UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE

UNDERLYING CONSTRUCTS OF FARMERS' PERCEPTIONS AND ADOPTION DECISION TOWARDS GENETICALLY MODIFIED CROPS AMONG SMALLHOLDER FARMERS IN NORTHERN GHANA

HUDU ZAKARIA

2019

UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE

UNDERLYING CONSTRUCTS OF FARMERS' PERCEPTIONS AND ADOPTION DECISION TOWARDS GENETICALLY MODIFIED CROPS AMONG SMALLHOLDER FARMERS IN NORTHERN GHANA

BY

HUDU ZAKARIA (M.Phil. Agricultural Extension)

(UDS/DIC/0013/14)

THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL EXTENSION, RURAL DEVELOPMENT AND GENDER STUDIES, FACULTY OF AGRIBUSINESS AND COMMUNICATION SCIENCES, UNIVERSITY FOR DEVELOPMENT STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A DOCTOR OF PHILOSOPHY DEGREE (PhD) IN INNOVATION COMMUNICATION

FEBRUARY, 2019

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original work, and that no part of it has been presented for another degree in this University or elsewhere:

Hudu Zakaria ....

(Name of Candidate) Signature Date

Supervisors' Declaration

We hereby declare that the preparation and presentation of this thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University for Development Studies.

Professor Albert K. Quainoo ....

(Principal Supervisor) Signature Date

Dr. Francis Kwabena Obeng ....

(Co-Supervisor) Signature Date

Dr. Adam Hamza ....

(Head of Department) Signature Date

ABSTRACT

As the debate on commercialization of Genetically Modified (GM)) crops continue to rage the perspectives of smallholder farmers in Africa regarding this novel technology is increasingly becoming relevant and imperative for both agricultural policy makers and researchers alike. This study assessed underlying constructs characterising smallholder farmers' perceptions and adoption decision towards the cultivation of GM crops. The study was conducted in the three northern regions of Ghana namely - Northern, Upper East and Upper West Regions. Through multi – stage sampling technique 360 smallholder farmers belonging to 120 Farmer Based Organizations (FBOs) from 10 sampled districts across the three northern regions were surveyed. Descriptive survey design and Q methodological procedure of gathering narratives were employed in sourcing data for the study. Descriptive and inferential statistics, discourse analysis and probit regression analysis were employed in analysing the study's data. The findings of the study revealed that smallholder farmers have very little knowledge about GM crops. Analysis of respondents' narratives on what they understood about GM crops revealed wide arrays of patchy and vague ideas. Q-factor analysis of respondents' narratives on their views about GM crops identified four underlying constructs characterising the perceptions of smallholder farmers towards GM crops. The constructs were 'GM crops positive or progressive perceivers, 'GM crops negative perceiver', 'GM crops cynic or sceptic perceivers' and 'GM crops neutral or dispassionate perceivers'. Regarding GM crops adoption decision among smallholder farmers surveyed, findings of the study revealed that many (41%) of the respondents intended adopting GM crops cultivation when commercialization commenced in Ghana. Results of the probit regression analysis shows that some selected demographic characteristics such as age, household size and marital status and farm characteristics such as farm seize, experience in crop farming, source of information on GM crops and use of certified seeds significantly influenced farmers' adoption decision towards GM crops. In general, smallholder farmers surveyed have high hopes of GM technology being used to incorporate drought tolerant, early maturing and high yielding traits into their local crop varieties and help reduce cost of weed, pest and disease control. However, the cost of GM seed and the possible unreliability of its supply were ranked as the most important possible constraints that might limit their cultivation of GM crops. The study recommends that conscious efforts should be made by Ministry of Food and Agriculture (MOFA) to actively engage smallholder farmers through their FBOs in formulating and implementing the country's agrobiotechnology programme. Also National Biosafety Authority should strengthen their public education on biotechnology activities to help create awareness of biosafety regulations and agrobiotechnology research activities in the country.

Keywords: perception, knowledge, adoption decision, GM Crops and Q methodology

ACKNOWLEDGEMENTS

My foremost thanks and gratitude goes to Almighty Allah for His guidance and protection throughout the course of my studies. This work couldn't have been possible without the contribution and support of many people in diverse ways.

My special gratitude goes to Professor Albert K. Quainoo and Dr. Francis Kwabena Obeng, my supervisors, for their guidance and advice. Their tireless and diligent constructive criticisms have contributed greatly in producing this thesis. I am grateful for their efforts.

I am greatly indebted to Mr konogini Nicholas of Ministry of Food and Agriculture (MOFA) in the Nadowli-Kaleo District, Mr Jatuat Moses of Masara N'arziki in the Wa Municipality for their assistance in contacting and organizing meetings with Farmer Based Organizations (FBOs) in the Upper West. Similarly my appreciation goes to Mr Hafiz Mumuni of MOFA in the Gushiegu District, Mr Alhassan of MOFA in the Nanumba North District, Mr Seidu Yedana, Mr Akumbole Abugri and Mr David for their assistance in organizing meetings with FBOs in the northern and upper east regions.

I appreciate the painstakingly efforts of Mr Akumbole Abugri, Mr Eliasu Dawda, and Mr. Akurugu Maxwell for their assistance in collecting data for this study. And my dear wife Jawhara Issahaku, thank you for your assistance in processing the data collected.

To my family I am very grateful for your support, patience and understanding during the period of my studies. Your support and encouragement have brought me this far. I will forever be indebted to you.

I am also thankful to the University for Development Studies (UDS) for granting me study leave to pursue this programme. To my colleagues in the Department of Agricultural Extension, Rural Development and Gender Studies, I appreciate your support and understanding.

DEDICATION

I dedicate this thesis to my lovely Mother (Nafisah Alhassan) and in memory of my late Father (Afa Zakaria Alhassan)

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

BACKGROUND TO THE STUDY

1.0 Introduction

This chapter presents general background to the study. It introduces the study, presents the research problem, research questions and objectives of the study. The chapter also presents justification of the study and definition of important concepts and terms used in the study.

1.1 Background Information

One of the major scientific advances of the last century featured the identification of the structure of Deoxyribose Nucleic Acid (DNA), the development of molecular biology and the technology to exploit these advances (Khush, 2012). For over two decades now, global agriculture has benefited from this breakthrough, with crop breeders harnessing the scientific advances in DNA and molecular biology in the process referred to as 'Genetic Engineering'. This technology allowed scientists to adjust, modify or alter the genomes of target organisms for improved performance and much desired results (CSIS, 2010). Genetic Engineering Technology has enable breeders to overcome natural limitations and barriers which hitherto prevented them from transferring desirable traits from one organism to the other with much precision. It had therefore unleashed a huge potential for crop breeders to produce better performing crop varieties capable of overcoming inherent limitations such as disease and pest susceptibility, drought susceptibility and low yield among others (Laura, *et al*, 2008; Baulcombe, *et al.*, 2014).

Over the last two decades, the application of genetic engineering technology has facilitated the production and development of many Genetically Modified (GM) crop varieties, notably Roundup

Ready (RR) soybeans and Bt cotton, which have seen wide spread adoption and cultivation, leading to sustain increase in global acreage of GM crops. Brookes and Barfoot (2011) reported that, on the global scale the area planted with genetically modified crops has increased substantially over the past decade. They observed that, in 2009, about 14 million farmers worldwide planted GM crops on approximately 134 million hectares with close to half (46%) in developing countries. Earlier studies by James (2008) indicated that developing countries, noticeable Argentina, Brazil, China, India, and South Africa contributed approximately 40% of the global total area of 46 million hectares in 2008.

Recent statistics from James (2013) indicated that, the global hectares of biotech crops have increased more than a hundred fold. Global production level of GM crops have soared from 1.7 million hectares in 1996 to over 175 million hectares in 2013, making GM crops the fastest adopted crop technology in contemporary agricultural innovation adoption history. Very recent statistics from Information Service for the Acquisition of Agri-Biotech Application (ISAAA) indicate that up to 18 million farmers in 26 countries planted 185.1 million hectares (457.4 million acres) of GM crops in 2016, an increase of 3% or 5.4 million hectares (13.1 million acres) from 2015. Of the total number of 26 countries planting GM crops in 2016, 19 were developing countries and 7 industrial countries (ISAAA, 2016). The leading world producers of GM crops are the United States (US) and Brazil, followed by Argentina, India, Canada, and China as observed by ISAAA (2016). Even though, experimentation with GM crop technology is widespread, the number of countries with significant levels of commercial production is limited (FAO, 2013; Fukuda-Parr and Orr 2012 & ISAAA, 2016).

African countries are lagging behind when it comes to commercial application of GMOs in their agricultural production and this is raising concerns regarding combating hunger and food insecurity which is widespread on the continent (FAO, 2013). Increasing agricultural productivity is one of the best ways to increase rural income, and one promising but controversial means of achieving that is biotechnology, including GM crops and other modified organisms (IFPRI, 2013). However, in spite of the proven good results from global production level and promising potential of GM crops in solving not only food insecurity but nutritional deficiency among Africans (Brookes and Barfoot, 2012; James, 2012; James, 2013; Baulcombe, et al, 2014), it has seen very little uptake in African agriculture.

IFPRI, (2013) reported that, as of 2011, Africa accounted for less than 1.6 percent of the 160 million hectares worldwide planted with GM crops. Some Africa countries have made progress with commercialisation of GM crops. For instance, Bt cotton, soybean and canola have been approved and released for commercial production in Burkina Faso, Egypt, and South Africa. Also, confined and contained research and adaptive trials are being conducted in many African countries whilst appropriate institutional, legal and regulatory regimes are being put in place in many other countries in the African continent (Fukuda-Parr *et al*, 2012).

Africa Union (AU) declared 2014 as the Year of Food Security, with collective recognition that enhanced agricultural performance is the key to growth and poverty reduction, food security, improved nutrition and resilience building (CAADP, 2014). This declaration however, requires concerted efforts to ensure adoption of efficient agricultural innovations and learning from best practices elsewhere. The declaration plans to eradicate hunger on the continent by 2025 amidst controversy over whether GM crops can help countries reach that goal (IFPRI, 2013). This is a clear manifestation of the continent seeming lack of consensus and collective direction regarding commercialization of GM crops. However, there seems to be overwhelming inclination of African political leaders and scientist towards commercialization of GM crops, despite the generally low level of actual GM crop production. At an African Agriculture Conference in 2012 held in Accra Ghana, (FARA, 2012), 24 African countries agreed to allow the use of GM crops as part of their agricultural development agenda. So far, commercial use of genetically engineered seeds in the content is permitted only in South Africa, Egypt, Sudan and Burkina Faso (Fukuda-Parr, *et al*, 2012; James, 2012; James, 2013; IFPRI, 2013).

Unlike the traditional improved varieties of crops released through conventional crop breeding techniques, adoption of commercial production of GM crops requires institutional, legal and biosafety frameworks and compliance with international conventions and protocols (such as Convention on Biological Diversity and Cartagena Protocol on Biosafety) to ensure safe handling, transfer and production of GM crops without jeopardising human health and the environment. The requirement of biosafety regulatory frameworks have often been cited as being partly responsible for the low level of adoption of GM crops observed in Africa (IFPRI, 2013 and Fukuda-Parr, 2012) although 48 countries on the African content have either acceded to or ratified the Cartagena Protocol on Biosafety which provide for broad legal and regulatory regimes for global biosafety (Timpo, 2011).

In order to successfully harness the huge potential of Genetically Modified Technology (GMT) and GM crops in particular, the government of Ghana has for some time now been putting in place measures to ensure successful commercialisation of GM crops. In line with this, the country ratified the Convention on Biological Diversity on August 29, 1994 and the Cartagena Protocol on Biosafety on May 30, 2003 (Ashitey, 2013 and Sarpong, 2004). Through collaborations and sponsorship of international organizations such as United Nations Environment Program (UNEP), Global Environment Facility (GEF), International Food Policy Research Institute (IFPRI) and Forum for Agricultural Research in Africa (FARA), government of Ghana has made significant progress in establishing legal and regulatory regimes in preparations towards eventual uptake of GMOs technology in commercial agricultural production.

In July, 2004, with financial and technical assistance from the United Nations Environment Programme and the Global Environment Facility (UNEP/GEF), Ghana adopted a draft Biosafety Framework, paving the way for the final passage of the country's biosafety law (Ashitey, 2013). Also, between 2004 to 2008, Ashitey, (2013) noted that through USAID-sponsored Programme for Biosafety Systems (PBS), implemented by a consortium led by IFPRI, significant efforts were made in developing the underlying legal framework for biotechnology and biosafety policy in Ghana.

Also from 2009 to 2011 the country together with Burkina Faso, Kenya, Malawi, Nigeria and Uganda benefited from the Forum for Agricultural Research in Africa (FARA), project on Strengthening Capacity for Safe Biotechnology Management which had helped in addressing information gathering and dissemination, awareness creation and outreach, and stewardship in biotechnology (FARA, 2012).

All these efforts culminated in the enactment of Biosafety Act (**Act** 831) in 2011 which provides broad legal framework to guide the generation and application of GMOs. The objectives of the Act are to:

(a) ensure adequate level of protection in the field of safe development, transfer, handling and use of genetically modified organisms resulting from biotechnology that may have an adverse effect on health and the environment, and

(b) establish a transparent and predictable process to review and make decisions on genetically modified organisms specified in paragraph *(a)* and related activities (*Biosafety Act, 831, 2011).*

Also Plant Breeders' Protection Bill is currently being considered by Ghanaian parliament to provide legal basis for protecting intellectual property of plant breeders and research institutions applying GMOs technology in producing improved varieties of crops. This Bill is expected to be passed into law to help create favourable environment for the development and commercialization of biotechnology seeds and crops as observed by Ashitey (2013), and also attract private investment in GM seeds production and marketing. As observed by Bennett and Jennings (2013) that progress had been made with respect to enactment of enforceable regulatory framework for GMOs in Ghana, and as such the country can be considered to have positive stance towards commercialization of GM crops.

With regard to progress in biotechnology research and GM crops development and commercialization, Savannah Agricultural Research Institution (SARI) of the Council for Scientific and Industrial Research (CSIR) is currently undertaking adaptive trials and research into genetically modified cowpea and cotton. As part of the trial process, SARI has established a biotechnology cowpea farm at Nyankpala in the Tolon District and a biotechnology cotton farm at Kpalkore in the Mion District (Ashitey, 2013 and GNA, 2013).

1.2 Problem Statement

Ghana has made steady progress towards application of GMOs technology in commercial agriculture within two decades since the country's ratified Cartagena Protocol on Biosafety. The necessary legal and regulatory frameworks have been laid to ensure safety application of GMOs technology in Ghanaian agriculture (Ashitey, 2013; Bennett *et al*., 2013). Ghana's biosafety act (Act 831) passed in 2011, had layout the necessary institutional and regulatory frameworks required for the smooth commercialization of GM crops. National Biosafety Authority had been established to regulate and oversee safety commercialization of GM crops in line with the National Biosafety Act (GNA, 2015).

Inspite of the progress the country has made in ensuring the transformation of agriculture through commercial application of GMOs technology, there exist some opposition mounted by campaigners against GMOs. Some Non-governmental and Civil Societies Organizations notably Food Sovereign Ghana, Faith-Based Organizations, Action Aid Ghana, Centre for Indigenous Knowledge and Organizational Development and Peasant Farmers Association of Ghana coming under the banner 'National Campaign Against Plant Breeders' Bill' are leading nationwide campaign against the country's agrobiotechnology agenda (available on http://foodsovereigntyghana.org/ accessed on 20th June, 2014).

Almost all countries where GM crops are commercialised went through opposition by anti-GM activists who often used media propaganda and public protests to galvanize support against GM food and agrobiotechnology (Hanrahan, 2010; Vigani and Olper, 2013). The arguments put forward by these ant-GM activists often received wide media coverage and thereby having direct effect on farmers' and consumers' acceptance of GM food (Hanrahan, 2010).

Campaigners against commercialization of GM crops in Ghana within the last five years have intensified their activities embarking on media propaganda, public protest and legal litigation all in an attempt to stop government from allowing commercialization of GM crops. Food Sovereignty Ghana (FSG) in 2015 engaged government in a legal showdown at Accra High court in an attempt to secure injunction to restrain SARI from conducting adoptive trials impending commercial release of Bt cowpea and GM rice (GNA, 2015). Although FSG failed to secure the injunction and SARI had been contacting the trials, the legal action alone demonstrates the depth of opposition to Ghana's agrobiotechnology programme.

In this on-going debate on Ghana's agrobiotechnology agenda the views of smallholder farmers, who account for over 80% of the country's agricultural production (MOFA, 2016), is conspicuously missing. Also Farmer Based Organizations (FBOs), which have been formed across the country to facilitate smallholder farmers' participation in the formulation and implementation of agricultural policies (FBOs) (AgSSIP, 2007; MOFA, 2016; MOFA, 2012; Salifu, Francesconi and Kolavalli, 2010), have not been effectively engaged in the country's agrobiotechnology agenda. Notwithstanding the fact that, farmers' role in agricultural policy formulation is critical, in most developing countries including Ghana, smallholder farmers' participation in agricultural policy planning leave much to be desired (Aref, 2011; Iqbal, 2007 and Nxumalo and Oladele, 2013).

Notwithstanding the proven benefits of agrobiotechnology (Brookes et al, 2012; James, 2012; Baulcombe, et al, 2014) and the fact that there have never been any scientific validated evidence linking GM crops to health and environment risks (DG Research, 2010; Fagerstrom et al., 2012), Ghanaian farmers decision to adopt the cultivation of GM crops would depend largely on information they have about GM crops and Ghana's agrobiotechnology programme.

However, literature on GMO debate is dominated by experts and advocates views, with very little information on the views of smallholder farmers. The few studies which examined public perceptions towards GMO products often failed to assess farmers' knowledge, perceptions and adoption decision towards GM crops. A study by Robert, *et al*, (2008) on 'Stakeholder Approach to Investigating Public Perceptions and Attitudes towards Agricultural Biotechnology in Ghana' failed to include farmers, an important stakeholder in the application of agrobiotechnology.

However, a recent study by Ademola, *et al*, (2014) on potential benefits of biotechnology on food security in West Africa, identified challenges such as lack of awareness, inadequate training, low level of education and poor extension services among others as the main challenges facing the introduction of GM technology to resource poor farmers. The study called on governments to put in place policy measures to address these challenges. Their study highlighted important policy issues regarding farmers' perceptions about GM crops in Ghana and Nigeria but they did not thoroughly examine farmers' adoption decision.

As the debate on application of GMOs technology in commercial agriculture intensifies in the country, it is appropriate to contribute to knowledge on smallholder farmers' perspectives regarding the adoption of GM crops. This study therefore examined smallholder farmers in Northern Ghana perceptions and adoption decision towards GM crops.

1.3 Research Questions

The study proceeded by examining the question ''what are the underlying constructs characterising farmers' perceptions towards GM crops and how do these perceptions shape farmers' adoption decision?''. Specifically, the study sought to answer these questions:

1. What knowledge and understanding do smallholder farmers in Northern Ghana have about GM crops?
2. What are the underlying constructs characterising smallholder farmers in Northern Ghana perceptions towards GM crops?
3. What factors determine the adoption decision among smallholder farmers in Northern Ghana regarding GM crops cultivation?
4. What expectations do smallholder farmers in Northern Ghana have about Ghana's agrobiotechnology agenda?

5. What are the likely prospects and constraints of commercialization of GM crops from the perspective of smallholder farmers in Northern Ghana?

1.4 Research Objectives

The main objective is to analyse the underlying construct characterising farmers' perceptions and adoption towards GM crops among farmers in Northern Ghana.

1.4.1 Specific objectives

The study sought to examine these specific research objectives:

1. To examine the knowledge and understanding smallholder farmers in Northern Ghana have about GM crops.
2. To analyse the underlying constructs characterising the perceptions smallholder farmers in Northern Ghana hold towards GM crops.
3. To determine factors predicting smallholder farmers in Northern Ghana adoption decision towards GM crop cultivation.
4. To analyse the expectations farmers have about Ghana's agrobiotechnology agenda.
5. To examine the likely prospects and constraints of commercialization of GM crop production from the perspective of smallholder farmers in northern Ghana.

1.5 Justification of the Study

The ultimate aim of this study is to add to knowledge and make input into policy decision as Ghana moves towards commercialization of GM crops in particular and application of agrobiotechnology in commercial production in general. Typically, policymakers in Ghana regarding the agrobiotechnology initiative are faced with at least three challenges. The first is the unavailability of empirical information on farmers and other stakeholders understanding, perceptions and underlying logic that could result in their adoption behaviour when the country finally approves and releases GM seeds for commercial production. The second is the understanding of factors that could potentially affect farmers' willingness and adoption decision. The third is how to provide for the needs of farmers and address their concerns and perceived potential risks associated with the cultivation of GM crops through policy directions and appropriate implementation strategies to be used in disseminating agrobiotechnology innovation.

The study is therefore relevant to Ghana' s agrobiotechnology agenda because it presents empirical information providing insight into the knowledge, perceptions and adoption decision of smallholder farmers towards GM crops. This information is expected to help guide policy directions and streamline implementation strategies in this preparatory stage of the country's agrobiotechnology agenda. It will also contribute to knowledge regarding farmers' perceptions and factors which explain farmers' adoption decision towards GM crops.

Although adoption and perception studies have received considerable attention, the adoption of GM crops presents different institutional and regulatory frameworks compared with the conventional bred crop varieties. This is so because, commercialization of GM crops requires institutional and biosafety legislative and regulatory frameworks to guide the production and handling of genetically modified products. It also presents new demand on farmers to respect patents and right of breeders over GM seeds and the need to cooperate with Biosafety Monitory and Evaluation Agencies on risk assessment of GM products. How farmers in Ghana would perceive and respond to these demands has not received that much attention and as such it is not adequately expressed in available literature. This study therefore contribute to knowledge in helping bridge this knowledge gap by presenting empirical information on how farmers are perceiving and intending to response to these new demands associated with the cultivation of GM crops.

1.6 Definition of Terms

Definition of terms and concepts used in the thesis is presented in the Table 1.1

Table 1.1: Definition of terms

Term	Definition
Biotechnology	According to the Protocol on Biosafety, modern biotechnology is the application of (a) *In vitro* nucleic acid techniques, including recombinant deoxyribonucleic acid (DNA) and direct injection of nucleic acid into cells or organelles or (b) Fusion of cells beyond the taxonomic family, that overcome natural physiological reproductive or recombination barriers and that are not techniques used in traditional breeding and selection. (http://www.biodiv.org/biosafety/protocol.asp) According to Ghana Biosafety Act (2011)"biotechnology" means a technological application that uses biological systems, living organisms or derivatives of those systems and organisms to make or modify products or processes for a specific use
Genetically Modified Organism (GMO)	According to American Heritage New Dictionary (2005) the term genetically modified organism (GMO) is used to refer to any microorganism, plant, or animal in which genetic engineering techniques have been used to introduce, remove, or modify specific parts of its genome. In this study, any biological product produced through the process of genetic engineering in which the genetic constituent of the organism is altered by insertion or deletion of genes. All organisms produced through this process will be referred to as **Genetically Modified Organisms (GMOs)**. Living modified organisms (LMOs) and transgenic organisms are other terms often used in place of GMOs.
Living Modified Organism(LMO)	Living Modified Organism (LMO) according to Biosafety Protocol refers to any living organism that possesses a novel combination of genetic material obtained through modern biotechnology. A living organism is biological entity capable of transferring or replicating genetic material.
Genetic Engineering	According to the Heritage New Dictionary, Genetic Engineering is the manipulation of DNA to produce new types of organisms, usually by inserting or deleting genes. Or the development and application of scientific methods, procedures, and technologies that permit direct manipulation of genetic material in order to alter the hereditary traits of a cell, organism, or population. It is also a technique that produces unlimited amounts of otherwise unavailable or scarce biological product by introducing DNA isolated from animals or plants into bacteria and then

	harvesting the product from a bacterial colony, as human insulin produced in bacteria by the human insulin gene (Dictionary.com). This study will refer to the scientific process that permits manipulation or alteration of genetic constituents of organisms as **Genetic Engineering**.
DNA (Deoxyribo Nucleic Acid)	DNA is a molecule that encodes genetic information in cells. It is constructed of a double helix held together by weak bonds between base pairs of four nucleotides (adenine, guanine, cytosine, and thymine) that are repeated at infinitum in various sequences. These sequences combine together into genes that allow for the production of proteins (Dictionary.com).
Germplasm	Germplasm is living tissue from which new plants can be grown—seed or another plant part such as a leaf, a piece of stem, pollen or even just a few cells that can be cultured into a whole plant. Germplasm contains the genetic information for the plant's heredity makeup.
Genetically Modified (GM) Crop	Genetically Modified Crop (GM crop) is a crop whose genetic material has been altered through genetic engineering process resulting in the change of one or more of its characteristic traits. GM crops are developed by a process of genetic modification by which selected individual genes are inserted from one organism into another to enhance desirable characteristics ('traits') or to suppress undesirable ones. All crops whose genetic material has been altered through the process of genetic modification are referred to in this study as Genetically Modified Crops.
Transgenic plants	Transgenic plants result from genetic engineering process in which genetic material of plants is modified either by alteration or insertion of genetic material from another organism so that the plant will exhibit a desired trait. All plants or crops whose genetic material have been altered through the process of genetic modification are referred to in this study as transgenic plants or crops
Bacillus thuringiensis (Bt)	Bacillus thuringiensis (Bt) is a soil bacterium that produces toxins against insects (mainly in the genera Lepidoptera, Diptera and Coleoptera). Bt preparations are used in organic farming as an insecticide. "Bt" crops, primarily cotton and maize, have been developed to include the bacterium, Bacillus thuringiensis (Bt), in the genetic makeup of a plant, making it poisonous to certain insects and therefore insect resistant
Herbicide-tolerant (HT) crops:	These are crop which are produced from the insertion of an herbicide tolerant gene onto their germplasm thus making them tolerant to wide-spectrum herbicides. This makes it possible for farmers to spray wide-spectrum herbicides on their fields to kill all other plants except the HT crop. The most common herbicide-tolerant crops (cotton, corn, soybeans, and canola) are tolerant to glyphosate and to glufosinate-ammonium, which are the active ingredients of common wide spectrum herbicides.
Bt crops	Bt crops are genetically modified to carry genetic material from the soil bacterium Bacillus thuringiensis. Crops containing the Bt genes are able to produce Bt-toxin, thereby providing protection against insects during the growth-stage of the plant. Examples are Bt maize and cotton

Biosafety	Biosafety means the mechanism developed through policy and regulatory standards to ensure environmental and health safety in the production, handling, transfer and use of GMOs. "Biosafety" is a term used to describe efforts to reduce and eliminate the potential risks resulting from biotechnology and its products (Biosafety Act 831, 2011)
Cartagena Protocol on Biosafety	Cartagena Protocol on Biosafety is a legally binding global protocol that seeks to contribute to ensuring the safe transfer, handling and use of living modified organisms (LMOs) created through modern biotechnology
Confined use	"confined use" means a field trial of a genetically modified organism in an open system in which physical barriers are employed to effectively limit their impact with, and their impact on, human and external environment (Biosafety Act 831, 2011)
Contained use	"contained use" means an activity undertaken within a facility, an installation or any other physical structure which involves genetically modified organisms that are controlled by specific measures (Biosafety Act 831, 2011)
Perception	The process by which people translate sensory impressions into a coherent and unified view of the world around them. Though necessarily based on information, perception is equated with reality for most practical purposes and guides human behaviour in general. Perception can be defined as our recognition and interpretation of sensory information. Perception also includes how we respond to the information. We can think of perception as a process where we take in sensory information from our environment and use that information in order to interact with our environment.
Attitude	A predisposition or a tendency to respond positively or negatively towards a certain idea, object, person, or situation. Attitude influences an individual's choice of action, and responses to challenges, incentives, and rewards – refers to as together called stimuli. In this study, attitude is defined as the predisposition or tendency of smallholder farmers to respond or act towards GM crops in particular and agrobiotechnology in general
Innovation Adoption Decision	Innovation adoption is a decision of "full use of an innovation as the best course of action available" and rejection is a decision "not to adopt an innovation" (Rogers, 2003; p. 177).
Farmer Collective Action	In this study, collective action is used in the sense of "voluntary action taken by a group to achieve common interests"

1.6 Organization of Thesis

This thesis is organized into five chapters. The first chapter presents background of the study, research problem, objectives and research questions that the study sets out to answer. The chapter one also contains Justification of the study and definition of concepts used in the study. Chapter two presents theoretical and conceptual frameworks guiding the study and review of relevant literature.

The literature review covers in chapter two includes concepts such as crop improvement and genetically modified organism technology, debate on GM crops, and global production of GM crops, Benefits of GM crops and biosafety regularity regimes in Ghana.

Chapter three present methodology used in the study. It presents detail description of research design, data collection and analytical methods employed in achieving the research objectives. Chapter four presents results and discussions of findings of the study. In chapter, presentation of findings are organised in subsections based on the objectives set out in the study. It also cover detail discussion of the findings with appropriate reference and comparison made to relevant previous research findings. Finally, chapter five presents summary of major findings of the study and the conclusions and recommendations drawn from the findings.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents theoretical and conceptual frameworks guiding the study and review of literature on various issues and concepts relevant to the study. It presents literature review on crop improvement, genetically modified technology, debate on GM crops, benefits and risks of GM crops and biosafety regulatory regime in Ghana. Also literature on farmers' collective action and the operations of farmer based organization in Ghana are reviewed and presented in this chapter.

2.1Theoretical and Conceptual Framework

This section presents theoretical review of theories and methodological concepts employed in the study. It undertook thorough examination and provides insight into theoretical concepts of innovation adoption behaviour of farmers. Here extensive review of theories explaining farmers' adoption behaviour and conceptual frameworks which have been put forward to explain farmers' adoption decision making process. Also this section presents detail and comprehensive description of Q methodological process and the various chronological stages involved in a typical Q study. This is necessary because, Q methodological approach was employed in this study in gathering narratives of smallholder farmers regarding GM crops and Ghana agrobiotechnology.

2.1.1 Theoretical Overview on Adoption Decision

A theoretical framework is a conceptual model of how one theorizes the relationships among the several factors that have been identified as important to the problem or issue being studied. Sinclair (2007) explained that a theoretical framework can be thought of as a map or travel plan. When planning a journey in unfamiliar country, people seek as much knowledge as possible about the best way to travel, using previous experience and the accounts of others who have been on similar trips. As such, this study relied on relevant theories underpinning individual adoption decision and behaviour as a framework in identifying factors influencing farmers' decision regarding the adoption of GM crops. As observed by Lai (2017) the various theories and model of technology adoption include but not restricted to the Theory of Reasonable Action (TRA) (Fishbein and Ajzen, 1975), Theory of Planned Behaviour (TPB) (Ajzen, 1991), Decomposed Theory of Planned Behaviour, (Taylor and Todd, 1995), Roger innovation diffusion theory (Roger, 2003), the Technology Acceptance Model (TAM) (Davis, Bogozzi and Warshaw, 1989), Technology Acceptance Model 2 (TAM2) Venkatesh and Davis (2000) and Technology Acceptance Model 3 (TAM3) Venkatesh and Bala (2008). However Roger's innovation diffusion theory is widely cited and used theory in modelling technology adoption.

Rogers after synthesizing over 508 adoption and diffusion studies came out with the 'diffusion of innovation' theory to explain innovation adoption and diffusion among individuals and organization (Rogers, 1995). The theory had since been widely applied in research on innovation acceptance and adoption. The theory explicates "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 1995; p. 5). Essentially, Rogers' (1995) diffusion of innovation theory explained that the innovation and adoption happened after going through several stages including understanding, persuasion, decision, implementation, and confirmation that led to the development of Rogers (1995) S-shaped adoption curve of innovators, early adopters, early majority, late majority and laggards (Lai, 2017).

Segmentation of innovation adoption and diffusion process is also highlighted in Parasuraman and Colby (2001) in which innovation adoption process is classified based on individual's technology readiness. Technology readiness (TR) is defined as people's propensity to embrace and use new technologies (Parasuraman and Colby, 2001 as cited Lai, 2017). Based on individual's technology readiness score, Parasuraman and Colby (2001) further classified technology consumers into five categories as explorers, pioneers, sceptics, paranoids, and laggards. Comparable it matches with Rogers (1995) S-shaped adoption curve of innovators, early adopters, early majority, late majority and laggards.

Earlier attempts at understanding and predicting behaviour and relationship that exist between attitude and behaviour led to the Theory of Reasoned Action (TRA), proposed by Fishbein and Ajzen (1975). The theory of Reasoned Action postulate that an individual's behavioural decision in a specific context depends on their attitude toward performing the target behaviour and on subjective norm, which refers to how one reacts to influence and pressure coming from other people he or she is related to and considered important regarding the performance or otherwise of a behaviour. Subjective norm visualized social context which demand conformity to socially accepted norms and behaviours. Venkatesh and Davis (2000) commenting on the applicability of TRA in explaining the influence of social pressure on behaviour indicated that the TRA holds that the practical impact of subjective norm on behavioural intention is that an individual may choose to perform a specific behaviour, even though it may not be favourable to him or her to do so but just to conform with social norms.

Despite the fact that a good number of adoption studies have successfully applied the TRA to predict behavioural intention (Sapp and Laczniak 2003; Venkatesh, Morris, Davis and Davis 2003; Bobbitt and Dabholkar, 2001), some concerns have been raised about the theory's failure to consider perceived behavioural control which explain the perception an individual may hold about the presence or absence of certain factors that might facilitate or impede the performance of the said behaviour. Also the inherent assumption that intention directly leads to action as portrayed in the TRA have been criticised for failing to acknowledge that individual may have intention to act in one way or the other but certain limitations can prevent them from exhibiting the said action. This obvious limitation of TRA necessitated further conceptual advances which led to Ajzen, (1991) and (2006) Theory of Planned Behaviour (TPB).

The overall aim of the TPB is to predict deliberative and planned behaviour. The theory includes the construct perceived behavioural control as an addition to the TRA to take into account the more common situation in which individuals do not have complete voluntary control over their behaviour, such as when they lack skills or resources to perform a particular task (Ajzen 1991and Ajzen 1985). In a nutshell, the TPB posits that behavioural decision is a function of an individual's beliefs in three areas:

1) behavioural beliefs (Attitude toward Behaviour) reflecting or representing individual perceptions about the probable outcome of a behaviour
2) normative perceptions (Subjective Norm) – meaning individual perceptions about the normative expectations of his/her immediate social environment such as family, friends/colleagues and society at large; and
3) control perceptions (Perceived Behavioural Control) – meaning the perceptions/beliefs regarding absence or presence of factors that might facilitate or impede the performance of the behaviour (Ajzen 1991).

The theory of planned behaviour holds that only specific attitudes toward the behaviour in question can be expected to predict that behaviour. However, in measuring attitudes toward behaviour, there is the need to measure people's subjective norms, explaining their beliefs about how people they care about will view the behaviour in question. Therefore to predict someone's intention, knowing his/her beliefs and attitudes is very important. Finally, perceived behavioural control, which refers to people's perceptions of their ability to perform a given behaviour, have been shown to have influence on their intentions to perform the said behaviour (Ajeze, 2006, and Barbara and Viswanath, 2008). The general rule of thumb is that, the more favourable the attitude and the subjective norm, and the greater the perceived control the stronger the person's intention to perform the behaviour in question will be. Thus intention or behavioural decision is a function of attitude, subjective norm and perceived behavioural control.

Other adoption theories emphasised on potential users of technology perceptions about the usefulness of the technology and how easy or otherwise it is to use the technology. Technology Acceptance Model (TAM) demonstrated the influence of people's perception about 'usefulness' and 'ease of use' of technology on acceptance of the technology. TAM is an information systems theory that models how users come to accept and use a technology (Davis, 1986).Two factors namely, perceived usefulness and perceived ease of use is critical in determining individual technology acceptance and as such are important variables in TAM (Davis, 1986, Lai, 2017 and Surendran, 2012). Davis (1986) defines perceived usefulness as the prospective user's subjective probability that using a specific application system will enhance his or her job or life performance. Perceive ease of use (EOU) can be defined as the degree to which the prospective user expects the target system to be free of effort. Surendran, (2012) observed that these two factors are influenced by external variables. The main external factors that are usually manifested are social factors, cultural factors and political factors.

Lai, (2017) observed that there has been a great deal of research on the Theory of Reasoned Action (Ajzen & Fishbein, 1980; Sheppard, Hartwick, and Warshaw, 1988) Theory of Planned Behaviour (Ajzen, 1991) and Decomposed Theory of Planned Behaviour, (Taylor and Todd, 1995) but mostly used for products already in the marketplace and included the view of society (Subjective norm). However, Technology Acceptance Model (TAM) specifically tailored for modelling users' acceptance of information systems or technologies.

These adoption theories have been applied in various adoption studies over the years. They have been relied upon to explain technology adoption behaviour of individual, groups, firms and organization. The theories have varying strengths and limitation, as different variables are highlighted and added by the different models. Study by Davis, Bagozzi and Warshaw's (1989) compared TAM with TRA and resulted in the convergence of both models. The converged model is based on three theoretical determinants as perceived usefulness, perceived ease of use and behavioural intention (Lai, 2017). The findings of Davis *et, al* (1989) indicated that social norms as an important determinant of behavioural intention is weak and that TAM does not include it as a determinant of behaviour intention while TRA and TPB highlighted subjective norms as an important determinant of behavioural intention.

Arguing for the usage of combination of TRA, TBP and TAM to overcome their individual limitation and maximize their collective strengths, Mathieson (1991) and Yi, Jackson, Park, and Probst (2006) argued that human and social factors could play a role in the adoption of technology using TPB model. Therefore, the TAM could be extended with constructs from the TPB to incorporate the social factors that could explain technology adoption. Some studies have applied more than one adoption theories in explaining adoption behaviour.

For instead, Shih and Fang (2004) examined the adoption of internet banking by means of the TPB as well as Decomposed TPB and found that it was in line with the findings of Venkatesh and Davis

(2000) that subjective norm was likely to have significant influence on behavioural intention to use in a mandatory environment, whilst the effect could be insignificant in a voluntary environment.

Davis, Bagozzi and Warshaw (1989) explained that social norms had very poor psychometric standpoint, and might not exert any influence on individual's behaviour intention, especially when the technology being disseminated is fairly personal while individual usage is voluntary. TAM was also specifically designed to address the factors of users' system technology acceptance (Chau and Hu 2002). Thus, the comparisons of the study confirmed that TAM was easy to apply across different research settings. Han (2003) as well as Lai and Zainal (2014; 2015) noted that using TAM capability was favourable compared with TRA and TPB.

The various adoption theories and models identified perceptions, individual attitudes and subjective norms as critical and imperative in predicting individual adoption behaviour. The focus of this study is to investigate the perceptions of smallholder farmers have about GM crops and factors influencing their intention to adopt the technology. Q methodological process was employed because it allows provides effective means of studying people's own perspectives, meanings, opinions and subjective viewpoints (Previte *et al*. 2007; Brown, 2003 and Stephenson, 1935). TPB which posit that individual behavioural intention is determine by three antecedents as attitude, perceived behavioural control and subjective norm was considered appropriate in modelling smallholder farmers behavioural intention towards the adoption of GM crops.

2.1.2 Theoretical Basis of Factor Analysis

This section presents theoretical aspects of factor analysis from a practical and applied perspective. The theoretical treatments of factor analysis have received much attention offering excellent and comprehensive overviews of this technique and its practical application in identifying structures and underlying dimensions of data (Field 2000; Ramelo and Newman, 2011; Rietveld and Van Hout, 1993).

The starting point of factor analysis is a correlation matrix, in which the intercorrelations between the studied variables are presented. The dimensionality of this matrix can be reduced by "looking for variables that correlate highly with a group of other variables, but correlate very badly with variables outside of that group" (Field, 2000). These variables with high inter-correlations could well measure one underlying variable, which is called a 'factor'.

This factor creates a new dimension and structure which Field (2000: 424) argued that it "can be visualized as classification axes along which measurement variables can be plotted". This projection of the scores of the original variables on the factor leads to two results: factor scores and factor loadings. The factor loadings are the "correlation of the original variable with a factor". The factor scores can then for example be used as new scores in multiple regression analysis, while the factor loadings are especially useful in determining the "substantive importance of a particular variable to a factor" (Field, 2000: 425).

2.1.2.2 Factor Analysis Model

Typically, factor analysis is based on Common Factor Model, illustrated in figure 2.1. This model proposes that each observed response (measure 1 through measure 5) is influenced partially by underlying common factors (factor 1 and factor 2) and partially by underlying unique factors (E1 through E5). The strength of the link between each factor and each measure varies, such that a given factor influences some measures more than others (Kline, 2002).

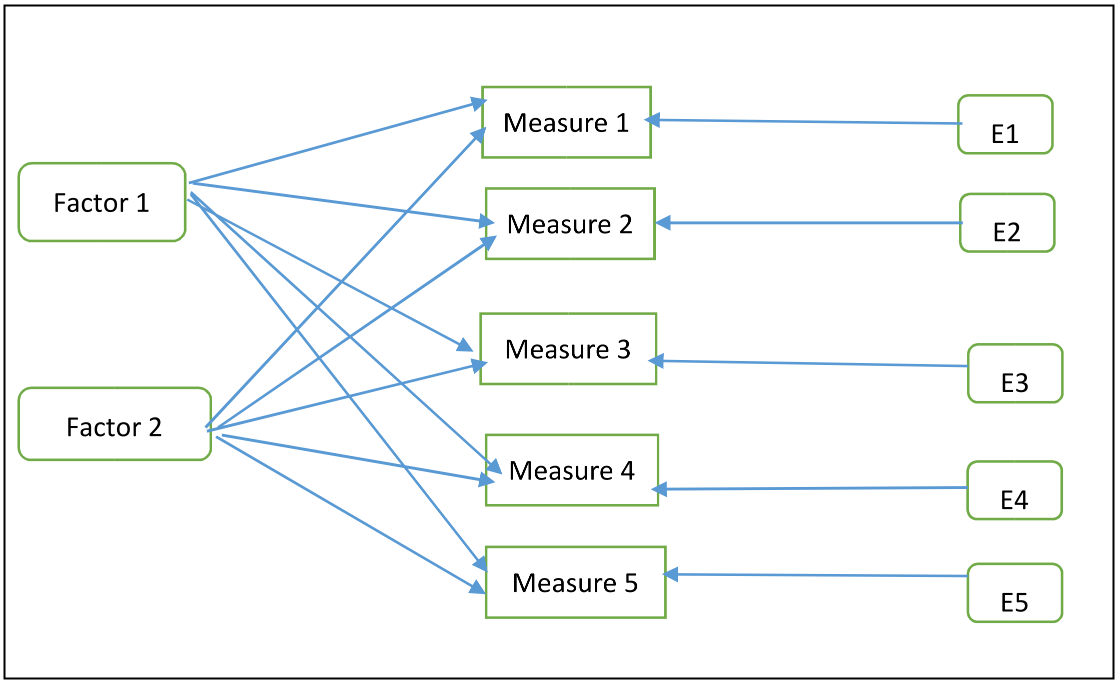

Figure 2.1: The Common Factor Model

Source: Kline (2002)

Factor analyses are performed by examining the pattern of correlations (or covariance) between the observed measures. Measures that are highly correlated (either positively or negatively) are likely to be influenced by the same factors, while those that are relatively uncorrelated are likely to be influenced by different factors. The common factor model provides visual understanding of the basis of factor analysis uses an estimate of common variance among the original variables to generate the factor solution. This is based on the fundamental assumption that some underlying factors, which are smaller in number than the observed variables, are responsible for the covariance among the observed variable (Anderson, 2003 & Bengt and Kaplan, 2011).

Factor analysis is a method for investigating whether a number of variables of interest Y_1, Y_2, ……., Y_i, are linearly related to a smaller number of unobservable factors F_1, F_2, ……., F_k. The fact that the factors are not observable disqualifies regression and other multivariate analytical techniques (Bengt and Kaplan, 2011).

The factor analysis model can be written algebraically as expatiated in Manly (2005) and Rencher (2002). If we have p variables $X_1, X_2, \ldots, X_p$ measured on a sample of ɲ subjects, then variable i can be written as a linear combination of m factors $F_1, F_2, \ldots, F_m$ where, as explained above $m < p$. Thus,

$$X_i = \alpha_{i1}F_1 + \alpha_{i2}F_2 + \ldots + \alpha_{im}F_m + e_i \quad \ldots\ldots (2.1)$$

Where the α is the factor loadings (or scores) for variable i and e_i is the part of variable X_i that cannot be 'explained' by the factors.

In obtaining the empirical model, there are three main steps to be followed in undertaken the factor analysis. These are (1) calculating initial factor loadings, (2) factor rotation and (4) calculation of factor score.

Calculate initial factor loadings: This can be done in a number of different ways; the two most common methods are principal component method and principal axis factoring (Bengt and Kaplan, 2011; Manly, 2005 and Rencher, 2002). With the principal component method as the name suggests, carry out a principal components analysis. However, the factors obtained will not actually be the principal components (although the loadings for the k^{th} factor will be proportional to the coefficients of the k^{th} principal component). While Principal axis factoring tries to find the lowest number of factors which can account for the variability in the original variables that is associated with these factors (this is in contrast to the principal components method which looks for a set of factors which can account for the total variability in the original variables).

These two methods will tend to give similar results if the variables are quite highly correlated and/or the number of original variables is quite high. Whichever method is used, the resulting factors at this stage will be uncorrelated (Jolliffe, 2014).

Factor rotation: Once the initial factor loadings have been calculated, the factors are rotated. Definitions of factor rotation as applied in principal component analysis and exploratory factor analysis abound in literature. For example, as cited in Brown (2009b), McDonald (1985, p. 40) defines rotation as "performing arithmetic to obtain a new set of factor loadings (v-*f* regression weights) from a given set," and Bryant and Yarnold (1995, p. 132) define it as "a procedure in which the Eigen vectors (factors) are rotated in an attempt to achieve simple structure." Perhaps a bit more helpful is the definition supplied in Vogt (1993, p. 91) that "any of several methods in factor analysis by which the researcher attempts to relate the calculated factors to theoretical entities.

This is done differently depending upon whether the factors are believed to be correlated (oblique) or uncorrelated (orthogonal)." And even more helpful is Yaremko, *et al* (1986), who offers the following explanation of factor rotation: "In factor or principal components analysis, rotation of the factor axes (dimensions) identified in the initial extraction of factors, in order to obtain simple and interpretable factors."

In nutshell, factor rotation is done to find factors that are easier to interpret. If there are 'clusters' (groups) of variables— i.e. subgroups of variables that are strongly inter-related — then the rotation is done to try to make variables within a subgroup score as highly (positively or negatively) as possible on one particular factor while, at the same time, ensuring that the loadings for these variables on the remaining factors are as low as possible. In other words, the object of the rotation is to try to ensure that all variables have high loadings only on one factor (Bruce, 2004).

There are two types of rotation method, orthogonal and oblique rotation. In orthogonal rotation the rotated factors will remain uncorrelated whereas in oblique rotation the resulting factors will be correlated. Simply put, orthogonal rotation methods assume that the factors in the analysis are uncorrelated whereas in contrast, oblique rotation methods assume that the factors are correlated (Brown, 2009a). There are a number of different methods of rotation of each type. Gorsuch (1983, pp. 203-204) lists four different orthogonal methods as equamax, orthomax, quartimax, and varimax. Varimax orthogonal rotation is widely used.

