium Development Goals
NGO	Non-Governmental Organization
SASAKAWA GLOBAL 2000	NGO working in Africa on Agriculture and food security
SEAMACO	Regional Center for Graduate Study and Research in culture
TAMU	Texas A&M University
USAID	United States Agency for International Development
WARDA	The African Rice Center

Delimitations

The population of this study was delimited to policymakers and stakeholder representatives in three African countries (Malawi, South Africa, and Ghana) during the 2008 summer. Further, the study was delimited to those respondents who completed the research instrument.

Limitations

This study involved samples from three specific African countries; therefore caution should be exercised in generalizing results from this study to populations in other African countries.

Definitions

Perception: is both the response of the senses to external stimulus and purposeful activity in which certain phenomena are clearly registered while others recede in the shade or are blocked out (Tuan, 1990).

Attitude: Primarily a cultural stance, a position one takes vis-à-vis the world. It has greater stability than perception and is formed for the long successions of perceptions that is of experience (Tuan, 1990). Attitude was operationalized by summing respondents' scores to statements in which they indicated their level of agreement or disagreement. A positive attitude and a high score were achieved when a respondent strongly agreed to the positively worded statements and respondents strongly disagreed to negatively worded statements.

Diffusion: A process by which an innovation is communicated through certain channels over time among the members of the social system (Rogers, 2003).

Communication: A process in which participants create and share information with one anther in order to reach a mutual understanding (Rogers, 2003).

Innovation: An innovation is an idea practice or object perceived as new by individuals or other unit of adoption (Rogers, 2003).

Adoption: A decision to make full use of an innovation as the best course of action available (Rogers, 2003).

CHAPTER II

REVIEW OF LITERATURE

Technology and its relationship to organizational structure, process, outputs, and outcomes have long been of interest to researchers. Today, both technologies and organizations are experiencing unprecedented levels of dynamism, as a result of the continuous competition in technology development at global levels, as a critical factor for attaining economic and political power. Such a situation resulted in dramatic changes in organizational and psychological relation of societies, which in turn calls for reforming organizational structures, rules, and laws in response to such changes.

Technology is primarily social and thus, politically neither neutral nor autonomous (Ruivenkamp et al., 2008). Biotechnology, like all other technologies, is a function of social relationships and a mode of production that reflects the relationship between the inherent characteristics of the technology artifact and the value, conscious and knowledge of the agents in the system. As a revolutionary finding in the sciences, biotechnology has advanced the capacity of science in manipulating nature to a new level, of impacting "'Agri' and 'Culture'." Hence, biotechnology resulted in qualitative changes as opposed to the usual incremental changes experienced by all other recurrent innovations familiar to us. Consequently, its impact on social relationships and production has forced the emergence of a new type of social relationship, prompted by the tension created as a result of the divergences in the "structure" and "system" of the social relationship that exists.

This tension essentially is between the embodied characters of the technology, its unique capacity, and the new enactment of applying and using the technology, and the rules and values that exist to facilitate food production. As Ruivenkamp et al. (2008) stated

> This tension between a technological rationality that inclines toward an instrumentalisation and a denial of the complexity of life, and one which inclines to the affirmation of life as fundamental, this tension between so-called life denying and life –affirming technologies is especially striking when it concerns

> the development of technologies dealing with bios, with life and living things themselves. (p. 17)

The tension that reflects itself in different ways does not always necessarily lead to negative consequences; initiating a new and a better action, such as setting of new rules and regulations that are required to be in place in order to function, is an example of a positive output of the emergent new systems. Such actions, are imperative, in order to comprehend and perceive the “syntagmatic” and “paradigmatic” dimensions of the social relationship among different agents and the community at large. This is particularly important for biotechnology, where tension between opponents and proponents is increasingly growing; reaching a critical level that could potentially risk further investment in improving the applicability of the technology in addressing extremely important issues in society, such as fighting against poverty, food insecurity, environment, and health.

In the absence of establishing rules and regulation for the new game of using biotechnology the chance of popularizing, and mainstreaming, the new system into the day to day living condition of the society will be very difficult if not impossible. The old rule, “structure,” that at best contributes for the birth of the new innovation, neither has the capacity nor inherent quality to accommodate the new. In other words, the set of principles that are embraced in old social relationships are the reflection of old modes of production. As Herring (2007) described the new innovation needs to change and include some measures or amendments in the technology itself in order to enable it to comply with some of the elements of the social relationships, including facilitation of easy comprehension in the day-to-day practical operations.

> Almost universally, opponents of genetic engineering label its products ‘GMOs’ for ‘genetically modified organisms’. Thus develops market segmentation and a niche for ‘GMO-free’ labeling on grocery shelves and export baskets. ‘GM-free zones’ crop up in southern Brazil, but also in California. The designation ‘GMO’ posits and refines a category, and thus a niche for mobilization and product differentiation, where many biologists would find none–an artificial distinction.

> Genetic modification is the history of agriculture. All existing crops are genetically modified, that is the purpose of plant breeding, which has been with us in a more or less scientific form for over a hundred years, and with us as a species for at least 6000 years. The current distribution of plant species cultivated for food and fiber has involved radical and purposive reduction of biological diversity for instrumental human ends. We would otherwise be, as a species, unable to feed ourselves. (Herring, 2007, p. 4)

Adaptive Structuration Theory

This study used Adaptive Structuration Theory (AST) for the theoretical framework. Adoptive structuration theory is based on Giddens' (1984) structuration theory which is formulated as "the production of the social systems through members' use of rules and resources in interaction" (p. 17). AST criticizes the exclusive technocratic view of technology use and emphasizes the importance of its social aspects.

AST essentially argues that groups and organizations using different communication techniques for their work can create perception on the use and the role the specific technology can play, and how it can be applied to specific situations. Such perceptions, therefore, vary across the group and may also influence the adoptability and the way the technology can be used in the group. Several scholars (Brown & Duguid, 1991; Hutchins, 1991; Sewell, 1992; Weick, 1993) of structuration theory examined how people, as they interact with a technology in their ongoing practices, enacted structures which determined their emergent and situated use of that technology.

Giddens (1984) structuration theory essentially describes three concepts of "structure," "system," and "duality of structure." Giddens explained how structure was wrongly being understood by "functionalists" and among major social analysts as some kind of patterning visible and vivid social phenomena. He also discussed how such a concept closely related with the dualism of subject and social object. Structure here appears as ‘external’ to human actions, as source of constraint on the free initiatives of the independently constituted subject (p. 16). The constitution of agents and structure are not two independently given sets of phenomena, a dualism, but represent a duality. According to the notion of duality of structure, the structural properties of social systems are both medium and outcome of the practices they recursively organize, implying that structure always remains an “internal,” rather than “external” process.

These two concepts relate the important aspect of AST by recognizing the differentiation between the concepts of “structure” and “system.” The relationship can be perceived as syntagmatic and paradiagmatic dimensions of the social relation. Syntagmatic, represents the patterning of social relations in time and space involving the reproduction of the perceived practices; the paradigmatic dimension represents the virtual mode of structure that is shaped as a result of recursively implicated actions. AST is being used for the first time for studying the role of advance technologies in organizational change. It examines the change process from two angles: (1) the type of structures that are provided by the technologies, and (2) the structures that actually emerge in human action as people interact with these technologies. AST’s appropriation process might be a good model to analyze the utilization and penetration of technologies in our society. Social interaction theory is graphically represented in Figure 2.

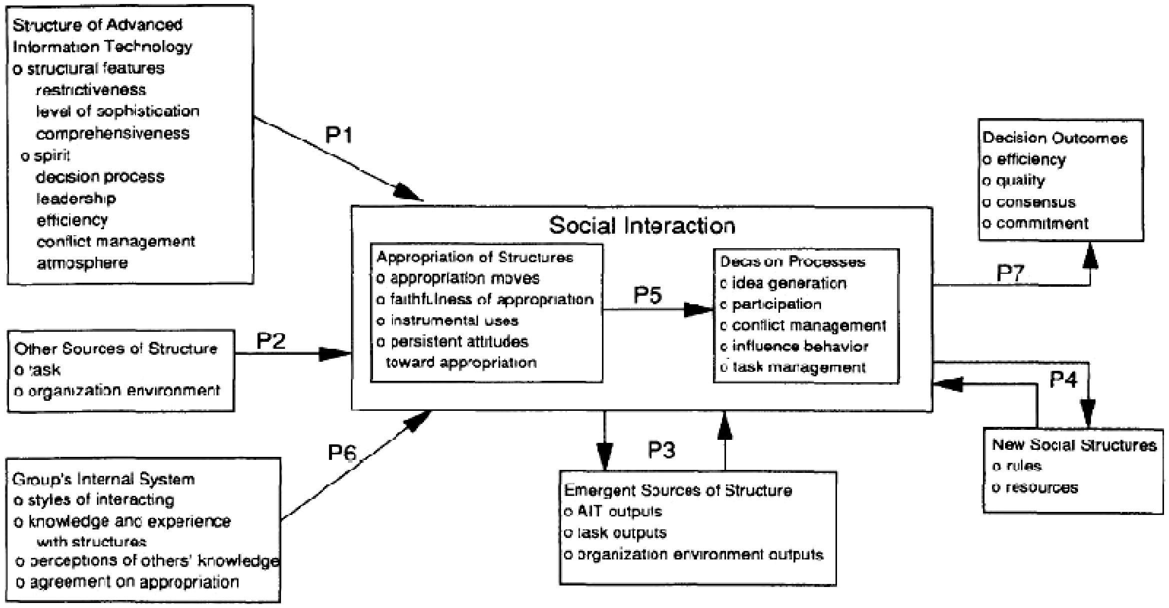

Figure 2. Social interaction theory. From G. DeSanctis and S. M. Poole, 1994, *Organization Science*, *5*(2), p. 121.

AST is further elaborated on by Orlikowski (2000) in that the existing structurational perspective on technology is augmented with a practice orientation which focuses specifically on how people's recurrent interaction with technologies enacts distinctive structures of technology use. These structures of technology utilized are not fixed or given, but constituted and reconstituted through the everyday, situated practices of particular users using particular technologies in particular circumstances. Orlikowski examined existing structurational models of technology and what people do with technologies, positing such an appropriation of the "structures" inscribed in the technologies. DeSanctis and Poole (1994) distinguished between those who were "faithful" and "unfaithful" of the technologies structure, highlighting the degree to which use of technology corresponds to the structures embedded in the technology and related expected outcomes. Their analyses included different types of appropriations which "preserve, substitute for, combine, enlarge, contrast, constrain, affirm, or negate the structures provided by the technology" (DeSanctis & Poole, 1994, p. 129).

Nicolosi (2008) discussed the relationships between ecological environment and socio cultural conditions of human beings that inhabit it. Giddens (1984) used "*technique and territory*" as a metaphor to explain this relationships. According to this metaphor, *territory* is defined as socially rooted and continuous mutual exchange between ecological environment and socio cultural condition of human group that inhabit it, and *technique* as a main form of mediation implied in such exchange. By means of technique, Man projects, his culture, to the outside, in time, creating an objective and *meaningful* world, in which he lives. But technique is not only the medium of man's relationship with the non- human and the non-social. Technical action, namely "a kind of action that creates artifacts," is also one of the fundamental conditions that determine the very social nature of man.

Orlikowski (2000) tried to provide a practice-oriented analysis on the recursive interaction between people, technologies, and social action. He showed the relationship between notion of embodied structure with that of emergent structure, and the notion of appropriation with that of enactment. These considerations offer notions that awareness of social rules, expressed for most and first in the form of knowledge of consciousness (mainly practical consciousness) characterizes the human agent in society. As main actors in social relationships, human beings learn practical knowledge through production and reproduction in the day-to-day life, and through recursive mechanism.

Ruivenkamp et al. (2008) discussed reconstruction of biotechnology as a deliberate act of re-orientation, applied at the level of knowledge system and technical artifacts. They emphasized the process should take place by changing the social relationship from which the artifacts emerge, as well as by modifying the material content of the artifact.

In the vision of social constructivists and AST too, technology is primarily social, and thus politically neither neutral nor autonomous. Given the level of impact, there is a clear shift in perception whether technology is an end or a means to an end. Ruivenkamp et al. (2000) stated that technologies abstractum was emphasized when the technology changed from a means to an end, the relationship between people, technology, and development will also change. Ruivenkamp et al. (2008) stated lack of "consciousness, of the potential use of biotechnology as a force of emancipation, a lack based primarily on the widespread belief of the technology as a value free, neutral instrument at the disposal and applicable for the benefit of human kind" (p. 35).

People have become part of the technological system in which objectives and ideals, means and ends are also technically defined. This shift has taken place worldwide. The shift contrasts from a society with technology as a means to achieve a certain goal, to one which the impact and expansion of the means decides the end. The notion of this statement has to do with the biotechnology's potential for shaping the future of the social relation in the production relation. Agriculture, using biotechnology, may not necessarily require the same inputs that traditional agriculture has been known to use. Likewise, it is imminent the input-output ratio will substantially differentiate from what used to be in traditional production systems.

We may see changes in the quality of human resources deployed in agriculture. For example, seed production within a corporate structure, will only be pursued using a few highly qualified personnel in contrast to the conventional seed production system which involves large numbers of unskilled and skilled labor in agriculture. It will not be difficult to imagine agriculture that may be transformed to controlled, sheltered production, as opposed to open fields. Some indication of zero tillage, the wide adoption of weed and pest resistance and tolerance varieties in the U.S. and other emerging economic countries, exhibits the immanency of such changes in the production relation for Africa.

Appropriation and substitution have been indicated as two crucial historical trends within which the particular development of biotechnology has taken shape. Appropriation refers to the gradual takeover of biological activities from farming practices by externals, mainly industry, while substitutions refers to the replacement of agrarian food sources by products delivered by an industrial biochemical methodologies (Goodman et al., 1987; as cited in Ruivenkamp et al., 1994). Appropriation and substitutions are historical trends that shape the development of biotechnology through quantitative changes through biological developments in such a way that it leads to the qualitative ongoing transformation of social organizations.

The politics of biotechnology is another aspect to be examined. Politics in the generic form may be defined as favoring certain ideas or thoughts. The support usually prompted by the popularity of cause, or expected outcome anticipated as a result. The bottom line is such favors are not only consistent among the same groups, but ever unwavering, even when mistakes are prevalent. Politicians usually do not account for the rationality of their ideas, but instead prefer to take risks, rather than make changes in their beliefs.

Indeed, as opposed to outright rejection or passive acceptance of technological development, as it is being thought by social constructivists' studies, in the case of biotechnology different phenomena are apparently observed. To explain these relationships include rejection, resistance and reconstruction of the technology for use. One unique aspect about biotechnology is that rejection, resistance and reconstruction of the technology are simultaneously pursued. Refusing to accept the technology (rejection), as is the case in the case of consumers in Europe and some in the U.S. as well as some politicians in Africa. The disruptive response by activists in both Europe and Africa, (resistance), and the creative attempts by the international community and development scientists, in developing new form of the technology (reconstructions) (Ruivenkamp et al., 1994, p. 18).

Genetically modified crops (GM crops) have emerged as a highly politically contested issue, both in industrialized and developing countries. The proponents of GM crops emphasize benefits such as increased crop productivity, more efficient input use, reduced pesticide application, and–in developing countries–a contribution to poverty alleviation and food security. The opponents of the GM technology are concerned with the risk of negative environmental effects, such as the reduction of biodiversity, loss of domestic and export markets, and with potential negative social and economic effects, such as health problems (allergies), conflicts within farm communities and disparities in wealth distribution.

Poverty has figured prominently in conflicts over genetic engineering in development strategy. India's former Prime Minister Atal Bihari Vajpayee sketched the pro-poor developmental state 'vision' of "shaping biotechnology into a premier precision tool of the future for creation of wealth and ensuring social justice – especially for the welfare of the poor" (Herring, 2007, p. 4). "Biotechnology is to fight obdurate diseases, increase agricultural production, combat nutritional deficiencies and protect the environment" (Department of Biotechnology, 2001, as cited in Herring, 2007, p. 3). Any and all of these outcomes could be pro-poor if realized.

Public intellectuals in India have written of 'seeds of death' in referring to GM crops (Shiva, Jafri, Emani, & Pande, 2000). Both supporters and detractors of transgenic have a poverty story to tell. Proponents have resurrected the Reverend Malthus in a view of aggregate food security that is often global: 'feeding a hungry world' is the corporate expression. Pinstrup-Andersen and Schiøler, in a book that won the World Food Prize for 2001, concluded "once again Malthus's clash between population growth and food production looms threateningly on the horizon" (Pinstrup-Andersen & Schiøler, 2000).

Despite the emphasis on the potential biotechnology could bring to arrest several issues related to food production and other factors that perpetuate poverty, proponents never claimed that biotechnology was a panacea to food insecurity and poverty problems in Africa and other developing countries. As stated by James (2008)

> This is no silver bullet to the food insecurity in Africa and the rest of the developing world, but it must be looked at as one of the most important tools that will contribute to increased food production and thus, poverty reduction.

Biotechnology advocators, always talk about how to make use of the best conventional technologies such as no-till or low-till farming and combine it with biotechnology for increased food production. They blame opponents for over blowing the expectation among those to explain this relationship need, knows that the technology could only work if it gets accompanied by the right policy, investment, and tools such as infrastructure.

Controversiality of Biotechnology: Possible Causes

The introduction of biotechnology for the use in agriculture has remained unpopular in last two decades, in both Europe and U.S. Though the degree of unpopularity varies, consumers in both regions have shown unprecedented levels of resistance on the use of the technology, especially for food and agriculture. Apparently the reason for the resistance has to do with avoiding uncertainty and possible risks the technology could cause on the life of consumers as well as on the environment. Ironically, those same consumers who live in these two continents have warmly welcomed the technology for medical purposes. Given the sensitivity of drugs to human health, in comparison to any other consumed product including food, risk does not explain these resistances. Instead absence of benefit from the technology seems to be the main factor for rejecting biotechnology.

In the case of medicine, both Europe and the U.S. are desperately looking for ways to combat several health issues, such as diabetes and cancer, and realizing the potential the technology has for arresting these deadly plagues, not only made them support the popularization of biotechnology, but also to invest heavily in its development. Food, on the other hand, is not a limiting factor in these continents. As people have several choices for food, there is little to be gained from shifting their food source and subsequent tastes. By 1999, only 47% of citizens in Europe supported the use of biotechnology in food, but 87% supported it in drugs (Gaskell et al., 2000).

As explained by Paarlbrerg (2008), the fact that the technology for the first time being introduced by private sectors such as drug companies which have already known to be controversial during second world war, as result of their trade behavior worsened by a growing frustration with the high public cost of storing and disposing of surplus agricultural production, (mainly in Europe) a political rise of green parties opposed to science intensive farming (especially in the post Thatcher United Kingdom) as a shift away from relying on public – sector founding for anything. Over the course of the past century, agriculture technologies, for the most part, originated out of the public research of the land grant – system or USDA. Biotechnology has been developed through private research; therefore, the results are looked upon as capitalistic and profit driven rather than a public good Davis, Mk.(1997).