Tabachnick and Fiddell (2007, p. 646) and also cited in Brown (2009b) argue that "Perhaps the best way to decide between orthogonal and oblique rotation is to request oblique rotation [e.g., direct oblimin or promax from SPSS] with the desired number of factors and look at the correlations among factors. If factor correlations are not driven by the data, the solution remains nearly orthogonal. As observed by Brown (2009b; 71) 'the goal of rotation and of choosing a particular type of rotation as seeking something called simple structure, or put another way, one way we know if we have selected an adequate rotation method is if the results achieve simple structure'. As defined by Bryant and Yarnold (1995, p. 132-133) simple structure is 'a condition in which variables load at near 1 (in absolute value) or at near 0 on an eigenvector (factor). Variables that load near 1 are clearly important in the interpretation of the factor, and variables that load near 0 are clearly unimportant. Simple structure thus simplifies the task of interpreting the factors'.

Thurstone (1947) as cited in Brown (2009a) first proposed and argued for five criteria that needed to be met for simple structure to be achieved as:

1. Each variable should produce at least one zero loading on some factor.
2. Each factor should have at least as many zero loadings as there are factors.
3. Each pair of factors should have variables with significant loadings on one and zero loadings on the other.
4. Each pair of factors should have a large proportion of zero loadings on both factors (if there are say four or more factors total).
5. Each pair of factors should have only a few complex variables

Brown (2009a) noted that experts in factor analysis seem to think that an abbreviated version of simple structure is important. There is agreement among experts of factor analysis of the essence of achieving simple factor in identifying and explaining underlying dimensions and structure of concepts being studied. For example, Kline (2002, p. 66) says, "…I am in agreement with Cattell (1978) and all serious workers in factor analysis that the attainment of simple structure is essential to factor analysis. Where this has not been done there is little reason to take the results seriously."

2.1.3 Conceptual Framework

Ajzen (2006) Theory of Planned Behaviour (TPB) was adapted in conceptualizing farmers' perceptions and attitudes towards GM crops and their effects farmers' adoption decision regarding the cultivation of GM crops. Ajzen (2006) posit that peoples' adoption behaviour is determined by their attitudes towards the said behaviour, and that attitude is a product of people perception about the outcome of the behaviour and the subjective norms which may facilitate or impede the adoption of the said behaviour. Figure 2.2 presents adapted schematic flow diagram of TPB used to demonstrate conceptual relationship between variables identified in this study to exert effect on farmers' adoption decision towards GM crops.

As shown in the Figure (Figure 2.2), farmers' attitude towards GM crops which reflects their perceptions about possible outcome of adopting the technology (which is informed by the information and knowledge they have about the GMOs) is conceptualized as exerting influence on farmers' adoption decision. Also individual farmers' perceptions and personal attributes influence their decision to adopt GM crops or otherwise, are subject to societal view about the technology. With regard to perceived behavioural control which is visualized as the beliefs regarding absence or presence of factors that might facilitate or impede the adoption of the technology such as perceptions about benefits or risks associated with GM crops, source of information and knowledge about GMOs and socioeconomic factors of farmers such as age, education and experience in crop production, compatibility, complexity or otherwise and cost involved in adopting the technology, were examined as having influencing on farmers' adoption decision.

Also farmers' perceptions about institutional and regulatory frameworks put in place to guide the effective implementation of the country's agrobiotechnology agenda and their capacity to response and adjust their farming system to suit the requirement for the cultivation of GM crops were conceptualized in this study, in explaining farmers' adoption decision regarding GM crops cultivation. The visual representation of this is shown in the Figure 2.1.

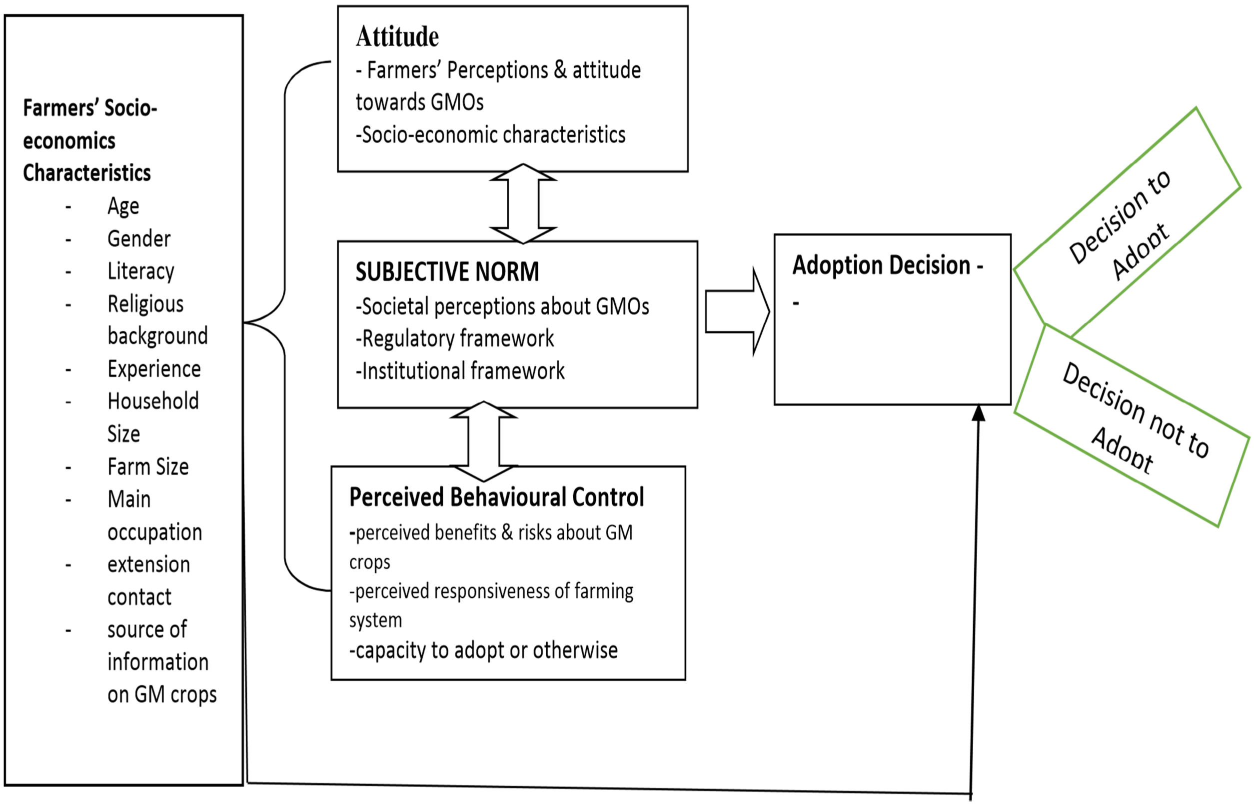

Figure 1.2: Conceptual Framework
Source: Author (Adapted from Ajzen, 2006)

2.2 Historical Perspective of Crop Improvement

Ever since humans settled from their nomadic lifestyle of being hunters, gatherers and scavengers of wild animals and plants some 10, 0000 years ago (Heiser, 1990), to the domestication of these wild animals and plants, there have long been a continue interventions by man to improve on the domesticated plants species and breeds of animals (Prakash, 2001) using the available technology to them. The efforts of man to improve on the domesticated plant species started through a process of gradual selection, where our ancestors selected some plants from the wild plant community and transformed them into cultivated crops (Prakash, 2001; Suslow, Thomas and Bradford, 2002). As observed by Prakash, (2001; PP9) 'some profound alterations in the plant phenotype occurred during such selection, and these include determinate growth habit; elimination of grain shattering; synchronous ripening; shorter maturity; reduction of bitterness and harmful toxins; reduced seed dispersal, sprouting and dormancy; greater productivity, including bigger seed or fruit size; and even an elimination of seeds, such as in banana'.

Murphy (2007) observed that modern plant breeding can be traced back from the earliest experiments at the dawn of the scientific revolution in the seventeenth century to the present day existence of agrobiotechnology. He further argued that historical antecedents of crops improvement and plant breeding should be examined from both scientific and socioeconomic perspective, and the ways in which these factors interact and impact on agricultural development. Scientific discoveries and new understanding of biological process in plants have always provided scientific tools for crop improvement. For instance, scientific studies of genetics which began around 1900 based on the work of Gregor Mendel (Laird and Lange, 2011 and Suslow, 2002) which led to the discovery of genes and their role in hereditary had provided scientific basis for cross breeding as tool for crop improvement. As observed by Acquaah (2007;pp4) that 'the work of Gregor Mendel and the further advances in science that followed his discoveries established that plant characteristics are controlled by hereditary factors or genes that consist of DNA (deoxyribose nucleic acid, the hereditary material)'.

Further understanding of the genes being composed of DNA (deoxyribonucleic acid) bundled together in the form of chromosomes within the nucleus of every living cell of an organism, provided even greater impetus in breeding and crop improvement (Laird and Lange, 2011, and Acquaah, 2007). The knowledge of genetic principles and their application to plant breeding technology has greatly accelerated the rate of improvement of many crop plants. Further advances in science led to other breeding methods such as grafting and tissue culture techniques which has been used in woody tree and vine crops such as citrus, peaches, walnuts, grapes, and ornamental trees. Surgically cutting a scion or bud from one variety and grafting it onto a rootstock from a different genetic variety is commonly used to enhance disease resistance, productivity, and growth habit of tree crops and other perennials (Wongkaew and Fletcher, 2004, Idowu, Ibitoye and Ademoyegun, 2009 and Thomson, et al, 2010). Idowu, *et al*, (2009) asserted that over 100 years ago, Haberlandt envisioned the concept of plant tissue culture and provided the groundwork for the cultivation of plant cells, tissues and organs in culture. Again plant tissue culture provided scientific tool for crop improvement as it serves as a research tool for the study and development of small, isolated cells and segments of plant tissues for propagation.

Further understanding of genes and DNA structure had brought dramatic improvement in the efficiency of plant breeding through marker-assisted breeding and genomics. Through this method, marker-assisted breeding and genomics breeders can select plants with desirable combinations of genes (Thomson *et la*, 2010). A marker is a "genetic tag" that identifies a particular location within a plant's DNA sequences and it enable breeder in transferring a single gene into a new cultivar (Johnson, 2004; Thomson, *et al*, 2010).

Inherent in the efforts of plant breeders have always been to achieve genetic improvement of plant varieties exhibiting desire traits such as high yielding, disease resistant, drought tolerant, improved nutrition among others. Many have argued that the history of crops improvement dates back some 12,000 years when man settled down from nomadic lifestyle and learned to select the best seeds for planting and to domesticate animals (Heiser, 1990; Prakash, 2001; Acquaah, 2007). Through the history of plant improvement, plant breeders have used a wide range of techniques including selection, cross breeding, inter-specific hybridization, polyploidization, embryo rescue, mutagenesis and cell fusion based on the available scientific knowledge (Johnson, 2004; Azadi and Ho 2010; Thomson, et al, 2010).

More recent advancement in the field of molecular biology which have help sheared more light on the nature and structure of DNA and genes - the hereditary unit, have enable plant breeders employed gene transfer or genetic engineering as an additional tool for improving crop varieties for better performance (Thomson, et al, 2010; Fukuda-Parr and Ory, 2012). This new tool of crop improvement through gene transfer in the form of recombinant DNA techniques enables a small piece of highly characterized DNA to be inserted into the genome of a plant species (transformation event), allowing the genetically enhanced plant to acquire a new desired trait (ISAAA, 2006; Acquaah, 2007; Fukuda-Parry et al, 2010; Yang *et al*., 2010).

2.3 Genetic Engineering and Development of GM Crops

Within the last 30 years, the field of genetic engineering has developed rapidly due to the greater understanding of deoxyribonucleic acid (DNA) as the chemical double helix code from which genes are made (Adenle, 2011 and ISAAA, 2006). The term genetic engineering is used to describe the process by which the genetic makeup of an organism can be altered using "recombinant DNA technology" (ISAAA, 2006; PP 1). This involves the use of laboratory tools to insert, alter, or cut out pieces of DNA that contain one or more genes of interest. Genetic engineering or modification is the tool for developing GM crops, which is also referred to as transgenic or biotech crops, through the process of genetic modification by which selected individual genes are inserted from one organism into another to enhance desirable characteristics ('traits') or to suppress undesirable ones (Fukuda-Parr *et al*, 2012).

Genetic engineering had been noted to provide precise and fast way of achieving development of desire traits and suppression of undesired traits on crops as way of improving crop varieties for increase productivity, nutrition and easiness of production. In contrast to conventional plant breeding methods which take years to develop or supress traits by selection, genetic modification techniques allow breeders to manipulate genetic material with precision, efficient and relatively faster leading to the development of crops with the desire traits and eliminating the undesired characteristics (ibid). The most commercialised varieties of GM crops released for production carries traits such as herbicide resistant (Round-up Ready (RR)) and insect resistant Bt crops and few crops such as golden rice fortified for improved nutrition (Adenle, 2011; Brookes, et al, 2012; Fukuda-Parr et al, 2012; James, 2013; ISAAA, 2013). RR soybean cultivar is the most widely cultivated transgenic crops grown, especially in the United States. In 2012, about 93% (28.6 million ha) of the total US soybean crop was planted to genetically modified herbicide tolerance cultivars (Brookes, 2012).

GM crops which carry RR traits have gene inserted in them which make them resistant to glyphosate, the active ingredient in broad spectrum herbicide such as round-up weedicides. Whiles Bt GM crops are genetically engineered crops through insertion of some genes of toxin producing soil bacteria called Bacillus thuringiensis (Bt) to enable them produce protein toxic to certain caterpillar pests common to cotton, cowpea and maize. While Bt cowpea is genetically modified to be resistant to the Maruca pod borer, an insect pest that destroys the conventional type of cowpea, thereby reducing yield and causing substantial loss on investment made by farmers (Ashitey, 2013). That of Bt cotton is genetic modified through insertion of genes from Bacillus thuringiensis (Bt) that encode and promote the production within the plant of proteins toxic to certain caterpillar pests common to cotton (Perlak et al., 1990).

The development of GM crops requires huge investment in research infrastructure, technological expertise, institutional and legal regulatory frameworks and such require government and public policy choices to guide its successful implementation. Fukuda-Parr *et al*. (2012) identified three critical stages that development of GM seeds go through before it is released for commercial production, each of which demand certain institutional and legal frameworks and some level of investment and expertise to ensure successful application. They noted that the first step is 'laboratory research', which requires expertise in biotechnology to conduct scientific experiments to modify genes to create an 'event'. Successful event is a scientific innovation that is patented by the innovator. The second stage of GM seed development is the agronomic adaptive field trials to adapting plant varieties to specific locations. At this stage agronomy expertise, legal and institutional frameworks require to ensure safety contained release into the environment. A successful adaptive trial results in transgenic seed innovation which is then patented after going through biosafety certification process which require biosafety regulatory institutions and regulatory legal regimes to facilitate process of testing for environmental and health safety of the new varieties. The final stage involves seed multiplication and commercialization, which is necessary to take seeds to market and to farmers.

Even though genetic engineering research have been conducted on large varieties of crops and traits for the development of transgenic crops for over three decades now, since 1980s, only few of these crop varieties have been released and placed on the market. Notable among the transgenic crops which have been released for commercial production so far included soy, cotton, maize and canola carrying traits such as herbicide resistant (RR soy, RR canola) and insect resistant (IR) genes (Bt cotton, Bt maize) (Adenle, 2011; Brookes, *et al*, 2012; Fukuda-Parr, et al, 2012) .

At the front of commercial production and marketing of GM seeds, since its commercialization in the 1996, are few multinational notable Monsanto, although there is overwhelming public involvement in biotechnology research in many nations with academics and government researchers carrying out both pure and applied research in biotechnology (Adenle, 2011; Fukuda-Parr, et al, 2012). However, National Agricultural Research Systems (NARS) of China, Brazil and India is making progress in their respective national biotechnology agenda and some international and regional agricultural research organizations such as International Institute for Tropical Agriculture (IITA), African Agricultural Technology Foundation (AATF) and the Forum for Agricultural Research in Africa (FARA) are providing supports for biotechnology research and development (FARA, 2007; Adenle, 2011; Fukuda-Parr et al, 2012).

2. 3.1 On-going Debate on GMOs Technology

Arguable, in the history of crop improvement, the introduction of GM crops through genetic engineering had been the most controversial plant breeding techniques in the recent history of agricultural research and development. The underlying constructs surrounding the narratives of the on-going debate on GM crops are largely issues relating to potential risks and uncertainty that the cultivation and consumption of GM crops might pose to human and animal health, and the possible negative consequences it might pose to the environment and biodiversity (ISAAA, 2013; Mannion and Morse, 2012; James, 2012; Zobiole *et al*, 2011; Binimelis, Pengue & Monterroso, 2009 and Shiva, 2006). Other issues often raised in the debate include arguments regarding threats to national food sovereignty and political economy (Azadi et al, 2010 and Fukuda-Parr et al, 2012) and the possible distortion of international trade regulations due to lack of harmonization of domestic standards and regulations regarding exports and imports of agricultural commodities containing GMOs (Bhuiya, 2012; Fukuda-Parr et al, 2012; Shiva, 2006 and McDonald, 2003).

These concerns about the development of GM crop varieties have raised a wide range of new legal, ethical and economic questions in agriculture. As a result, there is a growing body of literature highlighting the positive socio-economic and environmental impacts of GM while others raising issues with possible negative consequences on socio-economic impacts as well as health and environmental risks and uncertainties (Shiva, 2006; Pengue and Monterroso, 2009; Kremer and Means, 2009 and Zobiole et al, 2011James, 2012; Mannion and Morse, 2012 and ISAAA, 2013).

2.3.1.1 The Debate on Environmental and Health Risks

The most hotly debated issues about GMOs, perhaps is issues relating to the safety of GM crops and food to human and animal health and its potential negative effects on the environment and biodiversity. The thumb card of anti-GMO advocates is the argument that genetic modification which allows the introduction of new gene into plant may pose potential health risks such as allergic reactions, carcinogenic among others (Qaim, 2015 and Smith, 2007). Other concern raised is the possible direct and indirect effects of toxic transgenes from Bt (Bacillus thuringiensis) crops such as Bt maize escaping digestion and harming animals and human health when consumed (Lu, 2008).

Other concerns are that in genetic modification, the intended gene is incorporated into the genome of a crop using vector containing several other genes, including those of non-plant organisms which might carry potential harmful substances that may have negative impacts on human health (Kariyawasam, 2010 and Whitman, 2000). And that genetically engineered foods may also carry an antibiotic-resistant gene. Because, as often argued, that some of the antibiotics used for transferring genes are still used to treat human illnesses, and there is concern that resistant to the antibiotics could be transferred to humans and animals through food and feed products (Beever and Kemp 2000 and Clark, Stokes and Mugabe, 2002).

Anti-GM advocates often maintain that, since there is severe lack of independent scientific studies on the safety of GM crops for animals or humans, it consumption should not be rushed into the food chain (Domingo, 2007; Vain, 2007 and Brown, 2003). They often explained that since the complex functions and interactions of genes are not yet fully understood, there is legitimate fear that introducing new gene might possible cause the emergence of toxic substance and pose health risks to human and animals (Qaim, 2015 and Green, 2011). As such, anti-GM advocates continuing to press the caution button arguing that there has not been enough time to be able to tell whether GM crops do not have negative impacts on human and animal health and therefore rushing it into human food chain is not a wise decision (Greenpeace, 2011).

Environmental and ecological biodiversity concerns related to release of GM crops to the environment have received considerable research attention leading to the availability of ample empirical information on the impact of transgenes on the environment and biodiversity. The argument regarding possible consequences of toxin transgenes affecting non-target and beneficiaries organisms causing ecological imbalances by influencing population levels of competitors, preys, hosts, symbionts, predators, parasites, and pathogens (Zobiole et al, 2011; Kremer and Means, 2009; Binimelis and Monterroso, 2009 and Oliveira et al., 2007) are often trumpeted by anti-GM advocates. Also concerns of interaction of GM crops with its wild relatives and possibility of gene flow causing possible evolution of glyphosate resistance leading to the emergence of supperweeds and superbugs and thereby creating competitive weed to Roundup Ready GM crops (Lang and Otto, 2010 and Zobiole et al, 2011) are also often been raised and cited as a reason why GM crops should be rejected. Such possible gene flow and interaction of transgenes with wild relatives of other species is argued to pose negative consequence to biodiversity and ecosystem functions (Oliveira et al., 2007; Icoz, and Stotzky, 2008 and Rosi-Marshall et al, 2010).

There is also concern of target organisms developing resistant to toxin produced from Bt crops (Dalecky et al., 2007; Li et al., 2007 and Wu, 2007). Such development will pose high economic risks to farmers and biotech companies since their investment in producing these Bt crops will not serves the purpose it was developed for (Lu, 2008; Lang and Otto and Rosi-Marshall et al, 2010). Similarly, it is often argued that widespread spraying of crop fields rather than just spraying harmful weeds have a tendency of leading to development of weed species with herbicide resistant traits (Greenpeace, 2011 and Shiva, 2006). Shiva (2006) stressed that the unknown transgenic biochemical process will have a longer term consequences on the ecosystem, arguing that the introduction of transgenic products would shape the ecological landscape and lead to loss of biodiversity. One other concern often raised against Roundup Ready (RR) biotech crops is the controversy around the propensity of creating dependence on herbicide and eroding the economic benefits smallholder farmers might drive by cultivating GM crops because of the additional cost of herbicide (Fukuda-Parr, 2012).

Despite all these arguments and concerns of possible environmental and health risks associated with GM crops, empirical evidence so far on environmental and health risks assessment reports on GM crops, found no serious environmental or health risks attributable to the cultivation and consumption of GM crops (Qaim, 2015; Gilbert, 2013; James, 2011; Bakshi, 2003; FAO, 2004 and King, 2003). Fukuda-Parr et al, (2012) cited a comprehensive review of scientific evidence of environmental and health risks associated with transgenic crops, undertaken by FAO (2004) which concluded that, the GM crops that have been approved for commercialization do not have any known health and environmental risks.

Also Nicolia et al., (2014) observed that, since its commercialization in 1996 to recent times, there have been no confirmed incidents in which GM crops approved and released for the market have caused direct harm to the environment or to human health. On the contrarily, proponents of GM crops argued that the evidence so far suggests that crops approved and released in the market have contributed significantly to agricultural productivity gains and environmental benefits (Klumper and Qaim, 2014; Finger et al, 2011; Carpenter 2010 and Qaim, 2009). For instance, Bt maize and cotton have positive environmental impacts as they cut down the use of toxic pesticides by reducing pesticide applications.

2.3.1.2 Analysis of Health and Environmental Risks Debate

In order to analyse the debate on possible health and environmental risks associated with the cultivation and consumption of GM crops, this review adopted the recommendations of European Union Academies Science Advisory Council (EASAC) policy report on GM crops (EASAC, 2013). The policy report observed that the GM debate had suffered from several conceptual problems and lack of standardization in interpreting impact assessment results. The first problem, as pointed out in the EASCA (2013), is the issue of isolating effects caused by GM crops from the effects caused by general agricultural practice. Because, as a matter of fact, every agricultural practice causes certain changes to the environment, such as deforestation, land degradation, polluting of water bodies from agrochemical residues among others. Qaim, (2015) also bemoaned the lack of clarity associated with the GM debate as it has to do with uncertainty regarding occurrence, timing, attribution and isolated effects, magnitude and significant levels of adverse effects specifically caused by GMOs.

Therefore to ensure scientific basis for comparison, is to be able to isolate the actual effects as a results of gene modification from the general effect of agricultural production practices. For instance, initial reports attributed the erosion of glyphosate efficacy to emergence of supperweeds due to gene flow from herbicide tolerant - RR GM crops (Lang and Otto, 2010 and Zobiole et al, 2011) which were later found to be caused by poor agronomic practices. Similarly, Helander, et al, (2012) found that erosion of glyphosate efficacy was caused by poor crop management procedures, not GM-specific technology as it was initially thought of.

Also, the argument that transgenes toxins from Bt trait GM crops might cause ecological imbalances by influencing population levels of competitors, preys, hosts, symbionts, predators, parasites, and pathogens (Binimelis, Pengue & Monterroso, 2009; Kremer and Means, 2009 and Zobiole et al, 2011) can also be argued with regard to conventional agriculture in which pesticide are widely used and cannot entirely be blamed on GM specific technology.

The effects of GM crops on human health have been of major concern in public debates, even though the crops are subjected to far greater levels of scrutiny than foods produced by more traditional plant-breeding techniques (Malarkey, 2003). And if there were to be any trace of possible harmful effects it would have been known from the many impact and risk assessments studies. The lack of methodological clarity and certainty in alarming studies linking the consumption of GM food to health risks and harmful effects is not helping the cause of scientific consensus needed to ensure public safety and good GMOs governance. For instance, refuting the alarming study by Séralini et al. (2012) which claimed that rats fed with GM maize are more likely to develop more and more serious tumours in live than those fed with conventional maize, Mampuys and Brom (2015) indicated that results of many reviews of Séralini and his team work by many national authorities and scientific bodies concluded that the study contained methodological shortcomings and that the conclusions could not be justified. Although the study was dismissed as unsound and incorrect by scientific advisory bodies and national authorities (Mampuys and Brom, 2015), many anti-GMOs advocates continue to cite Séralini *et al*. (2012) conclusion as a basis for their claim that GM crops are not safe for human consumption.

The second concern of EASAC (2013) is the apparent lack of definition of 'harm' and the lack of consensus on what constitute a tolerable level of harm to the environment. As observed by Bovenkerk (2012), that the GM debate is characterized by multi-level disagreements about definitional, factual, scientific, interest-based, value-based, moral and metaphysical aspects. The debate on safety of GM crops had been over hyped and sometimes misleading and complicated by the lack of clear definition on how to assign a value to the effects of GM crops in the context of current 'acceptable' environmental effects cause by the practice of conventional agriculture (EASAC, 2013 and Qaim, 2015). As argued by Prakash (2001) there is no such thing as safe food, and there have never been. This is not to suggest that all foods are dangerous, but only to acknowledge the fact that traces of some levels of such contaminants as toxins and carcinogens are present in everything we eat'. The efforts of proponents and opponents of GM crops will be very useful to consumers and the general public, if it is concentrated on whether the risks associated with GM crops and their derivatives are beyond 'tolerance' level to necessitate banning them altogether, or they fall within the substantial equivalence level as that of conventional crops and can be managed (Qaim, 2015 EASAC, 2013 and Fukuda-Parr et al, 2012).

The interpretation of GM crops impact assessment results is often being challenged by knowledge gaps about the natural variation occurring in any biological system and non-comparison with 'conventional' agricultural practices that cause 'acceptable' environmental effects (EASAC, 2013 and Sanvido et al, 2012). As observed by Sanvido et al, (2012), agricultural practices in general cause some level of harm to the environment, as such to define what constitutes a 'harmful' effect it requires the characterisation of the environmental protection goals and limits, which determine those environmental values which should not be harmed by GM crop cultivation or any other agricultural practice. Without this basis, any impact assessment data that report any change in any measurement are open to varied interpretation and cannot form a sound basis for drawing valid conclusion on the safety of GM crops.

It therefore be argued that the controversy over safety of GM crops should not be merely over the existence or otherwise of environmental and health risks, because every agricultural practice and product have some level of impact on the environment and some level of risks to human health in one way or the other. Public interest and policy will be better served if there is standardization regarding what constitute tolerable level of harm to the environment and acceptable safety limit in interpreting impact assessment results of GMOs.

The third conceptual issue as pointed out by EASAC (2013) is that GM crops need to be incorporated with other technologies or practices in sustainable management systems, because technology does not operate in isolation. They argued that transgenic crop improvement technology do not negate the necessity for good agricultural practices but have to be incorporated in integrated management practices such as integrated pest management and Integrated Weed Management programmes. Like any other technology, when applied wrongly or abused GM crops can result in adverse environmental and agricultural impacts.

It is therefore necessary that the emphasis of current debate should be focused on formulating appropriate scientific and agricultural policies required to ensure that the potential value of GM technology is safely harnessed for increase agricultural productivity in particular and the general well-being of the global population as a whole without jeopardising human health and the environment (EASAC, 2013). As such going forward emphasis on discussions on GM crops should not merely be whether GM crops pose some risks to human health and environment, but rather focus on formulating scientific and agricultural policies required to ensure that the potential value of GM technology is safely harnessed for increase agricultural productivity while ensuring its negative consequence is curtail through institutional and regulatory frameworks. Also strengthening risk assessment regimes and early warning mechanisms in the production, safe handling, transfer and consumption of GM products is critical in gaining public trust and confidence on GMOs regulatory frameworks and standards.

2.3.1.3 Argument of National Food Sovereignty

Grave concerns of anti-GM activists, especially in developing countries, is the fear of multinational corporate control of local agricultural production and food supply through the arrangement of seed patents associated with commercialization of transgenic crops. As observed by Katiraee (2014) that the common criticism of genetically modified foods is that their seeds are patented to developers who are mostly profit motivated multinational corporations. However, there have been varying aspects to this concern. While some argued that there should be no patents of any kind on seeds, others are of the view that farmers should not be forced to repurchase seeds and patents right should not be extended to cross pollinated seeds in nearby farms.

As such, it often been argued that the existence of Intellectual Property Rights (IPRs) in the commercialization of GM seeds is limiting smallholder farmers access to the existing agrobiotechnology which could have help improve rural agricultural productivity and reduce poverty. As observed by Karapinar and Temmerman (2007) that, the accessibility of the existing biotech technologies to small farms is arguably impeded by the IPRs leading to monopoly prices and hindering technology diffusion.

The nature of patents regimes associated with commercialization of GM crops is often fuelling fears that biotechnology industry which is dominated by large multinational corporations (MNCs), such as Monsanto, Syngenta, and DuPont will eventually take over the seed market to the detriment of national food sovereignty with its negative consequence on resource poor smallholder farmers and the attainment of food security in developing countries (Fukuda-Parr et al, 2012 and ETC Group, 2010). Many anti-GM activists have vehemently argued against the patents regimes governing GM seeds, describing it as an attempt to control global food production by few corporations with the tendency of creating a situation where resource poor farmers will have to perpetually depend on biotech companies for their seeds. Such, a situation, they claimed will further worsen the poverty level of smallholder farmers and food insecurity situation of developing countries (Specter, 2014 and Shiva, 2006).

Similarly, Bhuiya (2012) noted that, the advent of GM crops may shift local control and farming system to corporate control and thereby making global food production subject to international politics and geopolitical manipulation. There is the fear that seeds local farmers have been using over the years will give way to genetically modified seeds and then becomes the property of biotech corporate multinationals by patents. Such control, anti-GM advocates warned, will eventually alters farmers' ownership and control over seeds generation and use and thereby leading to the enslavement of local farmers to multinational biotech companies (Specter, 2014; Bhuiya, 2012 and Shiva, 2006). Traditionally, farmers select part of their harvest and store them as seed for the next season, and practice plant improvement by selecting and exchanging seeds with one another (Fukuda-Parr et al, 2012) and this give them ownership right over their seeds and as such put them in charge of growing their own food.

The possible shift in locally controlled farming system and food production to multinational corporate controlled in the cultivation of GM crops, is being argued in the wider scope of political economy with conspiracy theory of geopolitical manipulation of national food sovereignty. The conspiracy is that farmers in developing countries are likely to lose autonomy in their staple food production to profit driven biotech companies. Which eventually will torpedo locally control over food production and supply and thereby giving biotech multinational companies totally dominance in food production through seed supply and this can be used as tool to manipulate global politics (ETC, 2005; Shiva, 2006 and Bhuiya, 2012).

The fact that GM seeds come at a high cost due to westernized intellectual property regulations coupled with the poor biotechnology research capacity of developing countries is likely to help create condition for corporate control over biotechnology seeds generation and marketing. It is noted, that such situation if allowed to occur, will ultimately hinder any sustainable advancement towards food security for under-resourced farmers and consumers (ETC Group, 2009; Fukuda-Parry *et al*, 2012). There is a common saying that ‘he who controls the seed controls the food supply; and he who controls the food supply controls the world. This therefore lends some credence to the fears that, if GMO technology succeed in creating total dominance situation where 100% of all commercial seeds are genetically modified and patented then the whole global food supply can be manipulated and will then become an international political tools in the hands of western’s biotechnology companies (Greenpeace, 2011 and Shiva 2006). The increasing dominance of few multinationals in the seed market necessitated by the widespread commercialization of GM seed is destroying competiveness in seed supply with its negative consequences on resource-poor farmers and national food sovereignty (Shiva, 2006 and Bhuiya, 2012).

Howard (2009), asserted that in a situation in which only four biotech firms control about 40% of the seed market, then the seed market cannot longer be competitive. Roseboro (2013) indicated that four big biotech seed companies namely Monsanto, DuPont/Pioneer Hi-Bred, Syngenta, and Dow AgroSciences, popularly referred to as the ‘big four’ own 80% of the US corn market and 70% of the soybean seed market business. Recent media reports of mega merger among these companies

(Sullivan, 2017) further lends credence to the fear of monopolistic corporate control of the seed market with its consequences of national food sovereignty. This raises legitimate concern of corporate takeover of the global seed market. It can therefore be argued that the seed market cannot longer be expected to be competitive and can only be described as cartel monopoly, as the four companies can gang up to control price to the detriment of farmers and consumers.

Report of ETC group (2008) revealed that, in three decades ago, there were thousands of seed companies and public breeding institutions controlling global seed market, which have now reduced to just ten companies which control more than two-thirds of global proprietary seed sales. The report further observed that from dozens of pesticide companies three decades ago, ten now control almost 90% of agrochemical sales worldwide. From almost a thousand biotech start-ups 15 years ago, ten companies now have three-quarters of industry revenue. And, six of the leaders in seeds are also six of the leaders in pesticides and biotech. Over the past three decades, a handful of companies have gained control of one-quarter of the world’s annual biomass (crops, livestock, fisheries, etc.) that has been integrated into the world market economy (ETC, 2008). This trend bears amply evidence to a looming danger of corporate control of seed supply and global food production with consequence on national food sovereignty.

However, these fears and conspiracy theories have adequately been responded to by proponents of GM technology. For instance, Katiraee (2014) drew the attention of anti-GM activist to the fact that seeds from genetically modified crops are not the only ones that are patented. He observed that there are many conventionally bred crops that are patented under the US Patents and Trademark Office, as well as decorative plants and flowers. The argument against GMOs patents legislative regime might be appealing to sceptics, but it failed to acknowledge and provide alternatives for funding the huge investment require in breeding GM seed for farmers and consumers to benefit.

2.3.1.4 Analysis of the threat to food sovereignty argument

Considering the time, money and effort that it takes to create a plant through either genetic modification or the conventional breeding methods with the desire traits and qualities, it makes sense for private developers to protect their investment through patents regulatory legal regime. For instance, a survey of six companies on the cost of GM crop traits revealed that the mean cost associated with the discovery, development and authorisation of a new biotechnology derived crop trait introduced in the 2008-2012 timeframe is $136 million (McDougall, 2011). In addition, the study further revealed that the discovery accounted for an estimated 22.8% and 23% of total cost and time involved respectively. While regulatory science, registration and regulatory affairs being the longest single phase in product development and is estimated to account for 25.8% and 36.7% of total cost and time involved respectively (ibid).

Such heavy investment needs to be paid for and safeguarded so as to attract and assure private investors who are willing to invest in crop improvement and seed marketing. Patents regimes and institutional frameworks put in place to ensure the protection of investment of biotech companies and to motivate private investment in biotechnology research, had been lauded as the most robust and reliable arrangement in securing investment in biotechnology research whiles ensuring the development of crops with the desire traits for sustainable agricultural development. These patents are protected through the World Trade Organization (article 27) and the International Union for the Protection of New Varieties of Plants (also known as UPOV) which member nations are expected to rectify and implement through the enactment of specific domestic laws and legislations (Katiraee, 2014).

Therefore, the debate on whether or not these patents should exist in the first place is outside the scope of the GMO discussion and should be directed towards how best to attract and safeguard the huge investment require in producing successful GM seed. Public investment into research and development is purely public policy decision and priority of national governments. If national public investment into research in agrobiotechnology can provide for the require investment, expertise and capacity needed to develop GM crops then the issue of corporate takeover of national food sovereignty will not arise.

If national governments are committed to investing public resources on agrobiotechnology research as it is done in China and India (Fukuda-Parry et al, 2012), then the fear of corporate dominance and possible control of global food production will not arise. As Paarlberg (2008) queried 'Why do public sector research institutions, especially in developing countries, not invest in biotechnology research? Is it lack of capacity – do only corporations have biotechnology capacity? Or lack of finance – do only corporations have the finance? Or is it due to political pressure from anti-GM movements. As such the debate on GM crops within the context of political economy regarding control on biotechnology research and seed market, should rather focus on discussions on choices of national government in biotechnology research capacity and investment and their regulatory and legal regimes regarding patents of genetically modified seeds.

Also Public Private Partnerships (PPP), between national governments and biotech industries have been noted as an effective way of improving access to biotechnology research for the improvement of staple food crops varieties for smallholder farmers in developing countries, especially Africa. As asserted by Chambers, *et al* (2014) that in recent times PPPs had become increasingly prevalent in many African countries with the goal of ensuring that private research on GM crops is combined with local knowledge of varieties and cropping conditions that resides in public research organizations in order to develop GM crops suitable to Africa conditions. There are several successful examples of public-private partnerships which have facilitated access to biotechnology and development of improved crop varieties for developing countries. For instance, the transferred of golden rice, which is genetically modified to produce β-carotene the precursor to vitamin A, to developing countries particularly Philippines, India, China, Vietnam and Indonesia under PPPs is a clear demonstration of the effectiveness of PPP arrangement in improving smallholders farmers access to GM technology (Kryder et al, 2000).

The International Service for the Acquisition of Agri-Biotech Applications (ISAAA) has been facilitating PPPs at the international level. Through its regional operations in Africa, Asia and Latin America, ISAAA have been acting as an intermediary between developed country companies and public institutions in developing countries (Karapinar and Temmerman, 2007 and Kameri-Mbote, et al., 2001). Also, the Consultative Group on International Agricultural Research (CGIAR) had helped brokered partnership with a Japanese private company in producing the first Bt cassava variety developed in Africa (Rausser, et al., 2000). In Africa, Monsanto and the Kenyan Agricultural Research Institute (KARI) established a partnership based on the agreement that Monsanto would provide a royalty-free non-exclusive license to KARI for virus-resistant technologies in sweet potato; in return, KARI would undertake the marketing of the technology in Africa (Rausser, et al., 2000).

2.4 The Benefits of GM crops

The controversy over safety of GM crops and food appeared to be lingering on despite growing consensus based on results of scientific impact assessments revealing no evidence of negative effects on human health, the environment and biodiversity regarding the approval of GM crops for the market. As observed by Paarlberg (2010) there is a scientific consensus, even in Europe, that the

GMO foods and crops currently on the market have brought no scientific validated new harmful effects or risks either to human health or to the environment.

On the contrarily, since the first commercialisation of genetically modified crops in 1996, cultivation of GM crops have spread rapidly around the world. In 2014, a record of 181.5 million hectares of biotech crops were grown globally (James, 2014) registering an increase of more than six million hectares from 175 million in 2013 (James, 2013). The wide spread cultivation of GM crops have brought impressive socio-economic and environmental benefits to the 28 countries in which over 17 million farmers are engage in its cultivation. Thus within the second decade of its commercialization, global hectares of biotech crops have increased more than 100-folds soaring from 1.7 million hectares in 1996 to over 181 million hectares in 2014, making GM crops the fastest adopted crop technology in contemporary agricultural innovation adoption process.

This high rate of adoption is a strong vote of confidence in biotech crops, reflecting farmer satisfaction in both industrial and developing countries. James, (2011) indicated that around 15 million farmers in 29 countries grew biotech crops in 2010 and derived multiple benefits that included significant agronomic, environmental, health, social and economic advantages. The reasons for farmers choosing biotech crops included higher productivity, such as yield increases of up to 30% on the same amount of land, and extra income (European Association for Bioindustries, 2011; James, 2011; James, 2013). Significant environmental benefits such as reduced pesticide application and reduced CO_2 emissions, and decreased soil erosion through the adoption of zero-till practices have also been recorded in the adoption of biotech crops (European Association of Bioindustries, 2011).

2.4.1 Increase Farm Productivity and Income

Evidence available demonstrates significant role of GM crops in global food production, farm productivity, increasing farm income and poverty reduction among the world's small and resource-poor farmers (James, 2010 and Brookes *et al*, 2011). Findings from independent research into the economic impacts of GM crops cultivation, demonstrates clear benefits to farmers regarding farm level income as a results of increase yield and reduce farm cost through reduction in chemical usage and effective weed control.

The net global economic benefits at the farm level added by cultivating GM crops rather than conventional varieties have been estimated at $10.8 billion in 2009 (EAB, 2011). The positive significant impact of GM technology on farm income derived from a combination of enhanced productivity and efficiency herbicide and insecticide usage continue to be realised by millions of farmers who have adopted it cultivation. Compare with an estimated $10.8 billion in 2009 (European Association of Bioindustries, 2011) in 2012, the direct global farm income accrued from GM crops cultivation was estimated as $18.8 billion (Brookes and Barfoot, 2012; James, 2013). This is equivalent to having added 5.6% to the value of global production of the four main crops of soybeans, maize, canola and cotton (Brookes, *et al,* 2012).

Within the last five years, developing countries have planted more biotech crops than the industrial countries. Figures from International Service for the Acquisition of Agri-biotechnology Applications (ISAAA, 2016) indicate that in 2016, 19 developing countries planted 54% (99.6 million hectares) of the global biotech hectares, while 7 industrial countries took the remaining 46% (85.5 million hectares) share. This trend is expected to continue in the upcoming years due to the increasing number of countries in the southern hemisphere adopting biotech crops and the commercialization of new biotech crops such as rice and Bt cotton which is mostly grown in developing countries

(Brookes and Barfoot, 2017 and ISAAA, 2016). Similarly James (2014) observed that smallholder farmers adoption of GM crops in developing countries continue to grow at impressive rate year after year with a potential of not only improving farm income but reducing food insecurity among rural communities.

Recent studies by Brookes and Barfoot (2017) in their annual updated analysis shows that there continues to be very significant net economic benefits at the farm level amounting to $15.4 billion in 2015 and $167.8 billion for the 20 year period 1996–2015 (in nominal terms). Over half (51%) of these gains have accrued to farmers in developing countries. About 72% of the gains have derived from yield and production gains with the remaining 28% coming from cost savings. The technology has also made important contributions to increasing global production levels of the 4 main crops, having, for example, added 180 million tonnes and 358 million tonnes respectively, to the global production of soybeans and maize since the introduction of the technology in the mid-1990s.

The use of crop biotechnology, by 18 million farmers in 2015, has delivered important farm income benefits over the 20-year period to 2015. The GM IR traits have mostly delivered higher incomes through improved yields in all countries (Brookes and Barfoot, 2017).

2.4.2. Improvement in Food and Nutritional Security

GM crop technology has and continues to play a critical role in meeting the food security requirement for ever increasing global population. The world's population continues to increase putting pressure on agricultural resources needed to produce food and fibre for the growing global demand. However, the growing global demand for food and fibre can only be met either through commensurate increase in acreage under cultivation or increase agricultural productivity through technology application (Lamichhane, 2014). Higher productivity rates translate into higher food security in a world with continuing population growth and limited arable land. The additional production arising from GM crops between 1996 and 2007 has contributed enough energy (in kcal terms) to feed about 402 million people for one year, with additional production in 2007 alone contributing enough food to feed 88 million (Brookes and Barfoot 2009).

Fukuda-Parr *et al*. (2012) asserted that, the question 'can GM crops help improve food security, especially in Africa?' can be adequately addressed by examining two sets of issues. The first is whether the new varieties are beneficial to small scale farmers? This can be answered by reviewing micro-impact studies and short term analysis of farm incomes and productivity among the smallholder farmers who have adopted the cultivation of these crops.

There is a large body of peer-reviewed literature indicating higher economic returns of GM crops to small scale farmers (Paarlberg, 2008; Paarlberg, 2010; James, 2011; Brookes, and Barfoot, 2011 and James, 2013). This demonstrates that small scale farmers are equally benefiting economically from GM crops just as large small scale commercial farmers. The other concern is research and development focus and agenda. If GM crops are to meet the food security needs of Africa, then priorities of the transgenic crop technology must focus on improving the productivity and nutritional status of staples such as maize, sorghum, cassava among others. The food insecure households are subsistence farmers who are producing in risk prone environments at low productivity levels (Fukuda-Parr, et al, 2012).

Therefore for transgenic crops to have positive impact on the food security situation of these poor farming households and the citizens of developing countries in general, then biotechnology research should focus on developing the local staples food crops by enhancing their performance in terms of yield and resistance to drought, pest and diseases. Also food fortification through improving the nutritional status of staple grains like the case of golden rice will go along to help solve the problem of malnutrition in developing countries.

According to International Union of Nutrition Science (IUNS, 2012) whiles most consumers in high income developed nations have access to a relatively inexpensive supply of safe and healthy food, more than one-third of those from low income developing countries are faced with widespread food insecurity and malnutrition. It has been noted that the sustainable solution to food insecurity and malnutrition in developing countries is provision of a sufficient quantity of high quality diet. Genetic modification technology through the process of biofortification provides a low-cost strategy for improving nutritional and quality traits of staple foods in developing countries (Fukuda-Parr et al, 2012; IUNS, 2012).

2.5 Global Production of GM Crops

Notwithstanding the raging debate about biotech crops, since its commercial released in 1996, the area planted with genetically modified crops, at the global scale, continue to increase substantially over the past decade with annual growth rate of 8% spreading to over 20 countries majority of which are developing countries (James, 2011; Fukuda-Parry *et al*, 2012; James, 2013; James, 2014). Genetic engineering as a tool for crop improvement is wide spread in many countries although in some countries its application is at various stages of development. In the current global production level, US, Brazil, Argentina, India, Canada, and China are the leading producers, cultivating about 160.8 million hectares, representing almost 92% of the 175.2 million hectares of biotech crops cultivated globally in 2013(James, 2013).

In 2014 statistics from the International Service for the Acquisition of Agrobiotechnology Application (ISAAA), indicates that, the global hectares of biotech crops have increased more than

100-folds, from 1996 to 2014. Within this period GM crops production increased from 1.7 million hectares in 1996 to over 181 million hectares in 2014, making GM crops the fastest adopted crop technology in contemporary agricultural innovation adoption history (James, 2013; James, 2014). By the closed of 2014, a record of 181.5 million hectares of biotech crops were grown globally, increasing from 175.2 million hectares in 2013 to 181.5 hectares in 2014, at an annual growth rate of 3.5 % (James, 2013; James, 2014).

In terms of national statistics, the US, still maintain the lead role in the cultivation of GM crops. For the second consecutive years, developing countries planted more biotech crops than industrial countries in 2013. With 18 million farmers cultivating biotech crops, about 90% were small resource-poor farmers (James, 2012 and James, 2013). The five leading biotech crop growing developing countries in 2013 were Brazil, Argentina, India, China and South Africa accounting for 47% of global biotech crops grown in 2013 (James, 2013).

Very recent global production figures published by ISAAA indicates that up to 18 million farmers in 26 countries planted 185.1 million hectares (457.4 million acres) of GM crops in 2016, an increase of 3% or 5.4 million hectares (13.1 million acres) from 2015. Of the total number of 26 countries planting GM crops in 2016, 19 were developing countries and 7 industrial countries (ISAAA, 2016). Millions of farmers who have adopted the cultivation of GM crops worldwide are repeating its planting, demonstrating farmers' confidence in the technology. As observed by Fukuda-Parr *et al*, (2012) that both large and small scale farmers are convinced by the high returns from GM crops and are determine to continue its cultivation with virtually 100% repeat planting which is an acid-test for judging the performance and farmers' acceptance of any technology. The leading world producers of GM crops are the United States (US) and Brazil, followed by Argentina, India, Canada, and China as observed by ISAAA (2016).

Among Africa countries, South Africa and Burkina Faso are the leading GM crop producing nations. In 2013, South Africa cultivated 2.9 million hectares mostly Maize, soybean and cotton followed by Burkina Faso which cultivated half a million hectare of Bt cotton (James, 2013). The Asian continent, dominant developing countries who have adopted full commercialization of GM crops with China and India being the most advanced and dominant GM crop producers in the content. Of the global total area of 148 million hectares planted in 2010, China (3.5 million hectares) and India (9.4 million hectares) planted a combined total area of 12.9 million hectares mostly Bt cotton. Also in 2013 India cultivated 11 million hectares of Bt cotton with a growth rate of 17% over the 2010 hectare, while China cultivated a total of 4.2 million hectare of Bt cotton, papaya, poplar, tomato and sweet pepper registering a growth rate of 20% over the 2010 hectares (Adenle, 2011 and James, 2013).

2.6 Biosafety Regulatory frameworks

In the midst of on-going debate and in response to safety concerns regarding potential effects of biotechnology on human health, environment, socio-economic and market considerations, measures have been put in place to ensure the safe application of GMOs. Also because of the heavy investment associated with the development of agrobiotechnology products, there have evolved over the years regulatory frameworks to guide the development, transfer and use of the GMOs to safeguard investment capital. These safety regulatory regimes and operations assumed a structure ranging from global through regional to national level to ensure global safety compliance in the development, handling, transfer and utilization of GMOs. National biotechnology policy, especially biosafety regimes is an important factor in the diffusion and successful commercialization of GM crops and other living modified organism products (Timpo, 2011 and Fukuda-Parr et al, 20012).

According to Timpo (2011), the issues of safety in the production and utilization of GMOs are often overwhelmed by ideological, political, and market considerations and these have influenced the nature and scope of regulations being adopted by most countries or economic blocks. Biosafety regulatory regimes may range from permissive to precautionary, depending on the nature of requirement and barriers to biotechnology development and diffusion. Paarlberg, (2001) observed that, the permissive setting lower requirements while the precautionary regimes create barriers to development, commercialization and diffusion of biotechnology products such GM crops.

According to Fukuda-Parr et al, (2012) countries such as the US, Canada, South Africa, and Argentina have a relatively 'permissive' approach, while India and Brazil have a more precautionary regime with China noted to have a unique and pragmatic regime. The story of EU regarding biotechnology regulatory regime and policy directions, appeared rather dynamic with initially being more facilitating environment which suffered a policy shift in the late 1990s towards a precautionary policy approach culminating in enacted of a moratorium on the further application of transgenic technology in agriculture in 1998, which was later revoked in 2004 (Fukuda-Parr et al, 2012; Tiberghien, 2006). Inspite of the revocation of the moratorium, EU countries continues to demand strict labelling requirements for all products containing GM crops.

At the global level, the Cartagena Protocol on Biosafety had been and continues to provide legally binding global protocol that seeks to contribute in ensuring safe transfer, handling and use of living modified organisms (LMOs) created through modern biotechnology (ISAAA, 2004). Article 1 of the Protocol states that the aims of the protocol is to "contribute to ensuring an adequate level of protection in the field of the safe transfer, handling and use of living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focusing on trans boundary movements" (ISAAA, 2004; P1). Since its promulgation, many countries have signed onto and rectified/acceded the Cartagena Protocol on Biosafety, and have since put in place appropriate laws, legislative instruments and policies to ensure effective and efficiency national biosafety regimes as require under the protocol.

2. 6.1 Ghana Policy and regulatory regimes on biosafety

The application of modern biotechnology as a tool for crop improvement is increasing being regarded in Ghana as a promising technology not only for the attainment of food security in the country, but also for the overall living conditions of the population (Ashitey, 2013; MES/UNEP-GEF 2004). Within two decades now, after the country ratified the Convention on Biological Diversity on August 29, 1994 and the Cartagena Protocol on Biosafety on May 30th, 2003 steady progress have been made by way of biotechnology policy directions, regulatory and institutional frameworks being put in place to ensure safety application of biotechnology in crop improvement and agricultural development in general (Ashitey, 2013; Sarpong, 2004).

In guiding the country's agrobiotechnology process, national biosafety framework was drafted in 2004 with the support from the United Nations Environment Program (UNEP) - Global Environment Facility (GEF) (MES/UNDP-GEF, 2004). The adoption of national biosafety framework assisted in giving policy directions for enactment of the country's biosafety legal and regulatory regimes in preparations towards the eventual uptake of GMOs technology in commercial agricultural production. As observed by Ashitey, (2013) that the adoption of National Biosafety Framework have paved the way for the final passage of the country's biosafety law.

Also between 2004 to 2008, Ashitey, (2013) noted that through USAID-sponsored Program for Biosafety Systems (PBS), implemented by a consortium led by the International Food Policy Research Institute (IFPRI), significant efforts were made in developing the underlying legal framework for biotechnology and biosafety policy in Ghana. Also from 2009 to 2011 the country together with Burkina Faso, Kenya, Malawi, Nigeria and Uganda benefited from the Forum for Agricultural Research in Africa (FARA), project on Strengthening Capacity for Safe Biotechnology Management which had helped in addressing information gathering and dissemination, awareness creation, outreach, and stewardship in biotechnology (FARA, 2012).

2.6.2 Ghana National Biosafety Act (Act 831, 2011)

All these efforts culminated in the enactment of Biosafety Act (Act 831) in 2011 which provides legally enacted law to guide the generation and application of GMOs. Unlike other countries, Ghana biosafety law was passed without much controversy and debate, even though there were issues raised against the law by campaigners against GMOs after the law have been passed and acceded to by the president (Zakaria 2014 and Ashitey, 2013). Notwithstanding, Food Sovereignty Ghana (FSG), a civil society organization, sought court injunction against a plan release of Bt cowpea and GM rice by Council for Scientific and Industrial Research (CSIR) at the Human Rights Division of the Accra Fast Track Court which was thrown out giving further impetus to the Ghana agrobiotechnology agenda (GNA, 2015).

The scope of Ghana biosafety Act (Act 831) as contained in the Act is to provide additional enactment to, and not in derogation of, the requirements imposed by any other enactment and it does not apply to genetically modified organisms that are pharmaceuticals for human use, and which are the subject of any other enactment. The objective of the Act is to:

a) ensure adequate level of protection in the field of safe development transfer, handling and use of genetically modified organisms resulting from biotechnology that may have an adverse effect on health and the environment, and
b) establish a transparent and predictable process to review and make decisions on genetically modified organisms specified in paragraph (a) and related activities (Biosafety Act, 831, 2011).

2.6.2.1 National Biosafety Authority

The Act provide for the establishment of National Biosafety Authority with the functions of:

a) to receive, process, respond to and to make decisions on applications under and in conformity with this Act,
b) to establish administrative mechanisms to ensure the appropriate handling and storage of documents and data in connection with the processing of applications and any other matters covered by this Act,
c) to act as a national focal point responsible for liaising with any other agency, or international organizations concerned with biotechnology and biosafety
d) to promote public awareness, participation and education concerning the activities of the Authority under this Act.

The mandate of National Biosafety Authority (NBA) as enshrined in the Biosafety Act, 2011 (Act 831) is to act as administrative body that will manage the implementation of all issues related to Biotechnology in Ghana. NBA is the designated national authority on all issues related to modern agricultural biotechnology in Ghana. The authority is mandated to received and review all applicants, except for contained use and field trials by research establishments with functioning Institutional

Biosafety Committees. The governing body of the NBA is a Board whose chairman and members are appointed by the President for a period of three years (Ashitey, 2013).

Giving meaning to the provisions in the Ghana Biosafety Act, on February, 17th 2015, a 13member board of directors to steer the affairs of the National Biosafety Authority was inaugurated by the Ministry of Environment, Science, Technology and Innovation to oversee the regulation of biotechnology in Ghana (GNA, 2015). This is a further boost to the modest progress the country have been making towards her agrobiotechnology agenda for sustainable increase in agricultural productivity.

2.6.2.2 Technical Advisory Committee

The Act, also provide for the established of a 'Technical Advisory Committee' with the function of:

a) act as the national advisory body on matters concerning or related to genetic modification of organisms, and carry out risk assessment and audit of applications at the request of the Board, and

b) advise, on request or of its own accord, the Minister on matters concerning genetic modification of organisms including:

   I. aspects relating to the introduction and development of genetically modified organisms into the environment,

   II. proposals for specific activities or projects concerning genetic modification of organisms,

   III. aspects concerning the contained use of genetically modified organisms,

   IV. the importation and exportation of genetically

   V. modified organisms, and

VI. proposed Regulations and written guidelines.

One other equal important role of the National Biosafety Authority as provided for in the Biosafety law is biosafety Risk Assessment. Objective of the risk assessment is to identify and evaluate the potential adverse effects of genetically modified organisms on health and the environment. The Technical Advisory Committee as enshrined in the National Biosafety Act, is to consist of not more than eleven individuals from the regulatory agencies and from the private sector who are knowledgeable in science and socio-economic matters related to biotechnology (Biosafety Act; 831, 2011and Ahitey, 2013). The Technical Advisory Committee is to act as the national advisory committee on matters concerning or related to biotechnology and will carry out risk assessments of applications at the request of the Board. The risk assessment is to guide the board of National Biosafety Authority to make informed decisions regarding genetically modified organisms (Biosafety Act 831, 2011).

2.6.2.3 Regulatory Agencies

To monitor confined and/or contained release of genetically modified products into the environment and ensure safety production, handling and marketing of genetically modified products, the nation biosafety law provides for regulatory agencies and made provision for their operations.

The regulatory agencies are charged with the responsibility of:

a) monitoring an applicant's activities to ensure that those activities comply with the requirements of the biosafety Act, the Regulations and the conditions imposed in connection with the approval under the Act'.
b) 'where a regulatory agency becomes aware of significant new scientific information indicating that approved activities with genetically modified organisms may adversely affect

the environment or pose potential risks not previously known, the regulatory agency shall immediately inform the Authority of the new information and of the measures put in place to ensure the continued safe use of the genetically modified orgasm' (Biosafety Act, 2011; pp14).

In case of unintentional release into the environment clause 32 of the Act provides that.

a) A regulatory agency with knowledge of an unintentional or unapproved introduction into the environment of a genetically modified organism that is likely to have an adverse effect on the environment, shall, within twenty four hours of having that knowledge, notify the Authority of the occurrence.
b) A notification under subsection (1) shall include adequate information for the Board to undertake a risk assessment.
c) The Board, in consultation with the regulatory agency, shall determine whether an action is necessary to minimize an adverse effect on the environment.

Section 31 of the Act named the following institutions as constituting biosafety regulatory agencies:

a) The Food and Drugs Board
b) The Veterinary Services Directorate
c) The Plant Protection and Regulatory Services Directorate
d) The Environmental Protection Agency
e) The Customs Division of the Ghana Revenue Authority
f) District Assemblies, Metropolitan Assemblies, Municipal Assemblies and any other local government authority
g) The Standards Authority

These are existing institutions with many years of experience in their respective regulatory services. With the coming into force of the National Biosafety Law, their mandate has been expanded to include regulating genetically modified organisms in line with their respective operations and jurisdictions.

2.6.2.4 Institutional Biosafety Committees

Also, the Act provides for the establishment of Institutional Biosafety Committees in research institutions undertaking biotechnology research to ensure safety handling of genetically modified organisms under contained used and confined and control released to the environment. Institutional Biosafety Committees are expected to be registered and supervised by the National Biosafety Authority to ensure their activities comply with the national biosafety provisions and regulatory regimes.

2.6.2.5 Procedures for Biotechnology Applications

The Act provides procedure for applying for biotechnology activities under the national biosafety act. Section 11 of the Act, provides for Information required in the Applications for Contained or Confined use while section 12 and 13 provides for information required in applications for release, importation and placing on the market. All applications for permits to undertake activities in regarding GMOs have to be handled by the National Biosafety Authority either directly or indirectly through institutional biosafety committees.

Applications for contained use and field trials shall emanate from the Institutional Biosafety Committees. All other applications shall be requested through the National Biosafety Authority. After receipt of applications based on the type of request, the application shall be reviewed by the National Biosafety Authority for completeness, acknowledged with a tracking number and then passed on to the Technical Advisory Committee for risk assessment and risk management recommendations (Ashitey, 2013).

The Technical Advisory Committee as advisory body, will advise the board of National Biosafety Authority based on the findings of the risk assessments undertaken on any application and then the board will take decision on the application based on the report and any other relevant socio-economic considerations and comments from the public. The public shall be involved through the electronic media and the website of the authority. Opportunities shall be made available through public hearings and announcements for public comments (Biosafety Act 831, 2011 and Ahitey, 2013). Figure 3.3, presents schematic flow chart of biotechnology activities' application process and how the various entities and committees set up under the National Biosafety Act collaborate in ensuring safety in the handling, use and transfer of GMOs.

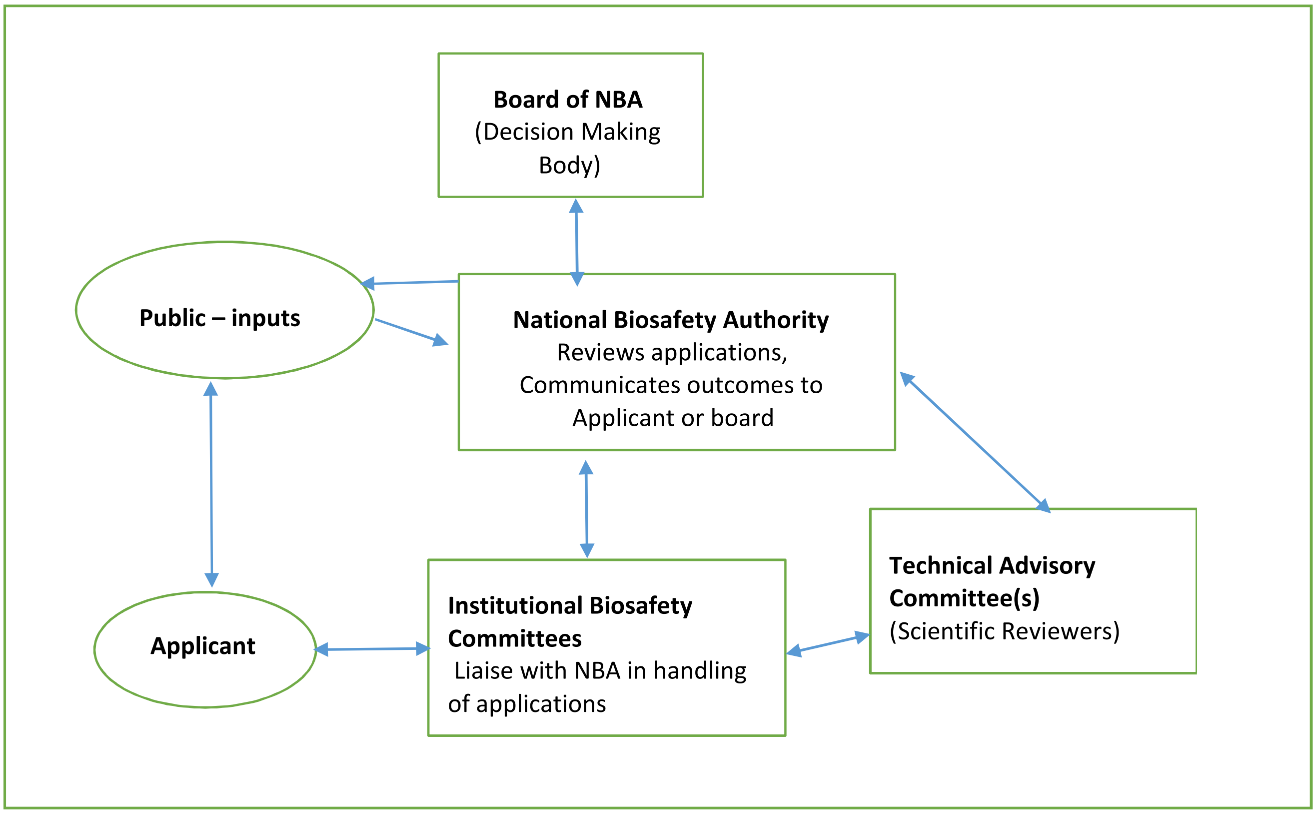

Figure 3.3: System for Handling Applications –Flow chart

Source: Adapted from (National Biosafety Framework, 2004 and Biosafety Act 831)

2.6.3 Seed Regulations and Plant Breeders' Right

As part of regional initiative of improving farmers' access to certified and improved seeds by encouraging private sector investment in seed production, Ghana have been putting in place legislative and regulatory frameworks to safeguard private investment in seed production and marketing. In line with the 2008 ECOWAS regional seed harmonization regulation, Parliament of Ghana passed a National Seed Law (Plants and Fertilizer Act, 2010) (World Bank, 2012).

The new Seed Law opens the door for an increased role for the private sector in seed production of different types of grains. Tripp and Mensah-Bonsu (2013) report on Ghana's Commercial Seed Sector, observed that a number of recent developments in seed commercialization have a considerable influence on Ghana's ability to provide commercial seed for its major field crops. The report mentioned the recent development in the seed sub sector as the enactment of the seed law, the development of regulations for implementing the law, new national agricultural policy, the activities of domestic and foreign seed companies, and donor interests.

2.6.3.1 Plants and Fertilizer Act 2010, Act 803

FAO (2009) observed that urgent government measures and increased public and private investment in the seed sector are imperative if agriculture is to meet the challenge of food security in the context of population growth and the threat of climate change on food production. Encouraging and safeguarding private investment in the breeding of improved cultivars, seed production and marketing, the public sectors are continuously and strongly encouraged to implement predictable, reliable, user friendly and affordable regulatory environment to ensure that farmers have access to high quality seed at a fair price (Tripp and Mensah-Bonsu, 2013; World Bank, 2012; FAO, 2009).

It is in response to this challenge that the Ghana's Plants and Fertilizer Act, 2010, Act 803 was promulgated to provide regulatory guidelines for the production, registration and marketing of seeds. The Plants and Fertilizer Act of 2010, combines the Seed Inspection and Certification Decree, NRCD 100 of 1972 and the Prevention and Control of Pests and Diseases of Plants Act of 1965, Act 307 (Act 803, 2010). The Act provides for the efficient conduct of plant protection to prevent the introduction and spread of pests and diseases to regulate imports and exports of plants and planting materials; the regulation and monitoring of the exports, imports and commercial transaction in seeds and related matters (MOFA, 2011b).

Notwithstanding the effort to formalized seed production, certification and regulation, most smallholder farmers in Africa sourced their seeds from the informal channels which include farmers' own saved seeds, seed exchanges among farmers or purchase from the local grain or seed markets (Louwaars and De Boef, 2012). However, Etwire *et al*, (2013) observed historical overlapped between the formal and informal systems, suggesting that there is potential for a hybrid system combining aspects of the two systems to emerge, which will be more relevant to the realities of smallholder farmers in terms of improving their access and affordability to improved and certified seed for increase crop productivity.

Due to considerable government efforts through seed regulatory enactments (Plant and Fertilizer Act 803, Prevention and Control of Pests and Diseases of Plants Act of 1965, Act 307 and Seed Inspection and Certification Decree, NRCD 100 of the 1972) and government seed policy, the formal seed system in Ghana have under gone significant improvement with increasing private investment in seed production (Tripp and Mensah-Bonsu, 2013).

The various stages of seed production and commercialization requiring institutional and regulatory frameworks are Crop Varieties development, Variety Approval and Registration, Breeder Seed development, Foundation Seed production and Commercial Seed Production. Most of the crop varieties that are sold as seed have been developed by Ghana's national Agricultural Research Institutes (NARIs) (Tripp and Mensah-Bonsu, 2013). At the front of Ghana research on crop improvement and breeding of new varieties of crops for improve productivity is the Council for Scientific and Industrial Research (CSIR) through its various institutions such as Savannah Agricultural Research Institute (SARI), Crops Research Institute (CRI), Soil Research Institute (SRI) among others and the Universities (MOFA, 2011and Tripp and Mensah-Bonsu, 2013).

The research institutions have the mandate to produce breeder seed, releasing the bred seed to the Grains and Legumes Development Board (GLDB) for the development and production of foundation seeds. Foundation seeds are then acquired by seed companies and seed growers to produce seeds that are certified for sale to agro-dealers, NGOs and in some cases directly to farmers or grain producers (Etwire et al, 2013; Tripp and Mensah-Bonsu, 2013). Etwire *et al*, (2013) noted that, previously GLDB was the only organization mandated to produce foundation seed, but as a result of increasing demand for foundation seed, research institutions are now also allowed to produce foundation seed.

Regulation, inspection and certification of the national formal seed system in the country are currently being undertaken by the National Seed Committee, National Seed Services and the Seed Inspection Division, all of the Ministry of Food and Agriculture. The Ghana Seed Inspection Division of MOFA is mandated to inspect and certify the production and distribution of foundation and certified seeds. A Schematic flow chart of the formal seed system in Ghana is shown in the Figure 3.4.

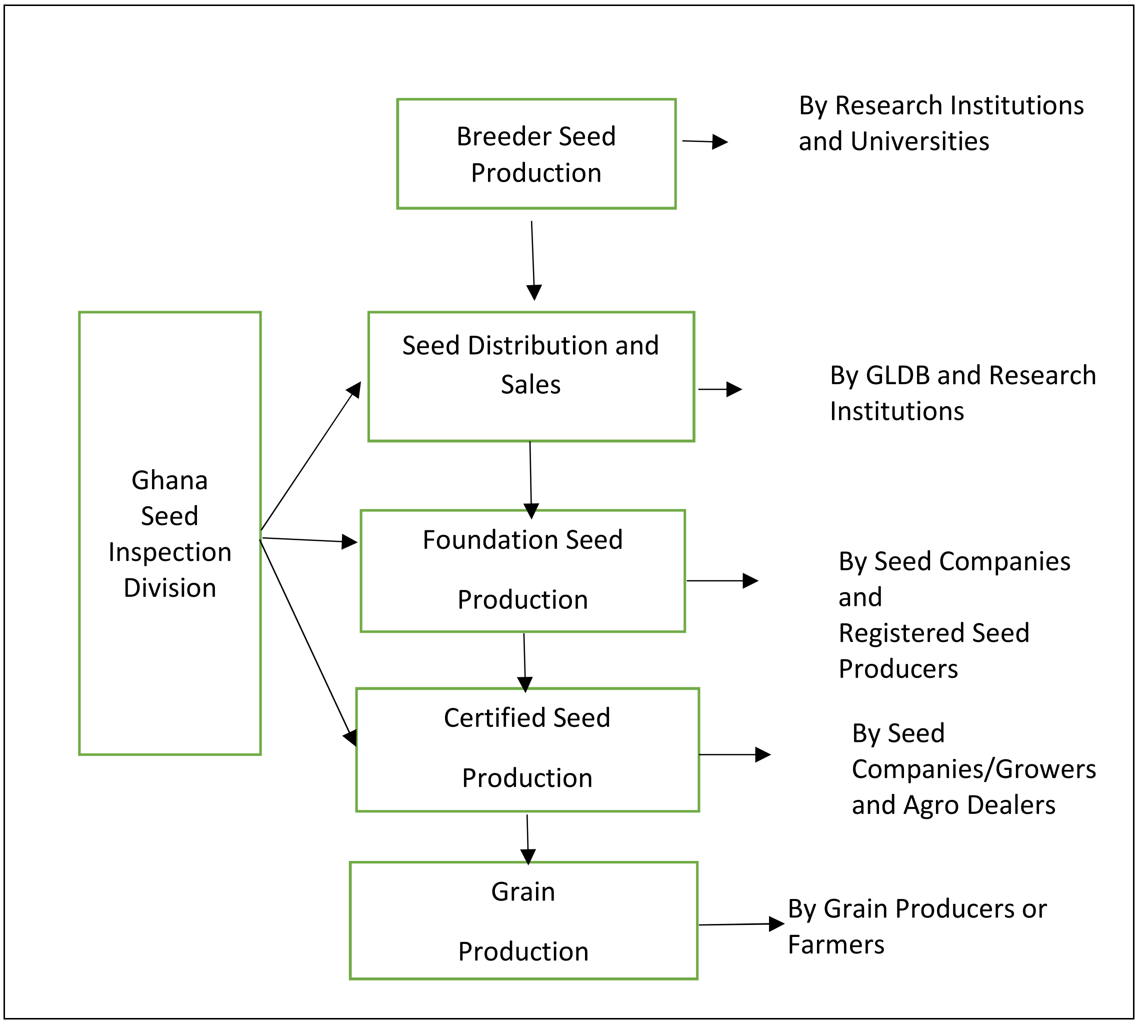

Figure 3.4: Flow chart of the formal seed sector in Ghana
Source: Adapted from Ghana Seed Policy, (2013); Etwire et al, (2013)

2.6.3.2 Plant Breeders' Bill

Currently the only regulatory framework guiding seed generation, production, certification and marketing in the country is the Plants and Fertilizer Act (Act 803, 2010). This law do not explicitly made provision for the protection of breeders intellectual right (MOFA, 2011b) which is critical in getting private investment in varietal development, especially novel technology like GMOs, which require heavy investment. It is to overcome this shortcoming that Plant Breeders' Bill was drafted which is currently being considered by Ghanaian parliament to provide legal bases for protecting intellectual property of plant breeders and research institutions applying GMOs technology in producing improved varieties of crops.

This will create a favourable environment for the development and commercialization of biotechnology seeds and crops as observed by Ashitey, (2013) and also attract private investment in GM seeds production and marketing. As observed by Bennett, et al, (2013) that progress had been made in respect to enactment of enforceable regulatory framework for GMOs in Ghana, and as such the country can be considered to have positive stance towards commercialization of GM crops. Therefore the passage of the Plant Breeders' Bill into enforceable law is critical to Ghana biotechnology agenda. The Bill provides for clear procedure for the application and approval or otherwise of plant breeders right so as to safeguard private sector investment in biotechnology seed production.

With regard to progress in biotechnology research and GM crops development and commercialization, Savannah Agricultural Research Institution (SARI) of the Council for Scientific and Industrial Research (CSIR) is currently undertaking adoptive trials and research into genetically modified cowpea and cotton. SARI had established a biotechnology cowpea farm at Nyankpala in the Tolon District and a biotechnology cotton farm at Kpalkore in the Mion District (Ashitey, 2013 and GNA, 2013).

2.7 Collective Action and Farmer Organization

This section provides an overview of the role, characteristics and operations of collective action, with a particular focus on its development, its strategies and dynamics in providing for and supporting farmers common action and agricultural productivity. Vanni (2014) argued that a very relevant issue to be considered when analyzing the dynamics of collective action is what type of organization develops and manages such action, a detailed description of the main institutional arrangements that may favour the development of grassroots collective action in rural areas. This section proceeds with the overview of traditional and historical development of farmers' collective action and its transformations into formalized Farmer Based Organizations (FBOs).

Collective action as a tool for pursuing group common interest, have received considerable research attention for well over two decades now. According to Marshall (1998) collective action is the action taken by a group (either directly or on its behalf through an organization) in pursuit of members' perceived shared interests, goals or aspirations. Collective action occurs when more than one individual is required to contribute to an effort in order to achieve an outcome (Ostrom 2004). In the pursuance of common interest through collective action, members can act directly on their own or through an organization; they may act independently or with the encouragement or support of external agents. Also, Vanni (2014) cited Meinzen-Dick, *et al* (2004) as arguing that, despite the varied definitions of collective action, the features which are common among the various definitions are: (i) the involvement of a group of people, (ii) shared interests and (iii) common and voluntary actions to pursue those shared interests.

2.7.1 Farmers Traditional Collective Action

In most Africa countries, it has been a long cherished tradition of farmers performing their farming activities in a form of informal labour grouping (Onumah *et al*. 2007). In Ghana, informal reciprocal labour exchange grouping arrangement guidance have long existed by customary practice for the provision of labour for farm work, usually weeding, sowing, harvesting and mounds raising. This form of arrangement among the Akan speaking communities in Southern Ghana is known as 'Nnoboa' and it is not only voluntary system and informal but also it is temporary with the group dissolving on completion of the task (Dadson 1988). Dadson (1998) described the 'Nnoboa' as a traditional form of cooperation in Ghana involving group action and mutual reciprocal basis guided by social, ethnic and family factors in the area. The Nnoboa system was used widely in traditional farming as well as in social projects, such as the construction of feeder roads, health centers, and wells (ibid).

The existence of informal traditional credit schemes known as the 'Susu' scheme, which have been in practice for a very long time, is yet another manifestation of the existence of traditional collective action by rural people, apart from the informal labour exchange groups. Citing Adjetey (1978), Aryeetey, (2004) explain that the longstanding existence of 'Susu' schemes in Ghana, is a system in which informal group of people may agree among themselves to contribute regularly a given amount of money into a pool, which are then handed to a participant at an appointed time. Under this system, participants in effect repay their loans by continuing to make their regular contributions to the group for other members to take their turns (Aryeetey 2004).

2.7.2 Farmer Based Organizations (FBOs) Development in Ghana

The formalization of informal local grassroots collective action groupings led to the recent development of Farmer Based Organizations (FBOs). Farmers in Ghana engaged in collective activities long before the introduction of formal farmer groups and cooperatives. As observed by Onumah *et al* (2007), collective activities among farmers are traced back to the pre-colonial period during which neighbouring farmers, usually relatives and friends, normally come together to form informal reciprocal labour pool in supporting each other farming activities.

Wanyama, Develtere, and Pollet (2008) traced back formalization of farmers collective action groupings in a form of cooperatives to the late 1920s, where the colonial administrators in Ghana introduced formal farmer organizations in the form of cooperatives to improve the quality and marketing of cocoa as well as provide loan facilities to farmers. To coordinate and manage these cooperatives, the then colonial administration established the Department of Cooperatives (DOC) in 1924 (Dadson, 1988). This development stimulated a rapid expansion of cooperatives first in the cocoa sector which subsequently expanded to other sectors.

Although FBOs are voluntary organizations, form as organization response to shared needs and constraints farmers face in their farming activities, often their formation are being influence by external actors and other motivations of public or private institutions in their external environment. Salifu, et al (2010) found a renew interest among both public and private organizations in the establishment and management of FBOs in Ghana, but with varying motives.

Profit maximization is the dominant motive for the private sector organizations support for the establishment of FBOs. This is to enable them increase profitability through reduction of transactional costs as they deal with farmers in group instead of individual farmers. As argued by Gulati *et al,* (2007), FBOs provide institutional framework by which farmers can be engaged more effectively and efficiently rather than dealing with individual smallholder farmers with its intended high operational cost and ineffectiveness in service delivery. They further argued that dealing with FBOs rather than individual smallholder farmers, enables private investors to reduce the cost of dealing with farmers, enhance the volume and quality of farm produce, and improve credit recovery from farmers.

FBOs also provides reliable marketing avenue for their members, as observed by Vorley, Fearne, and Ray (2007) that many buyers of farm produce prefer to work with FBOs instead of individual farmers because the groups are better able to provide stable and bulk supplies. Shiferaw *et al* (2011) stated that private buyers' transaction costs may be significantly reduced if they deal with a group of farmers selling an aggregated product of homogeneous quality rather than with many individual farmers selling small quantities of uncertain quality.

With regard to the motive of the public sector in supporting the establishment of FBOs, many governments establish FBOs to facilitate the provision of public goods such as extension service, agricultural inputs supply and marketing of agricultural produce to enhance economic growth and rural peoples' welfare (Stockbridge, Dorward, and Kydd, 2003; World Bank 2007). Change (2012) indicated that given the poor state of extension farmer ratios in developing countries, the establishment of FBOs will provide very effective means for public extension agents to reach out to larger numbers of farmers at relatively low cost in terms of resources and time.

In the case of Ghana for instance, each extension agent serve about 2,500 farmers (MOFA, 2016 and Owusu-Baah 2012), there is no way effective extension service could be achieved with this poor extension agent farmer ratio. FBOs are therefore seen by governments as an effective mechanism for increasing agricultural productivity in many African countries (Hussein 2001) since providing access to extension information and new agricultural technologies for large numbers of farmers play an important role in increasing productivity and enhancing food security.

Shiferaw *et al*. (2011) indicated some donor agencies require governments to organize farmers into FBOs as a condition to gain access to support such as grants or credit meant to improve agricultural development. As results, for some times, the desirability of establishing FBOs is finding its way into national development policy documents in some countries (Bernard *et al*. 2008). In Ghana, for example, government policy strategy documents such as the Growth and Poverty Reduction Strategy (GPRS II, 2006-2009), the Medium-term National Development Policy Framework and Ghana Shared Growth and Development Agenda (GSGDA, 2010-2013), as well as the Food and

Agriculture Sector Development Policy (FASDEP II) have all place strong emphasis on the establishment and strengthening of FBOs as one key strategy in developing the predominantly smallholder agricultural sector in the country (GOG, 2005; GOG 2007 and GOG, 2010).

As part of the implementation of Ghana Agricultural Sub Sector Investment Programme (AgSSIP) with the sponsorship from the World Bank, farmers' capacity on the establishment and running of FBOs were built leading to the establishment of FBOs throughout the country (MOFA, 2012; Salifu, et al, 2010 and AgSSIP 2007). Like governments, many nongovernmental organizations (NGOs) encourage the establishment of FBOs to improve rural service delivery, economic growth, and poverty reduction among farmers (Stockbridge et al. 2003; World Bank 2007). Donors and NGOs often prefer to deal with farmers through farmer organizations, particularly if they feel there is institutional failure in the public or private sectors (Rondot and Collion 2001).

However, it is important to note that the support of NGOs and donors in the establishment of FBOs is sometimes funnelled through government agencies (Tinsley 2004). For many donor and NGO projects, joining an FBO is the only way to participate in and receive support from the project, with no consideration given to farmers who do not belong to such groups (Tinsley 2004).

Also, Salifu *et al*. (2010) reported bilateral and multilateral donor communities showing interest and giving financial and technical support for the establishment and management of FBOs in Ghana. Since 2000, the Government of Ghana and many NGOs have implemented projects aimed at strengthening FBOs in the country. Among these projects, two projects have had greater impact on FBOs formation and capacity building. The first was the World Bank-sponsored Agricultural Services Subsector Investment Program (AgSSIP), implemented from 2000 to 2007. Under the FBO component, AgSSIP provided support for the development of FBOs to allow them to play a major role in shaping agricultural policy, providing services to farmers, and engaging in export activities (AgSSIP, 2007). By the end of AgSSIP, the World Bank had invested more than US$ 9 million in the establishment of FBOs and in providing leadership and technical training, farm inputs, credit, and agro-processing equipment to help build the capacity of these FBOs (AgSSIP 2007).

The second project was sponsored by the Millennium Development Authority (MiDA) to enhance the profitability of commercial agriculture among small farmers. MiDA worked with selected FBOs to enhance the technical and commercial skills of their members, simultaneously using the FBOs as platforms to supply farm inputs and facilitate access to credit. By the end of the program, 1,335 FBOs had benefited (Salifu, *et al*, 2010).

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter presents research procedure, research approach, population of the study, sampling procedure and method, data collection and analysis. It proceeds with description of the study area and research methodology employed to achieve the objectives of this study.

3.1 Study Area

The study was conducted in Northern Ghana, comprising of the three northernmost regions of Ghana, namely - Northern, Upper East and Upper West regions. All these regions are located in the Guinea Savannah Ecological Zone which is characterised by poor and fragile soils with erratic climatic conditions (MOFA, 2010; 2016). Figure 3.1 presents map depicting the three northern regions, while figure 3.2 and 3.3 presents maps showing the study districts in the Upper West Region, Upper East Region and Northern Region respectively.

The three regions are the poorest area in the country where food insecurity is a chronic problem with majority of its inhabitants living below the poverty line as observed in the results of round six of the Ghana Living Standard Survey (GSS, 2014). Poverty in this area is most severe among food crop farmers, who are mainly traditional, rural small-scale producers (GSS, 2016; 2014). The poor and vulnerable state of Northern Ghana have, over the years, created visible development gap between the North and South of the country. The three northern regions consistently registered higher levels of poverty and under development compared with the southern regions in the country (GSS, 2016; GSS, 2014; GSS, 2007).

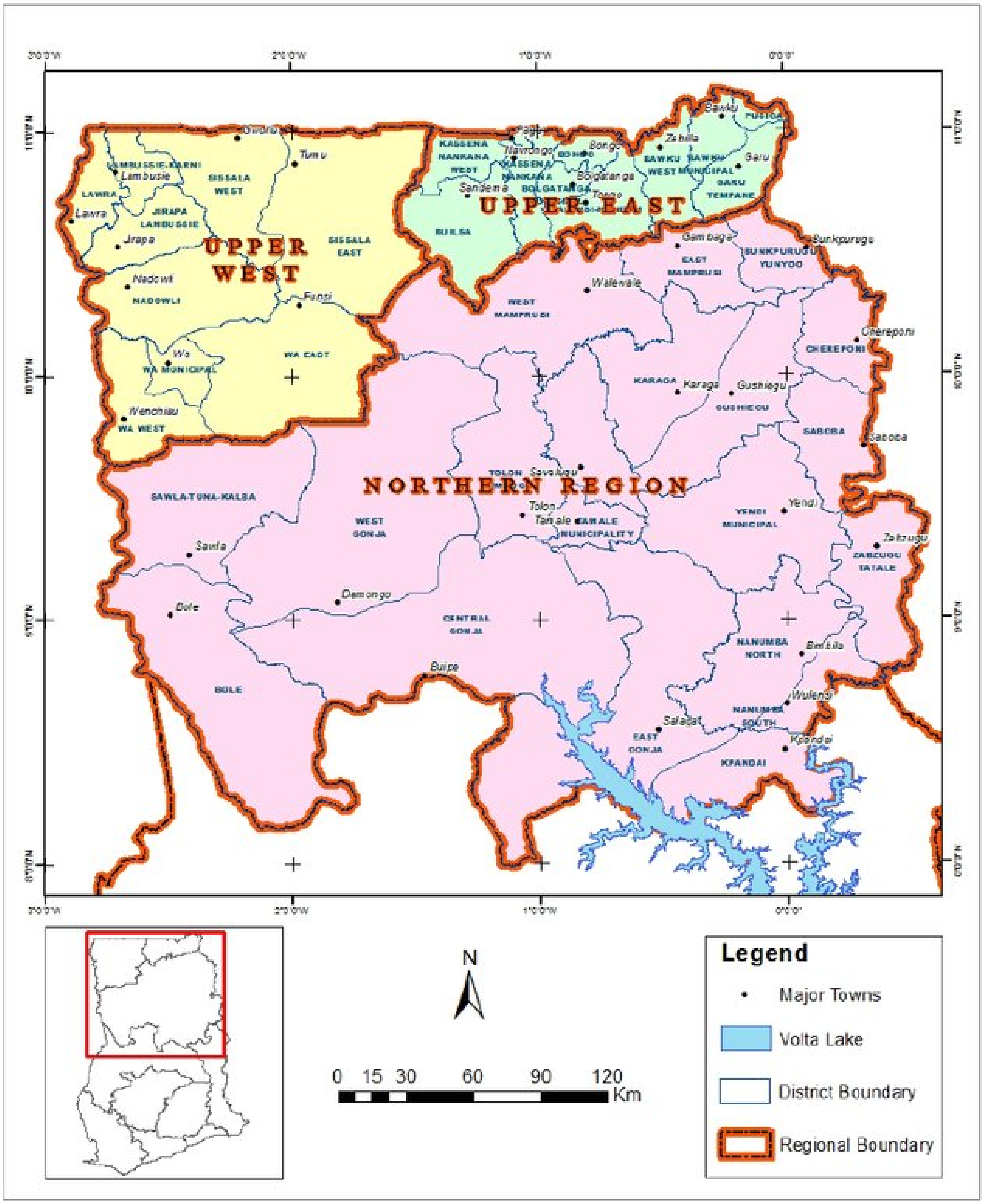

Figure 3.1: Map depicting the three Regions in Northern Ghana

Source: Antwi et al. (2014)

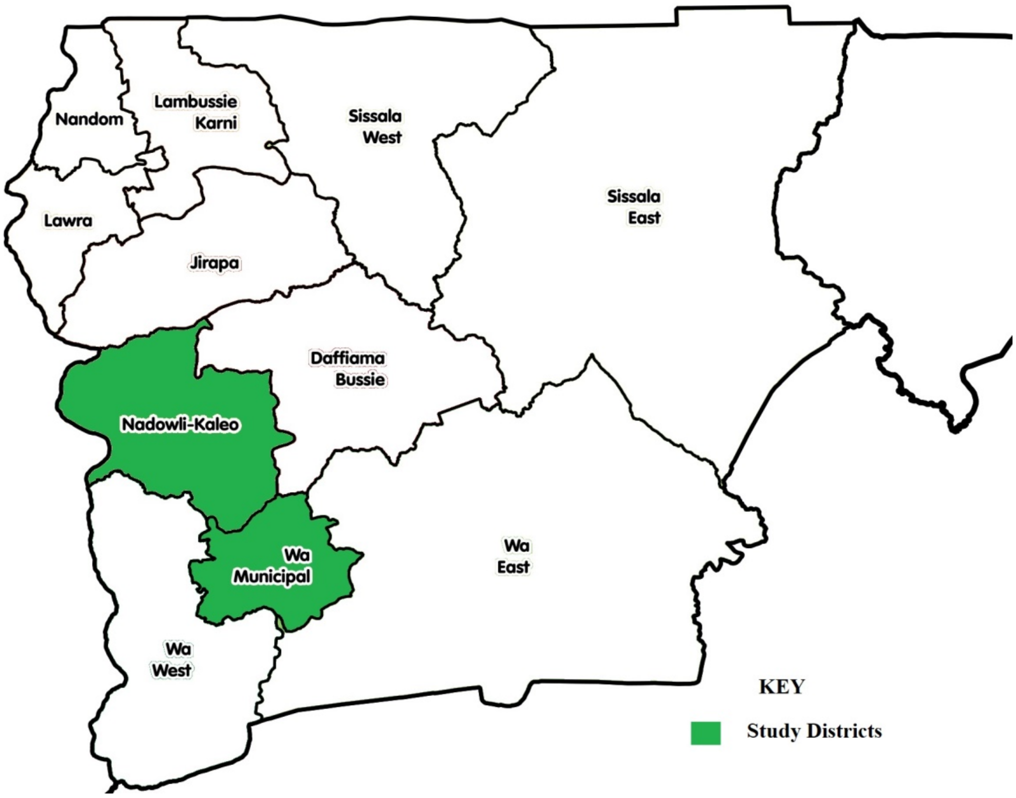

Figure 3.2: Map of Upper West Region depicting the study Districts

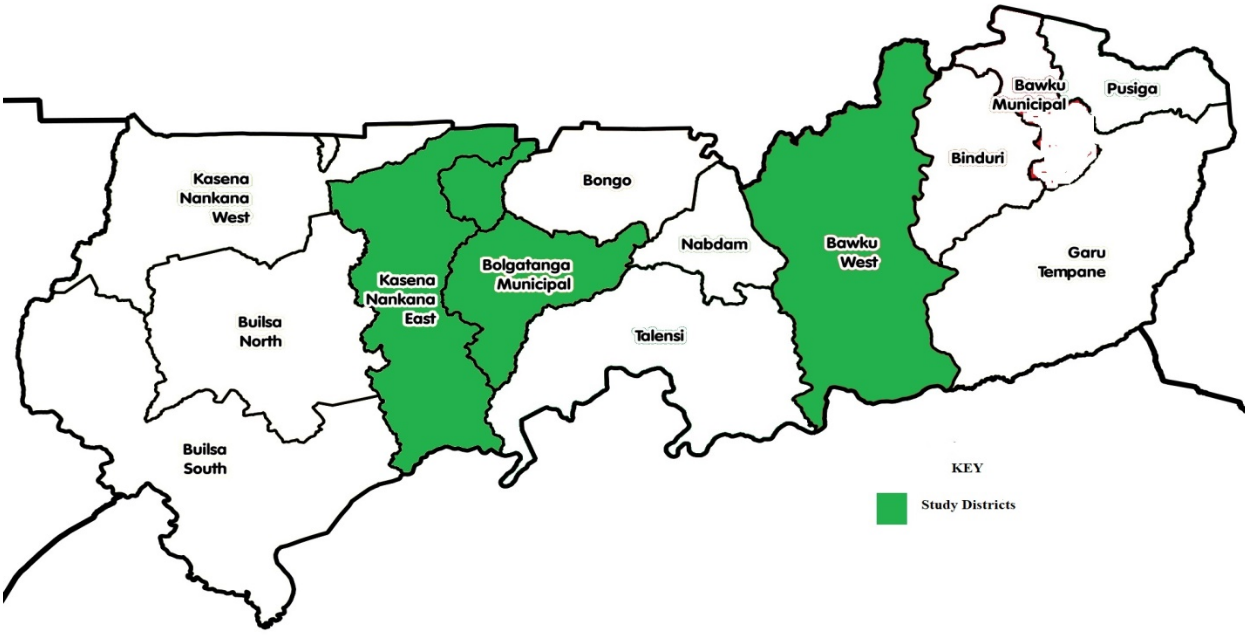

Figure 3.3: Map of Upper East Region depicting the study District

Figure 3.4: Map of Upper West Region depicting the study District

To improve agricultural productivity and development as a means of reducing poverty in the three northern regions, Savannah Agricultural Research Institute (SARI), one of the thirteen (13) research institutes of the Council for Scientific and Industrial Research (CSIR) was established with the mandate to 'provide farmers in the area with appropriate technologies to increase their food and fibre crop production based on a sustainable production system which maintains and/or increases soil fertility' (SARI, 2012).

As part of the institute's (SARI) drive to improve agricultural productivity in the area it is undertaking adaptive tries leading to eventual release of genetically modified cowpea and cotton (Bt cowpea and Bt cotton) (GNA, 2015 and Ashitey, 2013). Pending commercial release, SARI had established a biotechnology cowpea farm at Nyankpala in the Tolon District and a biotechnology cotton farm at Kpalkore in the Mion District (Ashitey, 2013 and GNA, 2013). The adaptive trials are in their final stages after which SARI will embark on seed multiplication of both Bt cotton and cowpea for distribution to farmers in the three northern regions for commercial production (Ashitey, 2013). As a result the three northern regions were selected for the study.