Unfortunately, the introduction of this technology coincided with a time when several grievances had been experienced by the public in both Europe and the U.S. In the U.S., this was the time when multinationals closed their plants and started moving overseas for cheap labor and materials. Such actions were facilitated by the new trade arrangements at a global level, such as WTO, and regional agreements such as NAFTA. In Europe, the end of the 1980's was known forever as consumers' lost confidence in the public regulatory systems that are supposed to protect the public from unhygienic acts by producers and farmers. The 1987 incident of salmonella and 1989 BSE (mad cow diseases) were the two major factors that destroyed public confidence with regulatory services. The public despite repeated complaint and notifications to the regulatory system over these issues, the regulatory system either down played or overconfident, to control the situation.

This distrust appears to be stronger in Europe and other developing countries than in the U.S. For example, in 2003 Zambia rejected about 26,000 tons of food aid donated by the U.S. government, as humanitarian support for food insecure people. The story was not different in Malawi. Both governments opted to face the ugly consequences of starvation or consume food from GMO food-producing countries.

People's views of GMOs can vary from person to person and place to place, depending on different factors. Studies repeatedly exhibited that in the U.S., disapproval is strongest among people over 64, among women, and among people with low level of education (Gaskell et al., 2000). A study by The Institute for Studies in Research and Research Policy in Denmark also confirmed the same findings. In order to understand the perception of biotechnology in Denmark, a media survey was conducted for two years (1999-2000). The study suggested that the public assessment of biotechnology varied according to the application of the specific research area within the biotechnology field in question (Durant et al., 1998; as cited in Cetto, Freyvogel, Touré, & Thulstrup, 2001). There is generally a skeptical attitude toward biotechnology in food production, where the level of support for the application of the technology in the areas of genetic testing and the production of new medicine and vaccine is relatively high. The difference between male and female respondents according to the above study was marginal. There is a minor tendency toward a stronger emphasis on human and animal “cloning” amongst women. Age has a larger impact on perception of biotechnology than did gender.

With regard to sources of information, research has shown that the majority of information the public gets about biotechnology comes from media (Herman & Metcalfe, 2001) or from non-objective sources, such as Monsanto who supports it or Greenpeace, which opposed it. Such information sources widened the divergence between supporters and opponents as they were perceived by the consumers as biased sources.

Biotechnology: Impact in Creating New Social Relationships

Biotechnology appears to be one of the most influential technologies in human history. It has socioeconomic implications which are, not only very impactful, but also extremely powerful in creating a new kind of relationship between human being and nature across the board. This could be due to the sensitiveness and inclusiveness of the application of biotechnology, mainly medicine and food. Being compulsory’s for survival food and medical, they are great attraction points for investment and research, which implies the existence of big national and multinational companies, with strong political constituencies worldwide.

The new relationship essentially is a reflection and the outcome of the strong fight between the opponents and proponents of biotechnology. In the current farming operation, farmers being the main agent of farming, conduct their operations using land, labor, technology, as main inputs of production. Local and international research systems, depending on the level of economy, play a role in providing these technologies through the extension systems and helping farmers improve their productivity and earn better income. The input agencies also have a role to play in providing fertilizers, seeds, farm machineries, again depending on the farming system. Such agencies, depending on their capacity for production, may also be involved in research and development, beside their role in multiplying and retailing these inputs. Formulating rules and regulations are usually done at national levels. Hence, there has always been information exchange at a regional level in order to harmonize these rules and regulations among countries in the same regions.

The introduction of biotechnology in most cases is perceived to have great impact in reshaping the above features and bringing a new one. Though, many of these scientists may see the imminence of these changes, they may not agree on the importance of these changes. Some even argued such changes were not only unnecessary, but also dangerous. Some others have completely different stances and bitterly argue that the change is dialectical, the current world cannot sustain without these changes. The bottom-line is regardless of all these arguments, the change never stops, in fact to the contrary it changes gear and apparently invades a new horizon, such as in Europe, which was typically known previously as an immune zone for the anti-change forces. In 2007, the number of countries planting biotech crops increased to 23 as compared to 12 developing countries and 11 industrial countries with growth measured in hectares increasing from 117.7 to 143.7 million in 2007. Biotech crops achieved a very important milestone in 2007 with the number of resource-poor farmers benefiting in developing countries exceeding 10 million for the first time. “Of the global total of 12 million beneficiary biotech farmers in 2007, over 11 million were small and resource-poor farmers from developing countries like South Africa, Argentina, India and the Philippines” (James, 2007, p. xiii).

Ironically, both the pros and cons change forces agree on the potential of biotechnology to enhance global food security. Some argue it only works for commercial farms, not for small farmers. As Nnimmo Bassey (AllAfrica, n.d.), of Environmental Rights Action and FEI Nigeria, stated “GM crops would not solve poverty in Africa but would rather entrench poverty” (http://allafrica.com/stories/200802130917.html, 2008).

The main reason was that the scale of farming in Africa was too small to reap the benefits.

The push for GM crops is not the perfect solution that is being advertised. For starters, there is concern that biotechnology encourages monoculture and only lends itself to a large-scale, industrial style of agriculture, which is uncommon in Africa. The introduction of genetic engineering might well destroy Africa's model of production and consumption, which sustains more than 70% of the continent's farmers. According to Margaret Karembu, Director of the ISAAA Africentre in Nairobi, the criticism was unfounded because GM crops had not yet been given a fair chance on the continent.

Serious concerns among opponents remain about biotechnology's use, regulation effects of public safety, and the environment. Others, especially in the U.S. and Europe, as Paarlbrerg (2008) described in *Starved for science. How biotechnology being kept out of Africa*

> The new wealth brought by American and European farming by science was welcomed, but accompanying cultural demographic changes were socially difficult. The movement of labor out of farming required sometimes painful identity changes for those who left their familiar agrarian culture to seek work in town. (p. 58)

Whatever the case may be, change seems not only inevitable, but also leads to new kinds of arrangements that can be expressed both phenotypically and also in terms of content. New technologies in the future may not necessarily dwell on land to pursue agriculture production. However, since land is still very economical to be used as a main factor of production, it will continue to be the cheapest method of production. The labor force in the new system may include highly educated and sophisticated scientists beside the current working force. Considering, the current size of investment skewed toward international private corporate, agriculture would no longer be able to enjoy the widely available national and international public properties in technology and related information. National research systems and local farmers are now starting to adopt a new strategy initiating a new solidarity under the auspices of international conventions and rules and regulations, to resist to the aggressive invasions of multinationals backed by global institutions such as WTO.

The international convictions, which are ratified by respective nations, are considered as new frameworks of rules; however, these arrangements are equally influenced by changes in policies and strategies in existing multinationals and international organizations. For example economic restructuring of developing countries advocated by IMF in 1980's which have had a devastating effect in the economy of many developing countries in Africa, Asia and Latin America. Export promotion and governance policies of the World Bank are among some of the others revealed interventions with adverse effects in the development policies of developing countries.

In 2000, more than 120 countries approved the Cartagena Protocol on Bio-safety which was drafted "to provide protection in the face the risks to the environment and biodiversity that GMOs pose" (Tepper, 2001, p. 1). In response, the U.S., which opposed the protocol and has not ratified it, filed suit at the World Trade Organization against the European Union, to protest the moratorium on new commercial release of biotechnology crops, charging the ban was not based on scientific principles (Pollock, 2003).

Biotechnology and Africa

As Africa continues to struggle with civil wars, poverty, and AIDS, hunger remains the continent's most critical problem. Promoters of genetic engineering believe that genetically modified organisms are one of the answers that will eradicate starvation. The other side questions the safety and nutritious value of GM foods, as well as its inclination toward dependency.

The proponents of GM foods argue that if Africa gives GM foods a chance, it will curtail hunger in every country on the continent, especially in countries where crops fail to grow because of drought, pest infestations, or other natural causes and amid all of this, it is important to look at the bigger picture. Nearly 200 million Africans currently suffer from chronic hunger. At the start of 2003, the situation was so desperate that some 25 million Africans required emergency food aid.

In addressing the problem of hunger in Africa, it is perhaps most crucial to realize that hunger has many causes. The most important, among others, includes: access to and distribution of food, lack of good governance, civil wars/internal strife, imbalance in land distribution, and natural disasters (such as drought, floods, landslides).

In light of this broad range of challenges, it becomes quite obvious that the introduction of GM crops cannot be viewed as providing “the” answer. Many observers also worry that genetic engineering promoters are seeking to eliminate any possible competition from non-GM crops. In particular, this affects traditional crops that are more tailored to a country’s capacity to control its own future, and more appropriate to its technological developments and know-how. In addition, recent experience shows that countries–once they implement sound agricultural policies–can succeed without GM crops. In Africa there is little oversupply of food and few people are aware of the potential risks of GM crops. Yet, if genetic engineering technology is introduced on the continent, it will create new markets for seeds, herbicides, and pesticides. Multinational companies plan on using the new African Technology Transfer Foundation–funded by USAID, the Rockefeller Foundation, and the Monsanto Company–to persuade Africans to adopt the technology (United Nations Integrated Information Response Network, 2008).

This need is also consistent with the calls of African leaders in Durban, South Africa in May 2001, as well as in Abuja in October 2001, for revitalizing agriculture as the engine for economic growth on the continent, and the importance of research in making this happen, through the initiative for a New Partnership for Africa’s Development (NEPAD). In May 2001, the Forum for Agricultural Research in Africa (FARA), in collaboration with its sub-regional organizations, including ASARECA, has developed a Vision for African Agricultural Research, which calls for 6% annual growth in agricultural productivity in order to stem and reverse the decline in food production and incomes of rural poor in sub-Saharan Africa. FARA, in this Africa vision, focuses on catalyzing innovation and change in agricultural research in Africa. FARA also called on the international research system, including the CGIAR centers and advanced research institutions, to forge more effective and efficient partnerships with African NARS and achieve greater programmatic integrations. The present project will contribute to the realization of this vision.

Several African nations have signed and ratified the Convention on Biological Diversity (CBD) in 1994 in Proclamation Number 98/94. They also accepted the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), endorsed at global level in 2001. This treaty provides the legislative framework for the transfer, maintenance and public use of plant (crop, tree and forage) genetic resources, which is particularly relevant to put genetic resources under the custodianship of CGIAR centers. This treaty also recognizes the role of farmers in developing countries in the conservation and maintenance of indigenous plant genetic resources, and provides multilateral framework for the use and transfer of these resources. It does accept farmers´ rights for the use, storage, transfer and sale of these resources. This treaty also favors, embraces and promotes transfer of knowledge and practices in agricultural biotechnology.

African Union (AU) summit in 2007 in Ethiopia adopted a 20-year biotechnology plan for Africa, developed by the AU's High Level Panel on Modern Biotechnology (APB). At the summit, AU leaders also endorsed the African Seed and Biotechnology Program (ASBP) as a strategic framework for the development of the seed sector in Africa. The APB now provides African nationals with a body that can coordinate decision making, as well as make recommendations and goals for biotechnology development (The APB was created in 2005 and is made up of prominent individuals and biotechnology experts from different parts of Africa). The latter argues, however, that the question remains whether Africa's political leaders will have "the resolve and vision to capitalize on this opportunity to put biotech policy on a firm scientific footing." It notes that there has been a "backdrop of negative sentiments on genetically modified (GM) food on the African continent in recent years. And commentators have suggested that GM critics have a “political agenda,” not so much against explaining “GM technology itself,” but against “explaining that the multinational corporations promoting it neither pledge evidence-based decision making, nor the organization of campaigns promoting public understanding of biotechnology” will satisfy their concerns.

Africa also requested to be part to the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) and is expected to accept the treaty. This treaty provides for the establishment of standards for the range of intellectual property rights, including those concerned with biotechnology intellectual property assets. But patenting of knowledge and practices is not consistent with the age-old tradition of maintenance and transfer of indigenous knowledge and practice in traditional communities, in most African communities. The alternate arrangement in Sui-generis provides opportunities for developing countries to adapt this treaty to their needs and preferences. Several African countries (Ethiopia, Kenya, Ghana, and Zimbabwe) are moving in this direction. Accordingly, national laws have been drafted in two areas: 1) Access to indigenous knowledge and genetic resources, and 2) use correct management of biodiversity. About 27 African nations also accepted in 2002 the Cartagena protocol on biosafety. This protocol requires that signatory countries issue/enact legislation and guidelines to ensure that biodiversity, environment and human health are not adversely affected, or risks are kept to the minimum, by the transfer, use and handling of genetically modified organisms.

According to Professor Walter Alhassan (Program Coordinator of the Program for Biosafety Systems, for West Africa), the legislative environment in Africa seems over prudential and taking excessive time in its approval. To this effect, he called for an urgent cost effective legislative environment to promote the safe acquisition of the technology in Africa to enhance agriculture. He said there were bio-safety regulatory frameworks bounded by international conventions like the Cartagena Protocol in many countries to ensure safe use of biotechnology products in agriculture but where these regulatory systems existed they appeared too harsh to work with. Briefing the media on the current global status of commercial biotechnology for 2007 publication in Accra, Alhassan cautioned that if care was not taken the gene revolution, like the green revolution would pass Africa by and she would be left behind (United Nations Integrated Information Response Network, 2008).

Justification for Application of Agricultural Biotechnology

The potential increases in crop and livestock production can be achieved through enhanced agricultural research and generation of appropriate technologies. Available biotechnological tools for crop, livestock and forest production, and soil and food technology in the national research system can greatly speed up progress in generation of suitable agricultural technologies. National extension systems need to be revitalized for enhanced delivery and promotion of appropriate agricultural technologies for both the smallholder and commercial private sector. These call for increased capacity at various levels to generate, deliver and promote suitable biotechnological tools.

Biotechnology is the use of biological processes to achieve a specific purpose (see Figure 3). It is the application of scientific principles to the development of new forms of biological systems, and modification and utilization of living organisms. Although production/use efficiency increases with sophistication of traditional and biotechnological processes, technologies such as cloning and transgenic can be ethically very sensitive. The technology offers ranges of opportunities. Simpler technologies including tissue culture, micro-propagation, marker-assisted breeding, vaccine development, assisted livestock reproduction (AI, semen and embryo sexing) and promotion of existing useful microbiological processes (e.g. fermentation, nitrogen fixation).

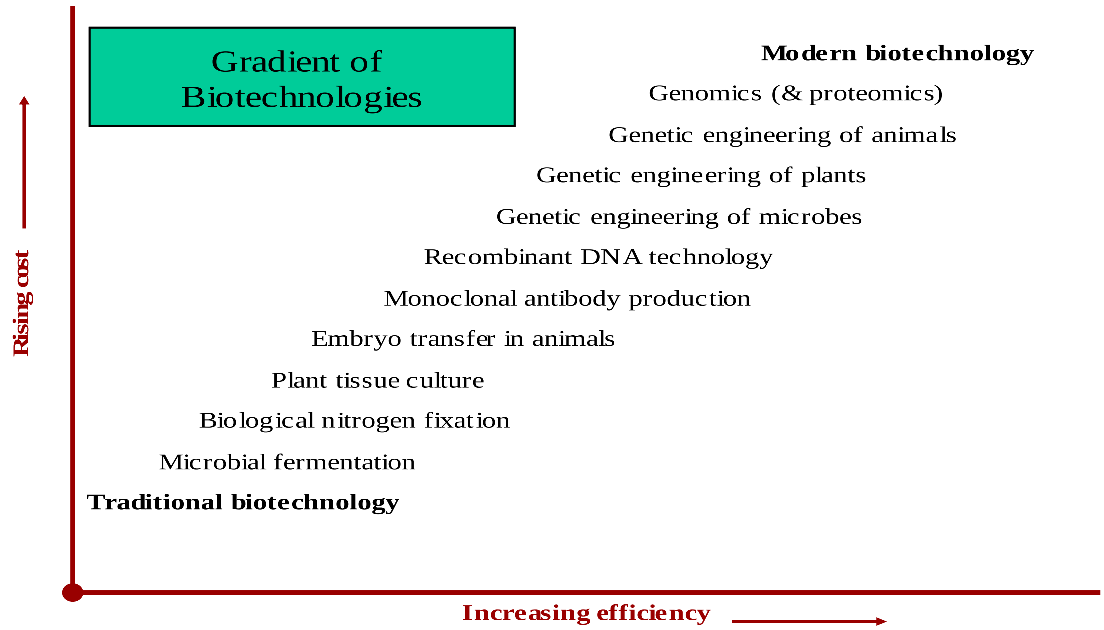

Figure 3. Gradient of biotechnologies and associated efficiency and cost. From G. Persley and J. MacIntyre, 1999.

Given the enormous potential for boosting agricultural output through use of current traditional and biotechnological innovations, there is a strong need in Africa for building traditional/biotechnological capacity for research and development. There are a range of biotechnological technologies which can quickly be adapted to meet specific needs in crop production, animal production and reproduction, indigenous forest rehabilitation, soil conservation and food processing. To the extent that biotechnology also has risks and is liable to mishandling of property, of equal importance here is the development of effective policy frameworks for supporting processes toward enacting policies in bio-safety, bioethics and protection of intellectual property rights.

Revolutionary advances in biotechnology offer potentially large benefits to poor producers and poor consumers. But today's investment in biotechnology concentrated in the private sector and driven by commercial interests, has limited impacts on small holders productivity in the developing World – with the exception of Bt cotton in China and India. Low public investment in

> biotechnology and small progress in regulating possible environmental and food safety risks have restrained the development of genetically modified organisms (GMOs) that could help the poor. The potential benefits of these technologies will be missed unless the international development community sharply increased its support to interested countries. (The World Bank, 2008)

In summary, agricultural biotechnology practices, policies, and issues in Africa are not academics issues. The policy debate about the satiability of biotech agricultural products should focus less on risk and more on building the necessary capacity that will exploit its advantages, while avoiding negative consequences; more on working toward solutions that reduce poverty and hunger while increasing the quality of the environment.

CHAPTER III

METHODOLOGY

This section provides information to ensure the validity of the research study. Therefore, it strives to provide clear and precise descriptions of how the study was accomplished, including data collection and analysis, methods used, and the rationale for why specific procedures were chosen. The methods used to complete this research were based on procedures outlined by Gall, Gall, and Borg (2007).

Research Design

The study design was based on explanatory descriptive research. According to Gall et al. (2007), *Descriptive research* is a type of quantitative research that involves making careful descriptions of studied phenomena. Description, viewed as understanding what people or things mean, also is an important goal of quantitative research. For this reason, when planning a descriptive research study one should be acquainted with both quantitative and qualitative approaches to descriptions. If the researcher's purpose is *explanation,* the focus of the study will be on understanding cause-and-effect relationships between variables. Causal-comparative designs can be used to discover and verify cause-and-effect relationships. However, correlational and experimental designs can be used as well.

Research Variables

The study sought to determine the relationship between the socio-cultural factors, worldviews and values, information sources, and policymakers' perceptions and attitudes toward agricultural biotechnology for making policy decisions.

Independent Variables

- Socio-demographic characteristics (gender, education level, occupation, geographic location);
- Information sources (interpersonal, print and electronic forms).

Dependent Variables

- Worldviews and values (moral value, labeling, regulation, consumers' rights, willingness to pay); and
- Understanding of agricultural biotechnology practices;
- Perceptions of agricultural biotechnology use in food production; and
- Attitudes toward agricultural biotechnology policies.