The field survey for the study was conducted in 10 sampled districts across the three northern regions. The districts were Kasena/Nankana East District, Bolgatanga Municipality and Bawku West District all in the Upper East Region; Nadowli/Kaleo District and Wa Municipality both in the Upper West Region. And the Bole District, West Mamprusi District, Savelugu/Nanton Municipality, Gushiegu District and Nanumba North District all in the Northern Region.

3.2 Research Approach

As Ghana prepares to boost agricultural productivity through the application of GMOs technology, this study sought to provide empirical information on farmers' knowledge, perceptions and underlying logic that could result in their adoption behaviour when the country finally approves and releases GM seeds for commercial production. The study also investigated factors that potentially affect farmers' willingness and adoption decision. It is hoped that these information will help in addressing farmers' concerns associated with the cultivation of GM crops through policy directions and implementation of agricultural development interventions.

To address these arrays of objectives, the study adopted multiple approaches for collecting, verifying and analysing data to offer insights into farmers' perceptions and adoption decision for policy implications. As such, three approaches were employed. These are (i) Discourse Analysis, (ii) an application probit regression model guided by Theory of Planned Behaviour (TPB) and Random Utility Theory (RUT); and (iii) an application of Q-Methodology and Q factor analysis in analysing perceptions and attitudes. Also, a probit regression model was adopted in analysing factors influencing farmers' adoption decision.

Firstly; Discourse Analysis was employed in extracting, making meaning and interpreting narratives gathered through focus group discussions and in-depth and key informant interviews conducted as part of a field survey undertaken. This approach is expected to throw more light on farmers' views and perceptions regarding GM crops by examining who said what, within what context and on what basis he or she is saying it. This allowed for adequate understanding of the various shades of opinions regarding GM crops within the context of sociocultural or economic backgrounds.

Secondly; the application of probit regression analysis guided by TPB and RUT were employed to give insights into dominant factors which accurately predict farmers' adoption decision regarding the cultivation of GM crops and to identify policy implications of those factors.

Thirdly; Q methodological approach was employed in gathering data and application of factor analysis to extract underlying constructs characterising farmers' perceptions and attitudes towards GM crops. The Q methodological process allowed for detailed systematic gathering and analysis of farmers narratives about GM crops and Ghana's agrobiotechnology agenda. It helped in providing insight into how farmers viewed GM crops, what they think about it and issues and concerns they have about it.

3.2.1 Research Design

Descriptive survey design was employed in carrying out this study with Q methodological approach used in guiding data collection. Descriptive survey is a most basic type of enquiry that aims to observe (gather information on) certain phenomena, often at a single point in time using cross-sectional survey to examine a situation by describing important factors such as demographic and socio-economic, behaviours, attitudes, experiences, and knowledge (Kelley, Clark, Brown and Sitzia 2003).

The study sought to examine farmers' perceptions and attitudes towards genetically modified crops and to identify the underlying factors which construct and shape farmers' perceptions and adoption decision towards the cultivation of genetically modified crops. As such descriptive research design, employing cross-sectional survey method provides appropriate research design in accomplishing the objective of this study.

Also to have a guided and systematic process of gathering farmers' narratives about GM crops, Q methodological process was adopted. At the heart of this study is identifying underlying constructs characterising farmers' subjective narratives about GM crops. Q methodological method allows the adoption of participant's point of view and understanding as central to its investigative procedures. Detail of how Q methodological procedures were employed is explained in the next section.

3.3 Q Methodology and Gathering of Narratives

This section discussed methodological procedure of Q methodology as a chronological procedure for gathering people's subjective narratives about an issue, event or activities. It covers theoretical foundation of Q methodology and how it was applied in this study.

3.3.1 Subjective Narratives and Q methodology

People's subjective opinions, perceptions, values, beliefs, taste and perspectives are and continue to be of interest to social researchers in understanding and exploring individual subjective 'viewpoints' on a particular topic and how it influence their behaviour and actions. Very often social sciences researchers desire to know the 'points of view' that are held around a particular topic within the context of available discourse or concourse surrounding the topic of interest. This is important in predicting people's attitude and possible response to policy issues surrounding the particular topic being investigated.

Several methodological approaches such as discourse or narrative analysis and follow by descriptive statistics are often being employed in analysing people's subjective view about a particular issue or topic (Teun, 2014 and Marianne and Louise, 2002). Since discourse is first of all a form of language use, it goes without saying that narrative methods of analysis always played a predominant role in the study of text and/or talk which is purely a qualitative data analytical approach. In measuring and operationalizing perception as a subjective viewpoint of people, Likert type scale is often used to generate numeric data making it amendable to the application of quantitative data analytical techniques such as descriptive and inferential statistics (Jyotsna, 2012 and Hasson and Arnetz, 2005).

Q methodology invented by British physicist/psychologist William Stephenson in 1935, is probably the most central and mixed-methodological approach for studying people's subjective 'points of view' about an issue or particular topic of interest (Stephenson, 1935). Q methodology is a research methodology that permits the systematic study of subjectivity and the communicability of subjective perceptions in a discourse on a specific topic (Goldman 1999; Leary, Jacob and Eve 2013). This method allows the adoption of participant's point of view and understanding as central to its investigative procedures.

In Q methodological approach, aside from its systematic approach of gathering communicable or discourse surrounding a topic under investigation, everything else about Q methodology falls between qualitative and quantitative approach which makes it robust for perception studies. Even after the development of mixed research methodological approach in the late 1980s by the works of Creswell (Creswell, 2010), both Q Methodology and Q factor analysis remain uncommon in behavioural and social science research even though neither are new techniques (Newman and Ramlo, 2010). However, the need to assess different perspectives on or attitudes towards topics of public concern is and continues to be an important research objective in many fields and disciplines (Sandbrook *et al*., 2011; Zabala, 2014; Zografos, 2007).

Also Q methodology is useful where psychometric knowledge of individuals and their disposition to act in one way or the other is of research interest (Gabor and Lorga, 2013; Leary *et al*, 2013). In agricultural research and development, farmers' preferences, perceptions, opinions and attitudes towards agricultural innovation are imperative in innovation dissemination and adoption studies. However, farmers' perceptions and attitudes are within the realm of their psychometrics and subjectivity based on knowledge and information available to them and their socio-cultural context. Q methodology, thus become relevance is such situation (Gabor *et al*, 2013; Shinebourne and Adams, 2007). Few studies have used Q methodology to gather farmers' narratives with the view of measuring farmers' perceptions towards agricultural innovation (Hall, 2010; Zakaria, 2016; Zakaria, Adam and Abujaja 2014).

Q methodology, as a hybrid of qualitative and quantitative approaches, is often used to guide the collection and analysis of data of studies on people's perception and subjective views of an issue under investigation. Subjective opinions are the variety of feelings each person has toward a topic. It is at the heart of issues relating to values (good/bad), ethical judgments (right/wrong), and moral choices (socially acceptable/unacceptable) (Joilo, 2008). Q methodology is robust in shedding light on complex problems in which human subjectivity is involved. Subjectivity is understood as how people conceive and communicate their point of view about a subject (McKeown and Thomas, 2013).

This study sought to examine farmers' subjective views and perceptions towards GM crops and how it influences their adoption intentions as such Q methodology was considered appropriate methodology in gathering farmers' narratives on GM crops. This was considered suitable because Q methodology provides researchers a systematic and rigorously procedure of gathering and measuring human subjectivity on array of social issues (Purnamita and Bhaskar, 2004).

3.3.2 Q Methodological Procedure Used

Q study has a laid down systematic procedure guiding gathering of discourse or narratives surrounding issue of interest. It contains systematic procedure of selecting representative statements from concourse gathered and presenting the selected statements to sampled participants for sorting. Watts and Stenner (2012) observed that Q is a clearly structured, systematic, and increasingly used methodology in studying narratives, perspectives and viewpoints of an issue of interest.

It therefore provides systematic methodology for researchers to explore distinct perspectives, discourses, or viewpoints within a group in order to address practical matters such as the acceptance of new policies and technology or issue of public concern. Du Plessis (2005) phased the process of Q methodology into five phases. The five systematic phases or procedures in Q study, begins with the researcher first collecting a concourse from people involved in it and then selects a sample of statements representative of the range of communicated ideas in the discourse (Charles, 2011 and Annette and Ulrike, 1997).

The very essence of Q-study is to capture people's subjective views about an issue and analyse it in order to identify shared views, connectivity, patterns and variations. As such, participants under study, are selected from the people involved in the discourse and asked to sort statements in their preferred order of importance on a large board refers to as Q sorting process. The participants' sorted statements are then compared by means of Q factor analysis. And finally, the results are analysed to establish trends in the discourse (Watts and Stenner, 2012; Ramlo and Newman, 2011and Stricklin and Almeida 2001). These five phases from theoretical standpoint and how they were applied in this study are explained in the next section.

3.3.1 Collecting Concourse of farmers' narratives

Concourse in Q methodology is referred to as the universe of discourse or narratives about a specific topic. It comprises of ordinary conversation, commentary and discourses about everyday life and includes all communication about a specific topic (Saheed, 2014 and Brown, 1991). It is a set of universal statements that could be set around any area of interest. In other words, the discourse about a specific topic is concourse. A concourse consists of all that can be thought of and said about a situation, event, or phenomenon.

Concourse can be obtained either from a primary or secondary source or both, depending on the issues being studied and availability of information on the topic of interest. According to Saheed (2014) primary sources include interviews, group discussions and talk shows, whiles the secondary sources include photographs, newspaper, literature and editorials. The primary and/or secondary sources, from which the concourse can be obtained, can be further clarified by means of Q sample types.

In this study, all ordinary conversation, commentaries, discourse or narratives about GM crops and the applications of agrobiotechnology in commercial agriculture in Ghana by selected smallholder farmers interviewed constituted the concourse. Very few studies such as Zakaria *et al*. (2014), Ademola *et al*. (2014) and Robert, *et al*. (2008) examined farmers' perception towards GM crops in the country, and as a result, there is not much literature capturing farmers' narratives about GM crops.

Therefore, primary source of gathering concourse was employed in this study. With the aid of a check list of open-ended questions, the researcher conducted telephone interviews with selected leaders of FBOs on issues regarding their general knowledge, perceptions and views concerning GM crops and application of agrobiotechnology in commercial agriculture. With the permission of interviewees, the discussion on the telephone interviews was recorded and later transcribed.

To ensure that the concourse gathered include all shades of views and opinions reflecting a universe of communication or narratives of farmers on GM crops, the telephone interviews covered as many people as possible until additional interviewees did not contribute new information or narratives to those gathered already. Also information regarding farmers and general public narratives about GM crops and the country's agrobiotechnology agenda was sourced from Ghana's Open Forum on Agricultural Biotechnology (OFAB) and National Biosafety Authority (NBA) since they have been undertaking public education on biosafety measures, biotechnology research and agricultural development.

After the concourse was gathered, statements capturing main issues were extracted from the course. These statements constitute the Q sample which was presented to lager participants for ranking on five point agreement Likert Scale.

Q sampling entails the process of selecting or excluding statements following a scientific procedure since the whole concourse cannot be administered because it may consist of hundreds of statements. From the concourse, a subset of statements is selected to form the Q-sample. The goal of the Q sample, as argued by Annette (1997) is to provide, in miniature, the comprehensiveness of the larger process being modelled.

Q sample types can be divided into two major types, namely naturalistic and ready-made Q samples. According to Du Plessis, (2005), naturalistic Q samples are compiled by obtaining written or oral statements on the topic by the participants who will be involved in the Q sort, while ready-made Q samples are compiled from sources other than communication of the participants, for instance, literature or radio shows. Naturalistic Q sample is mostly favoured in exploratory studies with the objective of understanding people's shared views and opinions on topics being explored since its statements are constructed from narratives and conversation with the people participating in the study.

Zakaria *et al* (2014) used naturalistic Q samples in assessing farmers' perceptions while Annette (1997) used naturalistic Q samples techniques in application of Q methodology in studying the opinions and views of healthcare workers about information technologies within the health care workplace. Naturalistic Q samples is mostly favoured in exploratory studies with objective of understanding people's shared views and opinions on topic being explored since it statements are constructed from narratives and conversation of the people participating in the study.

However, some studies used a combination of these two approaches. For example, Bulik and Sullivan (1993) in studying perceptions of substance of abuse used an existing card sort with 92 items, and added 9 additional items pertinent to their study. Wolf (2010) developed her concourse by asking university department staff members to anonymously give their views about workloads. She also looked at department heads' memos to staff, as a secondary source for obtaining concourse. From these sources, she collected 151 distinct statements for her concourse.

In this study, naturalistic Q sample was employed in gathering the narratives and preparing the statements for rankin. Other earlier studies have used naturalistic Q sample approach in sourcing and compiling statements for Q sorting. For instance, Zakaria *et al*, (2014) used naturalistic Q samples in assessing farmers' perceptions while Annette (1997) used naturalistic Q sample techniques in application of Q methodology in studying the opinions and views of health care workers about information technologies within health care. Other Q studies used both naturalistic and already-made Q samples techniques in examining perceptions (Wolf, 2010; Bulik and Sullivan, 1993).

3.3.2 Selecting representative Q sample/ Q set

It is not practicable to administer an entire concourse, which might consist of several hundreds of statements containing opinions and not facts reflecting ideas communicated by people on a topic being studied (Brown 1980). After the concourse surrounding the issue under investigation is gathered, the task of the researcher then becomes one of selecting or drawing a subset of the collected statements which is representative of the gathered concourse. The selected representative statements, which are usually 20 to 60 items, is referred to as the 'Q sample' and are eventually presented to participants for Q sorting (Saheed, 2014 and Lefin, 2009). Two Q sample structures are used to select or exclude statements from the concourse, namely, unstructured and structured Q samples (Saheed, 2014 and Watts and Stenner, 2012).

Unstructured Q samples include statements presumed to be relevant to the topic at hand and are chosen without excessive effort made to ensure coverage of all possible sub-issues. In unstructured Q sample there is high possibility that some topical aspects might be either under-sampled or over-sampled hence a bias of some sort could be unintentionally incorporated into the final Q sample (Saheed, 2014; McKeown and Thomas, 1988). This limitation is catered for in structured Q sample which provides for systematic procedure by which the researcher covers different aspects and sub-issues of the concourse to make the final sampled statements more or less representative of the concourse (Brown, 1980).

Structured Q sample is arrived at by applying Fisher's methods of experimental design to ensure representativeness through the application of principles of variance design (Fisher, 1960) in which the statements are conceptualised theoretically in order to include different aspects of each statement. Du Plessis (2005) stated that, once statements have been gathered from primary and/or secondary sources in the widest sense, the researcher has to organise, analyse and present them properly. In order to ensure balance and representativeness of all sub-issues identified in the narratives constituting the concourse, a 'structured Q sample' procedure is employed. Structured Q samples are composed more systematically because the researcher groups statements according to the categories identified in the narratives surrounding the topic of interest. This is to overcome the shortcoming of unstructured Q samples, where there is a risk that some sub issues or components may be over or under sampled, thereby introducing bias into the final Q sample (Saheed, 2014; Watts and Stenners, 2012; 2005 McKeown and Thomas 1988).

Also the possible unintended bias associated with the application of unstructured Q samples is offset by structured sample which is designed to overcome this bias by ensuring fair representations of all sub-issues by on analytical framework of issues revealed by the narratives gathered (Saheed, 2014). The Q sample statements which will eventually be arrived at, by using structured Q sample approach, would therefore be assigned on the basis of conditions defined by the analytical framework. Thus, the sample design would be deductive in nature, being based on hypothetical and theoretical considerations (Dasgupta and Vira, 2005).

One other strength of structured Q sample is that it enables the researcher to focus on Q sampling around conclusions drawn earlier by the researcher or available literature or expert opinions. As observed by Brown (1996) the method of reasoning can be either deductive, inductive or both. Du Plessis, (2005) opined that, in Q methodology, a deductive factorial design comprises categories and levels that are specified at the outset according to theory that has been clarified at the beginning.

This study employed structured Q sample procedure in arriving at the final Q sample statements. The sub-issues considered included views regarding benefits of GM crops, environmental and health risks associated with the cultivation of GM crops, possible market failures and food sovereignty and security issues. This categorization is informed by Hall (2010) in which underlying factors characterising farmers perceptions towards GM crops were identified as benefit factors, risks factors and fatalists. A similar observation was made by Robert et al (2008) in assessing stakeholders' perceptions towards agrobiotechnology in Ghana.

3.3.3 Selection of P set/Person sample

An equally important step in undertaking Q study is selecting participants from people involved in the discourse for them to Q sort the sampled statements in their preferred order on a Likert type agreement scale. This group of participants selected for Q sorting is referred to as the person-sample. The person-sample, unlike the structured Q sample, does not need to be representative of the population. Participants in Q methodology are sampled theoretically as they are in qualitative research using nonprobability sampling. When sampled theoretically, participants are purposively selected with the expectation that they will hold different points of view on the topic being studied

(Dennis, 1986). Ward (2009), stated that, rather than randomly selecting participants, Q sampling purposefully selects individuals to make sure that certain viewpoints are included based on the research question.

In this study, only smallholder farmers who have ever heard and/or read about GM crops were targeted for sampling. The purpose of the study is to analyse the views and perceptions of farmers about GM crops and how these perceptions and views shape their adoption decision. These farmers were purposively selected with the expectation that they will hold different points of view on the topic.

It can be argued that large samples, which are so fundamental in social research, are rendered relatively unimportant in Q methodology because the emphasis is on the nature of the segments of subjectivity that exist and the extent to which they are similar and dissimilar (Brown 1991). However, a reasonable number of participants are required to establish the existence of a factor for the purposes of comparing one factor with another. A reasonably large P sample tends to increase the reliability of findings of Q study as it expands the possibility of examining various viewpoints and shades of opinion people hold about an issue under investigation and the extent to which these viewpoints are shared or varied among participants (Van Exel, 2005).

In Q methodological approach, P sample, unlike probability sampling techniques is not selected randomly. But rather, it is a structured sample of respondents who are theoretically relevant to the problem under consideration; for instance, persons who are expected to have a clear and distinct viewpoint regarding the problem and, in that quality, may define a factor (Van Exel, 2005 and Brown 1980). Ward (2009), cautioned that, rather than randomly selecting participants, Q sampling purposefully selects individuals to make sure that certain viewpoints are included based upon the research question.

Therefore Q study are not generalised to the population, but to a specific factor type that is a generalisation of a particular perspective (Du Plessis, 2005 and Brown 1980). However, generalisations are valid for other persons of the same perspective, for instance, for those persons whose views would lead them to load highly on a factor (Du Plessis, 2005). Brown (1991) argued that since factors are qualitative categories of thought, additional participants would have virtually no impact on the factor scores (Brown 1991).

In order to ensure representation of all perspectives, Brown (2004), noted that, the strategy for selecting participants should be able to obtain as much diversity as possible on variables such as gender and age. However, the proportion of the population that belongs in one factor rather than another is not important in Q methodology. The focus is upon the views that the factors represent “rather than the group memberships” of the persons comprising the factors (Du Plessis, 2005). The strategy to ensure much diversity as possible in persons sample is not to achieve statistical representativeness of a specific category such as gender, race or generation, but rather to allow the likelihood that all factors of the issue will have an opportunity to show themselves (Du Plessis, 2005 and Brown 1999). The very essence of Q methodology is that, it requires factors to be well defined, for instance, on which four or five participants are substantially loaded. In most Q studies, no more than seven factors and often fewer emerge from the data and as such re-emphasised the need for a relatively small number of participants (Brown, 2008).

Similar view is held by Brown and Good (2013), as they noted that the sample of persons who perform the Q sort (P set) is usually selected on the basis of experimental design procedures and is typically balanced or semi-balanced for gender, age, party identification, or other salient variables arranged factorially. The P set is normally small (typically in the range of 30–50 participants), but as diverse as possible. The goal is for a representative set of participants to respond to a representative set of stimuli so as to maximize the likelihood that whatever subjective segmentations are in circulation will have an opportunity to reveal itself.

However, Brown (2008) states that because the researcher does not know in advance how many factors there are going to be, some tend to "oversample". But the beauty in it is that, the more factors that eventually turn up, the larger the number of participants that will be required to provide good factor definition. Notwithstanding, he emphasises that even though the exact number of participants required cannot be specified in advance, this does not mean that the figure is arbitrary. He further contended that whether or not a small number of participants are adequate also depends on the "factorial diversity" of the wider population (which is not known in advance) as well as on the diversity of the person-sample. He emphasises that a very large person-sample is "counter-productive" because "large numbers of Q sorts can overwhelm operant factors that cannot get out from under the pile".

This study adopted inferential statistic in predicting farmers' adoption decision, which requires a large sample selected through probability sampling techniques. As such, the study considered large P sample to ensure representativeness and robustness in predicting farmers' adoption decision. Also for reliability of Q methodology and suitability of set of data for factor analysis, it is particularly recommended that at least for every one variable or items there should be at least five participants (1:5). As such sample size determination was guided by these tests.

3.3.4 Q sorting process

Q sorting is the "technical means whereby data are obtained for factoring" (Brown 1980:17) and is the qualitative data collection technique in Q methodology (Denzine 1998). Q sorting requires the participant to sort statements about a topic along a specific dimension such as "how relevant", "how interesting", or "how pleasing" the Q sorting process is generally done in the presence of the researcher (Schlinger 1969:53). Prior to sorting the cards, participants are given their condition of instruction for the placement of the cards (Dennis 1986:12).

Administration of Q sorting can be done under many conditions of instruction. These are 'intensive' 'extensive' condition of instruction (Brown, 1991 and McKeown and Thomas, 1988). A condition of instruction is a guide to a participant for sorting the Q sort cards from his or her own point of view (Du Plessis, 2005). An intensive condition of instruction requires participants to sort Q sort cards under many conditions of instruction while under extensive condition of instruction many participants sort the Q sort cards under an identical condition of instruction. The use of an intensive or extensive condition of instruction depends on the nature and purpose of the study. This study sought to understand the factors influencing smallholder farmers' perceptions and attitudes towards GM crops and how these factors shape their adoption decision. As a results extensive person-sample procedure of Q sorting was adopted in instructing respondents to sort the statements on Likert type agreement scale.

A response format which refers to the names chosen for the ranking dimensions after person-sample had been decided on and participants selected, is a logical step to be decided upon so as to help guide participants in their ranking or Q sorting of statements based on their point of view and preference.

The ranking dimensions refer to the participant's viewpoint according to which statements are sorted, for instance, how agreeable or acceptable statements are to participants view points and preference.

If the researcher selects "agreement" as the subjective area of interest, participants would be asked to rank statements using a continuum of "most disagree" to "most agree" (Denzine, 1998). The agreement score is mostly favoured because participants' negative feelings can be as strong as their positive ones. Participants are asked to sort the Q sort cards according to those statements with which they most agree and those with which they most disagree. The current study adopted the agreement ranking score guided by five points Likert type scale format.

The actual data collection procedure for Q factor analysis in a Q study is the Q sorting process (Gabor et al, 2013 and Shinebourne and Adams, 2007). Q sorting is the "technical means whereby data are obtained for factoring" (Brown 1980:17) and is the qualitative data collection technique in Q methodological study (Denzine, 1998). Shinebourne (2009) noted that participants sort the cards according to the instructions given by the researcher. For example, an instruction could be to sort the cards initially into three piles according to whether the person "agrees," "disagrees," or "neither agrees, nor disagrees (neutral)" with the statement. In guiding the sorting process, typically there are two types of condition of instructions, namely, a "forced-choice" or "free-sort" condition of instruction (Dziopa and Ahern, 2011). The researcher then needs to decide whether to use a "forced-choice" or "free-sort" condition of instruction.

A 'forced-choice' condition of instruction requires participant to place the Q sort cards on a pre-set enlarged Q sort diagram with a space for each card. In this arrangement, a participant is forced to place each card on the Q sort diagram in terms of, for instance, agreement and disagreement but in line with his/her viewpoint. However, in the free-sort participants are the ones who determine how many piles (or categories) they need in order to represent their self-perceptions. Thus participants are in no way restricted when given a free sort condition of instruction. They are free to place the Q sort cards in as many piles needed for the specific research problem.

In this study participants' sorting process was guided by the 'forced-choice' condition of instruction. As such participants were asked to sort the statements according to those with which they strongly agrees to and those with which they strongly disagree. To ensure sorting is done in line with condition of instruction but based on participant's viewpoints, participants was instructed to commence the sorting process by initially dividing the statements into three piles comprising those statements they agree with as first pile placed on the right hand side, those they disagreed with as second pile to the left and the remainder in a third pile in the middle as those they are uncertain of or neutral to. This procedure was outlined by Mackeown and Thomas (1988) and has since been used to guide Q sorting process as piling facilitates participants sorting. However, after the participants have finished the piling they will be allowed to change their minds in moving one or more statement cards from one pile to the other.

After the arrangement of statement cards in piles is finished, participants were then asked to spread the statements under the distribution markers, while maintaining the general left-centre-right relationships. This is to facilitate contextual reading of the statements and making appropriate comparison. In the left pile participants were asked to further arrange statements they strongly disagreed with followed by those they just disagreed with. Similar procedure was used for the right pile, where participants sort statements they strongly agreed with and those they merely agreed with.

Individual ranking scores were entered into a questionnaire which contains the statements and various possible ranks of 1 to 5. These ranking score was again entered into SPSS version 20.

3.3.5 Q Factor Analysis

Factor analysis is a multivariate statistical approach commonly used in psychology, education, and more recently in the health-related professions and in social science research in general (Williams, Brown and Onsman, 2012). The primary feature of Q factor analysis is its focus on the correlation and analysis of similitudes among individuals. As a data reduction technique it aimed at reducing complex and large data set to smaller dimensions or constructs which explain much of the variability within the original data set. Factor analysis, as a statistical data reduction method, is usually applied in identifying patterns of shared views and variations in participants' perceptions of the topic being studied (McKeown and Thomas, 2013; Watts and Stenner, 2012).

In Q factor analysis, the correlations are between persons as opposed to variables are factored. It determines which sets of people cluster together. Q factors load on individuals rather than on tests. Kline (1994) referred to Q factor analysis as "inverse factor analysis" because the normal data matrix is turned on its side. The primary feature of Q factor analysis is its focus on the correlation and analysis of similitudes which enable researchers to extract narratives and perceptions of people about a topic of interest in order to identify the underlying dimensions and structures characterising their viewpoints.

In Q factor analysis, the researcher first undertakes factor extraction in order to obtain only the common factors or factors that are of any interest. In this process factors which have eigenvalues of more than 1.00 are extracted, whiles factors with eigenvalues of less than one and close to zero are regarded as insignificant and generally of too little interest to warrant further investigation (Brown, 2009a; Brown, 2009b; Brown 1980; Kline, 2002 and Newman et al, 2010).

In this study, 61 statements were sampled from the concourse of farmers' narratives on GM crops and subjected to Q factor analysis to reduce the dimensions in the data set. This was done to enable the identification of underlying constructs influencing participants' viewpoints as revealed by their ranking or scoring of the statements presented to them. Rank scores of the statements by respondents were therefore entered into SPSS version 20 and subjected to data reduction methods. Initially, a correlation matrix between Q-sorts of participants was built, and the chosen multivariate technique of data reduction applied to reduce the correlation matrix into components.

3.4 Population and Sampling Procedure

The targeted districts for the study comprises of all the twenty six (26) districts in Northern region, the eleven (11) and the thirteen (13) districts in the Upper West and East regions respectively (GoG, 2010). The study targeted all smallholder crops farmers belonging to FBOs across the 50 districts in the three regions. Data on smallholder farmers belonging to FBOs sourced from the regional offices of MOFA in the three regions and complimented with data on FBOs obtained from MOFA' FBOs website http://fboghana.com/ (accessed on 15th December, 2015) was compiled and used to guide sample size determination. As at December, 2015 there were 4,288 FBOs with 96,853 of its membership being crop farmers (MOFA, 2015).

3.4.1 Sample Size Determination

Sample size determination was guided by Cochran's sample size determination formula:

$$n = \frac{N}{1+Ne^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.1)}$$

Where:

n = Sample size

N = Population of smallholder farmers

e = margin of error (0.05)

With the application of the formula the sample size used in the study was 120 FBOs and 360 smallholder farmers. The main respondents for study were 360 smallholder crops farmers.

3.4.2 Sampling Procedure

Multi-stage sampling procedures were adopted in selecting respondents for the study. Starting from purposive sampling of crop based FBOs and smallholder farmers who have ever heard and/or read about GM crops from the sampled FBOs. In selecting districts where the field survey was conducted, a stratified random sampling technique was employed. The three regions constituted the basis for stratification, where three (3) strata namely Northern, Upper East and Upper West regions were considered.

Only districts with registered FBOs with contact details on the portal of FBOs in Ghana captured on the website of MOFA for 2015 available on http://fboghana.com/ and those whose contact persons were obtained at the regional agricultural development units were considered for sampling. FBOs within each of the sampled districts were sampled using lottery method of simple random sampling technique.

With northern region constituting about half of the total FBOs in the three regions (Table 3.1), and based on proportion to size, five (5) districts were sampled from Northern region, while three (3) and two (2) districts respectively from Upper East and Upper West Regions making a total of ten (10) sample districts. Out of the twenty six (26) districts in the Northern region, four districts do not have their registered FBOs hosted on the FBOs portal of MOFA and as such were not included in the sampling process.

Kasena/Nankana East District, Bolgatanga Municipality and Bawku West District were sampled from the 13 Districts in the Upper East Region while Nadowli/Kaleo District and Wa Municipality were sampled from the 11 Districts in the Upper West Region. And Bole District, West Mamprusi District, Savelugu/Nanton Municipality, Gushiegu District and Nanumba North District were sampled from the 24 eligible Districts in the Northern Region. Similarly, the number of FBOs selected from each sampled district was done based on proportion to size taking the total FBOs in all the sampled districts in the region into consideration. The distributions of number of FBOs selected from each region and districts are shown in the Table 3.1.

Table 3. 1: Number of respondents sampled from regions and districts

Region	Districts	sampled Districts	No of FBOs in the region	FBOs in sampled Districts	Sampled FBOs	smallholder farmers sampled
Northern	26	5	2,573	584	74	222
Upper East	13	3	943	220	28	84
Upper West	11	2	772	140	18	54
Total	**50**	**10**	**4, 288**	944	**120**	**360**

Author, 2015

As shown in table 3.1, there were 944 FBOs in the ten (10) sampled districts, comprising of 584 from northern region and 220 and 140 FBOs from the Upper East and Upper West Regions respectively.

As such by proportion to size, 74, 28 and 18 FBOs were sampled from Northern, Upper East and Upper West Regions respectively. With 222, 84 and 54 smallholder farmers from the sampled FBOs selected based on their awareness of GM crops to response to the personal interviews conducted.

Also five focus group discussions, three in northern region and one each in the upper east and west regions were held with an average of 9 participants per focus group discussion. In all forty seven (47) participants took part in the focus group discussions. In addition, in-depth interviews prior to the actual field survey were conducted with thirteen (13) key informants comprising of ten (10) leaders of FBOs and three (3) commercial farmers across the three regions. Thus the total participants in this study were four hundred and twenty (420) comprising of 360 smallholder farmers who responded to the personal interviews, forty seven (47) participants of the five focus group discussions held and thirteen (13) key informants interviewed in gathering concourse of farmers' narratives on GM crops.

3.5 Data Collection Process

Both qualitative and quantitative data were collected from primary and secondary sources. Field survey, comprising personal observations, focus group discussions, key informant interviews and personal interviews were employed in collecting primary data for this study. Q methodological process of gathering concourse, formulating statements and Q sorting as explained in section 3.4 were fully employed in data collection.

3.5.1 Focus Group Discussion

Five (5) focus group discussions, three in northern region one in each in the upper east and west regions were conducted to gather information on farmers' general knowledge and views about GM crops. Since focus group discussion is noted to be useful in exploring and examining people's views, how they think, and why they think the way they do about the issues of importance to them without pressuring them into making decisions or reaching a consensus, as observed by Bhana (2009), it was considered as an appropriate data technique to be employed in this study. According to Kitzinger (2005), focus group method is an 'ideal' approach for examining the stories, experiences, points of view, beliefs, needs and concerns of individuals.

At each focus group meeting, participants were required to discuss issues relating to their awareness and knowledge of GM crops. Participants' source of information on GM crops was also explored and how these sources influence their basic knowledge of GM crops. Also participants' awareness and views on institutional, legislative and regulatory frameworks put in place to safeguard agrobiotechnology research and eventual commercial production of GM crops and food in the country with minimal risks to health and the environment were discussed. Similar methodology was used by Adenle, Alhassan and Solomon (2014) in assessing potential benefits of genetic modification (GM) technology for food security in Ghana and Nigeria.

To facilitate and guide discussions at the various focus group meetings, a check list on broad issues regarding awareness, knowledge, views and perceptions of participants was developed based on available literature and used to guide the discussions. With the permission of participants, the discussions were recorded and later transcribed for analysis. The discussions were conducted in the local dialects to ensure active and full participation of all participants who took part in the discussion.

3.5.2 In-depth Personal Interview

According to Boyce and Neale, (2006: pp3) 'in-depth interviewing is a qualitative research technique that involves conducting intensive individual interviews with a small number of respondents to explore their perspectives on a particular idea, programme, or situation'. As such an in-depth interview was conducted with ten (10) smallholder farmers (one from each sampled district) and one commercial farmer in each of the three regions. The broader issues which key informants responded to, included what they know about GM crops, their potential benefits and risks, among others. Also issues relating to Ghana's agrobiotechnology agenda, the country's agrobiotechnology research and biosafety regulatory regimes were presented to key informants to comment on. Other broad issues key informants commented on were farmers' ability and willingness to adopt GM crops cultivation, the prospects and challenges involved in the cultivation of GM crops among others.

Based on information obtained from in-depth interviews with key informants, concourse of farmers' narratives on GM crops were compiled and 61 statements were sampled from them. The sixty one (61) statements were then presented to the three hundred and sixty smallholder farmers interviewed during the personal interviews session.

3.5.3 Personal Interview Process

Three hundred and sixty (360) farmers from one hundred twenty FBOs in the ten (10) sampled districts were interviewed guided by semi structured interview guide. The personal interviews sessions were also used to allow respondents rank the sixty one (61) statements extracted from the narratives on GM crops gathered during the in-depth interviews sessions. Agreement rank scores designed in five points Likert scale on Q – sort board was used to guide the ranking process.

Force choice sorting condition of instruction was applied in ranking the statements. As such respondents were required to sort the statements into three piles. One pile on the right for statements respondents agreed with, the left pile for statements respondents disagreed with and the third pile for those statements respondents neither agreed nor disagreed with. Working from the right pile, participants then select statements they strongly agreed and then from the left pile they then select and placed the statements they strongly disagreed. Their ranks were then captured in the questionnaire for each statement. Similar procedure was used by Zakaria *et al* (2014) and Hall (2010) in assessing perceptions and attitudes of farmers towards GM crops.

The semi structured questionnaire used in gathering data were divided into five sections, namely section A, B, C, D and E. Section A, of the questionnaire contains questions designed to capture information on organizational characteristics of FBOs such as registration status, membership structure, operations among others. While sections B of the questionnaire contains questions relating to farmers demographic data such as educational background, age, sex, household size and annual income among others. Section C gathered information on farm characteristics of respondents such as farm size, major crop grown, access to labour, access to extension services and major problem in crop production among others. That of Section D contains questions designed to solicit data regarding GM crops and agrobiotechnology such as source of information on GM crops, knowledge on GM crops, prospects and challenges in cultivating GM crops. Section E contains statements to be ranked by respondents. This section provide table for recording individual respondents' Q sorts of all the statements presented to them for sorting.

3.5.4 Validity and Reliability of Data Collection Instruments

Semi – structured questions, check list for group discussions and interview guide were instruments developed and used by the researcher in collecting data for this study. Before the instruments were used to collect data, their validity and reliability were assessed. This was done to ensure that the instruments actual measure the concepts it were designed to measure and that they can be relied upon in collecting the required data for the study.

Validity shows how appropriate an instrument is in measuring the concepts it designed to measure. It tells how well an instrument is in measuring the required concept. Validity can also refer to the degree to which a study accurately reflects or assesses the specific concept that the researcher is attempting to measure. Two types of validity namely Content Validity and Criterion-related Validity, which are widely applied (Bowling and Ebrahim 2005 and Njoroge and Orodho 2014), are considered in this study. Content validity ensures that the items adequately represent the subject area and had a relationship with the concept as operationally defined. Content validity ensures that the measure includes an adequate and representative set of items of the concepts that are intended to be measured (Bowling and Ebrahim 2005). In other words, it is the function of how well the dimensions and elements of a concept have been delineated.

To ensure content validity, the data collection instruments were scrutinized by experts, including my supervisors and other senior academics in the faculty to assess whether the content of the instruments can adequately and appropriately measure what they were designed to measure.

3.5.4.1 Validity of Data Collection Instruments

Available literature on farmers' technology adoption, issues relating to farmers' knowledge and perception on GM crops, decision making and behaviour change guided by the Theory of Planned Behaviour formed the selection of concepts, variables and issues included in the data collection instruments used in the study. This was done to ensure that the instruments are valid and appropriate in addressing the study objectives. After the instruments were constructed, they were first, presented to two senior academics in the faculty with experience in adoption studies for validation and content adequacy and appropriateness assessment. Their review led to some corrections, modifications and restructuring of some items in the instruments. After which, my supervisors also did thorough assessment of the instrument. They assessed the face, content and construct validity of the instruments. Their reviewed also led to the amendment of some items in the instrument. The corrections and suggestions were incorporated.

Pre-tested of the instruments were done in the Central Gonja District to assess the instruments in terms of time required for each item; familiarity of the terminologies used and required; and participants' understanding of the statements in the instruments. Based on findings from the pre-test results the instruments were further amended to ensure easy understanding. The pre-test also provided data for Cronbach Alpha reliability test.

3.5.4.2 Reliability of data collection instruments

Reliability generally deals with how consistently the measurement technique measures the concept of interest under study. It deals with dependability, consistency, accuracy and comparability. In order to ensure that the questionnaire possessed reliability desire, the researcher conducted a pre-test by administering the questionnaire to 25 selected farmers who were smallholder farmers in the Central Gonja District of the Northern region. This was to assess how well the questionnaire can be relied upon to measure the concepts it was designed to measure and to identify the flaws and correct them. The pre-test afforded the researcher the opportunity to assess the reliability of the instruments and effect the necessary changes before it was used to collect the data for the study. Internal consistency (Cronbach alpha) of the questionnaire was assessed using the pre-test data. The results of the assessment found Cronbach alpha to be 0.82, indicating that the questionnaire is reliable (Warner, 2009).

3.6 Data Analysis

Both quantitative and qualitative analytical techniques were employed in analysing data collected in the survey. The study employed mixed methodological process of studying narratives, discourse, viewpoints and perceptions as well as quantitative variables such as ranking, scoring, farm outputs, annual household income among other socioeconomic characteristics, in describing factors influencing farmers' perceptions towards GM crops and inferential statistics in predicting farmers adoption decision regarding the cultivation of GM crops.

3.6.1. Qualitative Data analysis

For the qualitative data gathered from the focus group discussions and in-depth interviews, content analytical techniques with open coding and aided by F4 analyse software were employed in identifying main and sub themes portraying respondents' knowledge about GM. This analytical approach was employed to address objective one of this study, which sought to analyse farmers' knowledge and understanding about GM crops.

Content analysis is a widely used qualitative research technique. The applications of content analysis show three distinct approaches namely conventional, directed, or summative. All three approaches are used to interpret meaning from the content of text data and, hence, adhere to the naturalistic paradigm (Hsieh and Shannon, 2005). The major differences among the approaches are coding schemes, origins of codes, and threats to trustworthiness. In conventional content analysis, coding categories are derived directly from the text data. As such this study applied conventional content analysis with open and direct coding procedure.

Analysis of the qualitative data began with open coding system, where transcribed narratives obtained from focus group discussions and in-depth interviews were broken down into smaller parts. That is, all data obtained from qualitative research questions were closely examined for categories, main themes and sub-themes.

To successfully categorize and identify themes and subtheme from interview scripts, the following guide lines provided in Strauss and Corbin, (1990) were strictly followed:

a) Interviewees' responses were compared, grouped and labelled according to similar responses as main themes.
b) The labelled responses were again categorized according to similar concepts and later grouped and labelled as sub-themes.
c) Thereafter, the main themes and sub-themes were named according to what seem fit logically in each category, and
d) Finally, main themes were developed according to the research questions.

The central issue in analysing the qualitative data gathered was to find relationships and connecting the conceptual categories identified and labelled at stage one of the four steps outlined above. This enables alignment and merger of substantive codes or conceptual categories. That is, it was a way of rebuilding new relationships between main themes and sub-themes. To establish nexus of relationship between themes and sub-themes the following guide lines were adhered to:

a) First the main themes were branded from the open coding procedures for further categorization of the data.
b) Then, the main themes and sub-themes were interconnected to produce a set of scheme.
c) Selective coding was then applied to the scheme to produce the core categories.

The generated main themes and sub-themes were put together to build the concepts and summarization of the qualitative narrative. This method of qualitative data analysis is repeatedly applied to all data generated from the qualitative component of the study. Outcomes of the qualitative data analysis complement the descriptive and inferential statistics applied in the study.

Other apart of objective one, sought to examine farmers' self-examined knowledge and understanding on GM crops, which was measured on a five point Likert scale as 5 = 'very well informed' 4 = well informed 3 = somewhat informed' 2 = 'less informed' and 1 = 'not informed at all'. This was analysed by the use of descriptive. Similar approach was used by Chern (2006) in assessing respondents in Japan and USA information and knowledge on GM food and GMOs.

3.6.2 Analysis of Farmers' Perceptions towards GM crops

Exploratory Factor Analysis (EFA) was applied to farmers' rank scores of statements extracted from their narratives on GM crops and agrobiotechnology in general to identify underlying factors characterising farmers' perceptions towards GM crops. Factor analysis in general is a multivariate statistical procedure that has many uses, three of which is particularly important to this study. As observed by Williams, Brown and Onsman, (2012), firstly, factor analysis reduces a large number of variables into a smaller set of variables (also referred to as factors). Secondly, it establishes underlying dimensions between measured variables and latent constructs, thereby allowing the formation and refinement of theory. Thirdly, it provides construct validity evidence of self-reporting scales.

Despite EFA being a seemingly complex statistical approach, the approach taken in the analysis is in fact sequential and linear, involving many options (Thompson, 2004). As such, the sequential step by steps protocol of undertaking EFA suggested by Williams et al (2012) was strictly applied. These consist of five steps starting with assessing the suitability of the data set for factor analysis, factor extraction, determination of suitable number of factors to extract, rotation method to use and interpretation and labelling of extracted factors.

3.6.2.1Suitability of Data Set for EFA

The sample size consisting of 360 smallholder farmers who participated in ranking the sixty one (61) items (statements) were subjected to factor analysis suitability test to ensure the data set is suitable for factor analysis. Although sample size is important in factor analysis, there are varying opinions, and several guiding rules of thumb as observed by Williams *et al*, (2012). Also Tabachnick and Fidell (2007) lamented the lack of agreement on suitable sample size for factor analysis and suggested that at least 300 cases are needed for factor analysis. The Minimum of 300 cases or sample size being suitable for factor analysis is widely referred to as 'Tabachnick's rule of thumb'. However Hair et al (1995) suggested that sample sizes should be 100 or greater to allow for factor analysis. In this study the sample size is 360 and as such met 'Tabachnick's rule of thumb' and Hair et al, (1995).

Notwithstanding, MacCallum, Widaman, Zhang, and Hong (1999) and Henson and Roberts, (2006) as cited in Williams et al (2012) observed that such rules of thumb can at times be misleading and often do not take into account many of the complex dynamics of a factor analysis. They illustrated that when communalities are high (greater than 0.60) and each factor is defined by several items, sample sizes can actually be relatively small. Higher communalities with correlation coefficients of >0.80 require smaller sample sizes (Guadagnoli and Velicer, 1988), while Sapnas and Zeller (2002) point out that even 50 cases may be adequate for factor analysis.

Another set of recommendations also exist providing researchers with guidance regarding how many participants are required for each variable, often termed, the sample to variable ratio, often denoted as N:P ratio where N refers to the number of participants and P refers to the number of variables (Hogarty et al 2005 as cited in Williams *et al* 2012). The same disparate recommendations also occur for sample to variable ratios as they do for determining adequate sample sizes (Hair et al, 1995 and Hogarty et al, 2005 as cited Williams et al, 2012). For example, rules of thumb range anywhere from 3:1, 6:1 or 10:1 is considered suitable for factor analysis. In this study the sample to variable ratio is 6:1 which met the criteria for factor analysis.

Correlation matrix was also constructed to assess the correlation among variable in order to determine their suitability for factor analysis. According to Williams *et al* (2012) correlation matrix should be used in the EFA process displaying the relationships between individual variables. Henson and Roberts, (2006) noted that a correlation matrix is most popular among investigators. Tabachnick and Fidell (2007) recommended inspecting the correlation matrix (often termed Factorability of R) for correlation coefficients over 0.30. As such correlation matrix of variables used in the exploratory factor model was calculated and their relative strengths captured by factor loading were also determined.

Hair et al (1995) categorised these loadings using a rule of thumb as ±0.30 = minimal, ±0.40 = important, and ±0.50 = practically significant. After inspection if no correlations go beyond 0.30, then the researcher should reconsider whether factor analysis is the appropriate statistical method to apply on the data set (Williams *et al,* 2012). This means that, a factorability of 0.3 indicates that the factors account for approximately 30% relationship within the data, or in a practical sense, it would indicate that a third of the variables share too much variance, and hence becomes impractical to determine if the variables are correlated with each other or the dependent variable.

Before factors analysis was undertaken for factor extraction, Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy (Kaiser, 1970 and Kaiser, Little, Jiffy and Mark, 1974) and Bartlett's Test of Sphericity (Bartlett. 1950) were conducted to determine the accuracy and suitability of the data set for factor analysis. Williams *et al*, (2012) observed that KMO index, is particularly recommended at least for every one variable or items there should be at least five participants (1:5). In this study, 360 participants were involved in ranking 61 items, representing cases to variable ratio of 1: 6. The KMO index ranges from 0 to 1, with 0.50 considered suitable for factor analysis (Hair et al, 1995 and Tabachnick et al, 2007). The Bartlett's Test of Sphericity should be significant ($p<0.05$) for factor analysis to be suitable (Williams et al, 2012).

3.6.2.2 Method of Factor Extraction

There are numerous ways to extract factors, some of which include Principal Components Analysis (PCA), Principal Axis Factoring (PAF), image factoring, maximum likelihood, alpha factoring and canonical. However, PCA and PAF are used widely and most commonly in published literature (Henson and Roberts, 2006 and Tabachnick *et al*, 207 as cited in Williams et al, 2012).

In this study PAF was used in extracting factors. However, the decision whether to use PCA and PAF is fiercely debated among analysts (Henson and Roberts, 2006 and Williams et al, 2012), although according to Thompson (2004) the practical differences between the two are often insignificant, particularly when variables have high reliability, or where there are 30 or more variables. In this current study the variables being examined are 61 (far more than the threshold of 30 variables) hence the decision to used PAF.

3.6.2.3 Criteria in Determining Factor Extraction

The aim of the data extraction is to reduce a large number of items into factors. In order to produce scale unidimensionality, and simplify the factor solutions several criteria are available to researchers (Williams *et al*, 2012). However, given the choice and sometimes confusing nature of factor analysis, no single criteria should be assumed to determine factor extraction (Costello and Osborne, 2005). Many extraction rules and approaches exist including cumulative percentage of variance criterion, Kaiser's criteria (eigenvalue > 1 rule), the Scree test, the cumulative percentage of variance extracted, and parallel analysis.

Cumulative percentage of variance (criterion) is another area of disagreement in the factor analysis approach, particularly in different disciplines, for example, the natural sciences, psychology, and the humanities (Henson and Roberts, 2006). Williams *et al* (2012) observed no fixed threshold exists, although certain percentages have been suggested. According to Hair *et al* (1995) in the natural sciences, factors should be stopped when at least 95% of the variance is explained. In the humanities, the explained variance is commonly as low as 50-60%, as observed in Williams et al (2012).

The 'Scree Test' was given its name by Cattell (1978) due to the Scree Test graphical presentation, which has visual similarities to the rock debris (Scree) at the foot of a mountain (Williams et al, 2012). Inspecting and interpretation of a Scree plot involves two steps:

1. Draw a straight line through the smaller eigenvalues where a departure from this line occurs. This point highlights where the debris or break occurs. (If the Scree is messy, and difficult to interpret, additional manipulation of data and extraction should be undertaken).
2. The point above this debris or break (not including the break itself) indicates the number of factors to be retained.

However, as noted by Gorsuch (1983), Tabachnick and Fidell (2001) and Thompson (2004) interpreting Scree plots is subjective, requiring researcher judgement. Thus, disagreement over which factors should be retained is often open for debate. Although this disagreement and subjectivity is reduced when sample sizes are large, N:P ratios are (>3:1) and communalities values are high (Pett et al, 2003).

All these approaches were used in this study in settling on the number of factors to extract. Thus multiple decision rules were applied in guiding the number of factor solution to extract. The decision to apply multiple criteria for determining number of factors to extract was informed by literature. Thompson and Daniel (1996; p.200) stated that the "simultaneous use of multiple decision rules is appropriate and often desirable". Also Hair *et al* (1995) point out that the majority of factor analysts typically use multiple criteria. Williams *et al* (2012) observed that many peer-reviewed educational and psychological measurement journals now request that multiple extraction techniques are used for a manuscript to be accepted for publication.

3.6.2.4 Selection of Rotational Method

The aim of rotation is to simplify the factor structure of a group of items, or in other words, high item loadings on one factor and smaller item loadings on the remaining factor solutions (Costello and Osborne, 2005 as cited in Williams et al, 2012). Another consideration when deciding on how many factors to extract will depend whether a variable might relate to more than one factor. Rotation maximises high item loadings and minimises low item loadings, therefore producing a more interpretable and simplified solution (Williams et al, 2012). There are two common rotation techniques, namely orthogonal rotation and oblique rotation. Researchers have several methods to choose from both rotation options, for example, orthogonal varimax/quartimax or oblique olbimin/promax.

In this study, varimax rotation method was applied. Orthogonal Varimax rotation is the most common rotational technique used in factor analysis (Thompson 2004). However, regardless of which rotation method is used, the main objectives are to provide easier interpretation of results, and produce a solution that is more parsimonious (Hair and Anderson, 1995 and Kieffer, 1999).

In this study after the loading is calculated, Varimax rotation techniques was employed in transforming the Q factor loadings on orthogonal axes to obtained easily extractable factors. According to Kline (1994), the varimax factor rotation, devised by Kaiser (1958; 1959), is strictly mathematical and provides an orthogonal solution. This means that factors are rotated in such a way that they are always at right angles to each other, that is, the factors are uncorrelated. Pett, et al, (2003) explained that varimax rotation is an orthogonal rotation of the factor axes to maximize the variance of the squared loadings of a factor (column) on all the variables (rows) in a factor matrix, which has the effect of differentiating the original variables by extracted factor. By that rotation a varimax solution yields results which make it as easy as possible to identify each variable with a single factor by eliminating overlaps and simplifying the construct for interpretation.

3.6.2.5 Interpretation

Interpretation involves the researcher examining which variables are attributable to a factor, and giving that factor a name or theme (Williams et al, 2012). For example, a factor may have included five variables which all relate to pain perception; therefore the researcher would create a label of "pain perception" for that factor. Henson and Roberts (2006) observed that, traditionally, at least two or three variables must load on a factor so it can be given a meaningful interpretation. They further argued that labelling of factors is a subjective, theoretical, and inductive process. The meaningfulness of latent factors is ultimately dependent on researcher definition.

The factors extracted in this study were labelled based on the meaning of statements loaded onto them. Finally, calculation of factor score and the determination of factor constructs after rotation have been undertaken were accomplished by standardization of the factor score. This final phase of a Q study involves analysing and interpreting the results of the factor analysis. This is accomplished through the assessment of factor scores and the interpretation of the factor array as well as identifying consensus statements as shared view of the participants.

3.7 Analysis of Determinants of Adoption Decision

Farmers' adoption decision towards the cultivation of GM crops or otherwise, when the country eventually allows commercial production of GM crops, was modelled guided by Ajzen's (2006) Theory of Planned Behaviour (TPB) and Random Utility Theory (RUT). Respondents were asked a direct question, 'do you intend to adopt the cultivation of GM crops when the technology is finally commercialised in Ghana? As such their response was binary as 'Yes' or 'No'. And these responses provided basis for determining factors that could influence their decision regarding the cultivation of GM crops.

Theoretical basis relied on in modelling determinants of respondents' decision on the cultivation of GM crops were Ajzen's (2006) Theory of Planned Behaviour (TPB) and McFadden's (1974) Random Utility Theory (RUT).

3.7.1 Application of TPB

The overall aim of the TPB is to predict deliberative and planned decision undertaken under rational basis and within the context of societal and individual limitations and constraints. The theory posits that behavioural decision is a function of an individual's attitude toward the said behaviour which reflects individual perceptions about the probable outcome of the said behaviour. It further relates individual decision or intention to act on how they view societal perceptions about the said decision.

And this is referred to as subjective norm, because individual intention is subject to societal approval or otherwise which is dependent on societal norms and beliefs. As such individual decision or intention to undertake an action is strongly influenced by their social environment such as family, friends/colleagues and society at large. Finally perceived behavioural control which reflects individual perceptions or beliefs regarding absence or presence of factors that might facilitate or impede the performance of such intention is noted in the TPB as a critical variable in predicting individual intended behaviour (Ajzen 1991 and 2006).

All these understanding inform the modelling and selection of explanatory variables used in the determinants of farmers' adoption decision towards the cultivation of GM crops.

3.7.2 Application of Random Utility Theory

The random utility theory follows the utility-maximization condition which assumes that rational farmers will select a technology only if the said technology provides him the highest utility given a constraint. Based on this theory, the research attempts to deduce farmers' decision to adopt GM crops as a choice problem. McFadden (1974) developed the random utility models which are appropriate for modeling individuals' behaviour based on choice.

3.7.2.1 Basic Assumptions of RUT

RUT is based on the hypothesis that every individual is a rational decision-maker, maximizing utility relative to his or her choice. Specifically, the theory is based on the following assumptions.

a. The generic decision-maker i, in making a choice, consider m_i mutually exclusive alternative that constitutes her choice as I^i. The choice set may differ according to the decision-maker.

b. Decision-maker i assigns to each alternative j in his choice of set a perceived utility or 'attractiveness' U_j^i and selects the alternative that maximizes this utility;

c. The utility assigned to each choice alternative depends on a number of measurable characteristics or attributes, of the alternative itself and of the decision-maker ; $U^i_j = U^i(X_j^i)$, where X^i_j is the vector of attributes relative to alternative j and to the decision-maker i;

d. Because of various factors, the utility assigned by decision-maker i to alternative j is not known with certainty by the external observer (analyst) wishing to model the decision-maker's choice behaviour, thus U^i_j must be represented in general by a random variable.

From the above assumptions, it is not usually possible to predict with certainty the alternative that the generic decision-maker will select. However, it is possible to express the probability that the decision-maker will select alternative j conditional on her choice set I^i; with the probability that the perceived utility of alternative j is greater than that of all the other available alternatives as shown in the equation 3.2 (Cascetta, 2009) .

$$P^i (j/I^i) = Pr [U^i_j > U^i_k \ \forall k \neq j, k € I^i] \quad \text{…} (3.2)$$

In general, the utility a farmer derives from a technology can be represented as having two components; a utility function of observed characteristics known as the deterministic component of utility and the unobserved component known as the random component. The deterministic component is exogenous and includes farmers' characteristics and product characteristics and a set of linearly related parameters and the random component may result from missing data/variables (omitted variable), measurement errors and misspecification of the utility function.

This function is specified below:

$$U_j = X\beta + \varepsilon \qquad \text{...(3.3)}$$

Where,

$X\beta = v$

where U_{ij} is the maximum utility attainable when alternative j is chosen by decision-maker i; $X\beta$ is the deterministic component of the utility function, X is a vector of observable socio-demographic and economic characteristics, product-specific factors that influence utility, β is the unknown parameter vector to be estimated and ε is the stochastic term.

Wittink (2011) observed that in probabilistic choice theory, it is argued that we cannot approximate human behaviour by deterministic parameters. It seems plausible to state that human behaviour has a probabilistic nature. Furthermore, it can be argued that whilst the decision-maker has knowledge of his or her utility function, the researcher or analyst does not know the exact form. As such probit regression model, as a probability model was applied.

3.7.3 Probit Regression Analysis

In identifying determinants of farmers' adoption decision, probit regression analysis was used. Probit regression analysis being probability cumulative normal distribution function (Rencher, 2002 and Gujarati, 2004) was considered appropriate for modeling a binary choice situation. The dependent variable in this study is farmers' prospective decision or choice towards adoption of GM crops cultivation, which was measured as binary (1 = 'yes intending to adopt'; 0 = 'no, do not intend to adopt).

Therefore, a binary choice multivariate analytical technique was considered in assessing factors which accurately predict farmers' adoption decision. 'Multivariate analysis consists of a collection of methods that can be used when several measurements are made on each individual or object in one or more samples' (Rencher, 2002 pp1). In formulating analytical model for binary or dichotomy independent variable, usually a Cumulative Distribution Function (CDF) is used (Rencher, 2002 and Gujarati, 2004).

Another important binary choice model is the logit regression model which produces similar results as that of Probit model. The difference between logit and Probit models lies in this assumption about the distribution of the errors. The logit model has standard logistic distribution of errors where the Probit model has standard normal distribution of errors (Gujarati, 2004; Sesabo, Lang and Tol 2006 and Hill, Griffiths and Lim, 2008).

But then the choice of employing the probit model for the analysis was based on its realistic standard normal distribution of errors (Gujarati, 2004). The Probit model assumes that there is a latent continuous variable that determines the value of the observed dependent variable specified as;

$$y^* = \beta_0 + \sum_{i=1}^{n} xi\beta i + u_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.4)$$

Where y* is the latent continuous variable, X_i is a set of explanatory variables assumed to influence adoption, β_i is a vector of unknown parameter to be estimated and u_i is the statistical noise assume to be normally and independently distributed with a zero mean and a constant variance. The method of estimation of the Probit model was by maximum likelihood and interpretation of Probit results were based on marginal effects treated as probabilities, which explains the slope of the probability curve relating one explanatory variable to prob(y=1|x), holding all other variables constant.

The observable dependent variable is defined by:

$$y = \begin{cases} 1 \; Yes \; if \; y^* > 0 \\ 0 \; No \; if \; y^* \leq 0 \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.5)$$

The probit model Y follows the Bernoulli distribution with probability

$$\pi_i = prob(y = 1) = \Phi(X\beta) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.6)$$

Where π_i is the probability that individual intend to adopt the cultivation of GM crops, $X_i^{'}$ is the explanatory variables, β is the regression parameters to be estimated.

In the Probit model functional distribution of error is very important to constrain the values of the latent variable into desirable property of probability values of 0 and 1. The Probit model assumes a cumulative distribution function of standard normal distribution represented by Φ.

$$\begin{aligned} prob(y=1) &= prob(y_i^* > 0) = prob(\beta X + e > 0) \\ &= prob(e > -\beta X) \\ &= prob(e < \beta X) \\ &= \Phi(\beta X) \end{aligned} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.7)$$

In the case of normal distribution function, the model to estimate the probability of observing a farmer intend adopting the cultivation of GM crops can be stated as:

$$Pr\,ob(y_i = 1/\mathrm{X}) = \Phi(\beta X) = \int_{-\infty}^{\beta X} \frac{1}{\sqrt{2\Pi}} exp\left[\frac{-z^2}{2}\right] \partial z \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.8)$$

Where

Prob is the probability of the farmer intending to adopt the cultivation of GM crops, X is a vector of the explanatory Variables, z is the Standard Normal Variable (z ~N $(0, \delta^2)$) and β is a k by 1 vector of the Coefficients estimated.

3.7.3.1Empirical model

Theory of Planned Behaviour and Random Utility Theory were adopted in guiding the selection of explanatory variables used in the model. Explanatory variables consist of farmers' socioeconomic characteristics, knowledge, information and perception on GM crops were selected to be included in the model.

Therefore, the Empirical Probit model is specified in the following form:

$$Y_i = \beta_0 + \beta_1 X_1 i + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 i + \beta_6 X_{6i} + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10i} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} + \beta_{14} X_{14} + \beta_{15} X_{15i} + \beta_{16} X_{16} + \beta_{17} X_{17} + \mu \quad \ldots\ldots(3.9)$$

The definition, description and a priori expectations of variables used in the model above is presented in the Table 3.2.

Table 3.2 Definition of Variables used in the Probit Model

Variable	Description	A priori Expectation
	Dependent Variable	
Y_j	Adoption Decision (dummied as i = 1; if a farmer intend to adopt; 0 = otherwise)	
	Independent Variable	
X_{1i}	Sex (Dummied as i = 1 if male; otherwise = 0)	+/-
X_2	Age (in years)	+
X_3	Household size (number of persons)	+
X_4	Education (number of years of formal schooling)	+
X_{5i}	Religion (Dummied as i = 1: if traditional; i =0; if otherwise)	-
X_{6i}	Marital Status (Dummied i= 1 if married; i= 0 if otherwise)	+
X_7	Farm Size (acres)	+
X_8	Ratio of crop income to HH income	+
X_9	Experience in crop Farming (years)	+
X_{10i}	Source of Information on GM crops (Dummied as i= 1; if mass media; i=0; otherwise)	-
X_{11}	Positive attitude (Score on positive statements on GM crops)	+
X_{12}	Negative attitude (Score on negative statements on GM crops)	-
X_{13}	Sceptic attitude (Score on scepticisms statements on GM crops)	-
X_{14}	Dispassionate attitude (Score on Dispassionate statements on GM crops)	-
X_{15i}	Used of certified seed (Dummied as i= 1; if yes; i= 0; if otherwise)	+
X_{16}	Experience in FBO (in years)	+
X_{17}	Extension contact (number of extension contact/visit in a season)	+

Source: Author, 2015

3.8 Analysis of Prospects and Constraints

During the interview session, respondents were asked to list and rank the likely prospects and constraints to the adoption and cultivation of GM crops. Descriptive statistics analysis was undertaken to analyse the distribution of respondents' rank scores. Also Kendall's coefficient of concordance was applied to examine the level of agreement among respondents' ranks of the prospects and constraints to the cultivation of GM crops. Kendall's Coefficient of Concordance (W) is an index that measures the ratio of the observed variance of the sum of ranks to the maximum possible variance of sum ranks.

The idea behind this index is to find the sum of the ranks for each constraint being ranked and then analyse the variability of this sum (Legendre, 2010). If the rankings are in perfect agreement, the variability among the sums will be a maximum. It is used to assess the degree to which respondents in a study provide common ranking on an issue.

W, as an index ratio must vary between zero (0) to one (1). The closer *W* is to one (1) the higher the degree of agreement among rank score assigned by respondents. Similarly, the closer *W* is to zero the higher degree of disagreement among rank scores. If *W* is one (1) then the ranks assigned by each respondent are assumed to be the same as those assigned by other respondent and zero (0) when there is maximum disagreement among the rankings by the respondents.

Applying preference ranking, the total rank score for each item is computed and *W* calculated. The *W* is calculated using the formulae;

$$W = \frac{12(S)}{m^2(n)(n^2-1)-mT} \quad \text{……………………………………………………….(3.10)}$$

Where ***n*** is the number of objects, ***m*** is the number of variables and ***T*** is a correction factor, ***S*** is a sum-of-squares statistic over the row sums of ranks R_i, and R is the mean of the R_i values computed first from the row-marginal sums of ranks R_i received by the objects:

$$S = \sum_{i=1}^{n}(R_i - \bar{R})^2 \quad \text{……………………………………………………………. (3.11)}$$

To count for possible tied ranks ***T*** is;

$$T = \sum_{k=1}^{g} t_k^3 - t_k \quad \text{……………………………………………………………. (3.12)}$$

t_k = the number of tied ranks in each (*k*) of g groups of ties. The sum is computed over all groups of ties found in all m variables of the data table. *T*= 0 when there are no tied values and the equation becomes;

$$W = \frac{12(S)}{m^2(n)(n^2-1)} \quad \text{……………………………………………………………… (3.13)}$$

W is an estimate of variance of the row sums of ranks (R_i) divided by the maximum possible value the variance can take; this occurs when all variables are in total agreement. Hence $0 \leq W \leq 1$

W of 1 represents perfect concordance/agreement and 0 indicates perfect disagreement in the ranking. The Friedman's Chi-square statistic (χ^2) was used to test the significance of the *W* obtained. From Friedman's Chi-square statistic (χ^2) is given by;

$$\chi^2 = m(n-1)W \quad \text{……………………………………………………………………… (3.14)}$$

The Chi-square is asymptotically distributed with *(n-1)* degrees of freedom and it used here to test the significance of *W*. However, the data set have to meet reliability test to be sure it is satisfactory for Kendall analysis. The number of raters (n) and the factors (m) being rated should be reasonable large enough to allow for valid interpretation (Kendall and Babington Smith, 1939; Legendre, 2010). In this study 360 raters (n = 360) rated 11 factors (m = 11) and it is considered large enough for valid interpretation.

CHAPTER FOUR

RESULT AND DISCUSSION

4.0 Introduction

This chapter presents results and discussion of findings of a study conducted to analyse smallholder farmers' perceptions and prospective adoption behaviour towards Genetically Modified (GM) crops. The chapter is organised into seven (7) sections, with the first two sections presenting findings and discussions on the organizational attributions and characteristics of Farmer Based Organizations (FBOs) surveyed and the demographic characteristics of the sampled smallholder farmers.

Section three (3) dealt with findings on famers' knowledge and understanding of GM Crops, while section four (4) presented findings and discussion on the underlying constructs characterising farmers' perceptions towards GM crops. Section five (5) and six (6) dealt with findings and discussion on determinants of farmers' adoption decision towards GM crops and farmers' expectations on the country's agrobiotechnology agenda respectively. The last section, section seven (7), presents findings and discussion of the likely prospects and constraints of commercialization of GM crop production from stakeholders' perspective.

4.1 Organizational Attributes of FBOs Surveyed

This section presents organizational assessment of the FBOs surveyed for this study. FBOs are the most viable and time tested formalised grassroots farmers' active groupings in Ghana. In this study farmers were sampled by virtue of their membership of FBOs, because FBOs, by their grassroots nature, are expected to be the mouthpiece of farmers. It is therefore important, at this stage of Ghana's agrobiotechnology policy development, that the views, perceptions and adoption decision behaviour of members of grassroots farmer organizations are known and factored into policy formulation and implementation strategies.

4.1.1 Registration Status and evidence of FBOs

FBOs, just like any organization, are recognized by their corporate identity and name and their operations and activities give indication of their active existence. As a result, the registration status of all the 120 FBOs surveyed, evidence of their existence, operation of bank accounts and the type of enterprises the FBOs engaged in, were assessed and the results summarised in table 4.1.

The result clearly demonstrated that an overwhelming majority (86.7%) of the FBOs surveyed are registered either with MOFA (64.2%), District Assembly (5.0%), Registrar General Department (4.2%) or Department of Cooperatives (12.5 %). Also, about 13.3% of the 120 FBOs are registered with more than one institution. As shown in the Table 4.1, about 5.0% of the FBOs were registered with both MOFA and the Registrar General Department while 8.3 % registered with MOFA and the District Assembly.

Interactions with smallholder farmers at the various focus group discussion revealed that, initially formation of many of the FBOs are externally driven by extension officers of MOFA and field officers of Non - Governmental Organizations (NGOs) who actively encourage and facilitate the formation of these groups among farmers. Others were established in anticipation of accessing assistance from MOFA, the District Assembly, financial institutions and NGOs.

Table 4.1: Registration Status and evidence of existence of FBOs

FBOs' Attributes		Frequency	Percent (%)
Registration Status	Not Registered	16	13.3
	Registered	104	86.7
	Total	**120**	**100.0**
Registered With	MOFA	67	64.2
	District Assembly (DA)	5	5.0
	Registrar General Dep't (RGD)	4	4.2
	Department of Cooperatives (DC)	14	13.3
	Both MOFA & RGD	5	5.0
	MOFA & DA	9	8.3
	Total	**104**	**100.0**
Evidence of Existence	Certificate of Registration	26	21.9
	Minute Book	27	22.2
	Meeting Book	59	49.2
	Financial Record	4	3.1
	Place of Meeting	4	3.6
	Total	**120**	**100.0**
Active Bank Account	Not Active	29	23.9
	Active	91	76.1
	Total	**120**	**100.0**
Enterprise FBO Engaged in	Crop Production	83	69.4
	Marketing/Agro Processing	2	1.4
	Both Crops and Livestock	23	19.2
	Both Crop Production & Marketing	12	10.0
	Total	**120**	**100.0**

Source: Analysis of field survey Data, 2016

This finding confirmed the assertion of Salifu, et al (2010) that, although FBOs are voluntary organizations formed in response to shared needs and constraints farmers face in their farming activities, often their formation are influence by external actors and other motivations of public or private institutions in their external environment. In one of the focus group discussions at the Gushiegu District, participants lamented;

> ''*they deceived us to form the group, but ever since we have not received anything from them ...*'' (Verbatim comment by a participant).

At another focus group discussion in the Bole District, a participant observed that:

> ''*the MOFA people asked us to come together to form farmer group so they can give us loan to expand our farms, but several years after we formed this group they are yet to give us any loan ..*''(Verbatim comment by a participant)

This demonstrates that the concept of FBOs is not fully understood and appreciated by many members who join such groups. Therefore, the desire to see FBOs play active role in agricultural development through collective demand for agricultural services, bulk production and marketing will be greatly hampered because farmers' general lack of understanding of the concept of FBOs.

About half (49.2%) of the FBOs used the existence of meeting book as evidence of their existence and active operations, whiles only 21.9% had certificates of registration. Most of the meeting books showed by secretaries of the groups contained names of members and attendance list of meetings without minutes. However, 22.2% of FBOs showed meeting books which contained minutes of records of proceedings of their meetings. Upon further scrutiny of their meeting books it was revealed that most of the FBOs rarely meet as a group.

Only 3.1% and 3.6 % showed financial records of their FBOs and meeting place as evidence of existence of their FBOs respectively. Though, about three–quarters of the members interviewed said their FBOs were operating active bank accounts. It was, however, revealed in most of the focus group discussions that the bank accounts were opened with support from NGOs and MOFA and in anticipation of receiving loans and other financial support. In one of the focus group discussions a participants reiterated;

> ''*I have been asking chairman that we should go and take our monies from the bank and share among ourselves because I don't see the use of keeping it in the bank…''* (Verbatim comment by a participant).

Obviously frustrated because the anticipated credit and other financial support which motivated the opening of the bank accounts is not being realise

Regarding agricultural enterprise operated in the name of FBOs, more than two–thirds (69.4%) of the FBOs surveyed engaged in crop production and labour pool as group. With the labour pool they work on each other farms on rotational basis. Also 19.2% and 10 % of the FBOs were engaged in both crops and livestock production and crop production and marketing respectively. At the focus group discussion sessions, participants explained that they often used the proceeds from the enterprise operated in the name of the groups to finance the group activities, such as opening bank accounts, lobbying organizations for agricultural services, procuring meeting books and paying registration fees for the registration of their FBOs.

4.1.2 Membership Structure and Age of FBOs

The FBOs surveyed in this study have diverse membership structure, ranging from single sex to mixed sex members. As shown in the Table 4.2, the average membership size per FBO is about

29 (SD = 7.7) with a minimum of only 5 members and a maximum of 80 members. The average male and female members per FBO was found to be 17 (SD = 6.7) and 11.6 (SD = 1.4) respectively. There were relatively more male members than female members per FBO for the mixed sex FBOs and more only male membership FBOs than female only membership FBOs.

The male domination was expected because male farmers are more proactive in joining farmer groupings than female farmers (Salifu, et al, 2010). Customary practices in northern Ghana also expect women to seek the approval of their husbands before joining such groups. smallholder farmers interviewed in this study have been members of their organizations for an average of 10 years with the youngest having been a members for only 5 years and the oldest for about 21 years.

Table 4.2: Descriptive Statistics of Membership

Membership Structure	Mean	SD	Min	Max.
Number of Male Members in the FBO	17.1	6.7	0	80.0
Number of Female Members in the FBO	11.6	1.4	0	59.0
Total Members of FBO	28.6	7.7	5.00	80.0
Years of Membership of FBO	10.3	3.3	5.00	21.0

N = 360: SD = Standard Deviation
Source: Analysis of field survey Data, 2016

4.1.3 FBOs' external interactions with other organization

For two decades now, Government of Ghana assisted by donor agencies such as the World Bank and Millennium Development Authority (MiDA) under FASDEP I & II, has been facilitating the formation of FBOs to help facilitate agricultural service provision and technology adoption. Therefore, FBOs have been collaborating with and receiving support from public agencies, particularly MOFA, and other private agencies such as financial institutions, input suppliers and

NGOs over these two decades. As such, only 10.8% of the 120 FBOs surveyed were found not to have ever collaborated with nor received any support from any agencies, being it public or private.

As shown in figure 4.1, the remaining 89.2% FBOs ever received assistance and work with other organizations mentioned as MOFA (34%), private agencies (13%), the District Assembly (5%), financial institutions, mostly banks and MFIs (6%) and NGOs (41%). Thus many of the FBOs surveyed have received support and have been working in collaboration with NGOs as compared to other agencies.

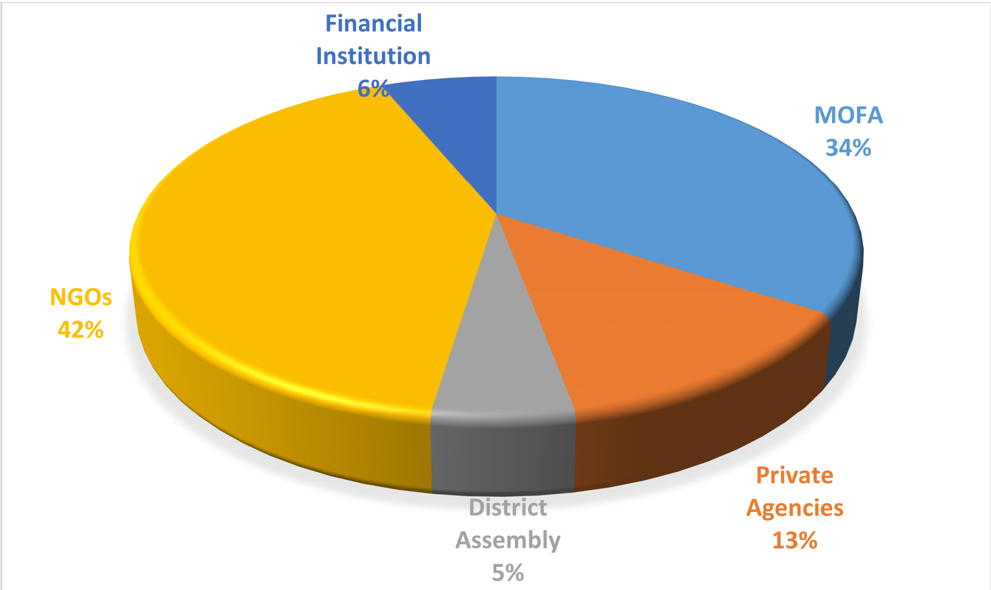

Figure 4.1: Organizations Assisting FBOs
Source: Analysis of field survey Data, 2016

Private agencies such as input suppliers (agrochemical dealers and tractor service providers) have also been collaborating and supporting FBOs in providing services and inputs to its members. Because of group solidarity, many input dealers and tractor operators are more willing to supply inputs and provide ploughing services respectively to FBO members in accordance with pre-arranged payment schedule. At the focus group discussions, many participants mentioned this pre-arranged payment schedule as the main benefits they derived from their membership of FBOs.

Capacity building and farmer training, inputs and financial credit, extension services and marketing services were identified as the main services and support usually provided to the FBOs. Table 4.3 presents frequency distribution of type of support and services the FBOs surveyed have being receiving from their collaborators and partners. Capacity building and farmer training support, as explained at the various focus group discussions, involve training FBO members in leadership skills and organizational management. The farmer training involved the training of farmers in good agricultural practices and farm record keeping and management and was mostly sponsored by MOFA and agriculture based NGOs. The development and capacity building of FBOs was one of the main components of the Agricultural Services Sub-Sector Investment Programme (AgSSIP) implemented by the MOFA.

In response to Ghana Government's Growth and Poverty Reduction Strategy (GPRS II) and the Food and Agriculture Sector Development Policy (FASDEP), MOFA formulated and implemented AgSSIP as a means of facilitating agricultural growth and development. Some of the FBOs surveyed benefited from the capacity building and farmer training implemented during the nine years within which AgSSIP was implemented.

About 30 % of the FBOs benefited from inputs and/or financial credit from NGOs and financial institutions. Most of the financial credits smallholder farmers benefited from was NGOs assisted and mediated credit facilities. Association of Church Development Projects (ACDEP), Presbyterian Agricultural Stations (PAS), Millennium Development Agency (MiDA) and

Adventist Development and Relief Agency (ADRA) have been implementing agricultural credit and other farm support services that target FBOs in the study area.

At the various focus group discussions it came to light that most of the support and services enjoyed by these FBOs were accessed during the FBOs' initial stages when the organizations were being formed and nurtured by external agencies, particularly MOFA and NGOs. But they lamented that such supports have since stopped. Information gathered from the various District Agricultural Developments Units (DADU) and NGOs operating in the area of agriculture at the study area also reveals that most of the support and assistance to FBOs were implemented under various projects with donor funding and grants. However, the support ceased at the end of those projects.

Table 4.3 Type of Support/assistance Provided to FBOs

Type of support/assistance	Frequency	Percent (%)
Training /Capacity Building	7	8.1
Input/Financial Credit	24	30.2
Extension/Advisory Service	9	10.6
Both Training/Capacity Building and Extension/Advisory Service	5	5.9
Both training/capacity building and Input/financial Credit	15	18.1
Both Extension/advisory Services and Input/financial Credit	17	21.5
Marketing service	4	5.6
Total	**81**	**100.0**

Source: Analysis of field survey, 2016

However, in spite of the support received in the areas of organizational management, proposal writing, sourcing funding, accessing agricultural services, and training in good agricultural practices, most of the FBOs surveyed can be described as inactive and unable to develop and operate their own programmes.

4.2 Demographic and Farm Characteristics

This section comprises of two sub-sections. The first sub-section presents analysis and discussion of the demographic characteristics of the farmers interviewed while the second sub-section presents results of analysis of their farm attributes.

4.2.1 Demographic Characteristics of Smallholder Farmers

Analysis of sex distribution as shown in Table 4.4a indicates that only a little over a third (37.8%) of the respondents surveyed were females with the remaining 62.2% being male. Most of the farmers interviewed were in their middle age bracket with average age of 43 years (SD = 10.5) with the youngest being 24 years and the oldest being 75 years old. This reflects the age of Ghanaian farmers as reported by MOFA, (2012). In spite of several efforts aimed at attracting the youth into farming, report of performance review of Ghana's agricultural sector from 2006 – 2012 (MOFA, 2012) reveals that the country's agricultural sector is characterised by aging farmer population.

Just about a quarter (20.3%) of the 360 smallholder farmers interviewed were single, being either never married, divorced or widowed with the remaining three–quarters (79.7%) being married. Besides, an overwhelming majority (79.2%) of respondents interviewed were from male headed households with a little over half (53.1%) being heads of their households. Respondents were from relatively large households with average household size of 9 persons per household (Table 4.4b) compared with the national average of 5 persons per household as captured in the last National

Population and Housing Census (GSS, 2012). Whiles the largest household had 24 persons, the smallest household contained 3 persons.

The study considered household characteristics such as headship of household and size because of their deterministic role in farmers' access to labour, land and other agricultural productive inputs. Most smallholders in Ghana depend largely on their household and family labour for their farm operations (MOFA, 2012). Household headship as either male headed or female headed has been noted as very critical in determining household access and entitlement to agricultural productive resources, particularly land. Literature abounds on household headship and gender consideration as a key determinant of access to productive resources among farming communities in developing countries (IFAD, 2010; World Bank, 2011 and FAO, 2012).

Most of the respondents (68.6%) could read and/or write with average years of formal schooling completed being 9 years (SD = 6). This corresponds with basic educational level within the country's educational structure. The results of educational background of respondents interviewed seem to suggest high level of literacy among farmers in the Savannah Ecological Zone, which contradicts MOFA (2012) which observed low literacy level among farmers in the zone. This apparent contradiction is due to the fact that the target population of this study was smallholder farmers who have ever heard and/or read about GM crops and it happens that most members serving as secretaries and chairpersons to the various FBOs sampled were those who were aware of GM crops and were mostly literate. Therefore, the finding on educational background of farmers established in this study is skewed within the population of smallholder farmers in northern Ghana (GSS, 2012).

Table 4.4a: Socioeconomic Characteristics of Respondents

Personal Attributes of smallholder farmers		Frequency	Percent (%)
Sex of Respondent	Female	136	37.8
	Male	224	62.2
	Total	**360**	**100.0**
Marital Status of Respondent	Single	73	20.3
	Married	287	79.7
	Total	**360**	**100.0**
Headship of Household	Female headed	75	20.8
	Male headed	285	79.2
	Total	360	100.0
Status Within the Household	Member	191	53.1
	Head	169	46.9
	Total	**360**	**100.0**
Can You Read and/or Write (Level of literacy)	No (Not literate)	113	31.4
	Yes (Literate)	247	68.6
	Total	360	100.0
Religious Background	Christianity	140	38.9
	Islam	128	35.5
	Traditional	92	25.6
	Total	**360**	**100.0**
Position held in the FBO	Chairman/chairperson	92	25.6
	Treasurer	27	7.5
	Organizer	6	1.7
	Secretary	84	23.3
	Member	151	41.9
	Total	**360**	**100.0**

Source: Analysis of field survey Data, 2016

The debate on GM crops sometimes evoked ethical, religious and moral sentiments. As such religious background of farmers interviewed was analysed and the results presented in the Table 4.4a. As shown in the table (4.4a), about 39%, 36% and 26% of the 360 farmers interviewed were Christians, Moslems and traditionalists respectively. This finding fairly reflects the religious persuasion of residents of this ecological zone as revealed in the findings of 2010 Population and Housing Census (GSS, 2012).

The respondents surveyed for this study have been members of their FBOs for an average of 10 years (SD = 3.3) and are serving in various positions such as chairperson (25.6 %), treasurer

(7.5%), organizer (1.7%) and secretary (23.3%). However, about 42% of the 360 smallholder farmers surveyed were ordinary members of their FBOs with no leadership positions. The majority (58%) of members interviewed hold leadership positions in their FBOs and as such are expected to play various roles in the formulation of the country's agricultural development policy. Therefore, findings of this study on farmers' views, perceptions, expectations and adoption decision behaviour towards GM crops presented here will serve as information resource to help shape the formulation and implementation of Ghana's agrobiotechnology agenda.

Results of analysis of annual household income indicate a wide income gap among the 360 smallholder farmers interviewed. The results, as shown in table 4.4b, reveal that respondents' annual incomes range from GH¢300.00 to GH¢92,000.00 with mean annual income of GH¢ 9,259.10. An average household size of 9 persons per household, indicates that, the per capita annual income of farmers interviewed is GH¢1,028.79. This is far below the National per capita income of US $1,550.80 (GH¢6,203.20) in 2016 (IMF, 2017).

Table 4.4b: Socioeconomic Characteristics of Respondents

Personal Attributes	Min.	Max.	Mean	SD
Age of respondent (years)	24.0	75.0	42.8	10.5
Household size	3.0	24.0	9.1	3.8
Years of formal schooling completed	0.0	16.0	8.8	6.0
Length of membership of the FBO (years)	2.0	21.0	10.3	3.3
Total annual household income	300.0	92,000.0	9259.1	15123.2

N= 360; SD = Standard Deviation; Min. = Minimum and Max. = Maximum Source: Analysis of field survey Data, 2016

4.2.2 Farm Characteristics

Information obtained from analysis of data gathered on respondents' farm characteristics are presented in tables 4.5a and 4.5b. The results reveal that most of the respondents are small scale farmers with average farm holding of 6 acres with a maximum holding of 70 acres and minimum of 1 acre which are to cultivate mostly food crops, cash crops and sometimes tree crops. Majority (70.6%) of the respondents surveyed have been growing both food and cash crops while 26.4% have been growing only food crops.

However, only 29.4% (table 4.5a) used certified seeds from certified seed growers whiles the remaining 70.6% have been using non-certified seeds mostly selected from their previous harvests (36.9%) or bought in the open market (32.8%) or from colleague farmers. Seed is an important input in crop production system and its quality is very critical in crop productivity. The finding that less than a third of farmers, who are smallholder farmers and are expected to have improved and collective access to agricultural information, used certified seeds in their crop production is a source of concern which requires extension service attention.

In spite of efforts made in improving farmers' access to certified seeds for improved productivity, smallholder farmers in Ghana still source their seeds from informal channels. Similar observation was made by Louwaars and De Boef, (2012) in which they lamented that notwithstanding the effort to formalize seed production, certification and regulation, most (80%) of smallholder farmers in Africa still sourced their seeds from the informal channels which include farmers' own saved seeds, seed exchanges among farmers or purchase from the local grain or seed markets.

Table 4.5a: Farm Characteristics of Respondents

Farm Characteristics		Frequency	Percent (%)
Type of crops mostly grown	Food crops Only	95	26.4
	Cash crops Only	2	0.6
	Both food and cash crops	254	70.6
	Both food and tree crops	8	2.2
	Food, cash and tree crops	1	0.3
	Total	**360**	**100.0**
Type of seeds mostly used	Non-certified	254	70.6
	Certified seed	106	29.4
	Total	**360**	**100.0**
Sources of seed mostly used for planting	Certified Seed Growers/firms	106	29.4
	Previous Year's Harvest	133	36.9
	Open Market	118	32.8
	Colleagues farmers	3	0.8
	Total	**360**	**100.0**
Source of Agricultural Information	MOFA extension service	157	43.6
	NGO extension staff	67	18.6
	Radio/TV & other mass media	95	26.4
	Colleague/friend/relative	41	11.4
	Total	**360**	**100.0**
Frequency of Extension Visit	Very frequent	31	8.6
	Frequent	238	66.1
	Fairly frequent	74	20.6
	Not frequent at all	17	4.7
	Total	**360**	**100.0**
How did you access your land	Own land	106	29.4
	Family land	212	58.9
	Communal land	11	3.1
	Leased	31	8.6
	Total	**360**	**100.0**
Do you keep livestock	No	62	17.2
	Yes	298	82.8
	Total	**360**	**100.0**

Source: Analysis of field survey Data, 2016

Table 4.5b: Descriptive Statistics Farm Characteristics

Farming Characteristics	Min.	Max.	Mean	SD
Land under cultivation in the last season (acres)	1.0	70.0	6.0	5.5
Size of land under food crops cultivation (acre)	0.5	70.0	4.5	4.7
Size of land under cash crop cultivation (acres)	0.0	10.0	2.0	1.7
Size of land left to fallow (acres)	1.0	5.0	1.4	0.8
Size of land leased/given out last season (acre)	0.5	100.0	11.9	26.8
Extension contact	0.0	20.0	4.1	2.4

N= 360; SD = Standard Deviation; Min. = Minimum and Max. = Maximum

Source: Analysis of field survey, 2016

According to Etwire *et al*, (2013) varietal development in Ghana had witnessed increased investments which resulted in the release of several varieties of crops such as maize, sorghum, millet, groundnut and cowpea. They, however, observed that in spite of the availability of these new varieties coupled with the promotional efforts of government and its development partners, the awareness and adoption of these new varieties seem to be low as a result of the weak seed delivery systems in place.

Interactions with farmers at the various focus group discussions brought to light farmers' limited knowledge of certified seeds and their inability to access certified seeds within their locality. Some of them were also skeptical about the quality and viability of the so called certified seed. A participant at one of the focus group discussions observed that *'the only difference between the certified seeds available here and our own selected seeds is that the certified seeds are properly bagged and packaged nicely…'* Although some participants expressed their approval for seed certification and indicated their satisfaction in planting their farms with certified seed, others were simply not bothered as they argued that they cannot guarantee that seed packaged nicely is properly and duly certified and as such they are not that much enthused about certified seeds. In effect, farmers covered in this study do not understand the process of seed certification, making it difficult for them to ascertain the authenticity of certified seeds. At one of the focus group discussions, a participant asked;

> ''*How can we know whether that so-called certified seeds are genuine*…?'' (Verbatim comment by a participant)

The revelation in this study of farmers' general lack of understanding of seed certification and the importance of using certified seeds in their crop production is worrying, considering the fact that 43.6% of the 360 respondents mentioned MOFA extension officers as their main source of agricultural information on crop production. Others mentioned extension officers from NGOs (18.6%), radio/TV and other mass media (26.4%) and colleague farmers (11.4%) as their main source of agricultural information on crop production. It is obvious from the results that majority of the farmers (62.2%) sourced their information on crop production from formal sources – either from MOFA or NGOs field extension officers. It is therefore surprising that most of the respondents lack general awareness and knowledge of certified seeds. Besides, about two–thirds (66.1%) and 20.6% (table 4.5a) of the respondents described the frequency of extension contact in the last season as frequent and fairly frequent respectively, with average extension contact of 4.1 times per farmer per season (table 4.5b).

The nature of land ownership is very critical in crop production. At the various focus group discussions, it was gathered that, land is accessed for farming purposes through direct ownership, family and communal ties, and lease. Agricultural land in northern Ghana is owned by the people, mostly native and held in trust by families and clan heads, land title chiefs and village and traditional area chiefs. As such farmlands are access through ones' connection to a family, a clan or community which entitles him or her the right to use the family, clan or communal land for farming upon approval by the family and clan heads, and land titled chiefs.

Results of the survey reveals that majority (58.9%) of the 360 farmers interviewed accessed their land for crop cultivation through their family ties, whiles 29.4% indicated they have direct ownership over the land on which they grow their crops and only 3.1% and 8.6% said they accessed their land from the communal land pool and through lease respectively (table 4.5a).

The smallholder farmers interviewed in this study operated relatively large farm lands with average farm size of 6 acres (SD = 5.5). The respondents are more into food crop production, with average farm size for food crop of 4.5 acres, compared with cash crop with average farm size of 2 acres (table 4.5b). However, respondents are not practicing land fallowing system, since only average of 1.4 acre were left to fallow by each farmer. They often practice continues farming and when they do not even intend to cultivate a piece of land in a particular season, they often leased it out.

Respondents indicated that they often leased unfarmed lands to their colleague farmers, mostly without charging any fees when they do not cultivate on those lands in a particular season. The average farmland leased/given out per respondent in the last season was 11.9 acres (SD = 26.8). At one of the focus group discussions, a participant retorted '*how can you leave your land fallow* *when others are looking for farmlands to cultivate…'* It was also gathered at the focus group discussion, that being able to clear virgin lands and prepare it for farming entitles one use right over the said land. Because it is difficult and expensive to clear virgin lands, some farmers depend on the benevolence of other, with large farmlands to access land for farming.

4.2.3 Problem with Crop Production

Four (4) main concerns stand out clearly from the analysis of respondents' narratives on problems they are facing in their crop production activities. These main concerns are:

- Varietal concerns
- Concerns regarding farming systems
- General production concerns
- Marketing concerns

4.2.3.1 Varietal Concerns

Problems raised regarding the current variety of crops respondents have been cultivating included low yield, drought, disease and pest susceptibility, post-harvest losses and poor storability. About 14% are most concerned about the low yielding varieties (table 4.6). Technology adoption regarding improved crop varieties is very low in the study areas (MOFA, 2010; 2012; 2016).

Being smallholder farmers, it was expected that their access to agricultural information and extension services will be facilitated and they will be more likely to adopt improved technologies than their colleague farmers who do not belong to farmer groups. But the findings indicated it was not the case regarding adoption of improved varieties of crops and the use of certified seeds. Respondents' habit of selecting their own seeds from their harvest for next planting season, as uncovered in this study, is responsible for poor yields being complained about.

At the focus group discussion, participants complained that even after applying the recommended fertilizer and controlling weeds, they still had low yields from maize, millet and rice.

Majority (58.6%) of the respondents interviewed complained that most of the crop varieties they are cultivating are susceptible to drought. They were of the opinion that the susceptibility of the crop varieties to drought is their main concern which is badly affecting crop production. In this era of climate variability, farmers are looking for early maturing crops varieties so as to mitigate the consequences of climate variability. Farmers complained that their maize, groundnut and cowpea crops, especially, begin to wilt as soon as there are few days of dry spell. This problem is further compounded because rain-fed agriculture is the main crop production practice in northern Ghana with very limited irrigated schemes (MOFA, 2012). Farmers depend entirely on weather conditions in cultivating their crops and anytime there are slight changes in rainfall – both intensity and distribution, it has adverse effects on crop production.

Other concerns raised by farmers were disease/pest susceptibility, post-harvest losses due to varietal traits and prolonged maturity period. About 14%, 9% and 4% respectively regard disease/pest susceptibility, post-harvest losses and prolonged maturity as the main problems bedevilling the varieties of crops they are currently cultivating.

This situation is worrying, considering the fact that, more than 80% of the farmers in sub-Saharan Africa grow most of their staple grains exclusively on rain-fed condition rendering them prone to drought stress (FAO, 2010). Developing and facilitating the adoption of drought tolerant varieties is widely viewed as the best way of mitigating crop losses due to drought. In response to the question as to what main improvement they would want to see in their current crop varieties, the majority (51.7%) of the 360 farmers interviewed want high yielding varieties, drought tolerant varieties (11.4%), early maturing varieties (28.6%) and disease/pest resistant varieties (8.4%). In order to deal with varietal shortcomings, about two–thirds (68.9%) of the respondents said they have been changing the varieties of crops they grow.