The variables and operational definitions of the various stakeholders used in the Torres et al. study (2006) were also used for this study. Other socio-cultural factors such as religion (socio-demographic variable), and worldviews and values were added to this study to broaden the socio-cultural dimension of the research.

Research Objectives

The purpose of this research project was to empirically verify communication factors that affect African policymakers' decisions about adopting agricultural biotechnology to alleviate food insecurity. The following objectives guided this research.

1. Record African policymakers' socio-demographic characteristics (gender, age, education level, occupation, geographic location);
2. Assess African policymakers' worldviews and values (moral value, labeling, regulation, consumers' rights, willingness to pay);
3. Determine African policymakers' information sources used to understand agricultural biotechnology practices;
4. Evaluate African policymakers' levels of understanding, perceptions of, and attitudes toward agricultural biotechnology use in agricultural development;
5. Test for significant relationships between independent (selected demographics) and dependent variables (African policymakers' worldviews and values, levels of understanding, and attitudes toward agriculture biotechnology); and
6. Develop a model for impacting African policymakers' decision making processes for agricultural biotechnology practices in food production.

Hypotheses

The following hypotheses were formulated to accomplish the purpose of the study.

Ho_1: No significant difference exists in policymakers' understanding of biotechnology when compared by country of origin.

Ha_1: At least one significant difference exists in policymakers' understanding of biotechnology when compared by country of origin.

Ho_2: No significant difference exists in policymakers' perceptions about biotechnology when compared by country of origin.

Ha_2: At least one significant difference exists in policymakers' perceptions about biotechnology when compared by country of origin.

Ho_3: No significant difference exists in policymakers' attitudes about biotechnology when compared by country of origin.

Ha_3: At least one significant difference exists in policymakers' attitudes about biotechnology when compared by country of origin.

Ho_4: No significant difference exists in policymakers' attitudes about biotechnology when compared by gender.

Ha_4: At least one significant difference exists in policymakers' attitudes about biotechnology when compared by gender.

Ho_5: No significant difference exists in policymakers' attitudes about biotechnology when compared by education levels.

Ha_5: At least one significant difference exists in policymakers' attitudes about biotechnology when compared by education levels.

Ho_6: No significant difference exists in policymakers' attitudes about biotechnology when compared by occupation type.

Ha_6: At least one significant difference exists in policymakers' attitudes about biotechnology when compared by occupation type.

Ho_7: No significant association exists between independent (selected demographics) and dependent variables (African policymakers' worldviews and values, levels of understanding, and attitudes toward agriculture biotechnology.

Ha_7: At least one significant association exists between independent (selected demographics) and dependent variables (African policymakers' worldviews and values, levels of understanding, and attitudes toward agriculture biotechnology.

As stated by Field (2000, 2005), when using a statistical test and when we have a specific prediction (on the direction of the change), about what will happen, and if we test this hypothesis statistically, the test is called a one-tailed test. Non-directional change, when we have no idea on the direction of the change and if we test this hypothesis statistically, the test would be a two-tailed test. Due to the nature of the issues to be addressed, all of the hypotheses were described as non-directional.

Population of Interest

The investigator solicited recommendations that were applicable for most of Africa, where a smallholder's production system is predominantly exercised; however, the research focused on three countries that had contrasting technology use levels in Africa: South Africa, Malawi, and Ghana. These three countries were at entirely different levels of technology use for agricultural growth. South Africa has an advanced technology use stage; Malawi and Ghana do not have an advanced technology use level for agricultural growth. In spite of the advanced technological use stage in South Africa, it had experienced several iterations in adopting its current policies. Likewise, Malawi and Ghana have debated the issue, but still have not made significant progress toward adopting policies affecting agricultural biotechnology practices. The investigator compared and contrasted the different communication and policymaking processes between these countries.

Malawi is a land-locked country of about 119,000 sq km with a population of about 12 million people. Agriculture in Malawi is the backbone of the economy, contributing about 40% of GDP and employing about 85% of the labor force. Food shortages, poor health, poverty, and environmental degradation are major problems faced by the country. These problems are due to low agricultural productivity, poor health services, poor environmental health, low industrial base, high unemployment, high population pressure on limited areas, and limited technological capacity to address the problems. The smallholder sub-sector of Malawi comprises about 2.4 million households with an average land size of 1.2 ha. Maize, the staple food crop, is grown by 97% of farming households on about 1.6 million ha of smallholders' farms and contributes 60% of the total caloric consumption.

South Africa has a dual agricultural economy, with both developed commercial farming and more subsistence-based production in deep rural areas. Covering 1.2 million square kilometers of land, South Africa is one eighth the size of United States and has seven climatic regions from Mediterranean to subtropical to semi desert. Agriculture activities range from intensive crop production to mixed farming during winter rainfall, cattle ranching in bushveld during high summer rainfall areas, and sheep farming in the regions. Maize is mostly grown, followed by wheat, oats, sugarcane, and sunflowers.

While 13% of South African land is used for crop production, only 22% is of high-potential arable land. The most important limiting factor is the availability of water. Rainfall is unequally distributed across the country, with some areas prone to draught. Almost 50% of South African water is used for agriculture with about 1.3 million ha under irrigation. Today South Africa is not only self-sufficient in virtually all major agricultural products, but is also a net food exporter. Farming remains vitally important to the economy and development of the country.

Ghana is located in West Africa’s Gulf of Guinea only a few degrees north of the equator. Out of the estimated population of 20 million (2000) 70% live in the southern half on Ghana. Population per square mile is estimated to be 209. It is a low land country, except for the range of hills on the eastern boarder. A tropical rainforest belt, broken by heavily forested hills, many streams and rivers, extends northward from the shore, near the Cote d’Ivoire frontier. The coastal area known as Ashanti produces most of the country’s cocoa, minerals, and timber. In the west, the terrain is broken by heavily forested hills and many streams and rivers.

Ghana is the third largest producers of cacao in the world. Large tracts of forest have been cleared for cacao crops. Deforestation, overgrazing, and periodic drought have led to desertification and soil erosion. Ghana has ratified international agreements protecting biodiversity, endangered species, wetlands, and the ozone layer.

Sampling Procedures

A sampling of the population, according to Gall et al. (2007), implies that the larger group that you wish to learn about is called a population. Sampling refers to the process of selecting a sample from a defined population with the intent that the sample accurately represents the population.

The sample size for different stakeholder groups was determined using statistical methods. Sample respondents were chosen from the following sectors in each specific country (Table 1).

Table 1

Population and Samples for Respondent Groups in Malawi, South Africa, and Ghana

	Malawi		South Africa		Ghana	
Respondent Groups	*N*	*n*	*N*	*n*	*N*	*n*
Business Leaders	100	55	200	75	100	55
Extension Workers	1,200	108	1,800	112	500	96
Farmer Leaders	500	96	1,000	106	200	75
Journalists	200	75	400	92	30	17
Government Officials	100	55	200	75	100	55
Religious Leaders	30	17	100	55	30	17

Instrumentation

In attitudinal research, in the absence of a scale suitable to your purposes that has already been constructed in the literature, you will need to develop one. The research instrument entitled "Communication Factors Affecting Africa Policymakers' Decisions about Agricultural Biotechnology" was designed to provide scales by which to measure understanding, knowledge, and perceptions of agricultural biotechnology, three important constructs of the overall study. These three constructs were used to design questions for 12 specific scales to measure African policymakers' socio-demographic characteristics (gender, age, education level, occupation, geographic location); worldviews and values (moral value, labeling, regulation, consumers' rights, willingness to pay); information sources (interpersonal, print, and electronic forms); understanding of agricultural biotechnology practices; perceptions of agricultural biotechnology use in food production; and attitudes toward agricultural biotechnology policies. Nine of the 12 sections employed a variant of the Likert scale. According to Gall et al. (2007) a Likert scale allows individuals to rate their levels of agreement (e.g., *strongly agree*, *agree*, *undecided*, *disagree*, *strongly disagree*) with various statements.

The first section measured respondents' worldviews and values. Respondents were asked their worldviews and values about agricultural biotechnology use in food production. Respondents rated their agreement levels for 11 statements, using a Likert-type, four-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *agree*, 4 = *strongly* *agree*). To avoid patterned response sets, reverse coding of some statements was used to reduce a biasing effect (Tuckman, 1999). Sample statements for worldviews and values about agricultural biotechnology use in food production included (a) Genetic manipulation takes mankind into realms that belong to God and God alone, (b) Genetic engineering means cheaper food for consumers, and (c) Genetically-altered foods should be labeled.

The second section measured respondents' biotechnology information sources used within the past two months (prior to their participation in the study). Respondents checked the number (0, 1, 2, 3, or 4+) of contacts for each of 12 sources. Sample biotechnology information sources included (a) Accessed a Web site on biotechnology, (b) Read books on biotechnology, and (c) Talked or heard from experts or scientists about biotechnology.

Section three measured respondents' trust levels for sources of agricultural biotechnology issues. Trust was measured using a Likert-type, four-point scale (1 = *completely untrustworthy*, 2 = *untrustworthy*, 3 = *trustworthy*, 4 = *completely untrustworthy*). Respondents were asked how much they trusted each of 17 sources on agricultural biotechnology issues. Samples of sources included (a) Activist groups, (b) Agricultural biotechnologies companies, (c) Agricultural input dealers, and (d) Religious leaders.

Similar to section three, the fourth section measured respondents' perceived levels of bias for sources of agricultural biotechnology issues. Bias was measured using a Likert-type, four-point scale (1 = *completely biased*, 2 = *biased*, 3 = *unbiased*, 4 = *completely unbiased*). Respondents were asked how biased each of the same 17 sources was on agricultural biotechnology issues. Samples of sources included (a) Consumer groups, (b) Food companies, (c) Newspapers, and (d) Radio broadcasts.

Section five measured how much respondents understood about agricultural biotechnology for food production. Respondents checked their understanding by answering True or False for each of 13 statements. Each statement had only one correct response. Sample statements included (a) Brewing yeast contains living organisms; (b)

By eating genetically modified corn, a person gene could also modify; and (c) Genetically modified crops are now being commercially grown in my country.

Section six measured the respondents' perceived importance of agricultural biotechnology in food characteristics. Importance was measured using a Likert-type, four-point scale (1 = *very unimportant*, 2 = *unimportant*, 3 = *important*, 4 = *very important*). Respondents were asked to rate the importance of 12 agricultural biotechnology uses in food characteristics, which included (a) Better tasting food/palatability, (b) Decreased ground water contamination, (c) Decreased use of water for production, and (d) Higher nutritional qualities. This section was part of a larger research project; therefore, although descriptive data were derived from respondents' input, no additional data analyses were performed in answering the objectives and/or hypotheses for this dissertation.

The seventh and eight sections measured respondents' perceptions of agricultural biotechnology with two questions. The first question, "Is the use of agricultural biotechnology in food production hazardous?" could be answered with one of four options (*Not at all Hazardous*, *Somewhat Hazardous*, *Very Hazardous*, or *I have No Opinion*). The second question, "Are there benefits associate with the use of agricultural biotechnology in food production?" could also be answered with one of four responses (*Not at all Beneficial*, *Moderately Beneficial*, *Very Beneficial*, or *I have No Opinion*).

The ninth section measured respondents' opinions about agricultural biotechnology policy. Opinion was measured using a Likert-type, four-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *agree,* 4 = *strongly agree*). Respondents were asked to rate the importance of 13 statements about agricultural biotechnology policy. To avoid patterned response sets, reverse coding of some statements was used to reduce a biasing effect (Tuckman, 1999). Sample statements included (a) Bio-safety regulations are adequate for protecting my country's food products, (b) Biotechnology in food production only benefits large agricultural companies, (c) Expert statements about biotechnology are based on scientific analysis and are therefore objective, and (d) Government agencies are doing their best to ensure that the food we eat is safe. This section was part of a larger research project; therefore, although descriptive data were derived from respondents' input, no additional data analyses were performed in answering the objectives and/or hypotheses for this dissertation.

Section ten measured respondents' concerns about the use of agricultural biotechnology for 11 situations. Concern levels were measured using a Likert-type, four-point scale (1 = *very unconcerned*, 2 = *unconcerned*, 3 = *concerned*, 4 = *very concerned*). Sample situations included (a) Consequences for farming and food production, (b) Economic implications, (c) Ethical implications, and (d) Religious concerns about altering nature. This section was part of a larger research project; therefore, although descriptive data were derived from respondents' input, no additional data analyses were performed in answering the objectives and/or hypotheses for this dissertation.

The eleventh section measured respondents' attitudes toward agricultural biotechnology for six specific issues. Respondents were asked, "To what extent do you believe that agricultural biotechnology practices will affect the following?" Attitudinal levels were measured using a Likert-type, four-point scale (1 = *very negative*, 2 = *negative*, 3 = *positive*, 4 = *very positive*). The six issues included (a) Commercial farming, (b) The environment, (c) Fish and wildlife, (d) Food production, (e) Small scale farms, and (f) Your health.

Section twelve measured respondents' global attitudes about agricultural biotechnology. Attitude was measured using a Likert-type, four-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *agree*, 4 = *strongly agree*). To avoid patterned response sets, reverse coding of some statements was used to reduce a biasing effect (Tuckman, 1999). Respondents were asked to rate 13 statements; sample statements included (a) I would not attend an information session on biotechnology in food production in my community, (b) God granted us the abilities to manipulate nature for our benefit, (c) I am not willing to pay extra for the labeling of genetically-modified foods, and (d) It is okay to introduce fish genes into strawberries to resist extreme freezing temperatures.

The final section recorded demographic information, such as gender, age, education level achieved, marital status, residence, religion, and self-perceived level of scientific knowledge (*low, somewhat low, average, somewhat high,* or *high*).

Data Collection

According to Gall et al. (2007), research requires a systematic method of collection data. The investigator had made a trip to the three focus countries in summer 2008. The researcher on this particular trip spent two weeks in each of the three countries, namely South Africa, Malawi and Ghana. The investigator, using local contacts, reached hundreds of respondents with questionnaires, physically as well as through electronic means such as email.

The investigator particularly benefited from attending the annual regional conference on biotechnology, which took place in Johannesburg from June 21-22 where he met several scientists, farmers, NGO leaders, regional agencies as well as government agencies, of different opinions on this meeting. Moreover, the research largely benefits from the face-to-face discussion the investigator had with policymakers in each of these countries. The interview list included Ministers, Permanent secretaries, Department and Agency heads and several scholars interested in the field. Based on the principle of purposive sampling, the investigator with the permission of the respondents' had recorded some of the interviews using a voice recorder.

In addition to these interviews, several consultation meetings with stakeholders on the preliminary findings of the data analysis took place in Kenya and Malawi during spring 2009. The investigator was joined by the chair the PhD committee who came to supervise the research work at the field level. Whereas informal discussions and dialogs with prominent individuals and institutions were predominantly used in exploring information in Kenya, a meeting with high level policymakers was a strategy adopted in Malawi. The scheduled meeting constituted high levels of government and non-government officials of different views. One of the criteria for inviting participants was their non-exposure of the study in the past. The participants were requested to complete the survey upon their arrival at the meeting. This was followed by a presentation on the major areas of the findings of the analysis by the researchers. The fact that most of these responses on the survey from Malawi had been shown to be significantly different from that of the other two countries, Ghana and South Africa, influenced the decision of choosing Malawi as a venue for the consultation. The discussion was extremely helpful in confirming the consistency of the data to that of the opinion of the policymakers.

Data Analyses

Data were analyzed using descriptive, bivariate, and multivariate techniques. The interaction between different groups of samples analyzed using ANOVA techniques. Dummy method is used to represent data in categorical form using only zero and one. According to Field (2000), dummy coding is a way of representing groups of people using only zeroes and ones.

Bivariate correlational analysis is a measure of linear association between two variables. The correlation coefficient value ranges between -1.00 (a perfect negative relationship) and +1.00 (a perfect positive relationship). A value of 0 indicates no linear relationship. While interpreting the correlation coefficient as a descriptive measure, Davis (1971) provided the example in Table 2.

Table 2

Descriptions to Interpret Correlation Coefficients

Size of Correlation	Interpretation
.70 to 1.00 (-0.70 to -1.00)	Very Strong positive (negative) correlation
.50 to .69 (-0.50 to -0.69)	Substantial positive (negative) correlation
.30 to .49 (-0.30 to -0.49)	Moderate positive (negative) correlation
.10 to .29 (-0.10 to -0.29)	Low positive (negative) correlation
.01 to .09 (-0.01 to -0.09)	Negligible positive (negative) correlation

Surveys were placed in numerical order and entered into secured server in order to reduce data entry and inputting errors. The analysis of the data was done using the Statistical Package for Social Science (SPSS, 2005) release 15.0 version. With regard to reporting, the study adopted SPSS reporting techniques.

Findings reported and presented to targeted policy-level decision makers in each respective country .The investigators worked together with the lead researcher to resolve issues of reliability and validity and to analyze the data collected. The validity and reliability of the scales were determined using a variety of techniques. Content and face validity were determined through exposure to an external sample of experts in South Africa prior to the survey. Cronbach's (1951) alpha is a widely used method for computing test scores reliability. The alphas for each conceptual scale are shown in Table 3.

Table 3

Alpha Coefficients of Reliability for Conceptual Scales

Conceptual Scales	Alpha Coefficients
Worldviews and Values	.65
Levels of Trust for Sources of Agricultural Biotechnology	.86
Levels of Bias for Sources of Agricultural Biotechnology	.84
Understanding of Agricultural Biotechnology	.50
Importance of Agricultural Biotechnology in Food Characteristics	.90
Perception of Agricultural Biotechnology	.65
Opinions about Agricultural Biotechnology Policy	.80
Concerns about the Use of Agricultural Biotechnology	.92
Attitudes toward Agricultural Biotechnology	.86
Global Attitudes toward Agricultural Biotechnology	.79

A significant level of alpha .05 was used in the data analyses, and reliability was tested using Cronbach's alpha (Cronbach, 1951). As defined by Gall et al. (2007), Cronbach's alpha coefficient is a general form of K-R 20 formula that can be used when items on a measure are not scored dichotomously. Given the involvement of several independent variables in the study multiple regression analysis (MR) was used.

"Multiple regression analysis is eminently suited for analyzing the collective and separate effects of two or more independent variables on a dependent variable" (Pedhazur, 1982, p. 6).

Multicollinearity assessment was done in order to learn inter-correlations among independent variables and decide the degree of independency of the independent variables. "The least ambiguous definition of multicollinearity is that it refers to the absence of orthogonality in the set of independent variables" (Farrar & Glauber, 1967, as cited in Pedhazur, 1982, p. 233). "Orthogonal means at right angles (90°). When two variables are orthogonal they are independent of each other . . . Multicollinearity is absent when a matrix of variables is orthogonal" (Pedhazur, 1982, p. 233).

CHAPTER IV

RESULTS

Objective 1

Respondents (N = 174) from Malawi (n = 76), Ghana (n = 69), and South Africa (n = 29) (see Figure 4) completed the survey section requesting their socio-demographic characteristics (gender, age, education level, occupation, geographic location) (Table 4). In addition to answering this first objective, the researcher gathered each respondent's employment title and number of years he/she had been in the current employment. Respondents averaged 12.18 years (SD = 11.27) in their current employment.

Government officials (n = 58) comprised the largest sub-group of respondents, followed by extension workers (n = 51), farmer leaders (n = 32), journalists (n = 17), business leaders (n = 13), and religious leaders (n = 3) (see Figure 5). For the purposes of statistical comparisons between groups, the sub-groups of journalists, business, and

Table 4

Respondents' Socio-demographic Characteristics (N = 174)

Variables	Sub-groups	*f*	%
Country of Origin	Malawi	76	43.7
	Ghana	69	39.7
	South Africa	29	16.7
Respondents' Professions	Government Officials	58	33.3
	Extension Workers	51	29.3
	Farmer Leaders	32	18.4
	Journalists	17	9.8
	Business Leaders	13	7.5
	Religious Leaders	3	1.7
Gender	Male	116	66.7
	Female	54	31.0
	Missing	4	2.3

Table 4 (Continued)

Variables	Sub-groups	*f*	%
Age Categories	21-30	38	21.8
	31-40	36	20.7
	41-50	50	28.7
	51-60	34	19.5
	61 and above	11	6.3
	Missing	5	2.9
Education Levels	Some Elementary	15	8.6
	Elementary Graduate	4	2.3
	Some High School	6	3.4
	High School Graduate	6	3.4
	Some College	31	17.8
	BS/BA Degree	46	26.4
	Post-graduate Degree	49	28.2
	Other	10	5.7
	Missing	7	4.0
Marital Status	Married	126	72.4
	Single	37	21.3
	Other	7	4.0
	Missing	4	2.3
Residence Type	Rural	49	28.2
	Suburban	30	17.2
	Other	91	52.3
	Missing	4	2.3
Religion	Protestant	86	49.4
	Roman Catholic	32	18.4
	Islam	7	4.0
	Other	40	23.0
	Missing	9	5.2
Self-perceived Level of Scientific Knowledge	Low	23	13.2
	Somewhat Low	13	7.5
	Average	60	34.5
	Somewhat High	37	21.3
	High	37	21.3
	Missing	4	2.3

Note. Frequencies may not total 100% because of missing data.

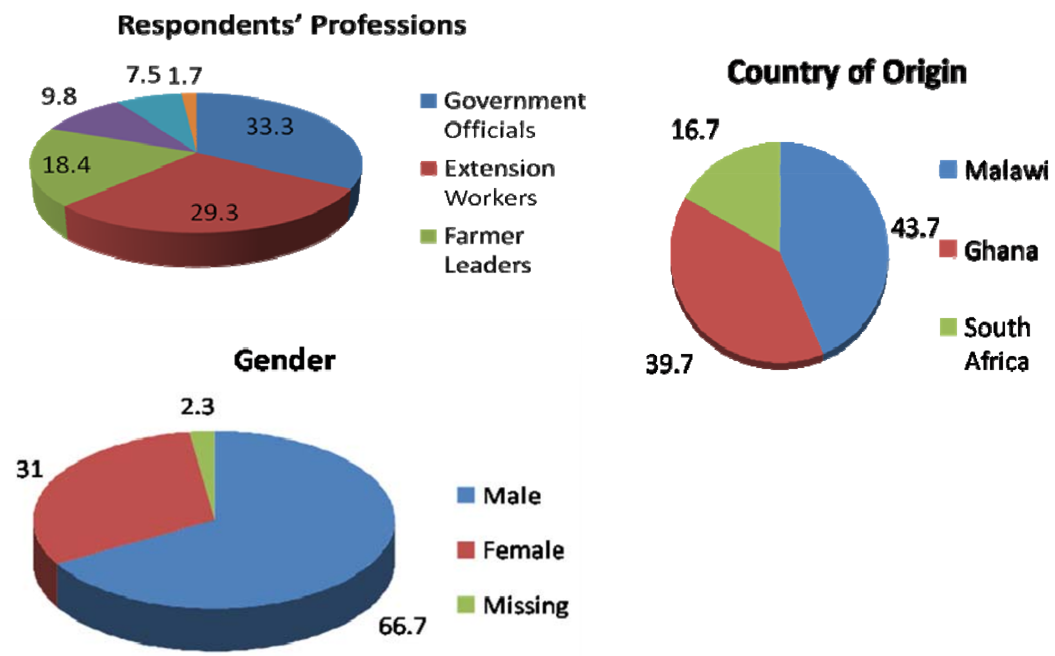

Figure 4. Socio-demographic characteristics: Professions, gender, and country of origin.

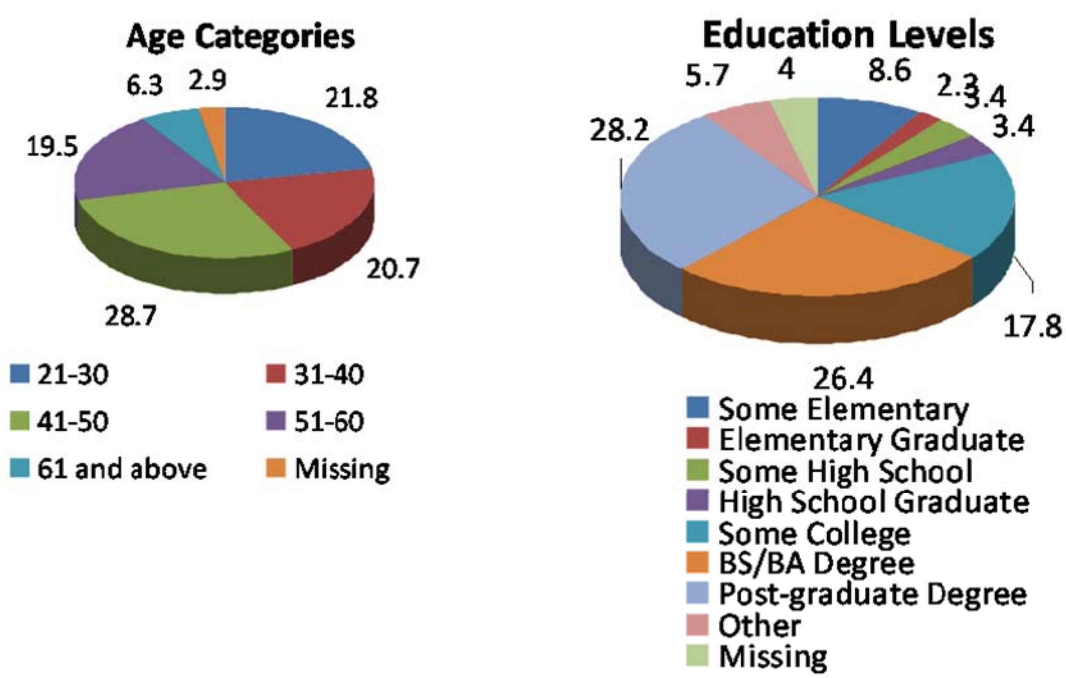

Figure 5. Socio-demographic characteristics: Age categories and education levels.

religious leaders were collapsed into one single sub-group termed “other.” Respondents were predominantly male (*n* = 116), 41 to 50 years of age (*n* = 50), possessed a post-graduate degree (*n* = 49), were married (*n* = 126), lived in an area (*n* = 91) other than rural or suburban, and were protestant (*n* = 86) (Table 4).

Objective 2

The second objective was to assess African policymakers’ worldviews and values (moral value, labeling, regulation, consumers’ rights, and willingness to pay) toward agricultural biotechnology. Respondents rated their agreement levels for 11 statements about worldviews and values toward agricultural biotechnology (Figure 6), using a Likert-type, four-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *agree*, 4 = *strongly agree*). To facilitate understanding of sub-group responses for later comparisons, respondents’ agreement levels for worldviews and values toward agricultural biotechnology are reported by country of origin and sorted in descending order by grand means (Table 5).

As a group, respondents strongly agreed (*M* = 3.73, *SD* = .52) with only one statement: Consumers have a right to choose what they eat; hence, to know what they are eating (Table 5). They agreed (*M* = 2.51-3.50) with five statements and disagreed (*M* = 1.51-2.50) with five statements. However, dispersion between country-specific responses indicated wide variation in agreements levels for specific statements (Table 5).

Table 5

Descriptive Statistics for Respondents' Worldviews and Values toward Agricultural Biotechnology (N = 174)

	Ghana (*n* = 69)		Malawi (*n* = 76)		South Africa (*n* = 29)		Total (*N* = 174)	
Statements	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Consumers have a right to choose what they eat; hence, to know what they are eating.	3.82	.49	3.64	.56	3.75	.44	3.73	.52
Genetically-altered foods should be labeled.	3.38	.78	3.33	.78	3.30	.95	3.34	.81
I would attend an information session on biotechnology in my community.	3.34	.69	3.32	.64	3.30	.67	3.33	.66
Until we know that genetically-altered foods are totally safe, those products should be banned.	2.69	1.14	2.86	.83	2.30	.91	2.70	.99
Genetic engineering means cheaper food for consumers.	2.59	.72	2.52	.88	2.68	.77	2.57	.80
Genetic engineering means more nutritious food for consumers.	2.70	.76	2.40	.89	2.61	.69	2.56	.81
I am willing to pay extra for the labeling of genetically-modified foods.	2.15	.95	2.46	.85	2.14	.85	2.28	.90
Genetic manipulation takes mankind into realms that belong to God and God alone.	2.29	1.02	2.30	.98	2.00	.92	2.25	.99
We have no business meddling with nature.	2.15	1.00	2.28	.86	2.07	.87	2.19	.92
The use of biotechnology in food production is against my moral values.	1.94	.87	2.29	.75	1.92	.84	2.09	.83
The regulation of modern biotechnology should be left mainly to industry.	1.94	.80	2.13	.91	1.93	.68	2.02	.83

Scale: 1.00-1.50 = *strongly disagree*, 1.51-2.50 = *disagree*, 2.51-3.50 = *agree*, 3.51-4.00 = *strongly agree*.

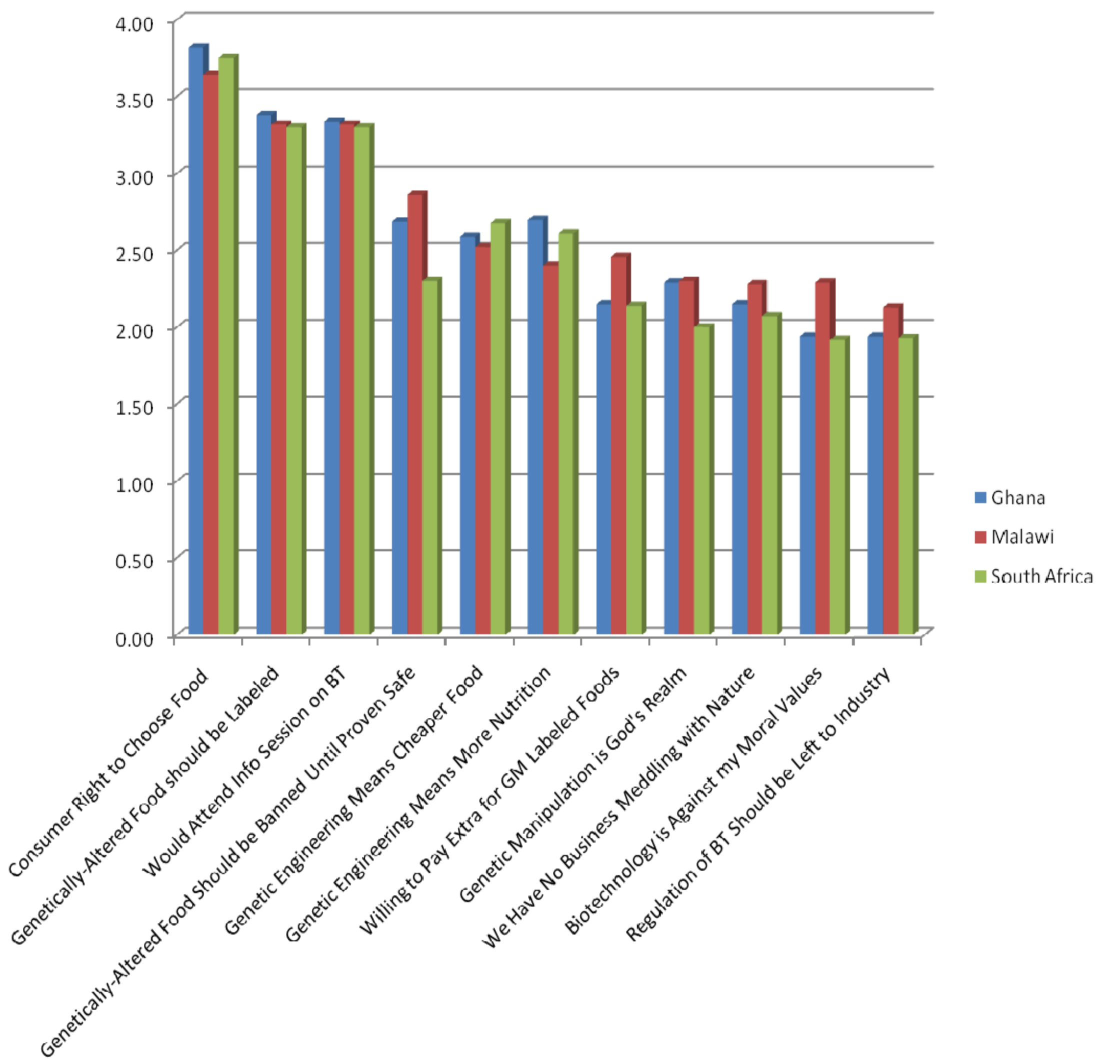

Figure 6. Mean responses for respondents' worldviews and values toward agricultural biotechnology by country of origin.

Objective 3

The third objective was to determine African policymakers' information sources used to understand agricultural biotechnology practices. Respondents recorded the number of contacts (within the past two months at the time of the survey) for 12 information sources (Table 6). As a group, respondents were most apt (*n* = 119) to frequent printed materials (newsletters, pamphlets, or brochures) as their source of biotechnology information within the two months prior to completing the survey (Table 6). They were least likely (*n* = 21) to talk with or hear from a religious leader as a biotechnology information source.

Table 6

Frequency Distribution for Number of Contacts for Biotechnology Information Sources by Country of Origin

		Number of Contacts					
I have…	Countries	1	2	3	4+	Sub-total	Total
Read newsletters, pamphlets, brochures on biotechnology	Ghana	21	10	9	9	49	119
	Malawi	22	5	5	14	46	
	South Africa	9	4	8	3	24	
Read and watched about biotechnology in the mass media	Ghana	16	10	6	9	41	103
	Malawi	17	9	2	11	39	
	South Africa	5	9	4	5	23	
Talked or heard from experts or scientists about biotechnology	Ghana	13	9	8	13	43	98
	Malawi	14	8	4	11	37	
	South Africa	6	4	4	4	18	
Read books on biotechnology	Ghana	11	7	6	13	37	92
	Malawi	15	11	5	8	39	
	South Africa	8	3	2	3	16	
Talked to or heard from family/friends/neighbors about biotechnology	Ghana	18	8	6	6	38	87
	Malawi	13	7	4	5	29	
	South Africa	8	8	1	3	20	

Table 6 (Continued)

I have…	Countries	Number of Contacts 1	2	3	4+	Sub-total	Total
Talked or heard from a NGO about biotechnology	Ghana	11	7	3	5	26	75
	Malawi	14	7	6	7	34	
	South Africa	3	5	6	1	15	
Talked to or heard from food regulators on biotechnology	Ghana	16	7	4	4	31	74
	Malawi	11	8	4	5	28	
	South Africa	7	3	3	2	15	
Talked to or heard from agricultural biotechnology companies	Ghana	11	5	5	2	23	71
	Malawi	16	9	1	7	33	
	South Africa	3	7	3	2	15	
Talked to or heard from local politicians/leaders about biotechnology	Ghana	15	6	5	4	30	65
	Malawi	11	1	2	7	21	
	South Africa	6	5	2	1	14	
Attended seminars or public forums on biotechnology	Ghana	11	8	3	5	27	59
	Malawi	9	7	4	0	20	
	South Africa	6	3	2	1	12	
Accessed a Web site on biotechnology	Ghana	9	6	4	12	31	59
	Malawi	8	2	4	3	17	
	South Africa	5	1	0	5	11	
Talked to or heard from a religious figure e.g. nun, priest, monk, imam, cleric	Ghana	4	1	0	1	6	21
	Malawi	4	4	2	1	11	
	South Africa	2	1	1	0	4	

Note. Frequencies do not comprise 100% of all respondents because some chose zero number of contacts for individual information sources.

In addition to assessing respondents' frequencies of use for selected biotechnology information sources, respondents were also asked to evaluate the level of trust they had for each of 17 information sources. Trust was measured using a Likert-type, four-point scale (1 = *completely untrustworthy*, 2 = *untrustworthy*, 3 = *trustworthy*, 4 = *completely trustworthy*). To facilitate understanding of sub-group responses for later comparisons, respondents' perceived levels of trust for information sources on agricultural biotechnology are reported by country of origin and sorted in descending order by grand means (Table 7).

As a group respondents rated university-based scientists as completely trustworthy (*M* = 3.11, *SD* = .73). They also rated activists as completely untrustworthy (*M* = 2.41, *SD* = .80). They rated science magazines as trustworthy (*M* = 2.96, *SD* = .71) and family/friends/neighbors as untrustworthy (*M* = 2.43, *SD* = .75).

Table 7

Descriptive Statistics for Respondents' Perceived Levels of Trust for Information Sources on Biotechnology Agricultural Issues (N = 174)

	Ghana (*n* = 69)		Malawi (*n* = 76)		South Africa (*n* = 29)		Total (*N* = 174)	
Information Sources	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
University-based scientists	3.13	.67	3.07	.82	3.15	.61	3.11	.73
Science magazines or newsletters	3.00	.60	2.84	.79	3.19	.63	2.96	.71
Web sites on biotechnology	2.92	.56	2.69	.87	2.75	.53	2.79	.72
Private sector scientists	2.77	.71	2.76	.84	2.68	.80	2.75	.78
Consumer groups	2.62	.72	2.75	.78	2.68	.56	2.69	.72
Government officials	2.48	.70	2.95	.81	2.40	.82	2.68	.81
Religious leaders	2.74	.69	2.74	.80	2.33	.76	2.68	.77
Television broadcasts	2.68	.68	2.73	.73	2.50	.58	2.68	.69
Non-governmental organizations	2.67	.77	2.62	.76	2.72	.74	2.65	.75
Farmers/farmer groups	2.73	.69	2.47	.78	2.85	.78	2.63	.76
Agricultural biotech companies	2.69	.71	2.49	.81	2.56	.77	2.58	.77
Radio broadcasts	2.55	.72	2.66	.67	2.31	.62	2.56	.69
Newspapers	2.47	.68	2.53	.84	2.42	.58	2.49	.74
Agricultural input dealers	2.40	.59	2.41	.72	2.71	.55	2.45	.65
Food companies	2.52	.60	2.38	.73	2.42	.58	2.44	.66
Family/friends/neighbors	2.62	.74	2.36	.71	2.19	.80	2.43	.75
Activist groups	2.41	.86	2.40	.72	2.46	.88	2.41	.80

Scale: 1.00-1.50 = *completely untrustworthy*, 1.51-2.50 = *untrustworthy*, 2.51-3.50 = *trustworthy*, 3.51-4.00 = *completely trustworthy*.