According to La Rovere *et al*, (2010) developing drought-tolerant varieties can boost harvests in many African countries by 10 to 34% and generate more than US$1.5 billion in benefits for producers and consumers. Under the project 'Drought Tolerant Maize for Africa (DTMA)' executed by CIMMYT, drought and heat-tolerant maize varieties have been developed and released to farmers (Sipalla and Cairns, 2015).

Ghana is one of 13 countries in Sub-Saharan Africa that participated in the DTMA project, funded by the Bill & Melinda Gates Foundation. The project was implemented jointly by the International Institute for Tropical Agriculture (IITA) and the International Center for Maize and Wheat Improvement (CIMMYT), in partnership with the Crop Research Institute (CRI), Savannah Agricultural Research Institute (SARI), seed companies, community-based seed producers, and other organizations in Ghana. Its aim was to develop maize varieties that are resistant/tolerant to key constraints limiting production, including drought, witch weed, and major foliar diseases such as maize streak virus (MSV), southern corn leaf rust and southern corn leaf blight. Progress made in varietal development and release carried out between 2007 and 2012 by CRI and SARI of Ghana, in collaboration with IITA and CIMMYT is expected to be adopted by farmers to help improve maize production and reduce crop losses due to drought and high temperatures (DTMA, 2013).

Some of the drought tolerant maize varieties released by SARI are available in the study area. They include 'Etubi' which was released in 2007, 'Enii-Pibi' or 'Enibi' released in 2010, 'Ewulboyu' and 'Sanzal-Sima' which were both released in 2012 (DTMA, 2013). However, the farmers interviewed were not aware of these varieties and as such are still planting their drought susceptible varieties. Facilitating farmers' access to these drought tolerant varieties is critical in dealing with the problem of drought.

4.2.3.2 Farming system related problem

In this study farming system problems are constraints limiting farmers' ability to efficiently access and utilize farm resources for the production of crops. Major farm productive resources which determine agricultural production practices are land, labour, agricultural information and capital. At a focus group discussion, discussants were of the view that their ability to access land, labour and capital in addition to securing reliable production information is what determine the type of crops and the kind of agricultural production activities they engage in.

As such these productive inputs (land, labour, capital and information) are the determinants of farming system farmers engage in. Analysis of farmers' responses to the question ''what is the main constraint you faced within the context of your farming system?' indicates that many of the respondents (40%) have problem with accessing labour for their farm operations due to labour scarcity and cost, especially during peak farming season (table 4.6). At the focus group discussion, it was stated that farmers in the study area mostly depend on their family labour to carry out most of their farm operations. Since agricultural production in the area is labour intensive, access to labour is critical in crop production.

Due to the aging farmer population in northern Ghana, coupled with the fact that most youth are not attracted to agriculture in addition to the problem of youth migration out of rural areas, there is increasing shortage of farm labour, especially during the peak of farming season and this makes it difficult to access labour for crop production. Respondents observed that the labour shortage is constraining them to reduce their farm size and the kind of production technologies they can adopt. This problem is further worsened because agricultural mechanization is virtually none existing in the study area. Farmers in this area still depend largely on hoe and cutlass in carrying out their farming activities, with tractor ploughing services only use in land preparation. A participant observed in one of the focus group discussion that;

> ‘‘*if you don’t have many people in your house, how can you have a big farm, who will do the sowing, weeding and harvesting for you?*” (Verbatim comment by a participant)

Another participant observed;

> ‘‘*but for the weedicides we are now using, we wouldn’t have been able to get people to weed our farms*’’. (Verbatim comment by a participant)

A lady discussant also lamented;

> “*all our young girls have gone down south for ‘kayayo’ so now getting people to harvest maize, groundnut and soybean is very difficult here*’’(Verbatim comment by a participant).

About 17% of the 360 respondents interviewed mention land accessibility problem as the main constraint to their crop production system, while 28.3% and 14.4% viewed poor access to capital and poor access to extension and mechanization services as their main problem respectively. Farmers depend on their own savings, money raised from sale of livestock and credit from informal sources to finance their crop production activities. They require money mostly to access tractor services, as many of them do not have their own tractors, to purchase inputs such as fertilizers and weedicides and sometimes pay for hired labour. However, their limited capital, coupled with their poor access to formal credit is making it difficult for them to expand their farms and apply the recommended inputs needed to boost productivity. A discussant at one of the focus group discussion sessions lamented that;

> ''*I join this FBO so that I could access credit from bank to expand my farm, but several years down the line I am yet to receive even one Ghana cedi as credit*'' (Verbatim comment by a participant).

Another participant observed that;

> ''*the market women who lend us money for our farming which we pay with our farm produce are cheating us but the banks too are not willing to give us loan despite the fact that we have formed this group*'' (Verbatim comment by a participant).

4.2.3.3 General Crop Production Problems

Other crop production problems facing respondents are poor soil fertility, high cost of farm inputs, poor and erratic rainfall pattern and pest/disease outbreaks. These were classified as general crop production problems. Analysis of responses regarding which of these general production problems are their main constraints revealed that majority (53.6%) regard high cost of farm inputs as the main constraint they faced. Also 22.8% viewed poor and erratic rainfall pattern as the major setback limiting their crop production activities, whiles 13.9% and 9.7% respectively regard poor soil fertility and pest/disease infestation as their main problems in crop production (table 4.6).

Agricultural input sector had widely been regarded as critical in national agricultural productivity improvement as it influences farmers' access to and use of productivity enhancing inputs. Increasing cost of agricultural inputs and reducing government subsidy on agrochemical inputs is having negative impact on farmers' affordability and application of these inputs. High and rising input prices often lead to low use of agricultural inputs with its consequences on agricultural productivity and farmers' income. According to Krausova and Banful (2010) low agricultural input use is often associated with declining soil fertility, declining yields, and low farmer incomes.

Analysis of narratives gathered at the various focus group discussion sessions on general crop production problems point to high cost of agricultural inputs as the main problem limiting farmers' crop production activities. Farmers complain on rising cost of agricultural inputs centred on agro-chemicals such as fertilizer, weedicides and pesticides, seed and tractor services. In discussing the high cost of inputs in one of the focus group discussion sessions, a participant queried:

> *'how do they expect us to survive when you cannot buy one bag of fertilizer after selling one bag of maize you..'.*

The high and rising cost of these inputs is making agricultural production in the area very costly and risky, because farmers, who took loans, either from formal or informal sources, are finding it difficult to repay the said loans. These were sentiments expressed by participants in the various focus group discussion sessions. Information gathered from interactions with farmers further revealed that the rising cost of farm inputs is the main cause of reduction in current farm size and productivity being experienced. This confirms GNA report to the effect that farmers in the three northern regions have long been complaining of the rising cost of agricultural inputs. According to the report, majority of farmers in the three northern regions protested that the agricultural inputs in the areas was too expensive and almost intolerable to bear thus making agricultural production very costly and risky (GNA, 2011).

Many of the participants were therefore of the opinion that one of the best ways of addressing the problem of decreasing agricultural productivity is to ensure price stability in agricultural inputs. However, since 2008, one of the key agricultural policy intervention programmes introduced by government through the sector Ministry (Ministry of Food and Agriculture) aimed at enhancing food production and security in the country, is the national fertilizer subsidy programme. The purpose of the subsidy programme is to improve farmers' access to fertilizer at affordable prices so as to enhance fertilizer use for increased crop production and ensure food security.

However, the percentage of market price of bag of fertilizer covered by government subsidy has since been reducing and as such increasing cost to farmers. Fearon, Adraki and Boateng, (2015) observed that the subsidy programme still seems to be ineffective because available evidence suggests that little has been achieved by way of output growth that can be attributed to fertilizer use.

In reacting to the suggestion that government is subsidising these inputs, a participant in one of the focus group discussions retorted;

> ''*but how much is the subsidy? …. you will waste your time to secure the coupon for subsidy only for you to realise just GHc 10 reduction on a bag of compound fertilizer*'' (Verbatim comment by a participant)

Another participant also said that;

> ''*the subsidised fertilizer and weedicide is not available here … you will have to go to the nearby town before you can get those input dealers who sell the subsidised fertilize*r'' (Verbatim comment by a participant).

These sentiments expressed by farmers clearly indicate that farmers do not have faith in the current subsidy regime and as such are of the view that the current subsidy programme is not helping them manage the rising cost of agricultural inputs. Participants also argued that the current subsidized amount per bag of fertilizer is too small for its impact to be realised by smallholder farmers. They say that it can only help large scale producers who buy fertilizer in large quantities because of the cumulative effect of the subsidy.

About 22.8% of the 360 smallholder farmers interviewed considered poor and erratic rainfall pattern as the main challenge to their crop production. They were of the view that they have been experiencing variability in climate, especially rainfall amount, duration and distribution in the area and this is affecting their crop production which is mostly undertaken under rain-fed conditions. This situation, they observed, is making crop farming increasingly risky and unprofitable.

This finding confirms that of Amikuzuno, (2012) who established evidence of cointegration between seasonal, total rainfall and crop yields in the Sudano-Guinea Savannah and Guinea Savannah zones of Northern Ghana. Analysing farmers' narratives regarding climate variability at the various focus group discussion sessions, they are of the firm believe that climate patterns in the last decades have seen decreasing trend in precipitation, while temperatures and evapotranspiration have been increasing which they observed is not suitable for crop production. In addition, they were of a firm conviction that the onset of the rainy season has shifted forward and the duration is increasingly becoming shorter with poor distribution, resulting in long periods of drought and flooding. At one of the focus group discussion, an elderly participant observed that;

''*these days rains are not what we knew it to be some years back…*'.

He further explained that;

'*we used to know which month the rain will start, when there will be heavy rains and when the rain will end … but now we cannot tell …*''(Verbatim comment by a participant).

The role of small scale irrigation in mitigating the effects of climate variability was highlighted in the discussions held with FBOs surveyed in this study. Discussants were of the view that developing small scale irrigation schemes to provide water for all-year-round farming is the most feasible way of addressing the problem of erratic rainfall pattern being experienced in the Guinea Savannah Zone.

Vegetable farmers in this part of the country have been using water from wells and dugouts to water their vegetable crops. However, small dam irrigation facilities which can enable farmers grow cereals is virtually non-existent, except in the Kassena-Nankana East Municipality where the Tono irrigation scheme provides water for large scale cereal production in addition to vegetable farming. While irrigated agriculture is seen as the most important means for coping with the effects of climate change and variability in Ghana, just about 3% of Ghana's farmers practise irrigated agriculture (Kurukulasuriya and Mendelsohn, 2008, as cited in Amikuzuno, 2012).

Analysis of information gathered from discussions with smallholder farmers at the various focus group discussions held, showed farmers' general lack of trust in the commitment of both local and central government in developing small scale irrigation facilities to help deal with the consequences of climate variability and boost agricultural production and farmers' income. This reservation by farmers can be understood considering the observation made by Namara et al, (2011) that, despite considerable potential for agricultural development in Ghana, less than 2% of the total cultivatable area in Ghana is irrigated.

This view held by farmers interviewed, regarding lack of government commitment toward irrigation development in Ghana can be justified from available literature on irrigation development in Ghana. Namara et al, (2011) and MOFA, (2011) contend that public irrigation systems play an insignificant role in the overall agricultural economy of Ghana despite substantial efforts to develop the sector since 1950s. As at 2010, the total area of land under irrigation agriculture was only 30,269 ha, representing just 0.2% of the total land under cultivation (MOFA, 2011).

4.2.3.4 Marketing Problems

Despite being smallholder farmers, most of the respondents interviewed do not belong to marketing cooperatives, and they are also not producing under any formalized pre-arranged production and marketing contracts. They produce their crops, mostly cereals and legumes, and look for buyers when they want to sell their produce. As a result, they are bedevilled with many marketing challenges including low prices of their produce, poor access to marketing opportunities, poor storage facilities and post-harvest loses, high cost of transportation and lack of access to market information.

Analysis of responses gathered from the 360 respondents regarding marketing problems revealed diversified concerns. As shown in Table 4.6, a little over a third (36.1%) of the respondents considered low prices of farm produce, 33.1% and 20.6% respectively, considered market inaccessibility and poor storage facilities as the main marketing problems they faced in marketing their farm produce. Only 3.3% and 6.9% considered high transportation cost and poor access to market information respectively as their main marketing problem.

Table 4.6: Crop Production Problems of Respondents

Problem with Crop Production		Frequency	Percent (%)
Problem with current varieties of crops	Low yielding	50	13.9
	Drought susceptibility	211	58.6
	Disease/pest susceptible	52	14.4
	Long maturity variety	33	9.2
	Post-harvest losses	14	3.9
	Total	**360**	**100.0**
Problem with farming system	Land accessibility problem	62	17.2
	Labour cost and scarcity	144	40.0
	Capital accessibility problem	102	28.3
	Poor access to Extension services	52	14.4
	Total	**360**	**100.0**
General crop production problem	Poor soil fertility	50	13.9
	High cost of farm inputs	193	53.6
	Poor and erratic rainfall pattern	82	22.8
	Pest/disease infestation	35	9.7
	Total	**360**	**100.0**
Marketing problem	Low price of farm produce	130	36.1
	Market inaccessibility	119	33.1
	Post-harvest losses	74	20.6
	High transportation cost	12	3.3
	Poor bargaining power	25	6.9
	Total	**360**	**100.0**
Anticipated improvements in current crop varieties	Drought tolerance variety	41	11.4
	High yielding	186	51.7
	Early maturing crop variety	103	28.6
	Disease/pest resistant varieties	30	8.4
	Total	**360**	**100.0**
Have you been changing the variety of crops you been growing	No	112	31.1
	Yes	248	68.9
	Total	**360**	**100.0**

Source: Analysis of field survey Data, 2016

At the various focus group discussions, respondents generally were of the opinion that they are not receiving the right price for their farm produce. They were of the opinion that middlemen have unfair advantage over them in price determination. Because of the perishable nature of farm produce coupled with the lack of storage facilities farmers in this area have weak negotiation power with middlemen. Yankson, Owusu and Frimpong (2016) have asserted that millions of smallholder farmers in developing countries are bedevilled with challenges in marketing their farm produce. These challenges include lack of market information, collusion among middlemen in price determination and lack of transportation facilities. Respondents were of the firm conviction that with proper road network, improved storage facilities, accurate and timely market information their negotiation power will be improved.

4.3 Farmers' Knowledge and Understanding of GM crops

Notwithstanding the fact that commercialization of GM crops began some two decades ago and had attracted media attention and public concerns, information and knowledge of GM crops among farmers and consumers in Ghana is still very limited. Therefore, the criteria for selecting respondents of this study were that they must have been members of FBO and must have heard and/or read about GM crops. As a result of these selection criteria, many FBOs whose details were obtained from MOFA districts offices in the study areas were not selected because the members had never heard and/or read about GM crops in particular and agrobiotechnology in general. This was indicative of the fact that knowledge and information about GM crops among farmers in the study areas were very limited.

This was to be expected because Ghana is yet to start commercialization of GM crops even though policy formulation measures were far advanced (Ashitey, 2013 and GNA, 2013). This section therefore presents findings and discussions of smallholder farmers' source of information and knowledge of GM crops in response to the requirements of the first objective of this study which sought to examine smallholder farmers' knowledge and understanding of GM crops in particular and agrobiotechnology in general.

4.3.1 Source of Information on GM crops

As indicated in figure 4.2 below, the various sources of information about GM crops among respondents were extension officers, colleague farmers/friends/relatives, radio/TV and other mass media and traders/input dealers. Many (43%) of the smallholder farmers interviewed, first heard of GM crops on radio, television and other mass media, whilst close to a third (29%) first heard of GM crops from their colleague farmers, friends or relatives. However, only 10% of the respondents mentioned extension officers as their first source of information about GM crops, while 18% said they first heard of GM crops from input dealers and/or traders.

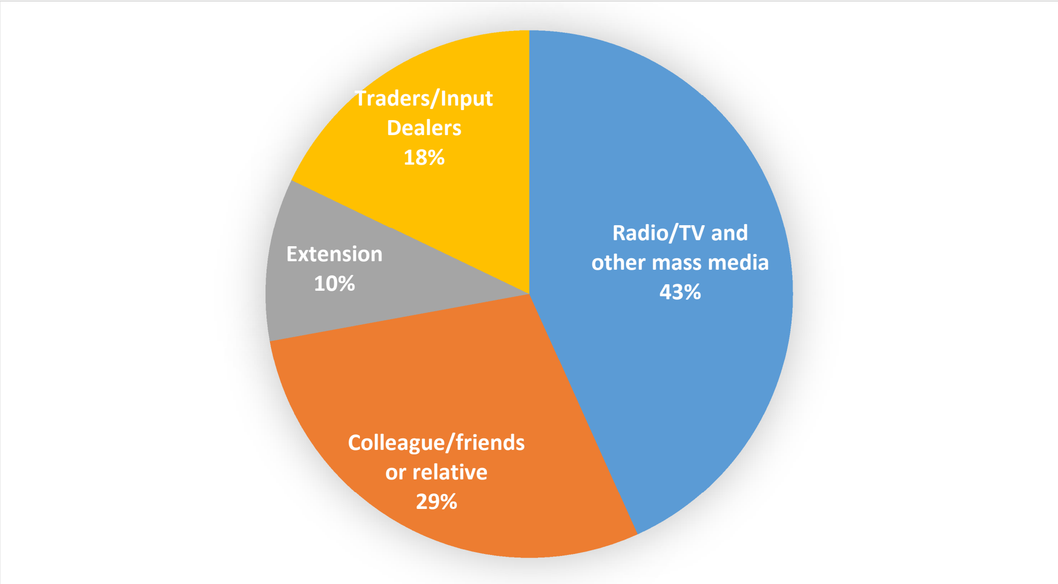

Figure 4.2: Respondents' Source of Information on GM crops
Source: Analysis of field survey Data, 2016

Information gathered among participants in the various focus group discussions held regarding their source of information about GM crops revealed that, information on GM crops was being constantly broadcast at the various local FM stations by anti–GM crops activists campaigning against commercialization of GM crops in Ghana and the passage of the 'Plant Breeders' Protection Bill'. Participants explained that during the period of the anti–GM campaigns, many local FM stations and other airwaves were inundated by activists who spread all kinds of information about GM crops and called on peasant farmers to join the campaign. This was vividly illustrated by a participant at one of the focus group discussion sessions who said;

> ''*all what I know about GM crops are what the people said when they were discussing it at the FM station, I don't know whether to believe it or not, but if what they say is true then the Whiteman is challenging God*'' (Verbatim comment by a participant).

The campaign which was led jointly by Food Sovereignty Ghana, Faith-Based Organizations, Action Aid Ghana, Centre for Indigenous Knowledge and Organizational Development and Peasant Farmers Association of Ghana under the banner 'National Campaign Against Plant Breeders' Bill' was against Ghana's possible adoption of biotechnology in agricultural production and the passage of 'plant breeders' protection bill.

Similar findings to that of this study were established by Zakaria *et al* (2014), Hall, (2010), Kenneth (2011) and Yawson et al, (2008). They established that the mass media is the main source of information on GM crops and food. Vigani and Olper, (2013) also found that the mass media drive and shape public views and perceptions towards GM crops because it is the main source of information on GM crops to most people.

4.3.2 Respondents' Knowledge and Understanding of GM Crop

Analysis of narratives gathered at the various focus group discussions regarding participants' knowledge of GM crops indicates a diverse understanding of what GM crops are among participants. These varying view and knowledge about GM crops ranges from general knowledge to wild, absurd and mythical understanding of GM crops. Sieving through the narratives of participants' descriptions of what they know about GM crops, the following themes were extracted:

- GM crops are artificially bred crops
- Seeds from GMOs are sterilised
- GM crops are bred to be herbicide tolerant
- GM crops are crops injected with chemical to boost their performance
- GM crops are crops impregnated with seeds/genes of other organisms to have dual performance

GM crops are artificially bred crops: some of the participants at the various focus group discussions understood GM crops as crops artificially bred through man made manipulation of the nature of the affected crops to enhance their performance. These crops are usually high yielding and their produce has long shelf life as observed by participants. This knowledge of GM crops as understood by farmers does not deviate so much from the definition of genetic engineering through which GM crops are produced. According to CSIS, (2010) genetic engineering allowed scientists to adjust, modify or alter the genomes of target organisms for improved performance and much desired results. It involves some level of manipulation, altering and modification of naturally occurring living organisms to produce new breed of organisms that might exhibit traits which differ from the original organism.

Seeds from GMOs are sterile: Another understanding of GM crop from the perspective of participants at the various focus group discussions was that GM crops seeds are sterilised and cannot be replanted. According to their understanding, a farmer cannot select seeds from his/her harvested

GM crops and replant the next season, which is a common practice among farmers in the study area but has to go back to the producers and buy the seeds again. In response to further probe on why GM crops seeds selected from farmers' own harvest cannot be replanted as they claimed, participants explained that;

> '*scientists who developed GMOs seeds deliberately sterilised them so that farmers will always have to come to them for seeds*' (Verbatim comment by a participant).

Another participant stated;

> "*these people want to replace our seeds with their sterilised seeds so that we will always have to purchase our seeds from them, so they can make more money from us poor farmers*". (Verbatim comment by a participant).

Such statements and reservations were echoed in many of the focus group discussions held.

This understanding of GM crops as indicated by respondents has some scientific basis because many of the GM crops grown are "hybrids" and as a result do not breed true and there is high possibility of degeneration in successive generation. Therefore the argument that GMOs seeds are deliberately sterilised to prevent farmers from replanting after harvest is mythical and unscientific. However, there are regularity regime by way of intellectual property right and breeders' protection legislatures to protect the investment on GMOs seeds development. As a result, GM seeds are licensed and covered by intellectual property right which requires farmers to obtain permission from corporate or individual entities holding the right to the particular GM seeds before they can use it (Specter, 2014, Fukuda-Parr et al, 2012 and ETC Group, 2010).

The issue of patents regulatory regime on GMOs seeds have been a long standing criticism against the commercialization of GM crops in developing countries. This fear and scepticism by respondents regarding re-use of GMO seeds for planting have been the concerns of many anti-GMOs activists. Katiraee, (2014) observed that the common criticism of genetically modified foods is that their seeds are patented to developers who are mostly profit motivated multinational corporations. This phenomenon is known to peasant farmers who traditionally select part of their harvest and store them as seed for the next season, and practice plant improvement by selecting and exchanging seeds with one another (Etwire et al, 2013).

GM crops are bred to be herbicide tolerant: Another theme characterising participants' understanding of GM crops is about the Round-up Ready (RR) traits of GM crops which are bred to be glyphosate tolerant. Participants indicated that, what they heard is that, GM crops can withstand all herbicides including non–selective round-up herbicides. They were also of the opinion that all GM crops carry this trait of tolerance to glyphosate herbicide.

Notwithstanding the fact that not all GM crops carried the glyphosate resistance trait, participants were right to some extent that GM crops are bred to be tolerant to herbicides because GM crops carrying the traits for glyphosate resistance is one of the common GM crops commercially produced globally. The most commercialised varieties of GM crops released for production carries traits such as herbicide resistance (Round-up Ready (RR)) and insect resistant Bt crops and few crops such as golden rice fortified for improved nutrition (Adenle, 2011; Brookes, et al, 2012; James, 2013; ISAAA, 2013).

Analysis of narratives gathered from participants in the various focus group discussions indicates that participants are very much aware of the glyphosate resistant traits of GM crops. They indicate that such crops will help them deal with the problem of weed control which they indicated will help boost crop production.

> "*I heard that this new crop when grown in the field can be sprayed with roundup weedicide to kill all weeds without affecting the crops ….. and this makes me very much interested in it …. I will grow them when I get the seeds. With the new crop, I can increase my crop yield because weed infestation is my major problem ...*" (Verbatim comment by a participant).

This view was widely shared among many of the participants.

GM crops are crops injected with chemical to boost their performance: One other opinion about GM crops gathered from the narratives of participants at the various focus group discussions is that GM crops are produced by injecting chemical into plants by scientists to boost their performance. They argued that, it is the chemical that makes GM crops possess the desired traits of high yielding, glyphosate tolerance and long shelf life among others. In response to a follow-up asking for the basis of their claim that GM crops contained chemical, a participants said;

> "*I saw this whiteman injecting chemical into tomato plant myself on TV. …*" (Verbatim comment by a participant)

Another participant in expatiating on this claim, said;

> "*just like how they have injection which can make human being grow fat and fast, there are injections too for plants and this is what they have done to this new plant*" (Verbatim comment by a participant).

These are obvious misconceptions and untruths about the process of producing GM crops which can affect farmers' perception and attitude towards GM crops.

GM crops are crops impregnated with seeds/genes of other organisms to have dual performance: One opinion and understanding of GM crops from the narratives of participants at the various focus group discussion, is the impression that GM crops are produced from fusion between organisms. According to the participants, GM crops exhibit dual attributes by showing traits of both organisms fused together.

This understanding of GMOs can be likened to gene insertion and manipulation through the process of genetic engineering. Further probing revealed that most of the participants are referring to hybrid plants, judging from their description of the process of the said fusion they claimed is used in the development of GM crops. One of the participants in a focus group discussion had this to say:

> "*you see what they do. They will bring for instance yellow maize and fuse it with white maize to produce a new maize variety which has the taste of both yellow and white maize and yield more than both yellow and white maize varieties….*" (Verbatim comment by a participant).

This clearly illustrates the process of crossbreeding leading to the generation of hybrid crops. Hybrid plants are nothing more than plants that have been successfully cross-bred with different varieties of plants to take advantage of certain traits and get rid of other less advantageous traits, and this has nothing to do with genetic engineering. When two dissimilar varieties are crossed, the result is a hybrid which will often be bigger, brighter, faster-growing or higher-yielding than either of its parents. Whiles hybrid technology is limited to crossbreeding within the same plant species, GMOs technology permits crossbreeding between plants of different species. There is therefore apparent misconception among respondents about the differences between GM crops and GM technology and hybrid crops breeding.

Analysis of responses gathered from the 360 personal interviews conducted among smallholder farmers surveyed, to the question "what do you know about GM crops?" reflect the views obtained from the focus group discussions. The analysis of narratives expressed by respondents also fall within the five main themes extracted from the information gathered from the various focus group discussions. While some respondents' narratives on their knowledge about GM crops spread across all the five main themes, others only covered four, three, and two or just on one. Analysis of the main ideas expressed by the 360 respondents about GM crops as shown in the Figure 4.3 reveals that overwhelming majority of the respondents share the view that 'seeds from GMOs are sterilised' (85%) and that 'GM crops are bred to be resistant to all herbicides' (81.7%). The opinions of about two–thirds of the 360 respondents interviewed fall into the category 'GM crops are artificially bred crops', whiles about half (52.5%) and 47. 6% of the respondents' knowledge about GM crops fall in the themes 'GM crops are impregnated with seeds/genes of other organism' and 'GM crops are crops injected with chemical to boost their performance' respectively.

This clearly illustrates that these five main themes identified as characterising smallholder farmers knowledge about GM crops is widely shared among respondents interviewed. Information gathered from the focus group discussions and personal interviews point to the fact that five main themes identified portrayed and represents farmers knowledge about GM crops.

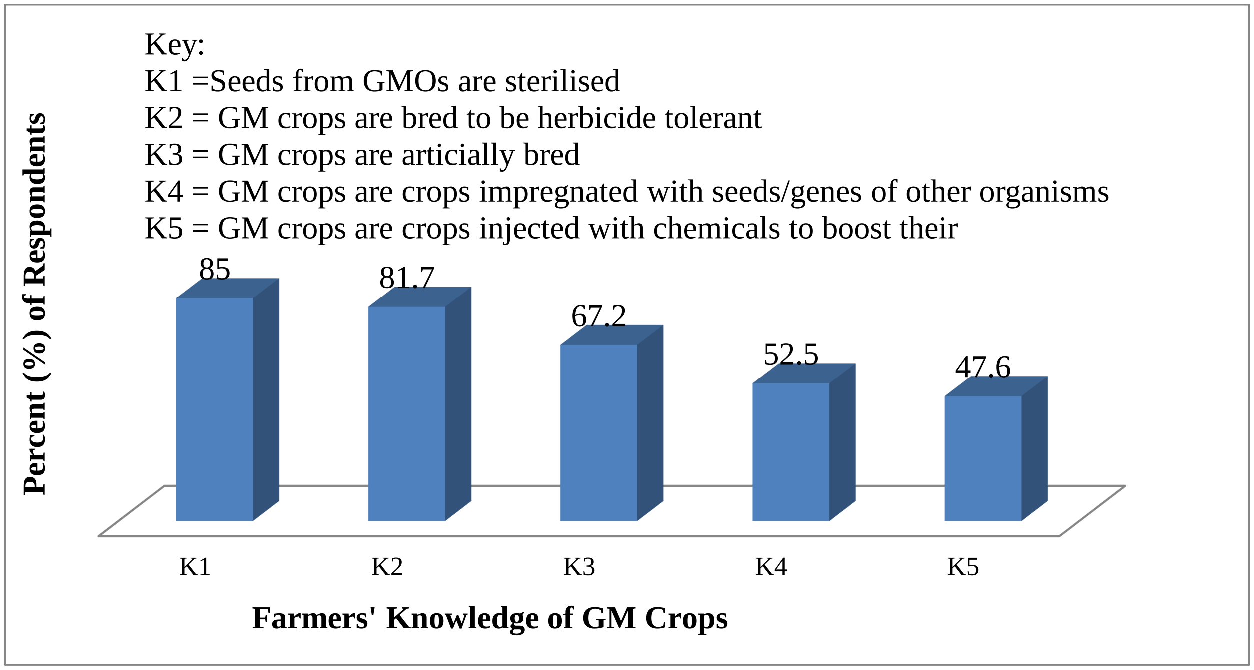

Figure 4.3: Bar Graph Showing Respondents Knowledge about GM crops

Source: Analysis of field survey Data, 2016

4.3.3 Accuracy of Respondents' Knowledge of GM crops

Analysis of narratives of respondents' knowledge and understanding about GM crops revealed an array of issues ranging from factual information, partly factual, misconceptions, fictitious and mythical. During the focus group discussions and personal interviews conducted, respondents were asked an open-ended question 'what do you know about GM crops?' and they were allowed to express themselves with some further probes for clarifications.

Analysis of responses to this question revealed that 17.5% of the respondents gave accurate and factual information about GM crops and GMO technology and they are labelled as 'wholly factual'. Other (15.3%) respondents' accounts of GM crops were not entirely accurate because they contained some incorrect information and as such are labelled as 'partly factual' (

4.4).

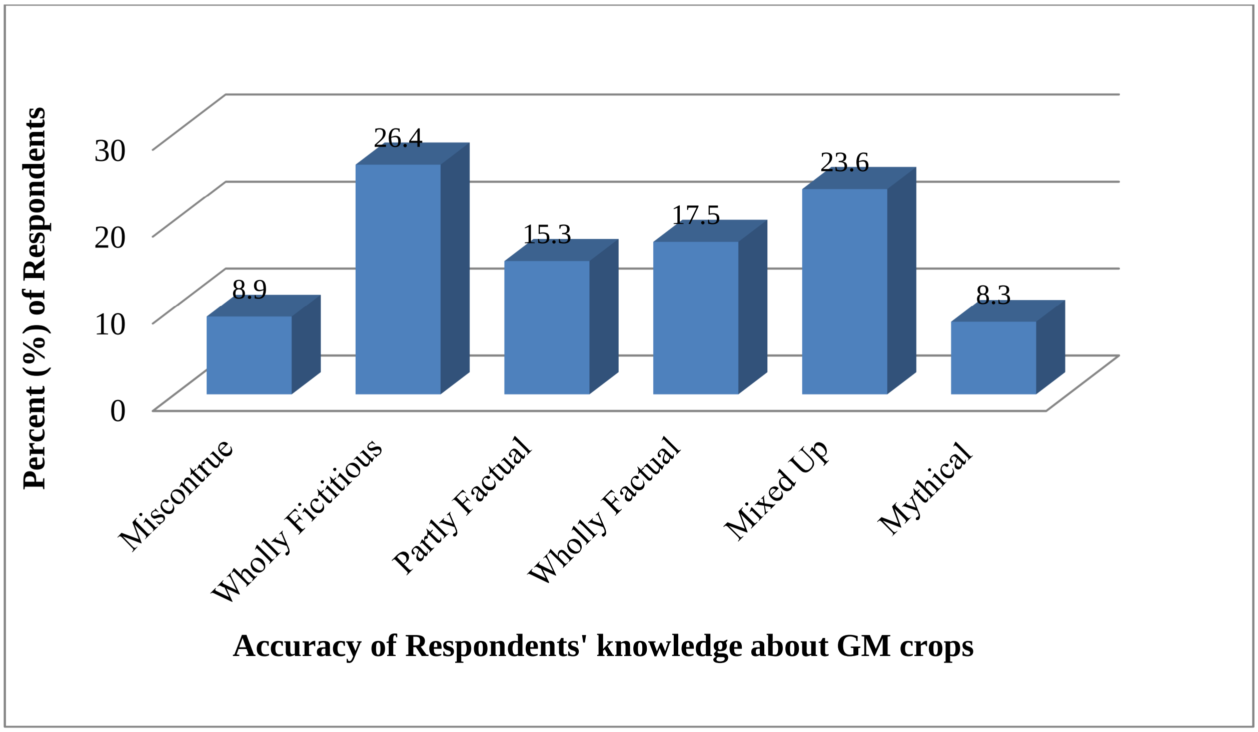

Figure 4.4: Accuracy of Farmers' knowledge on GM crops
Source: Analysis of field survey Data, 2016

In all, about a third (32.8%) of the respondents provided either wholly factual or partly factual information about GM crops. Respondents who provided wholly factual accounts of GM crops mentioned or alluded to one or more of the following statements:

1. GM crops are produced from manipulating existing crop varieties for improve performance
2. GM crops are produced from artificially inserting desired parts of plant (genes) into other plants to transfer the traits of one plant to the others
3. GM crops can be bred to be resistant to glyphosate (herbicide)
4. GM crops contains genes of other plants or varieties and as such can behave like them
5. Example of GM crops are Bt cotton and cowpea
6. GM food are not much different from their non – GM counterparts

The statements above largely represented accurate accounts of GM crops and GMOs technology. Responses from more than a quarter (26.4%) respondents were made of fabricated and made-up statements about GM crops and their understanding of GM crops is labelled as 'wholly fictitious'. The statements of these respondents included the following:

1. GM crops are produced by injecting chemical onto plants to enhance their performance
2. GM crops are farmed in laboratories and cannot be grown in open fields
3. GM crops are artificially produced or manufactured crops
4. GM food are produced for animal consumption only
5. GM crops contains animal parts in them to give more protein
6. The western world doesn't eat GM food they grow them to be shipped to Africa as food aid.
7. GM seeds after harvesting cannot be replanted, because they will change to something else when replanted.

It is clear that the above statements do not give accurate accounts of GM crops.

The account of other respondents of GM crops was generally about hybrid crops and they are labelled as having 'misconstrued' view about GM crops. In other words they have misconstrued hybrid crops for GM crops. About 9% of the respondents have their narratives on GM crops falling in this category. Finally, about a quarter (23.6%) of the respondents provided narratives some of which fit hybrid crops and others reflect that of GM crops. The account of this group of respondents were a mixture of two or more of the categories above and they were labelled as having 'mixed' knowledge about GM crops.

In addition, other respondents provided fairy-tale accounts of GM crops, making allusion to issues bordering on myths and fallacy. As such these respondents are labelled as having mythical understanding about GM crops. Some of their accounts of GM crops were to the effect that:

1. GM crops are crops whose natural purity have been corrupted by scientists to alter their performance
2. GM crops are like biblical angels who came down onto the earth, against the command of God, and defiled the daughters of man
3. GMO technologies are sacrilegious and acts of aggression against God and sanctity of creation
4. GM crops are produced through Whiteman witchcraft which are whispered upon plants to change their forms
5. GM crops are not natural as they can transform themselves anytime.

4.3.3 Source of information and accuracy of knowledge about GM crops

In assessing the extent to which respondents' source of information significantly influence the accuracy of their knowledge and understanding on GM crops, a Crosstabulation of source of information and accuracy of respondents' knowledge on GM crops as shown in the Table 4.7 was constructed and Chi-square test conducted. This was done to test the hypothesis that:

Null hypothesis (H_0): There is no significant relationship between source of information on GM crops and accuracy of respondents' knowledge of GM crop.

Alternative hypothesis (H_a): There is significant relationship between source of information on GM crops and accuracy of respondents' knowledge of GM crop.

As shown in Table 4.7, the Chi-square (χ^2) value of 17.282 (df = 5; P>| χ^2| = 0.004) means that there is statistically significant relationship (at less than 1% level of significance) between source of information on GM crops and accuracy of respondents' knowledge about GM crops. Thus, the null hypothesis (H_0) is rejected in favour of the alternative. This implies that respondents' main source of information (either from mass media such as radio and TV and other sources such as friends, colleagues, extension officers, agro-input dealers) on GM crops is a significant determinant of the level of accuracy of their knowledge about GM crops.

Table 4.7: Information Source and differentiated of Knowledge on GM crops

Source of information on GM Crops	**Differentiated knowledge about GMOs**						**Total**
	Mythical	Mixed up	Wholly Factual	Partly Factual	Wholly Fictitious	Misconstrue	
Mass Media	22(73.3)	26(30.6)	28(44.4)	23(41.8)	41(43.2)	16(50.0)	156(43.3)
Others	8(26.7)	59(69.4)	35(55.5)	32(58.1)	54(56.8)	16(50.0)	204(56.7)
Total	**30(100.0)**	**85(100.0)**	**63(100.0)**	**55(100.0)**	**95(100.0)**	**32(100.0)**	**360(100.0)**

χ^2 = 17.282; df = 5; P>| χ^2| = 0.004; Note that figures in brackets denotes column %

Source: Analysis of field survey Data, 2016

As shown in the Table 4.7, majority (55.5%) of respondents whose accounts of GM crops were found to be wholly factual did not source their information from the mass media. This means that those who sourced their information on GM crops from colleagues, extension officers and input dealers are more likely to have accurate information on GM crops than those who sourced their information from the mass media. Similarly, about 58% of respondents whose accounts of GM crops were partly factual sourced their information on GM crops from other sources other than the mass media.

As shown in the Table 4.7, overwhelming majority (73.3%) of the respondents who provided mythical accounts of GM crops sourced their information from the mass media. The mass media therefore provided a medium for churning out all kinds of information on GM crops. Some of the information were not only untrue but boarder on myths and fairy-tales which are influencing farmers' knowledge and view on GM crops and agrobiotechnology in general.

The apparent lack of scientific information about GMOs in the public domain is worrying, considering the fact that the mass media is an important driver of GMO standards as found in Vigani and Olper, (2013). The mass media have been an important source of information on GMOs and as such the main driver of public opinion about the safety or otherwise of GM products. Also, within the context of the debate over GM foods and crops, it is difficult to know where scientific evidence ends and where dogmatism and speculations begin because the mass media is inundated with all kinds of information and misinformation about GMOs.

4.3.4 Farmers' Self-assessment about their knowledge of GM Crops

In examining farmers' self-assessment about their own knowledge of GM crops, respondents were asked: 'how well informed they were about GM crops' Their responses were categorised into 'very well informed' if respondent thought he/she had much information on GM crop, 'somewhat informed' for respondents who thought they had some level of information and knowledge on GM crops and 'not informed at all' if respondent thought he/she lacks information on GM crops. Results of analysis of responses to this question are shown in Figure 4.5 indicates that only 8% of the respondents thought that they were very well informed about GM crops, while close to a quarter (18%) thought that they were just not well informed about GM crops. However, majority (74%) indicated that they were somewhat informed about GM crops.

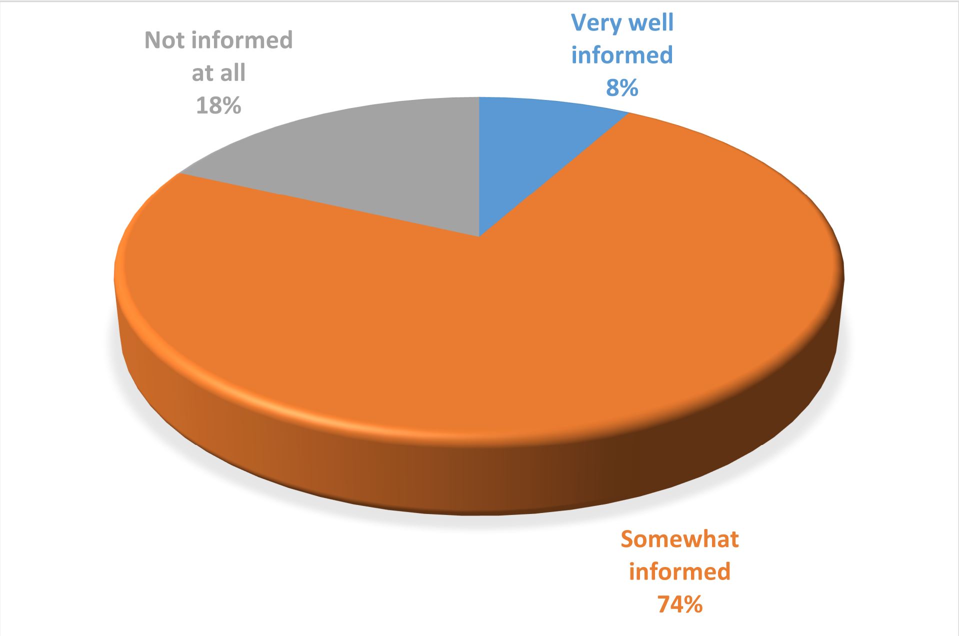

Figure 4.5 Respondent' Self-assessment of their knowledge of GM Crops
Source: Analysis of field survey data, 2016

Farmers' source of information on GM crops was expected to influence their self–assessed knowledge on GM crop. Respondents' sources of information on GM crops included mass media (mostly radio and TV), from their colleagues, extension officers and agro-input dealers. A cross tabulation of source of information on GM crops and respondents' self-assessed knowledge of GM crops as shown in the Table 4.8 demonstrates relationship between respondents' source of information on GM crops and their self-assessed knowledge of GM crops.

With a Chi-square value of 29.565 (χ^2 = 29.565; df = 2; P>| χ^2| = 0.004), the analysis established significant relationship at less than 1% level of significance between source of information and respondents' self-assessed knowledge of GM crops. Respondents who sourced their information on GM crops from mass media were found more likely to rank their knowledge of GM crops as 'very well informed' compared to those who sourced their information from other sources such as colleague farmers, extension officers and agro-input dealers.

As shown in the Table 4.8 about three quarters (75.9%) of the respondents who thought they were 'very well informed' about GM crops sourced their information on GM crops from the mass media while the remaining 24.1% who thought that they were 'very well informed' about GM crops sourced their information on GM crops from other sources such as colleague farmers, extension officers and agro-input dealers. An overwhelming majority (81.5%) of respondents who thought that they were just not well informed about GM crops sourced their information on GM crops from other sources other than mass media. Only 18.5% of those who sourced their information on GM crops from mass media scored themselves as 'not well informed' about GM crops. Effectively, respondents who sourced their information on GM crops from the mass media are very confident of their knowledge on GM crops compared to those who sourced their information on GM crops from other sources.

Table 4.8: Crosstabulation of Source of Information and Self-assessed Knowledge on GM crops

Source of information on GM Crops		**How well inform are you about GM crops**			**Total**
		Very well informed	Somewhat informed	Not informed	
Mass Media	Count	22	122	12	156
	within column%	75.9%	45.9%	18.5%	43.3%
Others	Count	7	144	53	204
	within column%	24.1%	54.1%	81.5%	56.7%
Total	Count	29	266	65	360
	within column%	**100.0%**	**100.0%**	**100.0%**	**100.0%**

$\chi^2 = 29.565$; df = 2; $P>|\chi^2| = 0.004$

Source: Analysis of field survey Data, 2016

4.3.5 Farmers' Opinion on the Benefits and Disadvantages of GM Crops

Three main issues ran through the narratives of respondents concerning their views on the possible benefits of GM crops. The three main issues are (1) 'improved food security', (2) 'increased farm profitability' and (3) 'reduced labour intensity'. These views about the possible benefits of GM crops were found to be widely shared by the 360 respondents interviewed. Most of them mentioned all the three issues; others mentioned only two or one.

Analysis of individual responses to a question 'what do you think are the possible benefits of GM crops?' revealed that the three main issues characterising respondents' opinion on the benefits of GM crops are widely held among most of the respondents to this survey. Most (80.2%) of the respondents were of the opinion that the cultivation of GM crops will help improve food security situation through increase in production and productivity. They were of the view that GM crops are high yielding because of their improved traits against crop production problems such as weed and insects infestation. They indicated that the cultivation of such crops will lead to increase in food production which will go a long way to improve on the food security situation.

The argument of whether GM crops, for that matter agrobiotechnology, can contribute to improving food security and ending global hunger abounds in literature. Fukuda-Parr et al (2012) asserted that, the question 'can GM crops help improve food security, especially in Africa?' can be adequately addressed by examining whether the new varieties are beneficial to small scale farmers and whether it actually addresses the food security concerns of developing countries? Micro-impact studies and short-term analysis of farm productivity among smallholder farmers who have adopted the cultivation of GM crops have demonstrated positive impacts on household income and food security (Paarlberg, 2010; James, 2011; Brookes, and Barfoot, 2011; James, 2013).

Majority (57.7%) of the respondents also shared the view that GM crops cultivation has the potential of increasing farm profitability through increased productivity and reduced cost of production. They were of the opinion that the high yielding nature of GM crops makes it possible for them to benefit economically from its cultivation. At one of the focus group discussion, a participant observed that;

> '*if GM crops are high yielding and can withstand roundup chemical, as they claimed in the radio, then cultivating it will make us gain more yield …*'(Verbatim comment by a participant).

There is a large body of peer-reviewed literature indicating higher economic returns on GM crops to small scale farmers (Paarlberg, 2008; Paarlberg, 2010; James, 2011; Brookes, and Barfoot, 2011 and James, 2013). Therefore, the view among respondents that cultivating GM crops have the potential of increasing farm productivity and profitability may not be misplaced.

However, just a little below half (48.1%) of the respondents included reduce labour intensiveness of weed control in their list of potential benefits of GM crops. They explained that with the cultivation of Roundup Ready (RR) traits of GM crops, the labour intensive nature of weed control will be much reduced. They observed that weed control is one of the areas of labour intensive operations in crop production. And as such adopting the cultivation of RR GM crops will bring relief to them regarding their current difficulties in controlling weeds.

With regard to potential disadvantage which might be associated with the introduction of GM crops, respondents identified four main concerns portraying their view on the disadvantages of GM crops cultivation. These issues are (1) Environmental and health risks, (2) high cost of GM seeds, (3) destruction of local and indigenous varieties of crops and (4) unreliable seed supply and viability. The respondents got all these information about the possible negative effects of GM crops mostly from discussions on radio and television. A participant at one of the focus group discussions made this observation;

> *''I heard on radio the other time that this new crop is not good for the environment and it poisons slowly when eaten…''* (Verbatim comment by a participant).