Equally, respondents were asked to rate the perceived levels of bias for each of the same 17 information sources on agricultural biotechnology issues. Bias was measured using a Likert-type, four-point scale (1 = *completely biased*, 2 = *biased*, 3 = *unbiased*, 4 = *completely unbiased*). To facilitate understanding of sub-group responses for later comparisons, respondents' perceived levels of bias for information sources on agricultural biotechnology are reported by country of origin and sorted in descending order by grand means (Table 8). With regard to perceived levels of biased respondents as a group rated University– based scientists unbiased (*M* = 2.94, *SD* = .76) and activists group biased (*M* = 2.05, *SD* = .84).

Objective 4

The fourth objective was to evaluate African policymakers' levels of understanding, perceptions of, and attitudes toward agricultural biotechnology use in agricultural development. Respondents evaluated their levels of understanding by answering True or False to each of 13 statements (see Figure 7). Each statement had only one correct response (Table 9). Two statements were found to be confusing to the respondents because of inadequate information regarding country-specific agricultural biotechnology policy; those two statements (Products from genetically-modified crops are now being sold in my country; and, Genetically-modified crops are now being commercially grown in my country) were removed from further analyses.

Table 8

Descriptive Statistics for Respondents' Perceived Levels of Bias for Information Sources on Biotechnology Agricultural Issues (N = 174)

	Ghana (*n* = 69)		Malawi (*n* = 76)		South Africa (*n* = 29)		Total (*N* = 174)	
Information Sources	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
University-based scientists	2.91	.63	2.93	.92	3.04	.52	2.94	.76
Science magazines or newsletters	2.88	.67	2.67	.82	2.88	.34	2.78	.71
Government officials	2.48	.67	2.78	.84	2.65	.63	2.64	.76
Consumer groups	2.52	.74	2.69	.89	2.56	.58	2.60	.79
Family/friends/neighbors	2.70	.67	2.52	.83	2.52	.64	2.59	.74
Private sector scientists	2.63	.79	2.52	.88	2.67	.62	2.58	.81
Religious leaders	2.60	.70	2.69	.86	2.19	.69	2.58	.79
Farmers/farmer groups	2.59	.56	2.49	.81	2.59	.64	2.55	.70
Television broadcasts	2.54	.66	2.57	.79	2.50	.51	2.55	.70
Web sites on biotechnology	2.57	.76	2.54	.90	2.50	.71	2.55	.82
Newspapers	2.53	.57	2.55	.82	2.42	.58	2.52	.70
Non-governmental organizations	2.47	.71	2.52	.72	2.59	.64	2.52	.70
Radio broadcasts	2.48	.64	2.54	.76	2.37	.56	2.49	.69
Agricultural input dealers	2.23	.66	2.29	.76	2.23	.59	2.26	.70
Food companies	2.34	.75	2.12	.77	2.30	.72	2.23	.75
Agricultural biotech companies	2.30	.74	2.21	.81	1.96	.66	2.20	.76
Activist groups	2.09	.84	2.14	.80	1.68	.90	2.05	.84

Scale: 1.00-1.50 = *completely biased*, 1.51-2.50 = *biased*, 2.51-3.50 = *unbiased*, 3.51-4.00 = *completely unbiased*.

Table 9

Frequency Distribution for Correct Responses to Understanding of Biotechnology by Country of Origin (N = 174)

	Number of Correct Responses			
Questions	Ghana (*n* = 69)	Malawi (*n* = 76)	South Africa (*n* = 29)	Total (*N* = 174)
With every emerging technology, there are always potential risks.	60	68	24	152
Brewing yeasts contain living organisms.	58	55	25	138
Plant viruses infect vegetables and fruits.	58	53	23	134
Ordinary tomatoes do not contain genes, while genetically-modified tomatoes do contain genes.	50	58	22	130
In genetic engineering, genes of interest are transferred from one organism to another.	58	50	20	128
By eating genetically-modified corn, a person's genes could also be modified.	58	40	25	123
Plant viruses are transferred to humans when they eat vegetables and fruits infected with plant viruses.	52	50	17	119
Scientific research guarantees zero-risk.	49	48	18	115
In reality, all crops have been "genetically modified" from their original states through domestication, selection, and controlled breeding over time.	39	50	24	113
More than half of human genes are identical to those of monkeys.	34	44	20	98
Golden rice (genetically-modified rice. contains beta carotene.	37	30	14	81

Note. Total number of correct responses ranged from 2-11; Mean average number of correct responses were Ghana: *M* = 8.13, *SD* = 2.09; Malawi: *M* = 7.18, *SD* = 2.11; South Africa: *M* = 8.29, *SD* = 2.03; Total: *M* = 7.74, *SD* = 2.14.

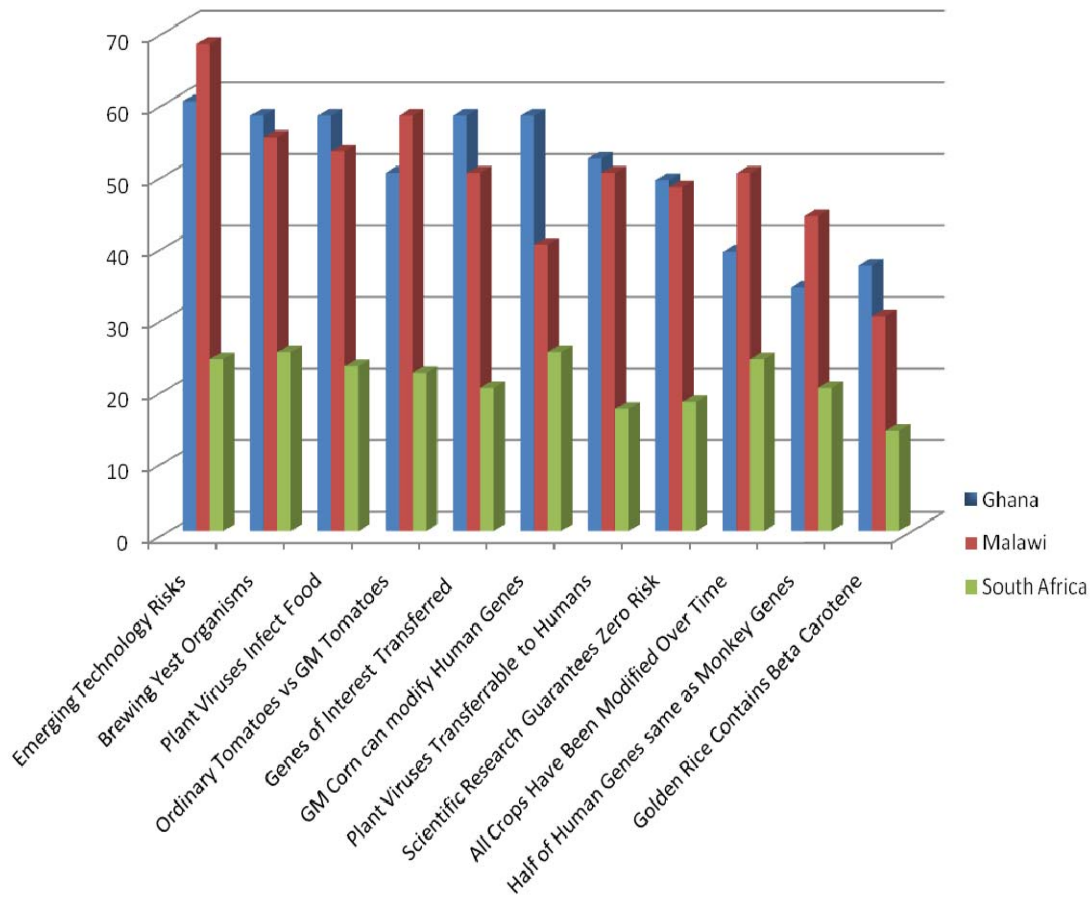

Figure 7. Frequency distribution for correct responses to understanding of biotechnology by country of origin.

Hypothesis 1

The first hypothesis was that no significant difference existed in policymakers' understanding of biotechnology when compared by country of origin. To test the research hypothesis, policymakers' total number of correct responses to 11 knowledge questions were summed and analyzed by country of origin using ANOVA, with post-hoc comparisons. A significant difference existed in the grand means of correct responses when compared by country of origin, in that respondents from Malawi achieved significantly less correct ($M = 7.18$, $SD = 2.11$; $F = 4.82$, df = 169, $p < .05$) responses to the 11 knowledge questions than did respondents from Ghana or South Africa. Therefore, the null hypothesis was rejected and the alternative was accepted as true.

The second portion of the fourth objective concerned African policymakers' perceptions of agricultural biotechnology, which was measured with two questions. The first question, "Is the use of agricultural biotechnology in food production hazardous?" could be answered with one of four options (*Not at all Hazardous, Somewhat Hazardous*, *Very Hazardous*, or *I have No Opinion*). The second question, "Are there benefits associate with the use of agricultural biotechnology in food production?" could also be answered with one of four responses (*Not at all Beneficial, Moderately Beneficial, Very Beneficial*, or *I have No Opinion*) (Table 10).

The majority (51%) of respondents from Ghana believed the use of agricultural biotechnology in food production was somewhat hazardous, while 38% of Malawians and 41% of South Africans believed the same thing. Twenty-five respondents from all three countries had no opinion on this question. Regarding the benefits associated with the use of agricultural biotechnology in food production, 59% of respondents from Ghana, 39% of Malawians, and 65% of South Africans believed the outcome was very beneficial (Table 10). Only 13 respondents from Ghana and Malawi combined had no opinion on this question.

Table 10

Frequencies for African Policymakers' Perceptions of Agricultural Biotechnology by Country of Origin (N = 174)

Questions			
Is the use of agricultural biotechnology in food production hazardous? [a]			
Country	Response Category	*f*	Percent
Ghana	I have No Opinion	7	10.1
	Very Hazardous	4	5.8
	Somewhat Hazardous	35	50.7
	Not at all Hazardous	16	23.2
	Total	62	89.9
	Missing	7	10.1
Malawi	I have No Opinion	15	19.7
	Very Hazardous	6	7.9
	Somewhat Hazardous	29	38.2
	Not at all Hazardous	22	28.9
	Total	72	94.7
	Missing	4	5.3
South Africa	I have No Opinion	3	10.3
	Somewhat Hazardous	12	41.4
	Not at all Hazardous	13	44.8
	Total	28	96.6
	Missing	1	3.4

Table 10 (Continued)

Questions			
Are there benefits associated with the use of agricultural biotechnology in food production? [b]			
Country	Response Category	*f*	Percent
Ghana	I have No Opinion	2	2.9
	Not at all Beneficial	2	2.9
	Somewhat Beneficial	17	24.6
	Very Beneficial	41	59.4
	Total	62	89.9
	Missing	7	10.1
Malawi	I have No Opinion	11	14.5
	Not at all Beneficial	1	1.3
	Somewhat Beneficial	30	39.5
	Very Beneficial	30	39.5
	Total	72	94.7
	Missing	4	5.3
South Africa	Somewhat Beneficial	9	31.0
	Very Beneficial	19	65.5
	Total	28	96.6
	Missing	1	3.4

Scale: [a] 0 = *no opinion*, 1 = *very hazardous*, 2 = *somewhat hazardous*, 3 = *not at all hazardous*. [b] 0 = *no opinion*, 1 = *not at all beneficial*, 2 = *somewhat beneficial*, 3 = *very beneficial.*

As a group, respondents held the perception that the use of agricultural biotechnology in food production was only somewhat hazardous (*M* = 2.51-3.0). However, the groups did not hold equivalent perceptions about the benefits associated with the use of agricultural biotechnology in food production. Respondents from Ghana and South Africa perceived “very beneficial” outcomes while Malawian respondents perceived only “somewhat beneficial” outcomes from the use of agricultural biotechnology in food production (Table 11).

Table 11

Descriptive Statistics for African Policymakers' Perceptions of Agricultural Biotechnology by Country of Origin (N = 174)

	Ghana (*n* = 69)		Malawi (*n* = 76)		South Africa (*n* = 29)		Total (*N* = 174)	
Perceptions	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Is the use of agricultural biotechnology in food production hazardous? [a]	2.22	.57	2.28	.65	2.52	.51	2.30	.60
Are there benefits associated with the use of agricultural biotechnology in food production? [b]	2.65	.55	2.48	.54	2.68	.48	2.58	.53

Scale: [a] 0.00-0.50 = *no opinion*, 0.51-1.50 = *very hazardous*, 1.51-2.50 = *somewhat hazardous*, 2.51-3.00 = *not at all hazardous*. [b] 0.00-0.50 = *no opinion*, 0.51-1.50 = *not at all beneficial*, 1.51-2.50 = *somewhat beneficial*, 2.51-3.00 = *very beneficial.*

Hypothesis 2

The second hypothesis was that no significant difference existed in policymakers' perceptions about biotechnology when compared by country of origin. To test the research hypothesis, policymakers' mean responses for two questions were analyzed by country of origin using ANOVA, with post-hoc comparisons. A significant difference existed for the question, "Are there benefits associated with the use of agricultural biotechnology in food production," when compared by country of origin, in that respondents from Malawi held significantly lower perceptions (somewhat beneficial) ($M = 2.10$, $SD = 1.02$; $F = 7.38$, df = 159, $p < .05$) than did respondents from Ghana or South Africa (very beneficial). Therefore, the null hypothesis was rejected and the alternative was accepted as true.

As part of a larger study, respondents' rated the importance of agricultural biotechnology in food characteristics, using a Likert-type, four-point scale (1 = *very unimportant*, 2 = *unimportant*, 3 = *important*, 4 = *very important*). Respondents rated the importance of 12 biotechnology uses in food characteristics, which are reported by country of origin and sorted in descending order by grand means in Table 12. As a group, respondents perceived that improved yields were a very important (*M* = 3.51-4.00) food characteristic of agricultural biotechnology (Table 12). These results did not require additional analyses to answer the objectives or hypotheses for this dissertation.

Table 12

Descriptive Statistics for African Policymakers' Perceptions of the Importance of Agricultural Biotechnology Food Characteristics by Country of Origin (N = 174)

	Ghana (*n* = 69)		Malawi (*n* = 76)		South Africa (*n* = 29)		Total (*N* = 174)	
Characteristics	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Improved yields	3.63	.73	3.41	.97	3.57	.79	3.52	.86
Lower pest susceptibility	3.51	.81	3.37	.91	3.46	1.04	3.44	.89
Higher nutritional quality	3.41	.82	3.32	.93	3.63	.74	3.40	.86
Non-poisonous ingredients	3.45	.87	3.25	.92	3.46	.88	3.36	.89
Lower pesticide residues	3.44	.85	3.23	1.05	3.41	.89	3.34	.95
Increased shelf-life	3.52	.82	3.07	1.02	3.52	.85	3.32	.94
Non-allergenic properties	3.45	.70	3.10	.97	3.39	.83	3.28	.87
Lower food prices	3.30	.80	3.04	1.15	3.41	.84	3.20	.99
Improved food appearance	3.10	.91	2.95	.95	2.85	.91	2.99	.93
Decreased use of water for production	3.14	.94	2.71	1.10	3.21	.96	2.96	1.04
Better tasting food/palatability	3.06	.94	2.93	1.06	2.63	.93	2.93	1.00
Decreased groundwater contamination	3.09	1.02	2.67	1.20	3.00	1.04	2.89	1.12

Scale: 1.00-1.50 = *very unimportant*, 1.51-2.50 = *unimportant*, 2.51-3.50 = *important*, 3.51-4.00 = *very important*.

The final portion of the fourth objective concerned African policymakers' attitudes toward agricultural biotechnology use in agricultural development. Respondents' global attitudes (13 statements) about agricultural biotechnology were measured using a Likert-type, four-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *agree*, 4 = *strongly agree*). To facilitate understanding of sub-group responses for later comparisons, respondents' attitudes toward agricultural biotechnology are reported by country of origin and sorted in descending order by grand means (Table 13).

Analyses of group data showed that respondents agreed with nine of the 13 statements, however the strongest level of agreement (*M* = 3.38, *SD* = .63) was for the statement that the public should be consulted in formulating food regulation and laws (Table 13). Also, the results revealed a “positive” attitude toward agricultural biotechnology use in viewing the four statements with which the respondents disagreed (*M* = 1.51-2.50). Those four statements included: I would contribute my time or money to an organization that promotes a ban on genetically modified foods (*M* = 2.07, *SD* = .91); All genetically-altered foods should be banned (*M* = 1.96, *SD* = .87); Genetically-altered foods do not need to be labeled (*M* = 1.72, *SD* = .84); and I would not attend an information session on biotechnology in food production in my community (*M* = 1.65, *SD* = .78) (Table 13).

Table 13

Descriptive Statistics for African Policymakers' Attitudes toward Agricultural Biotechnology Use by Country of Origin (N = 174)

	Ghana (*n* = 69)		Malawi (*n* = 76)		South Africa (*n* = 29)		Total (*N* = 174)	
Statements	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
The public should be consulted in formulating food regulation and laws.	3.40	.53	3.34	.74	3.43	.50	3.38	.63
It is acceptable to transfer genes from plant species into crop plants to make them more resistant to pests and diseases.	3.19	.69	3.07	.83	3.19	.74	3.13	.76
We should use genetic testing to detect and treat diseases we might have inherited from our parents.	3.25	.63	2.93	.78	3.37	.49	3.12	.70
It is appropriate to introduce human genes into bacteria to produce medicine and vaccines, for example to produce insulin for diabetes.	3.23	.66	3.00	.90	3.11	.79	3.10	.80

Table 13 (Continued)

Statements	Ghana (*n* = 69) *M*	*SD*	Malawi (*n* = 76) *M*	*SD*	South Africa (*n* = 29) *M*	*SD*	Total (*N* = 174) *M*	*SD*
It is acceptable to modify mice genes to study human diseases like cancer.	3.21	.64	2.96	.81	3.04	.84	3.07	.76
We should use biotechnology in food production to make them more nutritious, taste better, and keep longer.	3.10	.84	2.80	.90	3.25	.52	2.99	.84
God granted us the abilities to manipulate nature for our benefit.	3.00	.81	2.93	.88	2.71	.85	2.92	.85
I am not willing to pay extra for the labeling of genetically-modified foods.	2.81	.88	2.42	.94	3.07	.90	2.68	.94
It is okay to introduce fish genes into strawberries to resist extreme freezing temperatures.	2.71	.79	2.54	.94	2.68	.82	2.62	.87
I would contribute my time or money to an organization that promotes a ban on genetically modified foods.	2.05	.89	2.27	.93	1.61	.79	2.07	.91
All genetically-altered foods should be banned.	1.92	.82	2.19	.94	1.43	.50	1.96	.87
Genetically-altered foods do not need to be labeled.	1.74	.92	1.67	.77	1.82	.86	1.72	.84
I would not attend an information session on biotechnology in food production in my community.	1.56	.76	1.61	.73	1.96	.92	1.65	.78

Scale: 1.00-1.50 = *strongly disagree*, 1.51-2.50 = *disagree*, 2.51-3.50 = *agree*, 3.51-4.00 = *strongly agree*.

Hypothesis 3

The third hypothesis was that no significant difference existed in policymakers' attitudes about agricultural biotechnology when compared by country of origin. To test the research hypothesis, policymakers' global attitudes about agricultural biotechnology were summed and analyzed by country of origin using ANOVA. A significant difference existed (Table 14) in the grand means when compared by country of origin; post-hoc comparisons showed that respondents from Malawi held significantly lesser attitudes (*M* = 35.71, *SD* = 5.75; *F* = 5.75, df = 166, $p < .05$) than did respondents from Ghana or South Africa. Therefore, the null hypothesis was rejected and the alternative was accepted as true. However, the practical significance would suggest that the grand means for global attitudes toward agricultural biotechnology are not different when compared by country of origin.

Hypothesis 4

The fourth hypothesis was that no significant difference existed in policymakers' attitudes about agricultural biotechnology when compared by gender. To test the research hypothesis, policymakers' global attitudes about agricultural biotechnology were summed and analyzed by gender using ANOVA. No significant difference existed in the grand means when compared by gender (*F* = 0.63, df = 164, $p < .05$) (Table 14). Therefore, the null hypothesis failed to be rejected.

Hypothesis 5

The fifth hypothesis was that no significant difference existed in policymakers' attitudes about agricultural biotechnology when compared by education levels. To test the research hypothesis, policymakers' global attitudes about agricultural biotechnology were summed and analyzed by education levels using ANOVA; to find meaningful results, some education level categories were combined because of low responses to those categories. Some elementary education was combined with elementary school graduates, and some high school education was combined with high school graduates. A significant difference existed in the grand means when compared by education levels; post-hoc comparisons showed that respondents with some or elementary graduate degrees held significantly lesser attitudes (*M* = 32.76, *SD* = 5.73; *F* = 5.42, df = 162, $p < .05$) than did respondents with some or high school graduate, some college, BS/BA degrees, and post-graduate degrees (Table 14). Therefore, the null hypothesis was rejected and the alternative was accepted as true. However, the practical significance would suggest that the grand means for global attitudes toward agricultural biotechnology are not different when compared by education levels.

Hypothesis 6

The sixth hypothesis was that no significant difference existed in policymakers' attitudes about agricultural biotechnology when compared by occupation type. To test the research hypothesis, policymakers' global attitudes about agricultural biotechnology were summed and analyzed by occupation type using ANOVA; to find meaningful results, some occupation type categories were combined because of low responses to those categories. The sub-groups of journalists, business, and religious leaders were collapsed into one single group termed "other." A significant difference existed in the grand means when compared by occupation type; post-hoc comparisons showed that government officials held significantly more positive attitudes (M = 39.97, SD = 6.10; F = 6.92, df = 166, $p < .05$) than did all other respondents (Table 14). Therefore, the null hypothesis was rejected and the alternative was accepted as true.

As part of a larger study, respondents' indicated their agreement with 13 statements to assess their opinions about agricultural biotechnology, using a Likert-type, four-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *agree*, 4 = *strongly agree*). Respondents' opinions about agricultural biotechnology are reported by country of origin and sorted in descending order by grand means (Table 15).

Table 14

Significant Differences in Global Attitudes toward Agricultural Biotechnology When Compared by Country of Origin, Gender, Education, and Occupation (N = 174)

Variable	Sub-group	*N*	*M*	*SD*	Min	Max	F	Sig.
Country	South Africa	28	39.43	4.56	32	46	5.75*	.004
	Ghana	63	38.37	6.39	20	52		
	Malawi	76	35.71	5.75	19	49		
	Total	167	37.34	5.99	19	52		
Gender	Male	114	37.64	6.274	19	52	0.63	.428
	Female	52	36.85	5.237	28	48		
	Total	166	37.39	5.964	19	52		
Education	Post-graduate Degree	49	39.92	6.28	28	52	5.42*	.000
	Some or HS Grad.	12	38.00	7.98	25	52		
	BS/BA Degree	46	37.24	4.82	20	47		
	Some College	31	37.19	4.71	29	49		
	Other	8	32.88	3.14	29	38		
	Some or Elem. Grad.	17	32.76	5.73	19	40		
	Total	163	37.41	5.96	19	52		
Occupation	Government Officials	58	39.97	6.10	28	52	6.92*	.000
	Extension Workers	51	36.63	5.62	20	49		
	Other	32	35.75	6.48	19	46		
	Farmer Leaders	26	34.81	3.32	28	41		
	Total	167	37.34	5.99	19	52		

Note. ANOVA tests with Least Squares Difference post-hoc analyses.

Analyses of group data showed that respondents agreed with nine of the 13 statements, however the strongest level of agreement (M = 3.10, SD = .68) was for the statement that biotechnology regulation should include inputs from the non-governmental sector (Table 15). These results did not require additional analyses to answer the objectives or hypotheses for this dissertation.

Table 15

Descriptive Statistics for African Policymakers' Opinions about Agricultural Biotechnology by Country of Origin (N = 174)

	Ghana (n = 69)		Malawi (n = 76)		South Africa (n = 29)		Total (N = 174)	
Statements	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Biotechnology regulation should include inputs from the non-governmental sector.	3.22	.60	2.93	.78	3.29	.46	3.10	.68
Government agencies are doing their best to ensure that the food we eat is safe.	2.94	.81	3.18	.84	3.00	.82	3.05	.83
Biotechnology is good for my country's agricultural development.	3.02	.79	2.86	.69	3.43	.57	3.02	.74
Expert statements about biotechnology are based on scientific analysis and are therefore objective.	2.81	.83	3.03	.58	2.93	.66	2.93	.70
Government regulatory agencies have the scientific facts and technical information they need in order to make good decisions about biotechnology in food.	2.73	1.00	2.93	.85	2.96	.74	2.86	.90
The risks of genetic engineering have been greatly exaggerated.	2.65	.76	2.67	.89	3.22	.85	2.75	.85
Bio-safety regulations are adequate for protecting my country's food products.	2.65	1.03	2.66	.97	3.00	.90	2.71	.99
Bio-safety regulations are adequate for protecting my country's natural resources.	2.57	1.05	2.69	.85	2.89	.97	2.67	.95

Table 15 (Continued)

	Ghana (*n* = 69)		Malawi (*n* = 76)		South Africa (*n* = 29)		Total (*N* = 174)	
Statements	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Biotechnology in food production only benefits large agricultural companies.	2.77	.78	2.42	.83	2.68	.98	2.60	.85
My country's current regulations are sufficient to protect people from any risks linked to modern biotechnology.	2.13	.77	2.48	.87	2.73	.92	2.38	.86
Vital information about the health effects of genetically-modified foods is being withheld from the public.	2.36	.75	2.33	.90	2.41	1.01	2.35	.86
Genetic engineering of food products could contaminate products in unanticipated ways resulting in threats to public health.	2.20	.75	2.23	.79	2.59	.93	2.28	.81
Genetic engineering of food products could create unexpected new allergens resulting in threats to public health.	2.05	.72	2.04	.75	2.43	1.00	2.11	.80

Scale: 1.00-1.50 = *strongly disagree*, 1.51-2.50 = *disagree*, 2.51-3.50 = *agree*, 3.51-4.00 = *strongly agree*.

As part of a larger study, respondents' indicated their concern levels for 11 issues related to the use of agricultural biotechnology, using a Likert-type, four-point scale (1 = *very unconcerned*, 2 = *unconcerned*, 3 = *concerned*, 4 = *very concerned*). Respondents' concern levels about the use of agricultural biotechnology are reported by country of origin and sorted in descending order by grand means (Table 16).

Respondents were "concerned" about all 11 issues, however their strongest level of concern (*M* = 3.41, *SD* = .74) was for the issue related to the low level of public knowledge (Table 16). Respondents were least concerned (*M* = 2.52, *SD* = .94) about "religious concerns about altering nature." These results did not require additional analyses to answer the objectives or hypotheses for this dissertation.

Finally, as part of a larger study, respondents were asked, "to what extent do you believe that agricultural biotechnology practices will affect the following six issues (food production, commercial farming, small scale farms, your health, the environment, fish and wildlife)?" Respondents recorded their answers using a Likert-type, four-point scale (1 = *very negative*, 2 = *negative*, 3 = *positive*, 4 = *very positive*). Respondents' perceptions about the effects of agricultural biotechnology are reported by country of origin and sorted in descending order by grand means (Table 17).

Table 16

Descriptive Statistics for African Policymakers' Concerns about the Use of Agricultural Biotechnology by Country of Origin (N = 174)

	Ghana (*n* = 69)		Malawi (*n* = 76)		South Africa (*n* = 29)		Total (*N* = 174)	
Issues	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Low level of public knowledge	3.49	.64	3.38	.87	3.31	.55	3.41	.74
Consequences for farming and food production	3.41	.64	3.28	.75	2.89	.85	3.27	.74
Human health risks and safety issues	3.35	.88	3.38	.87	2.81	1.18	3.27	.95
Economic implications	3.27	.72	3.30	.79	2.78	.70	3.20	.77
Potential risks for the environment	3.31	.86	3.23	.97	2.75	.99	3.19	.95
Fear of food safety consequences	3.29	.89	3.14	.87	2.59	1.12	3.10	.95
Fear of genes moving unchecked to other plants, insects, or microorganisms	3.27	.89	3.08	.92	2.70	1.07	3.09	.95
International and global implications	3.23	.76	3.00	.88	2.60	1.00	3.03	.88
Scientific uncertainty about biotechnology's consequences	3.23	.88	2.88	.94	2.93	.83	3.02	.91
Ethical implications	2.83	.81	2.78	.95	2.30	.99	2.72	.92
Religious concerns about altering nature	2.56	.91	2.63	.92	2.15	.99	2.52	.94

Scale: 1.00-1.50 = *very unconcerned*, 1.51-2.50 = *unconcerned*, 2.51-3.50 = *concerned*, 3.51-4.00 = *very concerned*.

Respondents perceived "positive" effects for all six issues, with the most positive effect occurring in food production (*M* = 3.16, *SD* = .74) (Table 17). Respondents believed less positive effects would occur in the environment (*M* = 2.56, *SD* = .80) and for fish and wildlife (*M* = 2.56, *SD* = .80). These results did not require additional analyses to answer the objectives or hypotheses for this dissertation.

Table 17

Descriptive Statistics for African Policymakers' Perceptions about the Effects of Agricultural Biotechnology by Country of Origin (N = 174)

	Ghana (*n* = 69)		Malawi (*n* = 76)		South Africa (*n* = 29)		Total (*N* = 174)	
Issues	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Food production	3.18	.70	3.09	.81	3.28	.61	3.16	.74
Commercial farming	3.21	.79	3.01	.88	3.42	.50	3.15	.80
Small scale farms	2.71	.88	2.72	.80	3.12	.82	2.78	.84
Your health	2.66	.88	2.59	.94	2.96	.98	2.68	.93
The environment	2.61	.75	2.49	.86	2.62	.70	2.56	.80
Fish and wildlife	2.75	.77	2.39	.84	2.58	.65	2.56	.80

Scale: 1.00-1.50 = *very negative*, 1.51-2.50 = *negative*, 2.51-3.50 = *positive*, 3.51-4.00 = *very positive*.

Objective 5

The fifth objective was to test for significant relationships between independent (selected demographics) and dependent variables (African policymakers' worldviews and values, levels of understanding, and attitudes toward agriculture biotechnology). Selected demographics for independent variables included country of origin, gender, education, and occupation. Respondents' raw data scores for worldviews and values, levels of understanding, and attitudes toward agriculture biotechnology were summed, after some statements had been reverse-coded in each scale, then analyzed using bivariate analyses. Significant associations were determined using Pearson product-moment and Spearman rho tests (Table 18).

A significant substantial positive association ($r = .59$) existed between the dependent variables, worldviews and values and attitudes (Table 18). This relationship was expected because values and attitudes, as measured in this study, are complimentary descriptors of African policymakers' characteristics that may influence their decision making processes on agricultural biotechnology issues. Significant moderate positive relationships occurred between dependent variables, worldviews and values and understanding ($r = .45$) and understanding and attitudes ($r = .40$) (Table 18).

A significant moderate association was found between the independent variable education and worldviews and values (*r* = .32); significant low positive relationships were found between education and understanding (*r* = .28), and attitudes (*r* = .18). Worldviews and values, understanding, and attitudes had low positive associations with occupation (Table 18). No significant associations occurred between the dependent variables and gender or country of origin (Table 18).

Table 18

Significant Associations between Selected Independent and Dependent Variables (N = 174)

	Worldviews and Values		Understanding		Attitudes	
Variables	*r*	*p*	*r*	*p*	*r*	*p*
Worldviews and Values [a]	1.00		.45*	.000	.59*	.000
Understanding [a]			1.00		.40*	.000
Attitudes [a]					1.00	
Country [b]	.01	.97	-.14	.07	-.01	.86
Occupation [b]	.25*	.00	.16*	.04	.26*	.00
Gender [b]	.03	.69	.09	.16	.09	.23
Education [b]	.32*	.00	.28*	.00	.18*	.02

Note. [a] Pearson product-moment correlation; [b] Spearman rho correlation.
* $p < 0.05$.

Hypothesis 7

The seventh hypothesis was that no significant association existed between independent (selected demographics) and dependent variables (African policymakers' worldviews and values, levels of understanding, and attitudes toward agriculture biotechnology). To test the research hypothesis, summed scale scores for policymakers' worldviews and values, levels of understanding, and attitudes about agricultural biotechnology were correlated with selected independent variables. Significant associations ($p < 0.05$) existed between the dependent variables (worldviews and values, levels of understanding, and attitudes toward agriculture biotechnology) and education and occupation. Therefore, the null hypothesis was rejected and the alternative was accepted as true.

Objective 6

The sixth objective was to develop a model for impacting African policymakers' decision making processes for agricultural biotechnology practices in food production. To complete this research objective, multivariate analyses of data were performed using the stepwise procedure. This method was chosen because "a single dependent variable is predicted from several independent variables" (Coolidge, 2006, p. 366). Independent variables predicting the dependent variables, African policymakers' summed scores for worldviews and values, levels of understanding, and attitudes about agricultural biotechnology would have a significant *t*-value. Based on the results found in research objective five, country of origin and gender will not be included in the multiple regression analyses because no significant associations were found between these independent variables and the dependent variables. Dummy coding of the variables occupation and education was used to represent data in categorical form.

The multiple regression models were derived from respondents' worldviews and values with predicting variables occupation and education (Table 19). Three variables of significance were being a government official (t = 1.99), elementary school graduate (t = -2.11), and college graduate (t = -2.21), which contributed to predicting communication factors within worldviews and values.

With regard to understanding, four education variables significantly contributed to the overall model, however all four were contrary to being a positive influence as communication factors affecting African policymakers' decision on agricultural biotechnology. Not being associated with these variables, other education levels (t = -3.86), elementary school graduate (t = -3.39), some college (t = -2.53), or high school graduate (t = -2.42) would have a positive impact on African policymakers' agricultural biotechnology decision (Table 19).

Finally, three significant variables, government official (*t* = 3.80), elementary school graduate (*t* = -2.84), and other education levels (*t* = -2.46), contributed to the multiple regression model when analyzing respondents' attitudes toward agricultural biotechnology (Table 19).

Table 19

Multiple Regression Analysis on the Dependent and Selected Independent Variables

Dependent Variables	Source	df	SS	MS	*F*-ratio	*F*-prob.
Worldviews and Values	Regression	9	576.83	64.09	3.29*	0.00
	Residual	155	3017.36	19.47		
	Variable	B	SE B	Beta	*t*	Sig.
	(Constant)	30.16	1.11		27.10	0.00
	Govt. Official	2.22	1.11	0.23	1.99*	0.05
	Elem. Graduate	-3.43	1.63	-0.24	-2.11*	0.04
	Some College	-2.64	1.19	-0.22	-2.21*	0.03
Understanding	Source	df	SS	MS	*F*-ratio	*F*-prob.
	Regression	9	196.82	21.87	5.49*	0.00
	Residual	155	617.89	3.99		
	Variable	B	SE B	Beta	*t*	Sig.
	(Constant)	9.36	0.51		18.36	0.00
	Elem. Graduate	-2.59	0.76	-0.37	-3.39*	0.00
	HS Graduate	-1.76	0.73	-0.21	-2.42*	0.02
	Some College	-1.39	0.55	-0.24	-2.53*	0.01
	Other Education	-3.10	0.80	-0.33	-3.86*	0.00
Attitudes	Source	df	SS	MS	*F*-ratio	*F*-prob.
	Regression	3	1053.51	351.17	11.89*	0.00
	Residual	159	4695.95	29.53		
	Variable	B	SE B	Beta	*T*	Sig.
	(Constant)	36.87	0.59		62.72	0.00
	Govt. Official	3.52	0.93	0.28	3.80*	0.00
	Elem. Graduate	-4.11	1.44	-0.21	-2.84*	0.01
	Other Education	-4.87	1.98	-0.18	-2.46*	0.02

Note. *$p < .05$

Table 20 shows the specific percentages from the combined factors within each criterion [dependent] variable that can be attributed to the associated predictor [independent] variables. In this case, 16% of knowing the respondents' worldviews and values can be predicted by a combination of being a governmental official, having more education than only being an elementary school graduate, and having only some college education. Twenty-four percent of knowing the respondents' understanding of agricultural biotechnology can be predicted by a combination of having more education than only being an elementary school or high school graduate, and having only some college or other education. Similarly, 18% of knowing respondents' attitudes toward agricultural biotechnology can be predicted by a combination of being a governmental official, having more education than only being an elementary school graduate, and having only some college education.

Table 20

Model Summary for African Policymakers' Decision Making Processes on Agricultural Biotechnology Issues

Model	*R*	*R* Square	Adj. *R* Square	Std. Error of the Estimate
Worldviews and Values	.401[a]	.160	.112	4.412
Understanding	.492[b]	.242	.198	1.997
Attitudes	.428[c]	.183	.168	5.435

Note. [a] Predictors: (Constant), Government Official, Elementary School Graduate, and College Graduates; [b] Predictors: (Constant), Other Education, High School Graduate, Elementary School Graduate, and Some College; [c] Predictors: (Constant), Government Official, Elementary School Graduate, Other Education.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The first objective was to learn about African policymakers' socio-demographic characteristics (gender, age, education level, occupation, geographic location). Respondents from Malawi, Ghana, and South Africa had about 12 years of experience in their current employment, which included serving as a government official, extension worker, farmer leader, journalist, business, or religious leader. Two of three were male, in their 40's, had a bachelors degree or above, married, and lived in areas other than rural or suburban.