Participants at the various focus group discussions reiterated some of the worrying environmental and health risk warning they had heard on radio and other mass media regarding the cultivation and consumption of GM crops. They enumerated possible environmental effects of GM crops ranging from destruction of biodiversity to cross pollination of GM crop varieties with their wild relatives. They also raised health concerns such as possible food poisoning and toxicity caused by roundup resistant GM crop varieties, allergic reactions and carcinogenic effects among others.

Most (80.2%) of the respondents interviewed mentioned possible environmental and health risks as one of the main disadvantage of cultivating GM crops. They were of the view that many consumers will not like to consume GM foods because of the possible health risk that have been trumpeted to be associated with GM products. As a result, most of them expressed reservations about adopting GM crop cultivation.

Many anti–GM activists have been stressing the fact that GM foods might have negative impact on the environment and human health (Qaim, 2015; Lu, 2008 and Smith, 2007). Anti-GM foods advocates often maintain that, since there is no consensus among independent scientific studies on the safety of GM crops for animals or humans, its consumption should not be rushed into the food chain (Domingo, 2007; Vain, 2007 and Brown, 2003). It is some of the anti–GM information being churned out in the media landscape that is shaping the views of respondents interviewed in this study.

As shown in table 4.9, possible high cost of GM seeds was also identified by 71.1% of the respondents as one of the disadvantages of GM crops cultivation. Respondents were of the view that GM seeds might be too costly for smallholder farmers to buy. They fear that the high capital investment in producing GM crops coupled with the patent regimes accompanying GM seeds production and distribution will make GM seeds very expensive to cultivate. GM seeds production and distribution are usually controlled by Intellectual Property Right regimes which grant biotech companies patents over GM seeds (Specter, 2014; Katiraee, 2014; Bhuiya, 2012 and Shiva, 2006). This arrangement prevents farmers from generating their own seeds when they cultivate GM crops. Farmers in the study area are used to selecting, preserving and using seeds they have control over. They often select seeds from their harvest and store for the next planting season and sometimes share seeds among themselves as indigenous farmers. This gives them absolute control over their seeds and indigenous crop varieties.

Possible destruction of local and indigenous varieties was also mentioned by 52.2% of the respondents as one of the disadvantages farmers in Ghana will be faced with if commercialization of GM crops is allowed (Table 4.9). Their explanation was that GM crops might replace their indigenous crop varieties and this will compel them to continuously depend on biotech companies for their seeds supply. Anti–GM crops activists often argue that the patents regulatory regime accompanying the development of GM seeds have the tendency of shifting local control of seeds to biotechnology companies. As observed by Katiraee (2014), the common criticism of genetically modified foods is that their seeds are patented to developers who are mostly profit motivated multinational corporations. There is the fear that the seeds local farmers have been using over the years will give way to the use of genetically modified seeds.

Another possible disadvantage of GM crops expressed by 59.7% of the respondents is the fear that the supply of GM seeds from biotech companies might not be reliable and the viability of the seeds might also not be guaranteed. Respondents argued that agricultural input supply, especially certified seeds, are not properly managed and regulated. They fear that GM seeds supply might not be timely and readily available on the open market. An elderly participant at one of the focus group discussions observed;

> '*I stopped buying certified seeds because they are not reliable, anyone can bag any seed and label it as certified seed and you will buy it and later realise that the seeds are not good. One may even ask who is watching over those selling the certified seeds to us?*'' (Verbatim comment by a participant).

In spite of significant improvement in seed regulation and marketing, farmers surveyed still expressed reservations about the reliability of certified seed supply and marketing. However, due to considerable government efforts through seed regulatory enactments (Plant and Fertilizer Act 803, Prevention and Control of Pests and Diseases of Plants Act of 1965, Act 307 and Seed Inspection and Certification Decree, NRCD 100 of 1972) and government seed policy, the formal seed system in Ghana has undergone significant improvement with increasing private investment in seed production (IFPRI, 2013).

Table 4.9: Respondents' Knowledge of the possible Benefits/Disadvantage of GM crops

Knowledge of Benefits/Disadvantages of GM Crop		Frequency*	Percent (%)
Benefits of GM crops	Improved food security	289	80.2
	Increase farm profitability	208	57.7
	intensiveness of weed control	173	48.1
Disadvantages of GM crops	Environmental and health risks	209	58.1
	High cost of GM seeds	256	71.1
	Destruction of local/endogenous varieties	189	52.2
	Unreliable seeds (supply & credibility)	215	59.7

*multiple responses
Source: Analysis of field survey Data, 2016

4.4 Farmers' Perceptions and Attitude towards GM Crops

This section presents results and discussion on respondents' perceptions towards agrobiotechnology and possible cultivation of GM crops. The views and dispositions of smallholder farmers towards GM crops gathered during the field survey are presented in this section. The section also contains results of factor analysis conducted to identify underlying constructs characterising farmers' perceptions towards GM crops. The section is dedicated to presenting findings of the survey addressing objective two (2) of this study which sought to analyse the underlying constructs characterising the perceptions smallholder farmers hold towards GM crops.

4.4.1 Underlying Constructs of Farmers' Perception towards GM Crops

Respondents' agreement rank scores of statements extracted from the narratives of sampled FBOs members were subjected to factor analysis to identify the underlying constructs charactering farmers' perceptions and views on GM crops. Exploratory Factor Analysis (EFA) was employed as data reduction method in identifying the underlying factors explaining the variances among items in the correlation matrix of variables entered in the analysis. As the title suggests, EFA is exploratory in nature and as such the investigator has no expectations of the number or nature of the variables. That is, it allows the researcher to explore the main dimensions to generate a theory, or model from a relatively large set of latent constructs often represented by a set of items (Pett, Lackey and Sullivan, 2003; Thompson, 2004; Swisher, Beckstead and Bebeau, 2004 and Herson and Roberts, 2006).

Considering the limited information on main dimensions characterising smallholder farmers' perceptions, views and narratives towards GM crops and the fact that there have not been any established theory or model on underlying constructs of farmers' narratives regarding GM crops, exploratory factor analysis was considered appropriate for this study. Hall (2010) also applied exploratory factor analysis in identifying farmer attitudes towards GM crops in Scotland.

Correlation matrix between variables was calculated in order to assess the level of variance among variables and the suitability of factor analysis. As noted by Kalantari (2005), the first decision in using EFA is the determination of correlation matrix among all variables involved in the analysis. A correlation matrix in EFA displayed the relationship between individual variables involved in the analysis, demonstrating the variations among variables. Henson and Roberts, (2006) pointed out that correlation matrix is most popular among investigators, while Tabachnick and Fidell, (2007) recommended inspecting the correlation matrix (often termed Factorability of R) for correlation coefficients over 0.30. As such correlation matrix of variables used in the exploratory factor model was calculated and their relative strengths captured by factor loading were also determined.

A factor load ranging from zero (0) to +/- 1 indicates the extent to which a particular variable load onto a given factor. The closest it is to one the stronger it is loaded onto a given factor. Hair et al. (1995) categorised these loadings using a rule of thumb as ±0.30 = minimal, ±0.40 = important, and ±0.50 = practically significant. If no correlations go beyond 0.30 after inspection, then the researcher should reconsider whether factor analysis is the appropriate statistical method to apply on the data set, as observed by Williams, Brown and Onsman (2012). This means that, a factorability of 0.3 indicates that the factors account for approximately 30% relationship within the data, or in a practical sense, it would indicate that a third of the variables share too much variance, and hence becomes impractical to determine if the variables are correlated with each other or the dependent variable.

From the narratives of key informants, 61 statements were extracted and presented to the 360 respondents to be ranked on a scale of 1 to 5 denoting strongly disagree to strongly agree. Correlation matrix of respondents' ranks of these statements was calculated. Inspection of the correlation matrix revealed that fourteen (14) variables had their correlation falling below ±0.30 and as such they were removed from the analysis. Because the correlation values showed that there were no meaningful correlations with other variables, reducing the 61 items (or statements) to 47 items.

4.4.2 Suitability of Conducting Factor Analysis on the Data

As recommended by Williams *et al* (2012), prior to the extraction of the factors, several tests were conducted to assess the suitability of the set of data for factor analysis. These tests include Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy (Kaiser, 1970 and Kaiser, Little, Jiffy and Mark, 1974) and Bartlett's Test of Sphericity (Bartlett. 1950). Williams *et al* (2012) again observed in a KMO index test that for every one variable or item there should be at least five participants (1:5). In this study, 360 participants were involved in ranking 61 items, representing cases to variable ratio of 1: 6. The KMO index ranges from 0 to 1, with 0.50 considered suitable for factor analysis (Hair *et al*, 1995 and Tabachnick et al, 2007). The Bartlett's Test of Sphericity should be significant ($p<0.05$) for factor analysis to be suitable (Williams et al, 2012).

Table 4.10: Results of Sampling Adequacy test

Test of Sampling Adequacy	**Test Results**
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	**0.862**
Bartlett's Test of Sphericity	Chi-Square (χ^2) = 30098.948 df = 1081 Sig. = 0.000***

*** note the variable is significant at 1% level of significant

Source: Analysis of Field Survey Data, 2016

In order to test sampling adequacy of the collected data, KMO tests were conducted in SPSS together with Bartlett's test, which was used to test for the suitability of factorial analysis and to prove non-zero of the correlation matrix. Table 4.10 shows the value of KMO and the results of Bartlet test. As shown in the Table, the KMO measure of sampling adequacy was 0.862, indicating a very high level of sampling adequacy suitable for factoring, while Bartlett's test of sphericity was found to be significant at 1% level of significant. The meaningfulness of Bartlet test being significant at 1% and the appropriate value of KMO index showed that the correlation matrix in the sample is not zero. Therefore, the data set is suitable for factor analysis and as such the act of finding factors with this data is statistically justifiable.

4.4.3 Determination of Number of Factors to Extract

One of the most important decisions in EFA is perhaps the determination of number of factor solutions to retain as the underlying constructs of the concourse gathered on the subject of interest. As such many authors have commented on the importance of deciding on how many factors or components to retain when applying EFA (Ledesma and Valero-Mora, 2007; Hayton, Allen, and Scarpello, 2004 and Fabrigar, Wegener, MacCallum, & Strahan, 1999). Specifically, Hayton *et al* (2004) states three reasons why this decision is so important. These are:

Firstly, the decision on number of factors to retain can affect EFA results more than other decisions, such as selecting an extraction method or the factor rotation method, since there is evidence of the relative robustness of EFA with regards to these matters as further corroborated by Ledesma *et a*l (2007).

Secondly, the EFA requires that a balance be struck between "reducing" and adequately "representing" the correlations that exist in a group of variables; therefore, its very usefulness depends on distinguishing important factors from trivial ones.

Lastly, an error in terms of selecting the number of factors can significantly alter the solution and the interpretation of EFA results. Under-extraction can lead to the loss of relevant information and a substantial distortion in the solution; for example, in the variables loading. On the other hand, over-extraction although less grave, can lead to factors with few substantial loading, which can be difficult to interpret and/or replicate (Ledesma *et al*, 2007).

Therefore, both under-extraction and over-extraction have consequences that adversely impact on EFA efficiency and meaning. To avoid this, the right guiding principles have to be adopted to obtain optimal factor solution for meaningful explanation of the underlying constructs and connectivity existing within the data set.

The most widely used methods of extraction to determine the number of factors to retain in EFA are Kaiser's eigenvalue-greater than one rule (K1), parallel analysis method of Monte Carlo, percentage of variance explained by given number of factor and Scree test (Ledesma *et al*, 2007 and Hayton et al, 2004). As such in this study the number of factors extracted was guided by these principles to ensure optimal number of factors is retained for meaningful explanation and interpretation.

The K1 method proposed by Kaiser (1960) is perhaps the best known and most utilized in practice (Fabrigar *et. al*, 1999). According to this rule, only the factors that have eigenvalues greater than one are retained for interpretation. As observed by Ledesma *et al* (2007), despite the simplicity of K1 method, many authors agree that it is problematic and inefficient when it comes to determining the number of factors. As a result, this method was applied together with the scree plot and the Total Percentage Variance Explained by any given factor as recommended by Ledesma, *et al* (2007) and Hayton *et al* (2004).

Results of factor analysis conducted with the aid of SPSS, revealed that thirteen (13) factors have their eigenvalues greater than 1. The distribution of total variance explained by a given factor solution is shown in table 4.11 (see appendix 4 for detail table). As shown in table 4.11, a single factor dimension explained about 44% of the total variance accounted for by all the possible dimensions within the data set, while two factor solution cumulatively explained more than half (58.2%) of the total variance accounted for by the dimensions in the data set. Additionally, three and four factor solutions cumulatively explained about 65% and 72% of the total variance in the data set respectively.

Table 4.11: Total Variance Explained by number of factors retained

Factor	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	20.967	44.610	44.610	20.764	44.180	44.180
2	6.858	14.592	59.202	6.585	14.011	58.190
3	3.662	7.792	66.994	3.358	7.145	65.335
4	3.625	7.712	74.706	3.266	6.950	72.284

Extraction Method: Principal Axis Factoring
Source: Analysis of Field survey Data, 2016

Cumulative percentage of variance (criterion) used as a threshold in determining the number of factors to be extracted as underlying dimensions of a data set in factor analysis varied across disciplines and focus of research interest. Henson and Roberts (2006) asserted that, no fixed threshold exists as a criterion for determining the number of factors to be extracted as a true representation of the underlying dimensions within a data set. They, however, observed that certain cumulative percentages have often been used as threshold for terminating factor extraction in exploratory factor analysis.

The cumulative percentage threshold criterion for determining number of factors to be extracted, varies from one discipline to another. According to Hair et al. (1995), in the natural sciences, factors extraction should be stopped when at least 95% of the variance is explained. In the humanities, the explained variance threshold used is usually peaked at 50-60% (Pett, Lackey and Sullivan, 2003). As shown in Table 4.11, four (4) factor solutions cumulatively explained about 72% of the total variance and as such the factor extractions were terminated there. Therefore, four factors were extracted as the underlying constructs depicting farmers' narratives and perceptions towards GM crops. The cumulative percentage of variance explained by the four factors extracted is 72.3% of the total possible dimensions within the data set and it falls within the threshold cumulative variance explained percentage mostly used in humanities and social science as asserted by Pett *et al* (2003).

The four factors extracted were guided also by scree plot as shown in the Figure 4.6. A scree plot displays the eigenvalues associated with a factor in descending order versus the number of the factors. A scree plot shows the eigenvalues on the y-axis and the number of factors on the x-axis. It always displays a downward curve. The visual representation of a scree plot can be used in factor analysis to demonstrate and determine which factors explain most of the variability in the data. The point where the slope of the curve is clearly levelling off (the "elbow) indicates the number of factors that should be generated by the analysis (Tabachnick and Fidell, 2007). As shown in the figure 4.6, the point where the scree plot curve is clearly levelling off occurs at factor four and this indicates that four factor solutions are very appropriate in explaining the underlying dimensions or constructs characterising farmers' perceptions towards GM crops.

As noted by Gorsuch (1983), Thompson (2004), Tabachnick and Fidell (2007) and Williams *et al*, (2012) interpreting Scree plots is subjective, requiring researcher judgement. Thus, disagreement over which factors should be retained is often open for debate and varying interpretations (Pett et al, 2003 and Williams et al, 2012). This disagreement and subjectivity is, however, reduced when sample sizes are large relative to the items being ranked. As observed by

Pett *et al* (2003) and Gorsuch (1983), when the ratios of N:p (sample size: number of items) is greater 3:1 then the communalities values are high. This study met the large sample size criterion of (>3:1) because the sample is 360 respondents rating 61 statements with a ratio of about 6:1. As such the subjectivity as it relates to the number of factors to be extracted being guided by the scree plot is minimal and reliable.

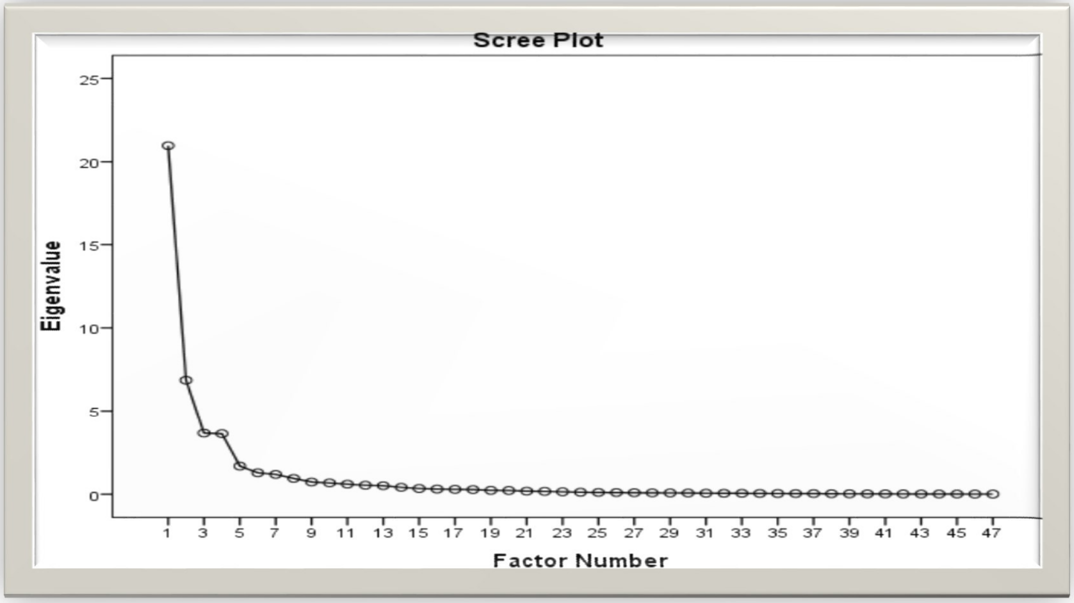

Figure 4.6: Scree plot of factor number and Eigenvalue

Source: Analysis of Field Survey Data, 2016

4.4.4 Interpretation of factors Extracted

Respondents' agreement rank scores of the 61 statements extracted from farmers' narratives on GM crops, was analysed using EFA as a dimension reduction technique in order to reduce the 61 dimensions in the data set to a manageable size which explain the underlying constructs of farmers' views on GM crops. However, 14 statements were dropped because their correlation falls below +/-0.3 with the remaining 47 statements showing reasonable correlation for interpretation. The four factors extracted explained about 72% (table 4.11) of the total variance characterising the various dimensions in the data set gathered from the narratives of smallholder farmers on issues relating to GM crops cultivation and Ghana's agrobiotechnology agenda.

Factor loading which measure the relationship of each variable to the underlying factor was used in determining the number of statements or items associated with each of the four factors extracted. Distribution of factor loadings across the four factors is presented in Table 4.12. Factor loadings below 0.4 were supressed in order to have a clear factor interpretation and to clearly determine which variable load strongly to which factor. As shown in the Table 4.12, the EFA with varimax rotation conducted revealed the following distribution of items loading onto the four factor solutions identified; fourteen (14) statements were loaded onto factor one (1), thirteen (13) statements were loaded onto factor two (2), twelve (12) statements were loaded onto factor three (3) and eight (8) statements were loaded onto factor four (4).

Table 4.12: Factor Loadings

Statements	**loadings**			
	F1	**F2**	**F3**	**F4**
Factor 1: Progressive views on GM crops	0.936			
1. All agricultural practices, not only GM crops, affect the environment				
2. Commercialization of GM crops in Ghanaian will help reduce cost of production	0.928			
3. I will be encouraged to grow GM crops because it can be bred to be resistant to the common plant diseases	0.927			
4. Reduction of chemical use in GM crops cultivation will benefit the environment	0.902			
5. Since US had allowed the cultivation of GM crops, we in Ghana shouldn't have reservation	0.887			
6. Both farmers and consumers stand to benefit from the introduction of GM crops in Ghana	0.881			
7. I will eat GM food because all what is being said are doubts	-0.879			
8. GM crops are substantially equivalent to their non-GM counterparts and as such pose no harm	0.822			
9. There wouldn't be problem if GM and conventional crops coexist in Ghana	0.818			

10. Farmers would benefit from improved yields if GM crops are introduced in Ghana	0.807		
11. I am satisfied with the country's progress towards the introduction of GM crops	0.806		
12. I will not mind, if a farm nearby grows GM crops	0.793		
13. I would choose to grow GM crops because technology should be embraced	-0.779		
14. With the country's open border system, it is unfair and unwise to prevent Ghanaian farmers from growing GM crops	0.738		
Factor 2: Negative views on GM crops			
1. The introduction of GM crops in Ghana would enslave Ghanaian farmers and consumers to foreign multinational companies		-0.772	
2. Commercialization of GM crops in Ghana will cause emergence of 'difficult to control' weeds		0.719	
3. The introduction of GM crops in Ghana will not benefit the resource poor farmers		-0.657	
4. It will be in the interest of farmers if Ghana is seen to be GM free		-0.642	
5. The introduction of GM crops in Ghana will not solve the problems of Ghanaian's agriculture		-0.632	
6. GM crops are not compatible with my farming system		-0.626	
7. I don't think there is any need for GM crops as we are struggling to get a decent price for what we grow now		-0.766	
8. I am discouraged from growing GM crops because of the negative campaign against it		-0.759	
9. I would not choose to grow GM crops because the risks are unknown and future generations should not be put at risk		0.729	
10. Ghana risks losing her food sovereignty if the country allows commercialization of GM crops		-0.709	
11. My religious belief will not allow me to cultivate GM crops because it is sacrilegious and against nature.		-0.657	
12. The introduction of GM crops in Ghana will destroy the indigenous and less economic but important local varieties of crops		0.605	
13. The introduction of GM crops would impact negatively on farmers' and consumers' health		0.442	
Factor: 3: Cynical Views			
1. If GM crops will not pose future risk to the environment then is good			0.884
2. I am not sure of the safety of GM crops, but if proven			0.861

safe then it would be good for Ghanaian farmers		
3. I don't think there is a place for both GM crops and non-GM crops	-0.842	
4. If Ghanaian consumers demand for GM - food, then I will be encouraged to grow it	0.837	
5. I will choose to grow GM crops if it comes with incentives	-0.795	
6. I am not sure Ghanaian research institutions can breed GM crops	0.745	
7. I am not sure Ghanaian regulatory agencies can ensure safe application of GMOs	0.726	
8. If many Ghanaian farmers accept GM crops, then I will also grow it	-0.681	
9. I am not sure Ghanaian farmers can manage GM crop farms	0.651	
10. If only 'natural' genes are added to GM plants then it's ok	-0.598	
11. Ghanaian consumers might reject GM food if it is introduce in Ghana.	0.570	
12. I am not sure Ghanaian extension services can manage information on GM crops	0.428	
Factor 4: Dispassionate views on GM crops		
1. I would choose to grow GM crop if it proven to be more profitable		0.724
2. To grow or not to grow GM crops would depend on the traits modified		-0.694
3. I don't have any opinion for or against the Plant Breeders' Protection Bill in its current form		-0.662
4. Whether GM crops is good or bad depend on the feature produced by genetically modification		-0.647
5. To grow or not to grow GM crops is more of international politics rather than scientific consideration		0.611
6. I don't think there is any difference between GM-food and conventional food		0.609
7. Some Ghanaian farmers may or may not have the capacity to adopt GM crops		0.546
8. Bad publicity is affecting my judgement on the appropriateness of GM crops		-0.432

Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 9 iterations

Source: Analysis of field survey Data, 2016

Factor One (1)

The fourteen statements loaded onto factor one included statements such 'All agricultural practices, not only GM crops, affect the environment' , 'Commercialization of GM crops in Ghanaian will help reduce cost of production', 'I will be encouraged to grow GM crops because it can be bred to be resistant to the common plant diseases'', ''Reduction of chemical use in GM crops cultivation will benefit the environment '' and ''Since US had allowed the cultivation of GM crops, we in Ghana shouldn't have reservation''. Others are ''Both farmers and consumers stand to benefit from the introduction of GM crops in Ghana'', ''GM crops are substantially equivalent to their non-GM counterparts and as such pose no harm'', ''I will eat GM food because all what is being said are doubts.'', ''There wouldn't be problem if GM and conventional crops coexist in Ghana'' and ''I am satisfied with the country's progress towards the introduction of GM crops''. The rest are ''I will not mind, if a farm nearby grow GM crops regardless of cross pollination/contamination'', ''I would choose to grow GM crops because technology should be embraced'' and ''With the country's open border system, it is unfair and unwise to prevent Ghanaian farmers from growing GM crops''.

Critical examination of the statements loaded onto factor one, clearly project positive views and approval of GM crops cultivation and consumption in Ghana. As such factor one was labelled as '**progressive views on GM crops**' (**GM positive perceivers**). The import of most of the statements portrayed farmers' positive and progressive views towards GM crops. Thus, one of the underlying constructs characterising smallholder farmers' views and perceptions towards GM crops relates to 'positive views and approval of the cultivation and consumption of GM crops.

Factor Two (2)

Also, the thirteen statements loaded onto factor two were ''The introduction of GM crops in Ghana would enslave Ghanaian farmers and consumers to foreign multinational companies'', ''Commercialization of GM crops in Ghana will cause emergence of 'difficult to control' weeds'', ''It will be in the interest of farmers if Ghana is seen to be GM free'' and ''The introduction of GM crops in Ghana will not solve the problems of Ghanaian's agriculture '' and ''GM crops are not compatible with my farming system''.

Others include ''I don't think there is any need for GM crops as we are struggling to get a decent price for what we grow now'', ''I am discouraged from growing GM crops because of the negative campaign against it'', ''I would not choose to grow GM crops because the risks are unknown and future generations should not be put at risk'' and ''Ghana risks losing her food sovereignty if the country allows commercialization of GM crops''. The rest were ''my religious belief will not allow me to cultivate GM crops because it is sacrilegious and against nature.'', ''the introduction of GM crops in Ghana will destroy the indigenous and less economic but important local varieties of crops'' and ''The introduction of GM crops would impact negatively on farmers' and consumers' health''.

All the above statements paint negative pictures about GM crops and the disapproval of their cultivation and consumption in Ghana. As a result, factor two was designated as '**negative views on GM crops**'. Thus one other dimension characterising members of smallholder farmers' perceptions towards GM crops have to do with 'negative views on GM crops'.

Factor Three (3)

With regard to construct three (3), the twelve (12) statements loaded on it were ''If GM crops will not pose future risk to the environment then is good'', ''I am not sure of the safety of GM crops, but if proven safe then it would be good for Ghanaian farmers'', ''I don't think there is a place for both GM crops and non-GM crops'', ''If Ghanaian consumers demand for GM - food, then I will be encouraged to grow it' and 'I will choose to grow GM crops if it comes with incentives''.

Others included ''I am not sure Ghanaian research institutions can breed GM crops'', ''I am not sure Ghanaian regulatory agencies can ensure safe application of GMOs'' and ''If many Ghanaian farmers accept GM crops, then I will also grow it''. The rest are ''I am not sure Ghanaian farmers can manage GM crop farms'', ''If only 'natural' genes are added to GM plants then it's ok'', ''Ghanaian consumers might reject GM food if it is introduce in Ghana'' and ''I am not sure Ghanaian extension services can manage information on GM crops''.

The import of underpinning all the twelve statements above loaded clearly demonstrates narrations of **scepticisms, cynicism** and **reservations** regarding the safety and appropriateness of GM crops in Ghana. Thus the third underlying constructs portraying smallholder farmers' perceptions towards GM crops was characterised by **Sceptical/cynical** or **uncertain views** which demonstrate a general lack of clarity and firm decision on the safety and appropriateness of GM crops cultivation among farmers in the study area. As such the third construct was labelled as '**cynical views on GM crops**'

Factor four (4)

Finally, the eight (8) statements loaded onto the last construct, thus factor four (4), included ''I would choose to grow GM crop if it proven to be more profitable '', ''To grow or not to grow

GM crops would depend on the traits modified''; ''I don't have any opinion for or against the Plant Breeders' Protection Bill in its current form'', ''Whether GM crops is good or bad depend on the feature produced by genetically modification'' and ''To grow or not to grow GM crops is more of international politics rather than scientific consideration''.

The others were ''I don't think there is any difference between GM-food and conventional food'', ''Some Ghanaian farmers may or may not have the capacity to adopt GM crops'' and ''Bad publicity is affecting my judgement on the appropriateness of GM crops''.

An examination of the eight statements loaded onto factor four portrays narratives of neutrality as they neither suggest positive nor negative views on GM crops cultivation in Ghana. As such factor four extracted is labelled **'Dispassionate attitude'**.

Therefore, the four underlying constructs characterising the perceptions of smallholder farmers in this study were ''**progressive views on GM crops**'', ''**negative views on GM crops**'', ''**cynical views on GM crops**'' and ''**dispassionate views on GM crops**''. Similar views of farmers towards GM crops were found in Scotland by Hall (2010). In a study to find out farmer attitudes towards genetically modified crops in Scotland, Hall (2010) characterised farmers' perceptions towards GM crops as 'benefit believers', and 'risks perceivers'.

According to Li and Dearing (2014: P1) stated that throughout the course of human history, new, innovative technological advancements have always created a diverging gap between the opposing conservatives and the supporting modernists'. It therefore not surprising that smallholder farmers surveyed held varying views towards GM crops.

4.4.5. Farmers' Attitude towards GM crops

Attitude is defined as a predisposition or a tendency to respond positively or negatively towards an idea, object, person, or situation. Attitude toward behaviour is the degree to which performance of the behaviour is positively or negatively valued (Ajzen, 2005 and Ajezen, 1991). Sutton (2002) defines attitude as the way that you think and feel about somebody or something; the way that you behave towards somebody or something that shows how you think and feel. Attitude influences an individual's choice of action, responses to challenges, incentives and rewards – referred to as stimuli. Attitude which demonstrates the feeling or way of thinking of people affects their behaviour and their decisions. In this study, attitude is defined as the predisposition or tendency of smallholder farmers to respond to or act towards GM crops in particular and agrobiotechnology in general.

Statements loaded onto the four underlying constructs characterising smallholder farmers' narratives on GM crops, established in this study, formed the basis for classifying respondents' attitudes. Attitudes of respondents towards GM crops in this study were measured on a five point Likert agreement scale as 1 = strongly disagree; 2 = disagree; 3 = undecided; 4 = agree and 5 = strongly agree. The mean score (M) for each statement was measured and one sample t-test applied to assess the representativeness of the sample mean.

4.4.5.1. Respondents' Progressive attitudes towards GM crops

Result of one sample t test on statements loaded onto progressive constructs of GM crops is presented in Table 4.13. The results depict respondents' agreement mean score (M) on their progressive tendency towards GM crops. As shown in Table 4.13, analysis of respondents' agreement score demonstrates that respondents generally agree strongly with the statements 'I will not mind, if a farm nearby grows GM crops' (M= 4.6; SD = 1,6; t = 31.1), 'I will be encouraged to grow GM crops because it can be bred to be resistant to the common plant diseases' (M= 4.6; SD = 1.5; t = 30.1) and 'All agricultural practices, not only GM crops, affect the environment' (M = 4.7; SD = 1.6; t = 29.7) at 1% level of significant.

However, respondents merely agreed to the statements 'Farmers would benefit from improved yields if GM crops are introduced in Ghana' (M = 4.2; SD = 1,6; t = 27.9), 'I would choose to grow GM crops because technology should be embraced' (M = 3.6; SD = 1.2; t = 40.3) and 'There wouldn't be problem if GM and conventional crops coexist in Ghana' (M = 3.7; SD = 1.4; t = 30.1) at 1% level of significant.

Table 4.13: Descriptive statistics of Farmers Positive attitude towards GM crops

Statements	M	SD	t	df	P<0.05
Both farmers and consumers stand to benefit from the introduction of GM crops in Ghana	2.6	1.6	31.1	359	0.0
Farmers would benefit from improved yields if GM crops are introduced in Ghana	4.2	1.6	27.9	359	0.0
I will not mind, if a farm nearby grows GM crops	4.6	1.4	33.3	359	0.0
Reduction of chemical use in GM crops cultivation will benefit the environment	2.4	1.5	30.2	359	0.0
I will eat GM food because all what is being said are doubts.	3.2	1.6	36.9	359	0.0
I would choose to grow GM crops because technology should be embraced	3.6	1.2	40.3	359	0.0
I will be encouraged to grow GM crops because it can be bred to be resistant to the common plant diseases	4.6	1.5	30.1	359	0.0
Commercialization of GM crops in Ghanaian will help reduce cost of production	2.5	1.7	28.0	359	0.0
There wouldn't be problem if GM and conventional crops coexist in Ghana	3.7	1.4	30.1	359	0.0
With the country's open border system, it is unfair and unwise to prevent Ghanaian farmers from growing GM crops	2.5	1.8	27.3	359	0.0
GM crops are substantially equivalent to their non-GM counterparts and as such pose no harm	2.7	1.4	32.0	359	0.0
Since US had allowed the cultivation of GM crops, we in Ghana shouldn't have reservations	2.1	1.2	31.4	359	0.0
All agricultural practices, not only GM crops, affect the environment	4.7	1.6	29.7	359	0.0
I am satisfied with the country's progress towards the	2.0	1.2	32.7	359	0.0

introduction of GM crops					

Source: Analysis of field survey Data, 2016
1 = strongly disagree; 2 = disagree; 3 = undecided; 4 = agree and 5 = strongly agree

The results demonstrate clearly that smallholder farmers in northern Ghana held the view that all agricultural activities have some negative effects on the environment in response to the argument that GM crops have negative consequences on the environment. The report of EASCA (2013) on the environmental effects of GMOs bemoaned the lack of clarity in isolating the effects of GM crops on the environment from the effects caused by general agricultural practice. The report asserts that every agricultural practice causes certain changes to the environment such as deforestation, land degradation, polluting of water bodies from agrochemical residues among others. Qaim (2015) also underscored the lack of clarity associated with the GM debate as it has to do with uncertainty regarding occurrence, timing, attribution and isolated effects, magnitude and significant levels of adverse effects specifically caused by GMOs on the environment.

The fear of cross pollination of GM crops with their wild relatives leading to possible development of superweeds and superbugs and possible contamination of non-GM crops by GM varieties appeared not to bother farmers surveyed in this study. Results of respondents' agreement ranking score on the statements 'I will not mind, if a farm nearby grows GM crops', as shown in Table 4.13, clearly shows smallholder farmers in northern Ghana were opened to having both GM and conventional crops grown in close proximity regardless of crosspollination and contamination.

The concerns of interaction of GM crops with its wild relatives and possibility of gene flow causing possible evolution of glyphosate resistance leading to the emergence of superweeds and superbugs have widely been highlighted in the GMOs debate (Lang and Otto, 2010 and Zobiole et al, 2011).

4.4.5. 2. Farmers' negative attitudes towards GM crops

Results of respondents' agreement scores on statements portraying negative attitudes of farmers towards GM crops as presented in Table 4.14 illustrates farmers concerns about protecting indigenous crop varieties and seed sovereignty. With average agreement rank score of 4.1 (SD = 1.2; t = 63.7), respondents generally agreed to the statement 'The introduction of GM crops in Ghana will destroy the indigenous and less economic but important local varieties of crops'. This indicates that farmers have some fears that GM crops might divert research and market interest away from their indigenous and less economic local varieties of crops.

The fear of losing national and local seed sovereignty to multinational biotech companies was also generally expressed by the farmers interviewed in this study. Respondents' agreement score for the statement ''the introduction of GM crops in Ghana would enslave Ghanaian farmers and consumers to foreign multinational companies'' (M = 4.0; SD = 1.1; t = 67.8) shows a general agreement among respondents.

The fear of commercialization of GM crops cultivation altering food sovereignty has been strongly pressed by activists against GM crops. A well-known activist against GM crops, Vandana Shiva is reported to have described the fight against agricultural biotechnology as a global war against a few giant seed companies on behalf of the billions of farmers who depend on what they themselves grow to survive (Specter, 2014). Similarly, Bhuiya (2012) noted that the advent of GM crops may shift local control and farming system to corporate control and international politics.

The uncertainty regarding possible risks of GM crops was found to be widely espoused by respondents. Such views are bound to shape smallholder farmers' attitude towards possible adoption of GM crops. As established from the analysis of respondents' agreement rankings, the decision of smallholder farmers regarding adoption of GM crops is likely to be influenced by their perception on whether or not GM crops could pose a risk to future generation. With agreement mean score of 4.2 (SD = 1.0; t = 77.3) respondents generally agreed with the statement 'I would not choose to grow GM crops because the risks are unknown and future generations should not be put at risk. This indicates respondents' general reservation towards possible adoption of GM crops. Concerns of possible health and environmental risks associated with GM crops have widely been raised and hence its influence on farmers' attitude towards possible adoption of GM crops (Todua, Gogitidze and Phutkaradze 2017). The findings indicated that farmers' adoption decision will be largely influenced by their understanding of the uncertainties surrounding the possible health and environmental risks associated with the cultivation and consumption of GM crops. As such clearing their minds of these uncertainties will significantly influence their adoption decision on GM crops.

However, farmers generally disagreed with the view that Ghana risks losing her food sovereignty if commercialization of GM crops are allowed. With an average agreement score of 1.7 (SD = 1.0; t = 31.6) regarding the statement 'Ghana risks losing her food sovereignty if the country allows for commercialization of GM crops' as shown in Table 4.14. This demonstrates respondents' general disposition to reject the national food sovereignty argument. Also, the argument of possible cross pollination of glyphosate GM crop traits with conventional crops leading to the development of superweeds was generally not espoused among the 360 farmers interviewed. The average agreement rank score of respondents for the statement 'Commercialization of GM crops in Ghana will cause emergence of 'difficult to control' weeds' was 2.2 (SD = 1.4; t = 30.1) indicating that respondents generally disagreed with the assertion that commercialization of GM crops in Ghana will introduce superweeds which will be difficult to control.

Inspite of the fact that all 360 smallholder farmers surveyed belong to religious groupings – Christianity, Islam or Traditional religion they generally rejected the notion that GMOs technology is sacrilegious and that it goes against religious beliefs of God being the creator of everything. As shown by the agreement ranking on the statement 'my religious belief will not allow me to cultivate GM crops because it is sacrilegious and against nature' with average agreement rank score of 2.2 (SD = 1.3; t = 32.5) (table 4.14). This indicates that respondents in general disagreed with the erroneous assentation that GMOs are sacrilegious and a corruption of natural creations. However, in the various focus group discussions some participants expressed this view of GM crops being sacrilegious and a corruption of nature's creation. Respondents got this information from visual publication of GMOs by anti-GM activists in which pictures and visuals portraying the process of genetic modification as satanic and corruption of natural plants and animals. Even though there is general rejection of this view, such information about GM crops can affect farmers and consumers acceptance of GMOs and their products and derivatives.

As illustrated by the average agreement ranks of the statements 'GM crops are not compatible with my farming system' (M = 2.9, SD = 1, t = 53), 'It will be in the interest of farmers if Ghana is seen to be GM free' (M = 3.1, SD = 1.2, t = 38.6) and 'The introduction of GM crops in Ghana will not benefit the resource poor farmers' (M = 3.3, SD = 1.5, t = 41.2) in Table 4.14 respondents could not form opinions on these statements. The mean values for these statements imply that they were undecided. Similarly, respondents were generally undecided, as illustrated by the average agreement rank scores of the statements 'I am discouraged from growing GM crops because of the negative campaign against it' and 'The introduction of GM crops would impact negatively on farmers' and consumers' health', indicating that the respondents are yet to be convinced by these negative campaigns about GM crops.

Table 4.14: Descriptive statistics of Farmers Negative attitude towards GM crops

Statements	M	SD	t	df	P<0.05
GM crops are not compatible with my farming system	2.9	1.0	53.0	359	0.0
Commercialization of GM crops in Ghana will cause emergence of 'difficult to control' weeds	2.2	1.4	30.1	359	0.0
It will be in the interest of farmers if Ghana is seen to be GM free	3.1	1.2	38.6	359	0.0
My religious belief will not allow me to cultivate GM crops because it is sacrilegious and against nature.	2.2	1.3	32.5	359	0.0
The introduction of GM crops in Ghana will destroy the indigenous and less economic but important local varieties of crops	4.1	1.2	63.7	359	0.0
The introduction of GM crops in Ghana will not benefit the resource poor farmers	3.3	1.5	41.2	359	0.0
I am discouraged from growing GM crops because of the negative campaign against it	2.8	1.1	45.3	359	0.0
Ghana risks losing her food sovereignty if the country allows commercialization of GM crops	1.7	1.0	31.6	359	0.0
I would not choose to grow GM crops because the risks are unknown and future generations should not be put at risk	4.2	1.0	77.3	359	0.0
The introduction of GM crops in Ghana will not solve the problems of Ghanaian's agriculture	3.7	1.5	45.8	359	0.0
I don't think there is any need for GM crops as we are struggling to get a decent price for what we grow now	2.7	1.2	40.4	359	0.0
The introduction of GM crops in Ghana would enslave Ghanaian farmers and consumers to foreign multinational companies	4.0	1.1	67.8	359	0.0
The introduction of GM crops would impact negatively on farmers' and consumers' health	3.1	1.2	67.5	359	0.0

Source: Analysis of field survey Data, 2016

1 = strongly disagree; 2 = disagree; 3 = undecided; 4 = agree and 5 = strongly agree

4.4.5. 3. Farmers' cynical attitude towards GM crops

Distribution of agreement ranks of statements portraying uncertainties and cynical attitude of respondents towards GM crops cultivation is shown in Table 4.15. As shown in the Table respondents interviewed have concerns about the ability of Ghana's agricultural extension systems to facilitate GMOs technology transfer and the preparedness of the country's regulatory agencies to ensure safe application of this novel technology. With average agreement rank score of 4.0 (SD = 0.9; t = 87.4) regarding the statement 'I am not sure Ghanaian extension services can manage information on GM crops', there is strong evidence that farmers interviewed in general agreed that the country's extension systems might not have the needed capacity to take on commercialization of GM crops. Similarly, respondents were generally of the opinion that the country's regulatory agencies lack the capacity to safely take on commercial production of GM crops, (M = 3.7, SD =1.3; t = 53.1).

Uncertainty about the future prospects of GM crops is one of the main issues characterising respondents' narratives about GM crops. Analysis of respondents' agreement scores on the statements 'If many Ghanaian farmers accept GM crops, then I will also grow it'' and ''If Ghanaian consumers demand for GM - food, then I will be encouraged to grow it'' with average agreement rank scores of 3.7 (SD = 1.3; t = 53.3) and 3.9 (SD = 1.4; t = 54.5) respectively demonstrates general agreement among respondents regarding the statements. Also, respondents in general have the disposition to wait until they see many farmers growing GM crops and consumers accepting and demanding for GM products before they take a decision to adopt its cultivation.

Respondents are also concerned about the uncertainty regarding safety or otherwise of GMOs. Respondents generally agreed with the statement 'I am not sure of the safety of GM crops, but if proven safe then it would be good for Ghanaian farmers' with average agreement rank score of 3.7 (SD = 1.7; t = 29.5) as shown in Table 4.15. Similar concern captured by the statement 'If only 'natural' genes are added to GM plants then it's ok' with average agreement rank score of 3.8 (SD = 1.41; t = 68.5) portray that this view is widely held among respondents.

Notwithstanding these concerns, if GMOs technology comes with incentive package it will have wide acceptance. This is illustrated by the analysis of respondents' agreement rank score on the statement 'I will choose to grow GM crops if it comes with incentives' with average rank score of 4.8 (SD = 0.89; t = 88.3) as shown in Table 4.15. This demonstrates a strong agreement among respondents regarding the view that farmers will choose to grow GM crops if it comes with incentives. At the various focus group discussions, participants were calling on government to provide incentives and free GM seeds if the technology is to be accepted by Ghanaian farmers. At one of such focus group discussion, a participant observed that;

> *'I hear in Burkina Faso tomato and cotton farmers are given GM seeds free, so if Ghana government can do that then we will try these new crops.''*(Verbatim comment of participant)

Also, respondents in general disagreed with the statements 'I don't think there is a place for both GM crops and non-GM crops' (M = 2.3, SD = 1.3; t = 32.9) and 'If GM crops will not pose future risk to the environment then is good' (M = 2.4, SD = 1.6; t = 27.7). Thus, respondents are of the opinion that both GM crops and conventional crops can coexist in Ghana. Activist against GMOs often raise the argument of possible cross pollination and contamination of conventional crops with GMOs as reason why GM crops and conventional agriculture should not be practiced together.

However, respondents could not form opinion about the capacity of Ghana's Agricultural Research Institutions to use agrobiotechnology to improve local crop varieties. Analysis of respondents' agreement rank score on the statement 'I am not sure Ghanaian research institutions can breed GM crops' revealed a mean of 3.2 (SD = 1.6; t = 37.8). This explained their inability to indicate whether national research and innovation system had capacity to employ agrobiotechnology to improve local varieties of crops.

Table 4.15: Descriptive statistics of Farmers sceptic/cynical attitude towards GM crops

Statements	M	SD	t	df	P<0.05
I am not sure of the safety of GM crops, but if proven safe then it would be good for Ghanaian farmers	3.7	1.7	29.5	359	0.0
I am not sure Ghanaian extension services can manage information on GM crops	4.0	0.9	87.4	359	0.0
I will choose to grow GM crops if it comes with incentives	4.8	0.9	88.3	359	0.0
I am not sure Ghanaian regulatory agencies can ensure safe application of GMOs	3.7	1.3	53.1	359	0.0
If many Ghanaian farmers accept GM crops, then I will also grow it	3.7	1.3	53.3	359	0.0
I am not sure Ghanaian farmers can manage GM crop farms	3.7	1.4	50.2	359	0.0
I am not sure Ghanaian research institutions can breed GM crops	3.2	1.6	37.8	359	0.0
I don't think there is a place for both GM crops and non	2.3	1.3	32.9	359	0.0
If Ghanaian consumers demand for GM - food, then I will be encouraged to grow it	3.9	1.4	54.5	359	0.0
If GM crops will not pose future risk to the environment then is good	2.4	1.6	27.7	359	0.0
If only 'natural' genes are added to GM plants then it's ok	3.8	1.1	68.5	359	0.0
Ghanaian consumers might reject GM food if it is introduce in Ghana.	3.1	1.2	38.7	359	0.0

Source: Analysis of field survey Data, 2016

1 = strongly disagree; 2 = disagree; 3 = undecided; 4 = agree and 5 = strongly agree.

However, information gathered from key informants with expertise in agrobiotechnology indicates Ghana's preparedness to improve local varieties of crops using GMOs technology. For instance, Savannah Agricultural Research Institution (SARI) of the Council for Scientific and

Industrial Research (CSIR) is currently undertaking adaptive trials and research into genetically modified cowpea and cotton. As part of the trial process, SARI has established a biotechnology cowpea farm at Nyankpala in the Tolon District and a biotechnology cotton farm at Kpalkore in the Mion District.

4.4.5. 4. Farmers' Dispassionate attitude towards GM crops

Results of analysis of agreement rank scores of statements extracted from the narratives of farmers interviewed which portrayed their dispassionate, neutral attitude towards GM crops is presented in Table 4.16.