The second objective was to understand about the worldviews and values of African policymakers toward agriculture biotechnology. The total number of respondents on this issue were 174; 69 were from Ghana, 76 from Malawi, and 29 from South Africa. As group respondents strongly agreed with only one statement: Consumers have the right to choose what they eat, to know what they are eating. As a group they agreed with five statements: (a) Genetically-altered foods should be labeled, (b) I would attend an information session on biotechnology in my community, (c) Genetic engineering means cheaper food for consumers, (d) Until we know that genetically-altered foods are totally safe, those products should be banned, and (e) Genetic engineering means more nutritious food for consumers. Likewise as a group they disagreed with five statements: (a) I am willing to pay extra for the labeling of genetically-modified foods, (b) Genetics manipulation takes mankind into realms that belong to God and God alone, (c) We have no business meddling with nature, (d) The use of biotechnology in food production is against my moral values, and (e) The regulation of biotechnology should be left to the industry. However dispersion between country specific responses indicated wide variation in agreement levels for specific statements.

The third objective was to determine African policymaker's information sources to understand biotechnology practices. Respondents were requested to record the number of contacts they made with these 12 media types, within the last two months. As a group, respondents were most apt to use printed materials such as newsletters, pamphlets, brochures. They least likely talked or heard about information on biotechnology from religious leaders. In addition to assessing respondents' frequencies of use for selected biotechnology information sources, respondents were also asked to evaluate the level of trust they had for each of 17 information sources. As a group, respondents rated university–based scientists as completely trustworthy. They also rated activists as completely untrustworthy. They rated science magazines as trustworthy and family/friends/neighbors as untrustworthy. Likewise they rated the perceived levels of bias for each of the same sources of information. Consistently, the respondents in their reaction confirm the above, by rating university-based scientists as unbiased and activist groups as biased.

The fourth objective was to evaluate African policymaker's level of understanding, perceptions of, and attitude toward agricultural biotechnology use in agricultural development. ANOVA tests were conducted for three different hypotheses for this objective. Post-hoc comparisons were done for those with significant differences.

The first hypothesis was that no significant difference existed in policymakers' understanding of biotechnology when compared by country of origin. A significant difference occurred in the grand means of correct responses when compared by country of origin, as respondents from Malawi achieved significantly less correct answers to the 11 questions compared to those from Ghana or South Africa. Therefore, the null hypothesis was rejected and the alternative was accepted as true.

The second portion of the fourth objective had to do with testing the level of perception of policymakers. This portion held two questions: "Is the use of agricultural biotechnology in food production hazardous?" and "Are there benefits associated with the use of biotechnology in food production?" As a group, respondents held the perception that the use of agricultural biotechnology in food production was only somewhat hazardous. However, the groups did not hold equivalent perceptions about the benefits associated with the use of agricultural biotechnology in food production. Respondents from Ghana and South Africa perceived “very beneficial” outcomes from the use of agricultural biotechnology production.

The second hypothesis was that no significant difference existed in policymakers’ perception about biotechnology when compared by country origin. To test the hypothesis policymakers mean responses on the two questions were analyzed by country of origin using ANOVA. A significant difference existed for the second question, “Are there benefits associated with agricultural biotechnology for food production?” When compared by country of origin, respondents from Malawi held significantly lower perceptions compared to Ghana or South Africa.

The final part of the fourth objective measured policymaker’s attitudes toward biotechnology for agricultural development. Respondents’ attitudes about biotechnology were measured using a Likert-type four point scale. To facilitate understanding for later analysis of the responses, respondents’ attitude toward biotechnology were reported by country of origin and sorted in descending order by grand mean. The outcome of the analysis showed that respondents agreed with nine of the 13 statements; however the strongest level of agreement was for the statement that the public should be consulted in formulating food regulations and laws. Also, the result revealed attitude toward agricultural biotechnology use in viewing the four statements for which respondents disagreed. The fact that respondents disagreed with statements such as “I would contribute my time or money to organization that promotes a ban on genetically modified foods; All genetically altered food should be banned; All genetically altered food should not need to labeled; and I would not attend an information secession on biotechnology in food production in my community” were considered as indicators of positive attitudes toward use of biotechnology for agriculture production.

The third hypothesis was that no significant difference existed in policymakers’ attitudes toward agricultural biotechnology when compared by country of origin. ANOVA tests revealed a significant difference between the means, showing that Malawi held significant lesser attitudes, than did respondents from Ghana and South Africa. Therefore, the null hypothesis was rejected and the alternative was taken as true. However, the practical significance would suggest that the grand means for global attitude toward agricultural biotechnology were not different when compared by country of origin.

The fourth hypothesis was that no significant difference existed in policymakers' attitudes about agricultural biotechnology when compared by gender. To test the hypothesis, policymaker's global attitudes about biotechnology were summed and analyzed by gender using ANOVA. No significant difference existed in the grand mean when compared by gender. Therefore, the null hypothesis failed to be rejected.

The fifth hypothesis was that no significant difference existed in policymakers' attitudes about agriculture biotechnology when compared by education level. To facilitate the analysis, some education levels were combined because of low responses to those categories. Some elementary was combined with elementary graduates and some high school was combined with high school graduates. The ANOVA analysis showed a significant difference existed in the grand means when compared by education levels; post-hoc comparisons showed that respondents' with some elementary education or elementary school graduates held significantly lesser attitudes, than did respondents with some high school education or high school graduates, or some college BS/BA degrees, and post-graduate degrees. Therefore, the null hypothesis was rejected and the alternative was taken as true. However, when it comes to the practical significance the result suggested that the grand means for global attitudes toward biotechnology were not different when compared by educational levels.

The sixth hypothesis was that no significant difference existed in policymakers' attitudes about biotechnology when compared by occupation type. To test the research hypothesis, policymakers' responses on global attitudes about biotechnology were summed and analyzed by occupation using ANOVA. The sub-groups journalists, religious leaders, and business leaders were combined in to a single group "others" because of low responses to these categories. The analysis showed a significant difference existed in the grand mean when compared by occupation type and post-hoc comparison showed government officers held significantly more positive attitudes that did all others. Therefore, the null hypothesis was rejected and the alternative was accepted as true. This was expected, as government officials are meant to execute policies, which in this regard are government polices on biotechnology; in all three countries attitudes were positive toward the use biotechnology for food production.

The fifth objective was to test for significant relationships between independent (African policymakers worldview, understanding, attitude) and dependent variables. Selected demographics independent variables included country of origin, gender, education, and occupation. Bivariate analyses were used to analyze these relationships and significant associations were determined using Pearson product moment and Spearman rho tests. A significant positive association existed between the dependent variables, worldviews and values and attitudes. These relationships indicated that world values, and attitudes measured in this study were complementary descriptors of African policymakers' characteristics that may influence their decision making processes on agriculture biotechnology issues.

Significant moderate positive relationships occurred between dependent variables, worldviews and values, understanding, and attitudes. These show that there were some levels of complementarities between worldviews and values and understanding and attitudes of African policymakers about biotechnology for agricultural development. Significant moderate associations between the independent variable education and worldviews and values implied some tendency of positive association between education levels and worldviews and values among policymakers in this study in Africa. All three dependent variables had low positive associations with occupation. A significant low positive relationship was found between education and understanding, and education and attitudes. No significant association occurred between the dependent variables (world values, understanding, and attitudes) of policymakers and gender or country. This implies there is no evidence as such to suggest gender-based attitudes toward biotechnology among African policymakers for those participants in this particular study. Similarly, the low positive association between occupation and world values, understanding, and attitude toward biotechnology implies there was minimal occupation-biased stance on biotechnology between those who participated in this research.

The seventh hypothesis was that no significant association existed between independent (selected demographics) and dependent variables African policymakers' worldviews and values, levels of understanding, and attitudes toward agriculture biotechnology. To test the research hypothesis, summed scales score for the policymaker's worldviews and values, levels of understanding, and attitudes were correlated with selected independent variables. Significant association existed between the dependent variables and education and occupation. Therefore the null hypothesis was rejected and the alternative hypothesis was accepted as true.

The seventh objective was to develop a model for impacting African policymakers' decision making process for agriculture biotechnology for food production. In order to complete this objective multivariate analysis of data were performed using step wise procedure. This method was chosen because "a single variable is predicted from multiple independent variables" (Coolidge, 2006, p. 366). Country of origin and gender were not included in the multiple regression analysis, as they were not significantly associated with the dependent variables (objective five). The multiple regression model was derived from African policymakers' worldviews and values with the predicating variables occupation and education.

Conclusions

Major advances in biotechnology indeed have opened a wide range of application opportunities in developing countries, especially in the health and agriculture sectors. However some advances such as GM foods and animal cloning are still controversial in most of these countries. Some African countries have boycotted GM grains in the midst of hunger because of safety concerns, the disputes around the issue fall into the ever-expanding category of policy disputes characterized by multidimensionality and complexity. Despite major scientific advancement in the application of biotechnology in agriculture, public attitude toward biotechnology in general and GMO in particular, remains very mixed. On the other hand, they are concerned about the perceived health, safety, corporate monopolies, and environmental risks often associated with the use of this technology on plants and animals.

Even current thinking in global development and change in environment indicate that expected changes in climate, as a result of global warming in Africa, unlike other regions, is not about carbon emission, but about agriculture adaptations. Professor Collier, in a recent article expressed this belief as,

> Africa cannot afford this self-denial; it needs all the help it can possibly get from genetic modification. For the past four decades, African agriculture productivity per acre; raising production has stagnated; raising production has deepened on expanding areas under cultivation. But with Africa's population still growing rapidly, the option is running out especially with the light of global warming. Climate forecast suggest that in the coming years most Africa will get hotter, the semiarid parts will get drier, rainfall variability on the continent will increase, leading to more droughts. It seems likely that in southern Africa, the staple food, maize, will at some point will become non viable. Whereas for other regions the challenge of climate change is primarily about mitigating carbon emissions, in Africa it is primarily about agricultural adaptations. (Collier, 2008)

It is said time and again that Africa is in a poverty trap. In order to be out of this situation, Africa needs rapid economic transformation that outpaces the current level at which poverty is perpetuating. Given the structural constraints the continent is facing—low input-low output, low investment and low capacities of production—it is rather futile to expect fundamental changes in the livelihood of millions of people through piece-meal and quick-win types of development approach. Africa needs to embark upon a series of changes that would enable realization of structural transformations in the areas of human, institutional and physical capacities in order to pursue sustainable development. This explains the need for adopting a voracious approach to overcoming the vicious nature of these problems. Africa in order to utilize its resource it should employ science in its agriculture development. Given land and labor are the two comparatively available resources; African governments should invest in education and science in order to make these resources more productive.

Adoptive Structuration Theory (AST) presents the need for emphasizing social aspects as opposed to exclusive emphasis on techno-centric views. Instead AST examines the change process from two angles: (a) The types of structures provided as a result of the advanced technologies, and (b) The structures that actually emerge in human action as people interact with these technologies. It further argues that rules and resources drawn upon in the production and reproduction of social action are at the same time the means of system reproduction (the duality of the structure).

The introduction of biotechnology has introduced new structures different from what has been perceived by society in the past. The discovery of DNA by itself is a new structure. Genetically modified seeds such as Slow-Softening (PG) Tomato, Insect-Resistant (Bt) Corn, Insect-Resistant (Bt) Cotton, and Herbicide-Resistant Soya bean are new products which would otherwise be non-existent without biotechnology. Likewise, new medicines such as insulin and new vaccines and serums for humans and animals, are among those that have been developed as a result of this technology. Bio-safety regulations, intellectual property rights, including breeders' rights, new regulation on bio diversity resources for both animal and crop diversity are some of the rules and regulations evolved in the process of using this technology in addressing the daily routine of regulation in production and reproduction, as well as future potential threats embodied in applying biotechnology.

According to the annual publication compiled by the International Service for the Acquisition of Agri-Biotech Application (ISAAA), in 2007, the number of countries planting biotech crops increased to 23 as compared to 12 developing countries and 11 in industrial countries with growth measured in hectares increasing from 117.7 million to 143.7 million in 2007. With regard to its contribution to fight poverty, the report further stated that biotechnology achieved a milestone in 2007 by making as many as 10 million resource poor farmers in developing countries beneficiaries of the technology for the first time “of the global total of 12 million beneficiary biotech farmers in 2007, over 11 million were small and resource poor farmers from developing countries like South Africa, Argentina, India and the Philippines” (James, 2007, xiii).

To be successful both domestically and internationally, biotechnology must establish an acceptable position in the sociopolitical framework (Fritz et al., 2003). People’s views of GMOs can vary from person to person and place to place, depending on different factors. Studies repeatedly exhibited that in the U.S., disapproval was strongest among people over 64, among women, and among people with a low level of education (Gaskell et al., 2000). A study by The Institute for Studies in Research and Research policy in Denmark also confirmed similar findings. The study suggested that public assessment on biotechnology varied according to the application of the specific research area within the biotechnology field (Durant et al., 1998; as cited in Cetto et al., 2001). With regard to sources of information, research elsewhere showed that the majority of the information that the public got about biotechnology came from the media (Herman & Metcalfe, 2001) or from non-objective sources, such as Monsanto the supporter, or Green Peace which opposed it. Such information sources not only widened the divergence between the opponents and proponents, but given the power of media, certainly have adversely contributed and made endless the fight between opposing groups’ views on the use of agricultural biotechnology in food production.

The purpose of this research was to empirically verify communication factors that affected African policymakers’ decisions about adopting agricultural biotechnology to alleviate food insecurity. This study explored the various dimensions of public perceptions by focusing on policymakers who are supposed to be responsible for making legal decisions on behalf of the larger public. Taking into consideration the formal and informal role of society in policymaking decisions, the study was designed to reach different segments of the society relevant to the issue, use of biotechnology for agriculture in Africa. Policymakers primarily, government officials, civil societies and activists, journalists, business leaders, religious leaders, farmers' leaders, and extension workers were involved as respondents and discussants in the study. The three countries where the study has been undertaken, despite their differences, in their level of using biotechnology for agriculture development, are currently actively engaged in the policymaking process, which implies the presence of live debates among society. The study indicated that regardless of occupation, gender, educational background, religion, and geographic locations that the public over time has established some kind of opinion about biotechnology in these countries. Whether these opinions are relevant, reliable and adequate to make policy decisions has been the concern of the study. The study therefore has taken this challenge as a central objective throughout the process.

Though the conducted survey might have limitations to exhaustively address all factors that would affect communications of biotechnology to policymakers, however it is believed to have succeeded in opening a critical discourse into what the policymaking process really means and sought sound decisions. By adopting both descriptive and explanatory methods for the surveyed data, the researcher offered insights not only on describing the nature of respondents, but also strived in analyzing the causal relationships between the different variables. The data reflect only a fixed point in time, thus necessitating repetition of surveys in the future. The surveys viewed in this study showed considerable levels of consistency between survey types and time, including levels of validity. The research benefited much from the joint visit by investigator and lead professor to the research area a second time to verify the data.

It remains questionable how survey data on the limited respondents of these few countries would be extrapolated and cannot be recommended to larger numbers of African countries living under different socio-economic realities. While this survey followed scientifically proven methods and techniques, its result would be taken as valuable recommendations, given the enormous heterogeneity between African nations. The method used might be more beneficial than the outcome per se, for African countries to adopt and conduct their own investigations.

Recommendations

The researcher developed six recommendations for adoption to help African policymakers make an informed decision on the use of biotechnology in Africa. Although, these recommendations evolved from findings in this study, the researcher believes that many of these suggestions may be applied to a wider audience in Africa.

- The study showed that a critical gap exists in the understanding of biotechnology between policymakers in Africa. Educating African public in general, and those of low educational backgrounds in particular, is strongly recommended.

- One of the facts that the study singled out was the positive relationship between African policymakers' educational background and their understanding of biotechnology. This difference in understanding based on education, suggests the need to adopt a target group approach in educating policymakers in Africa. Tailor-made educational materials that are pertinent to this group are essential to enhance their understanding. Case-based stories of success and failure, dialogs on pros and cons of biotechnology applications, facts and figures, evidence on advantages and disadvantages of biotechnology-based applications, and practical recommendations, as opposed to scientific papers and journals are the suggested means of education, along with educational packages to improve African policymakers' levels of understanding in agricultural biotechnology.

- On the other hand, the absence of a relationship between gender, occupation, country of origin, and policymakers' attitudes and understanding in Africa, suggests the enormous opportunity for an exchange of information between countries that can be used by a wide range of society.

- In response to the low confidence of society on mass media for information, pragmatic actions that would enhance the credibility of mass media should be initiated by respective countries. One action that can be considered, among, may be a close collaboration between university scientists with mass media for raising the levels of trust for media, as well as increasing the access to university scientists by members of society As a result of these collaborations, mass media should take the advantage of the high level of trust that university scientists are reputed to have according to the respondents. In addition, to its contribution in educating the public, this collaboration can be turned into a win-win situation for both the university scientists and mass media, as both of them would maximize their impact. Such collaborations could be done through various ways, including joint message formulation to the public, scientists leading public discussion forums conducted by the media, scientists could provide professional critics and judgment on sensitive issues such as the impact of GMO food, health, and environment using the media. The bottom-line is that given the importance that mass media has in educating the public in Africa, it is not advisable to ignore mass media as a important collaborator in effecting agricultural biotechnology policies.

- One other concern evolved as a finding in this research is society's low trust of activist groups. Activists have important, if not indispensable roles in creating public awareness and educating society as they have better access to people, because of their involvement at the grassroots level. Although, they can be involved in all aspects of society's development, experiences show that activists such as civic societies and NGOs have comparative advantages in educating the public with issues of sensitivity to culture, religion, and social values. Biotechnology policy has a considerable level of sensitivity, and should be noted that activists could play very constructive roles. On the other hand, it is neither effective nor encouraging for activists (both pro and con), to continue pursuing their causes under the current condition, of very low trust levels among society. The current judgment by the respondents implies that regardless of what effort is exerted by activist groups; society would not gain confidence in their trust levels for activist groups. It is therefore highly recommended that activists be a part of the collaboration recommended above.

The study revealed that there are significant differences between Malawi and the other two countries in five of the seven issues in the survey. These differences indicated wide variations among African policymakers in global understanding, attitude, and perception. On the other hand, it is strongly believed that a minimum level of understanding and attitude is a prerequisite for cooperation among African countries to build consensus on the issue. The researcher therefore, recommends the following measures to narrow these divergences between African countries.

- Encourage African governments to make use of existing networks and public and international research institutes (FANRPAN, FoodNCropBio, ISAAA Africentre ASARECA, WARDA, FARA, ILRI, CIMMYT), as an entry point for harmonizing policies, regulations, and protocols, that will lead to a common understanding as a base for future cooperation. Furthermore, these platforms and professionals' hubs can be explored to build African human and institutional capacities in order to backstop national efforts including public policy formulations. Further support (financial and political) to these institutions, in strengthening their capacities, is not only feasible but also economical to speed up the African effort in adopting agricultural biotechnology policies.
- The researcher strongly recommends the establishment of a core institutional cooperation between the Texas A&M University and African national and regional agricultural and policy research centers to pursue implementation of findings from this research. As the very objective of educating agricultural leaders on communicating policies is within the mission of the Department of Agricultural Leadership, Education and Communications; the researcher strongly believes this department without further delay should initiate a program as post-

dissertation discussions with partners in Africa. The fact that several US and African-based institutions supported this research is a strong sign of commitment to support future programs outlined in the recommendations.

- This study was explanatory and exploratory in nature. Despite the number of research studies completed in communications, only a few explored the combined effect of these variables when they were treated simultaneously. Based upon the findings of this investigation, it is recommended that a follow-up study be conducted using more stringent controls such as those found in the causal-comparative methods, to verify the impact of the combined effect of these dependent and independent variables when used simultaneously, through repetition of surveys over time.
    - A *Mixed Model ANOVA* factorial study is recommended as a tool to investigate the impact of the interaction between the dependent variables (African policymakers' worldviews and values, levels of understanding, and attitudes toward agriculture biotechnology) and selected independent variables such as age, occupation, gender, education, religion, marital status, and residence. As stated by Tolson (2008a, 2008b), Mixed Model ANOVA indicates that we have a factorial study in which one or more of the factors are housed between participants (people) and one or more factors housed within the participants(within people). Thus we have a combination of Between ANOVA and Repeated measures ANOVA.

Planet Earth is facing one of the greatest crises in history. Population growth is expanding beyond the ability to meet consumptive needs. Basic sustenance needs are beyond the reach of one in six of the world's 6.8 billion people. With many experts predicting an additional four billion people by 2050, the problem is likely to intensify (U.S. Census Bureau, 2008). Previous challenges to a sustainable food production system were addressed by Gregor Mendel (1822-1884) and Norman Borlaug (1914) through improved genetics. Both Mendel and Borlaug embraced new paradigms, new mindsets, and new blueprints to seek viable solutions to the problem.

This study examined the communication factors affecting African policymakers' decisions about agricultural biotechnology and the perceived opportunities and obstacles that affect the adoption and diffusion of the innovation. Clearly, there is a critical gap that exists in the understanding of biotechnology between policymakers in Africa and solutions essential for the Millennium Development Goals for 2015. The resulting recommendations offer hope to an expanding population with contracting natural resources only if there is proactive education followed by deliberate interdependent action.

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APPENDIX A

RESEARCH INSTRUMENT

Communication Factors Affecting African Policymakers' Decisions about Agricultural Biotechnology

Directions

Purpose: The purpose of this research project is to empirically verify communication factors that affect African policymakers' decisions about adopting agricultural biotechnology to alleviate food insecurity.

The Questions: Please read each question and respond immediately with your initial reaction. We are only interested in your honest opinions. There are no correct or incorrect answers. *This questionnaire takes about 20 minutes to complete*.

Confidentiality: We respect your confidentiality by removing your name and other identifying information from your survey. Your participation in this study is voluntary and you may withdraw at any time. Your privacy will be protected to the maximum extent allowable by law.

When Finished: Upon completion of the questionnaire, please return your survey booklet to the survey administrator.

Questions: Please do not hesitate to contact **Dr. Gary J. Wingenbach** at (979) 862-1507 or by e-mail g-wingenbach@tamu.edu if you have questions about this study.

By completing the survey, you acknowledge that this questionnaire is voluntary and recognize that you will not be penalized if you choose not to participate. By completing this questionnaire you give your consent to be included in the study.

Required Information:

What is your current employment? ____

How long have you been in your current employment? ______________________________

Turn page and begin survey.

Worldviews and Values

1. What are your worldviews and values about agricultural biotechnology use in food production? Please rate the following statements by checking the appropriate column.

Statements:	Strongly Disagree	Disagree	Agree	Strongly Agree
a) Consumers have a right to choose what they eat; hence, to know what they are eating.				
b) Genetic engineering means cheaper food for consumers.				
c) Genetic engineering means more nutritious food for consumers.				
d) Genetic manipulation takes mankind into realms that belong to God and God alone.				
e) Genetically-altered foods should be labeled.				
f) I am willing to pay extra for the labeling of genetically-modified foods.				
g) I would attend an information session on biotechnology in my community.				
h) The regulation of modern biotechnology should be left mainly to industry.				
i) The use of biotechnology in food production is against my moral values.				
j) Until we know that genetically-altered foods are totally safe, those products should be banned.				
k) We have no business meddling with nature.				

2. How often have you contacted the following sources of biotechnology information within the past two months? Please check the number of contacts for each of the following sources.

	Number of Contacts				
I have…	0	1	2	3	4+
a) Accessed a Web site on biotechnology.					
b) Attended seminars or public forums on biotechnology.					
c) Read and watched about biotechnology in the mass media.					
d) Read books on biotechnology.					
e) Read newsletters/pamphlets/brochures on biotechnology.					
f) Talked or heard from a non-government organization (NGO) about biotechnology.					
g) Talked or heard from experts or scientists about biotechnology.					
h) Talked to or heard from a religious figure e.g. nun, priest, monk, imam, cleric.					
i) Talked to or heard from agricultural biotechnology companies.					
j) Talked to or heard from family/friends/neighbors about biotechnology.					
k) Talked to or heard from food regulators on biotechnology.					
l) Talked to or heard from local politicians/leaders about biotechnology.					

Extent of Trust in Information Sources

3. How much do you trust each of the following sources on agricultural biotechnology issues? Please check the appropriate column.

How ***trustworthy*** are each of these sources about agricultural biotechnology issues?	Completely Untrustworthy	Untrustworthy	Trustworthy	Completely Trustworthy
k) Activist groups				
l) Agricultural biotechnology companies				
m) Agricultural input dealers				
n) Consumer groups				
o) Family/friends/neighbors				
p) Farmers/farmer groups				
q) Food companies				
r) Government officials				
s) Newspapers				
t) Non-governmental organizations				
u) Private sector scientists				
v) Radio broadcasts				
w) Religious leaders				
x) Science magazines or newsletters				
y) Television broadcasts				
z) University-based scientists				
aa) Web sites on biotechnology				

4. How biased are each of the following sources on agricultural biotechnology issues? Please check the appropriate column.

How ***biased*** are each of these sources about agricultural biotechnology issues?	Completely Biased	Biased	Unbiased	Completely Unbiased
a) Activist groups				
b) Agricultural biotechnology companies				
c) Agricultural input dealers				
d) Consumer groups				
e) Family/friends/neighbors				
f) Farmers/farmer groups				
g) Food companies				
h) Government officials				
i) Newspapers				
j) Non-governmental organizations				
k) Private sector scientists				
l) Radio broadcasts				
m) Religious leaders				
n) Science magazines or newsletters				
o) Television broadcasts				
p) University-based scientists				
q) Web sites on biotechnology				

Understanding Biotechnology

5. How much do you understand about biotechnology for food production? Please check your understanding by answering the following statements as **True** or **False**; check one column for each statement.

Statements:	True	False
a) Brewing yeasts contain living organisms.		
b) By eating genetically-modified corn, a person's genes could also be modified.		
c) Genetically-modified crops are now being commercially grown in my country.		
d) Golden rice (genetically-modified rice) contains beta carotene.		
e) In genetic engineering, genes of interest are transferred from one organism to anther.		
f) In reality, all crops have been "genetically modified" from their original states through domestication, selection, and controlled breeding over time.		
g) More than half of human genes are identical to those of monkeys.		
h) Ordinary tomatoes do not contain genes, while genetically-modified tomatoes do contain genes.		
i) Plant viruses are transferred to humans when they eat vegetables and fruits infected with plant viruses.		
j) Plant viruses infect vegetables and fruits.		
k) Products from genetically-modified crops are now being sold in my country.		
l) Scientific research guarantees zero-risk.		
m) With every emerging technology, there are always potential risks.		

Importance of Biotechnology

6. What is the importance of agricultural biotechnology in food characteristics? Please rate the importance of agricultural biotechnology for each of the following food characteristics by checking the appropriate column.

Characteristics:	Very Unimportant	Moderately Unimportant	Moderately Important	Very Important
a) Better tasting food/palatability				
b) Decreased groundwater contamination				
c) Decreased use of water for production				
d) Higher nutritional quality				
e) Improved food appearance				
f) Improved yields				
g) Increased shelf-life				
h) Lower food prices				
i) Lower pest susceptibility				
j) Lower pesticide residues				
k) Non-allergenic properties				
l) Non-poisonous ingredients				

Perceptions of Agricultural Biotechnology

7. Is the use of agricultural biotechnology in food production hazardous? Check one response below.
    a. ___ Not at all Hazardous
    b. ___ Somewhat Hazardous
    c. ___ Very Hazardous
    d. ___ I have No Opinion

8. Are there benefits associated with the use of agricultural biotechnology in food production? Check one answer below.
    a. ___ Not at all Beneficial
    b. ___ Moderately Beneficial
    c. ___ Very Beneficial
    d. ___ I have No Opinion

9. What are your opinions about agricultural biotechnology policy? Please rate your agreement for the following statements by checking the appropriate column.

Statements:	Strongly Disagree	Disagree	Agree	Strongly Agree
a) Bio-safety regulations are adequate for protecting my country's food products.				
b) Bio-safety regulations are adequate for protecting my country's natural resources.				
c) Biotechnology in food production only benefits large agricultural companies.				
d) Biotechnology is good for my country's agricultural development.				
e) Biotechnology regulation should include inputs from the non-governmental sector.				
f) Expert statements about biotechnology are based on scientific analysis and are therefore objective.				
g) Genetic engineering of food products could contaminate products in unanticipated ways resulting in threats to public health.				
h) Genetic engineering of food products could create unexpected new allergens resulting in threats to public health.				
i) Government agencies are doing their best to ensure that the food we eat is safe.				
j) Government regulatory agencies have the scientific facts and technical information they need in order to make good decisions about biotechnology in food.				
k) My country's current regulations are sufficient to protect people from any risks linked to modern biotechnology.				
l) The risks of genetic engineering have been greatly exaggerated.				
m) Vital information about the health effects of genetically-modified foods is being withheld from the public.				

10. People have different concerns about the use of agricultural biotechnology. How **concerned** are you about the use of agricultural biotechnology? Please check the appropriate column.

How **concerned** are you about each of the following issues?	Very Unconcerned	Unconcerned	Concerned	Very Concerned
a) Consequences for farming and food production				
b) Economic implications				
c) Ethical implications				
d) Fear of food safety consequences				
e) Fear of genes moving unchecked to other plants, insects, or microorganisms				
f) Human health risks and safety issues				
g) International and global implications				
h) Low level of public knowledge				
i) Potential risks for the environment				
j) Religious concerns about altering nature				
k) Scientific uncertainty about biotechnology's consequences				

11 What is your attitude toward agricultural biotechnology? Please rate your level of agreement for each of the following statements by checking the appropriate column.

To what extent do you believe that agricultural biotechnology practices will affect the following?	Very Negative	Negative	Positive	Very Positive
m) Commercial farming				
n) The environment				
o) Fish and wildlife				
p) Food production				
q) Small scale farms				
r) Your health				

Attitudes toward Agricultural Biotechnology

12 What is your attitude toward agricultural biotechnology? Please rate your level of agreement for each of the following statements by checking the appropriate column.

Statements:	Strongly Disagree	Disagree	Agree	Strongly Agree
a) I would not attend an information session on biotechnology in food production in my community.				
b) I would contribute my time or money to an organization that promotes a ban on genetically modified foods.				
c) God granted us the abilities to manipulate nature for our benefit.				
d) Genetically-altered foods do not need to be labeled.				
e) All genetically-altered foods should be banned.				
f) The public should be consulted in formulating food regulation and laws.				
g) I am not willing to pay extra for the labeling of genetically-modified foods.				
h) We should use biotechnology in food production to make them more nutritious, taste better, and keep longer.				
i) It is acceptable to transfer genes from plant species into crop plants to make them more resistant to pests and diseases.				
j) It is appropriate to introduce human genes into bacteria to produce medicine and vaccines, for example to produce insulin for diabetes.				
k) It is acceptable to modify mice genes to study human diseases like cancer.				
l) It is okay to introduce fish genes into strawberries to resist extreme freezing temperatures.				
m) We should use genetic testing to detect and treat diseases we might have inherited from our parents.				

Demographic Information

1. What is your gender?
   a. ___ Male
   b. ___ Female

2. What is your age group?

a. ___ 20 and below
b. ___ 21-30
c. ___ 31-40
d. ___ 41-50
e. ___ 51-60
f. ___ 61 and above

3. What is your highest degree of education achieved?
   a. ___ Some elementary
   b. ___ Elementary graduate
   c. ___ Some high school
   d. ___ High school graduate
   e. ___ Some college
   f. ___ BS/BA degree
   g. ___ Post-graduate degree
   h. ___ Other

4. What is your marital status?
   a. ___ Single
   b. ___ Married
   c. ___ Other

5. What is your primary area of residence?
   a. ___ Rural
   b. ___ Suburban
   c. ___ Urban

6. What is your religion?
   a. ___ Roman Catholic
   b. ___ Protestant
   c. ___ Islam
   d. ___ Other

7. How would you rate your level of scientific knowledge?
   a. ___ Low
   b. ___ Somewhat Low
   c. ___ Average
   d. ___ Somewhat High
   e. ___ High

LETTERS FOR THE SURVEY

AGRICULTURAL BIOTECHNOLOGY POLICY SURVEY

Communication Factors Affecting African Policymakers' Decisions about Agricultural Biotechnology

As you might be aware, biotechnology has been identified as a tool that would greatly assist both large and small scale farmers address various biological and physical constraints in agriculture with special relevance to developing countries. Despite over a decade phenomenal growth in the use of biotechnology in agriculture and its benefits clearly identified, it would seem that the technology is not widely applied in Ghana and many African leaders. African leaders at the AU, subregional and country levels have advocated for the use of the technology in agriculture to address food security and poverty reduction problems. Little concrete action has, however been taken to back their pronouncements. Very few African countries have the enabling legislation to promote the safe acquisition of the technology.

A study on **'Communication factors affecting African policymakers' decisions about agricultural biotechnology'** has been proposed to identify the communication factors underpinning the tardy pace of adoption of the technology for agricultural production. The study is being undertaken by Mr. Belay Ejugu Begashaw as part of his doctoral study at the Norman Borlaug Institute of Texas A and M University. The target countries for the study are Ghana, Malawi and South Africa.

Mr Belay Ejigu Begashaw is a former Minister of Agriculture in Ethiopia and is presently associated with the Norman Borlaug Institute at the Texas A & M University, USA. He holds a Masters degree in Public Policy from Harvard University, a Masters in Rural Development from University of Reading and a degree in Agricultural Economics from the Addis Ababa University. He has vast experience in agriculture from both an academic and policy making side.

The Forum for Agriculture Research in Africa (FARA), and the Norman Borlaug Institute are the international agencies behind the study. The outcome of the study will greatly assist in the development of strategies to facilitate the safe use of biotechnology in Africa.

Mr. Begashaw has barely 2 weeks to interact with stakeholders in the country to gather data for the study. He proposes to use questionnaire and personal interviews to gather the data for the research. FARA has nominated me to facilitate the data gathering process in Ghana.

We would greatly appreciate you devoting some of your precious time (about 20 minutes) to fill the attached simple questionnaire and to hold yourself in readiness for personal discussions on the subject in furtherance of the response to the questionnaire should this become necessary. Please do not indicate your name on the questionnaire.

Please send your response to the attached questionnaire in the course of the week to Mr. Begashaw at bhejigu@neo.tamu.edu with a copy to me, Prof. Walter S. Alhassan at walhassan@fara-africa.org.

FARA is located at Roman Ridge on No. 2 Gowa Close near M-Plaza Hotel and MedLab. My office is at the FARA Annex nearer to MedLab.

We thank you most sincerely for your time.

Thank you.

Prof. Walter S. Alhassan
FARA Secretariat, Accra and Former Director-General, CSIR, Ghana.
020 8146668

LETTERS FOR THE SURVEY

Subject: Visit Mr Belay --interviews

Dear Colleagues/ beste kollegas,

Onderstaande versoek is in Engels ten einde afsending en kommunikasie te vereenvoudig.U samewerking word waardeeer.

I have been approached to render some assistance to a foreign visitor in his investigation into communication in modern biotechnology and wish to request your cooperation in this regard. Other than facilitating his visit I have no personal involvement in this study.

Mr Belay Ejigu Begashaw is a former Minister of Agriculture in Ethiopia and is presently associated with the Norman Borlaug Institute at the Texas A & M University, USA. He holds a Masters degree in Public Policy from Harvard University, a Masters in Rural Development from University of Reading and a degree in Agricultural Economics from the Addis Ababa University. He has vast experience in agriculture from both an academic and policy making side.

The study “Communication Factors Affecting African Policymakers’ Decisions about Agricultural Biotechnology” is being done as partial fulfillment of his PHD study and the results are expected to form part of a wider policy approach to improve biotechnology communication and science promotion in Africa. The investigation will make use of interviews and a questionnaire. A copy of the latter is attached. You are also welcome to forward this questionnaire booklet to other colleagues.

You will be contacted by Mr. Begashaw shortly and your collaboration will be much appreciated. His temporary cell phone number is 071-938-0663.

Sincerely

Wynand van der Walt
FoodNCropBio
Tel. 012-347-6334 / 083-468-3471

LETTERS FOR THE SURVEY

Date: Monday, June 30, 2008, 8:00 AM

Dear Colleagues,

The Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN) has been approached to render some assistance to Mr Belay of Texas A&M University who is doing a PHD research on communication biotechnology to policymakers in Africa.

We kindly ask you to fill the questionnaire attached and submit it to me vial email. Should you require any further assistance, please do not hesitate to contact me.

Thanks for your Support

JULIANA IMMACULATE CHIDUMU

FANRPAN LIASION OFFICER TO MALAWI

REGIONAL SECRETARIAT
141 Cresswell Road, Weavind Park 0184
Private Bag X813, Silverton 0127
Pretoria, South Africa
Tel: +27 12 845 9100
Fax: +27 12 845 9110

VITA

Belay Ejigu Begashaw
United Nations Avenue , PO Box 30677-0010 Nairobi, Kenya

Education

- Master in Public Administration (MPA), Harvard University, Kennedy School of Government, June, 2007
- MSc, Agricultural Extension University of Reading, 1989
- BSc, Agricultural Economics, Addis Ababa University, Alamaya College, 1984
- Fellow, Edward S. Mason Program in Public Policy and Management, 2006-07

Experience

The Earth Institute at Columbia University

- Senior Agricultural Policy Specialist at The MDG Center East &Southern Africa, January 2009 to date .

Texas A&M University

- Graduate Research Assistant at the Norman Borlaug Institute for International Agriculture, July 2006-August 2009

Harvard University

- Research Assistant, Harvard University's Belfer Center for Science and International Affairs, November 2006-June 2007

Ministry of Agriculture, Ethiopia

- Minister of State for Agriculture and Rural Development, March 2004-January 2006
- Minister, February 2003-March 2004
- Vice Minister, March 1998-April 2003
- Head, Agricultural Extension Department, 1996-1998
- Division Head, Extension Division, 1993-1996
- Training Expert in Extension Department, 1990-1993
- Development Agent at district level, 1985-1997

Relevant International Consultancy Experiences

- Consultant, United Nations FAO (Food and Agriculture Organization), formulation of the National Action Plan on Food Production for Lesotho and Swaziland December 8, 2007 to December 29, 2007
- Consultant, United Nations FAO (Food and Agriculture Organization), policy review on special program for food production Rome, December 25, 2007-January 26, 2008