Table 4.16: Descriptive statistics of Farmers' Dispassionate attitude towards GM crops

Statements	M	SD	t	df	P<0.05
Whether GM crops is good or bad depend on the feature produced by genetically modification	4.1	1.8	42.9	359	0.0
To grow or not to grow GM crops would depend on the traits modified	3.9	1.1	64.1	359	0.0
Bad publicity is affecting my judgement on the appropriateness of GM crops	4.1	0.7	114.9	359	0.0
Some Ghanaian farmers may or may not have the capacity to adopt GM crops	2.3	1.0	32.3	359	0.0
I would choose to grow GM crop if it proven to be more profitable	4.4	1.0	85.1	359	0.0
I don't think there is any difference between GM-food and conventional food	3.3	1.4	48.2	359	0.0
To grow or not to grow GM crops is more of international politics rather than scientific consideration	3.2	1.3	48.1	359	0.0
I don't have any opinion for or against the Plant Breeders' Protection Bill in its current form	3.0	1.0	62.4	359	0.0

Source: Analysis of field survey Data, 2016

1 1 = strongly disagree; 2 = disagree; 3 = undecided; 4 = agree and 5 = strongly agree.

As shown in Table 4.16, respondents generally agreed with the statements ''Whether GM crops is good or bad depend on the feature produced by genetically modification'' (M = 4.1, SD = 1.8; t

= 42.9) and ‘‘to grow or not to grow GM crops would depend on the traits modified’’ (M = 3.9, SD = 1.1; t = 64.1). This clearly demonstrates that farmers are not only concerned about GM crops in general but what type of crop varieties and traits being engineered. Most participants at the various focus group discussions indicated that they are looking forward to GM crop varieties that are disease and pest resistant and drought tolerant.

GMOs technology, as it is for all crop improvement technologies, provides tools and techniques for breeding crops which overcome shortcomings of current and known varieties. It is therefore not out of place for farmers to expect GMOs technology to be employed in breeding drought tolerant crop varieties because they are experiencing shorter rainy season in the area. However, the reasons farmers cited for choosing biotech crops are higher productivity, such as yield increases of up to 30% on the same area of land, and economic and income gains (James, 2013 and James, 2012).

The possible economic and income gains expected from GM crops cultivation was highlighted in respondents view about GM crops. As shown in Table 4.16, the analysis of respondents’ agreement rank scores indicated that respondents in general agreed with the statement ‘‘I would choose to grow GM crop if it proven to be more profitable’’ (M = 4.4; SD = 1.0; t = 85.1).

Vigani and Olper, (2013) observed that, the mass media is rapidly spreading information about engineered food and crops which is shaping public perceptions and opinion on GM crops. Respondents confirmed this with generally agreeing on the statement ‘‘bad publicity is affecting my judgement on the appropriateness of GM crops’’ (M 4.1; SD = 0.7; t = 114.9). Thus, respondents generally are of the opinion that bad publicity about GM crops will likely influence their prospective decision towards adoption of GM crops. This finding is especially important because most of the information available in the public domain about GM crops and engineered food are those put forward by anti-GM advocates. This is so because the scientific community has neither adequately addressed public concerns about GM crops and its food derivatives nor effectively communicated the value of this technology for it to gain public acceptance, which is essential to the continued development and application of biotechnology in commercial agriculture.

With regard to farmers' capacity to adjust and accommodate the demand for GM crops cultivation, respondents were confident of their capacity to adopt GM crops cultivation.

However, information gathered from in-depth interviews with selected farmers, as part of the Q – methodological process employed in congregating farmers' narratives, brought to the fore farmers' fears regarding their capacity to adopt GM crops. They cited the requirement to respect Intellectual Property Right (IPR) governing GM seed purchase and distribution and keeping regulatory and standards among others. Nevertheless, analysis of respondents' agreement rank score on the statement ''Some Ghanaian farmers may or may not have the capacity to adopt GM crops'' revealed average agreement score of 2.3 (SD = 1.0; t = 32.3), indicating that respondents in general disagreed with the notion that they might lack the capacity to adopt GM crops.

However, respondents in general were unable to form opinions about the following statements: 'I don't think there is any difference between GM-food and conventional food, 'To grow or not to grow GM crops is more of international politics rather than scientific consideration' and 'I don't have any opinion for or against the Plant Breeders' Protection Bill in its current form' (M = 3.0; SD = 1.4; t = 48.2). This finding about the plant breeders' protection bill is unexpected because it has received unyielding opposition from anti-GM activists coming under the banner 'National Campaign against Plant Breeders' Bill'. They took to the media and mounted public campaigns and demonstrations in protest against the bill. All these were expected to have impact on farmers' attitude and opinion about the bill. Though, analysis of respondents' attitude revealed their neutral attitude towards the appropriateness of the bills.

4.5 Farmers' Adoption Decision towards GM crops

In line with the requirements of objective three of the study which sought to 'analyse determinants of factors predicting smallholder farmers' adoption decision towards GM crops cultivation', this section presents results and discussion of respondents' adoption decision towards future cultivation of GM crops. The section discusses findings of farmers' intended adoption decision on GM crops, the reasons for their decision and factors which significantly predict farmers' adoption decision towards GM crops cultivation.

4.5.1. Respondents' Adoption Decision

Analysis of responses of the 360 respondents regarding their intention to adopt GM crops cultivation when their commercialization is allowed in Ghana revealed that 2 out of every 5 farmers interviewed intends to adopt GM crops cultivation. Out of the 360 farmers interviewed, 149 of them (representing 41%) intent adopting the cultivation of GM crops when commercialization commences in Ghana. The reasons they cited for their decision to adopt GM crops cultivation range from curiosity to improved productivity. Responding to a fellow-up statement, 'indicate the reasons for your decision', analysis of responses as shown in the Figure 4.6a, shows that nearly half (46.3%) of the 149 respondents intending to adopt GM crops cultivation mentioned curiosity, 35.6% said for improved productivity and 18.1% cited confidence in the approved GM crops traits as their motivation for intending to adopt the cultivation of GM crops.

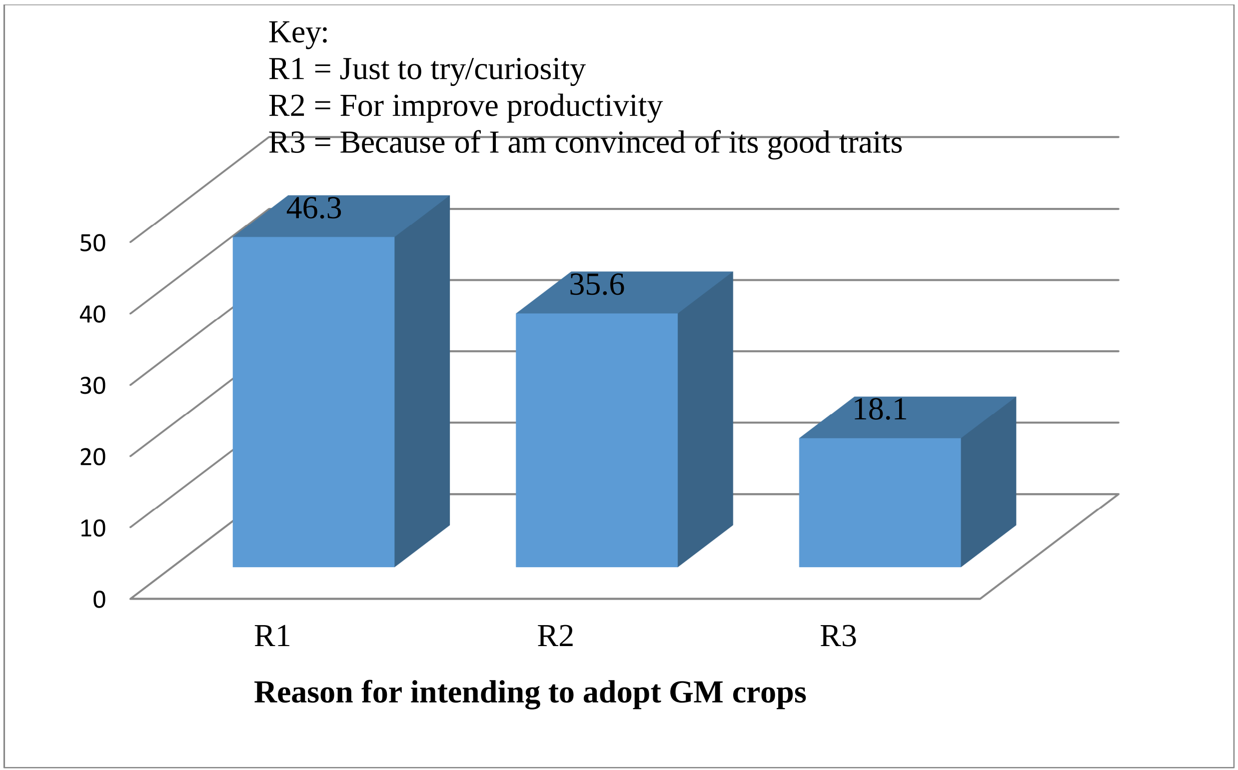

Figure 4.6a: Reasons for intending to adopt GM crops cultivation
Source: Analysis of field survey Data, 2016

However, the remaining 211 (representing 59%) who indicated their intention not to adopt the cultivation of GM crops cited reasons ranging from cost to safety concerns. Majority (54 %) of those not intending to adopt GM crops cultivation cited incompatibility concerns as their main reason for not intending to engage in GM crops production. See fig. 4.6b. They argued that the GMO technology is alien in Ghana and also comes with seed patents and safety regulatory regimes which do not fit well with their farming system and the national innovation system in Ghana. Also, as shown in the Figure 4.6b, 20.4% of the 211 respondents not intending to adopt GM crop cultivation, explained that they lack the capacity to adopt this novel technology, while

13.3% and 12.3% respectively cited high cost of GM seeds and safety concerns as the main reasons for their decision not to adopt the cultivation of GM crops.

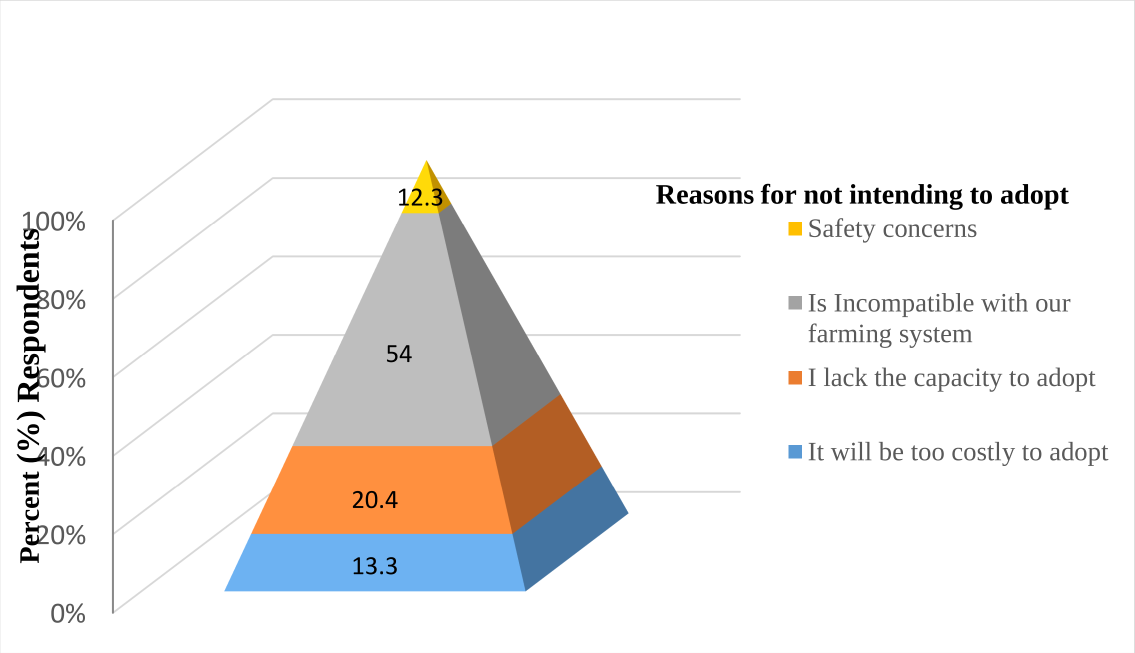

Figure 4.6b: Reasons for not intending to adopt GM crops cultivation

Source: Analysis of field survey Data, 2016

Possible high cost of GM seed was also highlighted by participants at the various focus group discussions as one of the reasons they, as smallholder farmers, might not benefit from GM crops cultivation. Responding to a further probe why they think GM seed might be expensive, one participant posited thus:

> ''*we are told that these GM seeds are produced overseas, so when they bring them here they will be very expensive, besides we cannot reproduce them and use, because they have killed their soul and they cannot be replanted …. meaning we have to always import the seeds from overseas every year..*'' (Verbatim comments by a participant)

Another participant retorted;

> ''*to deal with the high cost of this new crop seeds, why can't Ghana government do like what Burkina Faso government is doing for their tomato farmers, where the government buys GM tomato (sweet flavour) seed from overseas and distribute to farmers free ..*'' (Verbatim comments by a participant) .

This observation highlights the role of national government in improving smallholder farmers' access to GM crops. It has been noted that through Public Private Partnership (PPP) GM seeds can be made accessible and affordable to smallholder farmers in Africa (Chambers, et al, 2014).

4.5.2 Determinants of Farmers' Adoption Decision

In identifying factors determining farmers' adoption decision towards GM crops, McFadden's Random Utility Theory (RUT) and Ajzen's Theory of Planned Behaviour (TPB) were applied. The RUT follows the utility-maximization condition which assumes that rational farmers will select a product only if the product provides the highest utility given a constraint. The utility that a farmer derives from a product can be represented as having two components; a utility function of observed characteristics known as the deterministic component of utility and the unobserved component known as the random component.

The deterministic component is exogenous and includes farmers' characteristics and product characteristics and a set of linearly related parameters whiles the random component may result from missing data/variables (omitted variable), measurement errors and misspecification of the utility function (McFadden, 1994). However, in predicting an individual's decision, the TPB considers individual perceptions and attitude towards the issues to be decided on, and social views and norms regarding the decision.

Based on these theories, the research modelled farmers' Adoption Decision on GM crops by applying a probit regression model with selected independent variables from farmers' socioeconomic characteristics and their perception and attitude towards GM crops. Descriptive statistics of the independent variables used in the probit model is presented in table 4.17.

Table 4.17: Descriptive Statistics of Variables in the Probit Model

Variable	Description	Mean	SD	Min.	Max.
	Dependent Variable				
Y_j	Adoption Decision (dummied as i = 1 if farmer will be adopting; 0 = otherwise)	0.4	0.5	0.0	1.0
	Independent Variable				
X_{1i}	Sex (Dummied as i = 1 if male; otherwise = 0)	0.6	0.5	0.0	1.0
X_2	Age (in years)	42.8	10.5	24.0	75.0
X_3	Household size (number of persons)	9.1	3.8	3.0	24.0
X_4	Education (number of years of formal schooling)	8.8	6.0	0.0	16.0
X_{5i}	Religion (Dummied as i = 1 if traditional; i =0; if otherwise)	0.3	0.7	0.0	1.0
X_{6i}	Marital Status (Dummied i= 1 if married; i= 0 if otherwise)	0.8	0.4	0.0	1.0
X_7	Farm Size (acres)	6.0	5.5	1.0	70.0
X_8	Ratio of crop income to HH income	0.6	0.2	0.1`	1.0
X_9	Experience in crop Farming	20.8	10.5	2	53.0
X_{10i}	Source of Information on GM crops (Dummied as i= 1 if mass media; i=0; otherwise)	0.4	0.5	0.0	1.0
X_{11}	Positive attitude (Score on positive statements on GM crops)	3.7	1.6	1.0	5.0
X_{12}	Negative attitude (Score on negative statements on GM crops)	3.4	1.5	1.0	5.0
X_{13}	Sceptic attitude (Score on scepticisms statements on GM crops)	3.8	1.3	1.0	5.0
X_{14}	Dispassionate attitude (Score on Dispassionate statements on GM crops)	3.9	1.1	1.0	5.0
X_{15i}	Used of certified seed (Dummied as i= 1; if yes; i= 0; if otherwise)	0.3	0.5	0.0	1.0
X_{16}	Experience in FBO (in years)	8.3	3.3	2.0	21.0
X_{17}	Extension contact (number of extension contact/visit in a season)	4.1	2.4	0.0	20.0

Source: Analysis of field survey Data, 2016

As shown in table 4.7, the variable sex of farmer (X_{1i}) which is dummied as 1 for male and 0 for female, has a mean of 0.6 (SD = 0.5). This indicates that male farmers constitute 60% of the sampled respondents. Also, the variable age of farmer (X_2), measured in years, has an average of 42.8 (SD = 10.5), implying that the average age of the 360 farmers interviewed is about 43 years with the oldest being 75 years and the youngest 24 years. The mean of the variable household size (X_3) is 9.1 (SD = 3.5). This indicates that respondents interviewed are from large households with average of 9 persons per household. Similarly, the variable education, which is measured as number of years of formal schooling completed, has a mean of 8.8 (SD = 6.0), implying that on the average persons interviewed completed 9 years of formal schooling, which corresponds to basic level in Ghana's educational structure.

The variable religion (X_{5i}) which is dummied as 1 if respondents is a traditionalist and 0 if otherwise, has a mean of 0.3 (SD = 0.7), implying about a third (30%) of the respondents practise traditional religion whiles 70% are either Christians or Muslims. The variable X_{6i} (marital status), dummied as 1 if married; and 0 if otherwise, with a mean of 0.8 (SD = 0.4), implies that 80% of the 360 respondents interviewed were married, while the remaining 20% were single. Farm size denoted by the variable X_7 and measured in acres has a mean of 6.0 (SD = 5.5) with minimum and maximum of 1 and 70 acres respectively. This implies that the average farm size per respondent is 6 acres with a smallest farm size per respondent being 1acre and largest of 70 acres. Also, the variable 'ratio of crop income to household income', denoted by X_8 with a mean of 0.8 (SD = 0.4) indicates that income from crop production constitutes the largest proportion (80%) of annual household income of farmers surveyed for this study.

Analysis of farmers' experience on crop production denoted by the variable X_9 and measured by the number of years engaged in crop farming, produced a mean value of 20.8 years (SD = 10.5) with minimum and maximum experience being 2 years and 53 years respectively. Also, analysis of the variable source of information on GM crops (X_{10i}), which was dummied as 1 if information on GM crops was obtained from the mass media such as radio and television, and 0 if obtained from other sources, had a mean of 0.4 (SD = 0.5). This indicates that 40% of the respondents sourced their information on GM crops from the mass media.

Regarding perceptions and attitudes towards GM crops, analysis of respondents' average agreement score for all positive statements on GM crops denoted by the variable X_{11} and measured on a Likert scale 1 – 5 is 3.7 (SD = 1.6) as shown in the Table 4. 17. This implies that respondents generally lean towards agreeing with all the positive statements on GM crops. Similarly, the overall average agreement score for all the negative statements on GM crops denoted by the variable X_{12}, is 3.4 (SD = 1.5) and is indicative of respondents' general uncertainty or neutrality of all the negatives statements on GM crops.

Statements portraying respondents' cynical and scepticisms concerning GM crops which is denoted by the variable X_{13} have an overall mean agreement rank score of 3.8 (SD = 1.3). This indicates that respondents generally lean towards agreeing with those statements highlighting farmers' scepticisms about GM crops. For statements portraying respondents' dispassionate views on GM crops, the analysis of the agreement rank scores for those statements produced an overall average rank score of 3.9 (SD = 1.1). Thus, respondents in general are in agreement with all the statements portraying dispassionate attitude towards GM crops.

Regarding the variable 'use of certified seed' denoted by X_{15i} and dummied as 1 if yes use certified seed and 0 if do not use certified seeds, the mean as shown in the Table 16, is 0.3 (SD = 0.5). This indicates that only 30 % of the farmers surveyed used certified seeds. Also farmers average experience in FBOs denoted by the variable X_{16} and measured as how long a farmer had been a member of FBO is 8.3 years (SD = 3.3). For the variable 'extension contact' denoted by

X_{17} and measured as the numbers of visits or formal contacts received from extension officer within the last cropping season, the mean is 4.1 (SD = 2.4).

4.5.3 Coefficients of the Probit Regression Equation

The results of the probit model on the likelihood of a farmer adopting GM crop are presented in Table 4.18a, with marginal effects shown in Table 4.18b. Both were estimated using STATA version 11. The model is statistically significant at 1% significance level based on a likelihood ratio test, with LR Chi – Square (17) = 299.51; Prob > Chi2 = 0.0000. Also, with pseudo adjusted R – square of 0.86, it indicates that about 86% of the likelihood of farmers' adoption decision towards GM crops cultivation is jointly explained by the independent variables in the empirical model.

In the case of the continuous explanatory variables, the marginal effect relates to a one-unit change in the variable. For the binary explanatory variables, the marginal effect is the difference in probabilities between setting the explanatory variable to 1 and setting it to 0, given that all other explanatory variables are set at their sample means.

Out of the seventeen (17) independent variables in the model, eleven (11) were found to be significant determinants of farmers' adoption decision. The significant variables are 'age', 'household size', 'marital status', 'farm size', 'ratio of crop income to household income' and 'experience in crop farming'. Others are 'source of information on GM crops', 'score on positive views on GM crops', and 'use of certified seeds'.

Table 4.18a: Results of probit model on prospects of GM crop adoption

Variable	Coefficient.	Std. Err.	Z
X_1	0.6693	0.5530	1.21
X_2	-0.2091****	0.0586	-3.57
X_3	-0.2162**	0.0846	-2.56
X_4	0.0915**	0.0467	1.96
X_5	-0.7624*	0.5811	-1.31
X_6	-1.3678*	0.7658	-1.79
X_7	0.1385*	0.0774	1.79
X_8	-4.5216 ***	1.3887	-3.26
X_9	0.1838***	0.0664	2.77
X_{10}	-0.6029*	0.3426	-1.76
X_{11}	1.0624***	0.3592	2.96
X_{12}	-0.1054	0.1939	-0.54
X_{13}	-0.0665	0.3153	-0.21
X_{14}	0.2208	0.2099	1.05
X_{15}	4.5385 ***	0.9627	4.71
X_{16}	-0.0762	0.0779	-0.98
X_{17}	0.2316**	0.1225	1.89
_const.	7.2361***	2.6403	2.74
Log likelihood	**-23.4590**	-	-
LR $Chi^2(17)$	**299.51*** **	-	-
Pseudo R^2	**0.8646**	-	-

Note; ***, **, * denotes significant at 1%, 5% and 10% respectively
Source: Analysis of field survey, 2016

Table 4.18b: Marginal effects of probit model on prospects of GM crop adoption

Variable	dF/dx	Std. Err.	Z
X_1	0.0753	0.0803	1.21
X_2	-0.0195	0.0137***	-3.57
X_3	-0.0202	0.0115**	-2.56
X_4	0.0086	0.0062**	1.96
X_5	-0.0564	0.0482*	-1.76
X_6	-0.0802	0.0590 *	-1.79
X_7	0.0129	0.0091*	1.79
X_8	-0.4227	0.2632 ***	-3.26
X_9	0.0172	0.0131***	2.77
X_{10}	-0.0738	0.0747	-1.31
X_{11}	0.0993	0.0544***	2.96
X_{12}	-0.0099	0.0185	-0.54
X_{13}	-0.0062	0.0298	-0.21
X_{14}	0.0206	0.0228	1.05
X_{15}	0.9035	0.0869***	4.71
X_{16}	-0.0071	0.0088	-0.98
X_{17}	0.0217	0.0176**	1.89
Log likelihood	**-23.4591**		
LR chi^2(17	**299.51*** **	-	-
Pseudo R^2	**0.8646**		

Note; ***, **, * denotes significant at 1%, 5% and 10% respectively
Source: Analysis of field survey, 2016

Age of Farmers: The variable age of respondent (X_2) was found to be significant at 1% and negatively related to adoption decision. This implies that farmers' age significantly predicts their adoption decision. As shown in the marginal effects model (Table 4.18b) the coefficient of the variable 'age' was -0.0195, which illustrates that a unit change in respondents' age reduce the probability of farmers' adoption decision by 0.02 (or 2%).

Also the negative relationship between age and adoption decision, indicates that younger farmers are more likely to adopt GM crop cultivation compared to the aged. GMOs technology being a novel innovation appears to be more appealing to younger generation because they are more likely to have some level of education and as such can better understand the technology. A study on 'Attitudes of European farmers towards GM crop adoption' by Areal, Riesgo and Rodrıguez-Cerezo (2011) also concluded that age of farmers is a significant determinant of GM crops adoption among European farmers. Similarly, Gogitidze and Phutkaradze (2017) found age of farmers to be a significant determinant of GM crops adoption.

However, Paredes and Martin (2007) in studying the adoption of transgenic crops by smallholder farmers in Entre Rios, found age of smallholder farmers insignificant in influencing their adoption of transgenic crops. Their study established that young farmers as well as old ones are equally likely to adopt Bt Corn and/or Roundup Ready Soybeans cultivation. Thus their finding do not agreed with the finding in this study which established significant and negative relationship between age of famers and their adoption decision.

Since adoption of new technology involves risks and uncertainties, younger farmers are more likely to be risk takers compared to older farmers. Although their asset base may be limited, they have more years to recover from any potential loss, should anything happen. Also, because adoption of new and unfamiliar technologies may increase production and/or income risk, older and more traditional farmers may be less likely to adopt a new technology. A similar assertion was made by Gogitidze and Phutkaradze (2017) and Areal *et a*, (2011) in explaining the negative effect of age on adoption of GM crops.

Household Size: The study also found significant and negative (at 5% level) relationship between household size of respondents and their adoption decision towards GM crops cultivation. The marginal effect of the variable 'household size' (X_2), as shown in the Table 4.18b, is -0.0202. This signifies that one unit increase in respondents' household size will decrease the likelihood of adoption by 0.02.

The inverse relationship between adoption decision and household size is ample demonstration of the fact that respondents from smaller households are more likely to have intention of adopting GM crop cultivation than large households. Information gathered at most of the focus group discussions clearly shows that Roundup Ready (RR) GM crop traits are widely known among participants. Their understanding of the technology is that it reduces cost, time and labour requirement in weed control, which is one of the most labour intensive agricultural activities in this part of the country.

According to Chikoye *et al.*, (2007) smallholder farmers in Africa spend 50-70% of their total labour time weeding. It is normally expected that bigger households will have enough labour and as such less likely to adopt labour saving technology. Therefore any technology which seeks to reduce cost and labour intensity of weed control will be more appealing to smaller farm households with fewer farmhands compared with large households. Areal *et a*l (2011) shows in their study that economic issues such as the guarantee of a higher income and the reduction of weed control costs are the most encouraging reasons for potential adopters and rejecters of Genetically Modified Herbicide Tolerant (GMHT) crops.

Education: Probit regression results reveal positive significant (5%) relationship between respondents' education (X_4) and their adoption decision. The marginal effect of education, measured as number of years of formal schooling completed, was 0.0086 as shown in the Table 4.18b. This indicates that one-unit increase in number of years of formal schooling completed is likely to increase the probability of GM crops adoption by 0.0086, holding other variables constant. Education and for that matter literacy has been largely established to have effect on farmers' understanding and adoption of agricultural technologies.

Education also plays critical role in farmers' access to agricultural information in planning and making production decisions. Paredes and Martin (2007) also found positive and significant effect of farmers' education on adoption of Bt corn. Also Gogitidze and Phutkaradze (2017) found positive impact of farmers' education on their awareness and adoption of genetically modified crops. Similarly, conclusion of the effects of education on GM technology by smallholder farmers was made in Zakaria (2014). Education of the farmer was also found to have a positive effect on adoption of GM Oilseed Rape in Germany (Breustedt *et al.*, 2008) and on Bt and HT corn in the United States (Fernandez, Cornejo & McBride, 2002; Marra *et al.*, 2001).

Marital Status: The variable marital status (X_6) dummied as '1' if married and '0' otherwise, was found to be a significant predictor (at 10%) of respondents' adoption decision towards GM crop. The negative sign of the coefficient of marital status (table 4.18a) indicates that respondents who are married are less likely to intend adopting GM crops cultivation. In other words there is high probability of single respondents intending to adopt GM crops technology than married respondents.

The marginal effect of marital status (-0.0802), illustrate that the difference in probabilities between varying the variable X_6 to 1 and setting it to 0, given that all other explanatory variables are set at their sample means, reduce the likelihood of adoption decision by 0.0802. Marital status provides proxy to farm labour availability, because smallholder farmers depend on family labour for their agricultural activities. Marriage being the foundation of family and basis for laying claim to family labour is expected to have influence on farmers' decision towards adopting a technology they perceive to be labour saving. This explains the negative relationship between marital status and the prospects of farmers' adoption behaviour because both Herbicide Tolerant (RR) and insecticide tolerant (Bt) GM crops varietal traits are energy, labour, time and cost saving technologies.

Farm Size: The variable farm size (X_7) has a positive and significant effect on adoption behaviour of farmers, suggesting that farmers with large farm size are more likely to intend adopting GM crop cultivation than those with smaller farm size (table 4.18a). The marginal effect illustrate that a unit increase in farm size increases the probability of GM technology adoption by 0.0129 as shown in the table 4.18b. As expected, farmers with large farm holdings are more risk takers and therefore are more willing to adopt innovation. Keelan et al (2009) in their study 'Predicted Willingness of Irish Farmers to Adopt GM Technology' found farm size as a significant predictor of Irish farmers' willingness to adopt GM technology. Also, Paredes and Martin (2007) also found positive and significant effect of farm size on adoption of Bt corn.

Ratio of crop revenue to household income: The probit analysis (both stepwise and marginal effect models) confirms ratio of crop revenue to household income as negative and significant determinant of farmers' adoption behaviour at 1% level of significance. Thus farmers' crop income relative to their household annual income significantly influences the likelihood of farmers' adoption decision towards GM crops. A marginal effect of -0.4227 (table 4.18b), implies that a unit increase in the proportion of respondents' crop income relative to annual household income induces 0.4227 decrease in the probability of respondent decision to adopt GM crops cultivation, holding all other variable constant at their mean values.

However, the negative sign of the coefficient of the variable X_8, indicates that respondents whose main source of income is crop production are less likely to adopt GM crops cultivation compared with others who sourced significant proportion of their annual household income from other sources. It is understandable that farmers whose household income security depends largely on crop income will be more hesitant in taking the risk of adopting new and unfamiliar technologies. Those farmers with diverse sources of income will have more resilient income security and as such will not be that hesitant in taking the risk of adopting GM technology.

Income and other economic factors have always played critical roles in technology adoption among farmers. Many studies have established significant effects of income and other economic factors on farmers' adoption decision towards GM technology (Gogitidze and Phutkaradze, 2017; Keelan *et al*, 2009 and Paredes and Martin, 2007). Similarly, Areal et al (2011) showed in their study that economic issues such as the guarantee of a higher income and the reduction of weed control costs are the most encouraging reasons for potential adopters and rejecters of Genetically Modified Herbicide Tolerant (GMHT) crops.

Experience in crop farming: The variable X_9 – 'experience in crop farming' being one of the proxies for human capital of farmers (table 4.18a and 4.18b) was also found to be a significant determinant of farmers' adoption decision at 1% level of significance. The positive signs of the coefficients illustrate that more experienced farmers are more likely to adopt GM crop technology compared with less experienced farmers. This relationship was anticipated because more experienced farmers can understand crop improvement technology better as they have engaged in the enterprise for many years and have encountered and experienced the benefit of improved technology on yield, income and better crop management. Through many years of practicing crop farming, the experienced farmers are expected to accumulate a wide range of crop production knowledge and skills, which are critical in taking decisions regarding adoption of innovations.

As illustrated in the table 4.18b, the marginal effect of the variable 'experience in crop farming' is 0.0172, implying that, for every unit increase in years of practicing crop farming, the probability of a respondent intending to adopt GM crops cultivation increase by 0.0172. Thus, holding all other explanatory variables constant at their mean value, a unit variation in farmer's experience in crop farming induces about 2% corresponding change in the probability of the farmer adopting GM crop technology.

Source of information on GM crops: The variable X_{10} – 'source of information on GM crops' dummied as 1 if sourced from mass media and '0' if otherwise was found to have significant and negative effect on prospects of adoption behaviour towards GM crops at 10% (Table 3a). This demonstrates that farmers who heard or read about GM technology from the mass media are less likely to adopt the technology compared with those who heard about it from other sources (colleagues, input dealers, extension officers, scientists and researchers). The marginal effect in Table 4.18b indicates that a unit change in the source of information means that farmers who heard or read about GM crops from the mass media to grow GM crops than those who heard about it from other sources.

Considering the fact that most information on GM technology churned out from the mass media, particularly radio and television, are not validated by scientists and are mostly driven by anti-GM activists, there is a high tendency of creating misconceptions and negative attitude towards GM technology. As such, farmers who source their information from these sources are more likely to disapprove of GM crop cultivation. Therefore, this finding was to be expected. The arguments put forward by opponents of GM crops and food which have received wide media coverage (Durant, 2010; Hanrahan, 2010) have a high potential effect on consumers and general public attitude towards the consumption of GM food and its consequential effects on farmers' adoption decisions.

It has also been observed that societal anxiety over GM food hinges on several reasons, including consumer unfamiliarity, lack of reliable information, a steady stream of negative opinion in the media and vigorous campaigns by anti–GM activist groups (Prakash, 2001). Until the scientific community provide accurate information regarding safety and address the health and environmental concerns associated with GM technology using the media, societal anxiety and negative public opinion about GM food will continue to linger.

Positive attitude towards GM crops: The variable X_{11} – 'positive attitude towards GM crops' was found to be significant at 1% level of significance in predicting farmers' adoption decision.

The positive sign of the coefficient (table 4.17a) indicates a positive effect of farmers' positive attitude towards GM crops on adoption of the GM technology. Thus farmers who agreed with the fourteen (14) positive statements extracted from farmers' narratives on GM crops were found more likely to adopt GM crops than those who disagreed with those statements. In other words, respondents with positive attitude towards GM crops are likely to incline towards adopting GM crops than those with negative attitudes. The marginal effect of the variable (X_{11}) as shown in Table 4.17b is 0.0993, meaning that a unit increase in farmers score on positive attitude towards GM crops will induce 0.099 or 9.9% increase in probability of farmers' adoption decision.

Use of certified seed: As shown in Table 4.17a, the used of certified seed (X_{15}) measured as a dummy; was found to be a significant determinant of farmers' adoption decision at 1% level of significance. The positive sign of the coefficient of the variable indicates that farmers who mostly use certified seed are more likely to adopt GM crop cultivation than those who mostly rely on traditional sources such as seeds stored from previous harvest, seed exchange with colleague farmers and seed purchased from the open market.

The marginal effect of the variable as shown in table 4.18b is 0.9035 and this implies that one-unit change in use of certified seed means that farmers who mostly use certified seeds are 90% more likely to grow GM crops than those who do not use certified seed. This finding was expected, because farmers who mostly use certified seeds in their crop production enterprise will better appreciate the effect of improved crop varieties and seeds and as such will be more willing to adopt improved crop technologies.

Extension contact: The variable X_{17} – 'extension contact' measured as the number of extension contacts/visits within a production season, was found to be significant at 5% in predicting farmers' adoption decision towards GM crops. There was positive relationship between extension contact and farmers' adoption decision as shown by the positive sign of the coefficient of the extension contact variable (table 4.18a). Also, the marginal effect of extension contact, as shown in Table 4.18b, was 0.0217, which indicates that one-unit increase in extension visit received by a farmer will increase the probability of their adoption decision by 2.2%.

Extension contact – a proxy for farmers' access to agricultural information, has been shown in many studies to have positive effect on technology adoption. Indeed, the agricultural education and information level of farmers make them more receptive to new ideas and more willing to investigate alternative farming systems, such as the adoption of GM crops as observed by Keelan *et al*, (2009). Todua *et al.* (2017) also found significant and positive effect of extension access and agricultural education on Georgian Farmers' Attitudes and adoption decision towards GM crops.

However, variables such as X_1 – 'sex', X_5 – 'religion', X_{12} – 'negative attitude towards GM crops', X_{13} – 'sceptic attitude towards GM crops', X_{14} – 'dispassionate attitude towards GM crops' and X_{16} – 'experience in FBOs' were found as not significant determinants of farmers' adoption decision. Both male and female farmers were found equally likely to intend adopting GM crops cultivation. Contrary to expectation, religion of respondents was found not to be significant in predicting farmers' adoption decision. During many of the focus group discussions, participants expressed religious and spiritual sentiments in their argument against genetic engineering. It was therefore expected that one's religious belief will have a significant effects on their adoption decision towards GM technology and hence GM crops. Farmers' average agreement rank score on negative statements about GM crops and their sceptic attitude as well as their dispassionate views on GM technology did not influence their adoption decision towards GM crops significantly. These findings were least expected, because farmers' negative and sceptic views on GM technology were anticipated to have significant effect on their decision regarding growing GM crops. These were obviously contrary to the findings of Gogitidze *et al* (2017) and Zakaria (2014) who found significant relationship between negative attitudes towards GM crops and farmers' adoption decision.

4.6 Farmers' expectations of GMO technology

Analysis of narratives gathered from the in-depth interviews, focus group discussions and personal interview sessions reveal a wide range of expectations, outlooks and potentials which farmers hold about GM crops and GMO technology in general. Information gathered from these sources about farmers' expectations on GMOs technology can be broadly categorized into five (5) themes. The themes are expectations on varietal improvement, food and nutrition security, consumer satisfaction and patronage, economic and income gains and improved Research and Development (R&D).

In addition to these five broad themes their narratives contain some reservations and misgivings regarding the impending commercialization of GM crops in Ghana as well. The fear of possible shift of local seed control, research neglect and possible destruction of indigenous crop varieties, possible loss of viability of GM seeds, fear of health and environmental risks and possible consumer rejection were expressed by respondents.

Some discussants at the various focus group discussions were very hopeful that Ghana's agrobiotechnology research agenda can help breed early maturity and high yielding crop varieties, improve crops resistance to diseases, pests and weeds infestation. Others were anticipating that GMO technology can help boost food production and improve food and nutrition security.

4.6.1 Expectations on varietal improvement

Generally farmers surveyed were happy about the information they had concerning insect resistant, herbicide tolerant and drought tolerant traits of GM crops. They were hopeful that the GMO technology can be used to breed similar traits in their staple crop varieties.

Critical examination (through frequency counts of the main themes) of the narratives of respondents regarding their expectations on GMO technology, as shown in Table 4.19, reveals that almost all of the 360 (96.9 %) respondents mentioned the possibility of GMO technology being used to breed herbicide tolerant traits in local varieties of crops to help farmers deal with weed control. Also, an overwhelming majority (84.5%) of respondents were of the expectation that GMO technology could be used to breed drought tolerant traits of local crop varieties. While a little over half (59.7%) of the respondents were of the expectation that GMO technology could be used to breed disease/pest resistant traits in local varieties, majority (79.7%) were expecting GMO technology to be used in breeding early maturing and high yielding local varieties of crops.

These findings confirm that of Azadi *et al.* (2015) who observed that, the most important traits of GM crops which are more appealing and beneficial to small-scale farmers in developing countries are the insect resistant, herbicide tolerant, and drought tolerant traits.

Table 4.19: Farmers' Expectations of GMO technology

Expectations on GMO technology		Frequency	Percent (%)
Varietal improvement	Breed short maturing high yielding	287	79.7
	Breed drought tolerance	305	84.5
	Breed disease/pest resistance	215	59.7
	Breed herbicide tolerance	349	96.9
Food security and consumer Satisfaction	Improve food and nutrition security	186	51.7
	Improve taste	15	4.2
	Improve shelf life & reduce post-harvest loss	127	35.3
	Provide choice for consumers	36	10.0
Economic and Income Gains	Increase farm profit	165	45.8
	Reduce cost of plant protection	187	51.9
	Open new market opportunities	42	11.7
Research & Development (R & D)	Improve funding for R & D	52	11.7
	Patents regimes for seed development	65	18.1
	Biotech research on local crop varieties	146	40.6

Source: Analysis of field survey Data, 2016: note: % calculated over multiple responses

At one of the focus group discussions, a participant observed that:

> *"If the GMO technology can be used to make our maize, millet, sorghum and rice herbicide tolerant, then our biggest problem of weed control will be solved and there wouldn't be any hunger because the crops will yield more. Since hearing about the herbicide tolerant GM crops on radio, which was later confirmed by agrochemical seller, I have been praying that the agric people will do the same to our crops here* '(Verbatim comment by a participant)

4.6.2 Food Security and Consumer Satisfaction

As indicated in table 4.19, improvement in food and nutrition security, reducing post-harvest losses and widening consumer choices and satisfaction were prominent among the expectations of respondents on GMO technology. In spite of the fact that the contribution of GM crops to achieving food security is a subject of public controversy, the analysis of respondents' narratives on what they expect from the impending introduction of GM crops in Ghana's agriculture, shows that about half (51.7%) of the 360 smallholder farmers surveyed expect the introduction of GM crops to help improve food and nutrition security among Ghanaians.

They were of the view that the possible increase in crop productivity through adoption of GM crops will help increase food production and its availability to consumers. They observed that food production is being hampered by drought, plant diseases, pest and weed infestation and are therefore hoping that GMO technology can be used to solve these problems. This expectation is based on the fact that GMO technologies can be used to breed higher yielding crop varieties which are more robust to pests, diseases and weed infestations.

This they believe can help increase and stabilize food supplies to deal with the ever increasing food demand, climate variability, and land and water scarcity. Qaim and Kouser (2013) identified three possible pathways by which GM crops could impact food security. First, GM crops could contribute to food production increases and thus improve the availability of food at global and local levels. Second, GM crops could affect food safety and food quality. Third, GM crops could influence the economic and social situation of farmers, thus improving or worsening their economic access to food.

Also some respondents (35.3%) were hopeful that GMO technology can help reduce postharvest losses and improve shelf life and storability of crops. While very few of them (4.5%) expect GMO technology to help improve taste of local crop varieties. Also 10% were hopeful that GM crops can provide alternatives from which consumers can choose. At a focus group discussion in Kassena-Nankana East Municipal a participant expressed her hopes thus:

> ''*I hope that this GM technology can make our tomato stay longer after harvesting, just like Burkina tomato. The Burkina people have used this technology to make their tomato stay longer, healthier and tastier and because of that, tomato traders from Kumasi bypass us to the Burkina boarder to buy their tomato. Why can't the agric. people here in Ghana use the GM technology to produce the seed the Burkina Faso farmers are using?*" (Verbatim comment of a participant).

This narrative clearly demonstrates the desire of respondents to see GM technology being used to help reduce post-harvest loses, improve shelf life and taste of their crops, especially tomato farmers in the Kassena-Nankana East Municipality of the Upper Est region. Respondents' understanding that GMO technology can be used to reduce post-harvest losses and improve shelf life and taste is based on their experience with GM tomato (Flavr Savr) imported from Burkina Faso. Flavr Savr (also known as CGN-89564-2 and popularly called "flavour saver"), a genetically modified tomato, was the first commercially grown genetically engineered food to be granted a license for human consumption. "Flavr Savr" tomato is a genetically modified tomato that has altered DNA to delay ripening, thereby prolonging shelf-life (Adenle, 2011 and Bruening and Lyons, 2000). Burkina Faso is among the few Africa countries that have adopted the cultivation of GM crops. Bt cotton and "flavr Savr" are the GM crops currently being commercialised in Burkina Faso and are bringing significant economic gains to smallholder farmers in the country (Haroon and Ghazanfar, 2016).

4.6.3 Expectations on economic and income gains

Also prominent among respondents' expectations of GM crops is the hope that GM crops cultivation will lead to increase in farm profit (45%), possible reduction in cost of plant protection (51.9%) and diverse market opportunities (11.7%) as shown in Table 4.19. In other words respondents expect that the introduction of GM crops will lead to economic and income gains for smallholder farmers. They were hopeful that the herbicide and insecticide tolerant GM crops traits will help reduce cost of plant protection and overall cost of crop production significantly.

Using panel data collected over several years from farm households in India, Qaim and Kouser (2013) demonstrated that the cultivation of GM crops has brought significant economic gains to smallholder farmers in India. Haroon and Ghazanfar (2016) also found that the introduction of Bt cotton in Burkina Faso had raised yield of cotton by 126% and brought substantial income benefits to smallholder farmers engaged in its cultivation.

4.6.4 Research and Development (R&D)

Respondents again expect that the introduction of GM crops into Ghana's agriculture will result in improvement in Ghana's research funding, enactment of patents legislative regimes for GM seed development and improvement in local crop varieties using GM technology. As shown in table 4.19, fifty two (52) respondents (about 12%) included improved funding for R & D in their list of what they expects from the introduction of GM technology. About 41% and 18% expect biotechnology research to be conducted on local crop varieties and enactment of patents legislations to guide development of GM seeds respectively.

4.7 Farmers Perceived Prospects and Challenges of GM crops

This section presents results of perceived prospects and constraints farmers are likely to face by engaging in the cultivation of GM crops. This section is dedicated to addressing objective five of this study which sought to examine the likely prospects and constraints of commercialization of GM crop production.

4.7.1 Farmers' Perceived Prospects of GM Crops

Eleven (11) issues have been found most common among key informants' narratives on what they perceived as prospects of GM crops cultivation. These issues range from breeding drought tolerant crops to improving food security and farm productivity. The issues were therefore presented to the 360 respondents for ranking during the main field interviews sessions. Frequency distribution of respondents' rank scores of these issues is presented in table 4.20a.

Kendall's coefficient of concordance conducted to determine the significance and level of agreement among rank scores assigned to the eleven issues in respondents list of prospects of GM crops cultivation, shows significant agreement at 1% among respondents assigned ranks with Chi-Square (df = 10) = 651.147; Asymp. Sig = 0.000 (table 4.20b). Kendall's coefficient of concordance (W) = 0.47 indicates that there were 47% agreement among the rank scores of respondents.

As shown in Tables 4.20a and 4.20b, the prospects that GM technology can be used to breed drought tolerant Crop varieties was ranked as the number one prospects with 61%. The prospects of GM technology being used to breed early maturing and high yielding crop varieties was ranked as the second most important prospect with about 31%. The prospect of GM crop cultivation helping to reduce cost of weed control and bringing in high economic returns were ranked 6th and 4th respectively.

The prospects of GM technology being used to improve food security and seed viability were ranked 10th and 11th respectively and were the least preferred prospects by the 360 respondents. This implies that respondents do not attach much importance to the fact that GM technology can be used to improve seed viability and food security situation.

In general, respondents have much hope on GM technology being used to breed drought tolerant, early maturing and high yielding local crop varieties and help reduce cost of weed, pest and disease control. This finding confirms previous studies which have concluded that GM technology holds much prospects for Africa smallholder farmers. Mwamahonje and Mrosso (2016) in their study on 'Prospects of genetically modified maize crop in Africa' concluded that GM maize with its high yielding and drought tolerant traits hold much prospects for improving food security in Africa. Also, Barrows, Sexton and Zilberman (2014) in their study 'Agricultural Biotechnology: The Promise and Prospects of Genetically Modified Crops' identified insect resistance and herbicide tolerance as the most popular and promising GM crops traits.

Table 4.20a Respondents' ranks on Perceived Prospects of GMO technology

Items	Rank Score																					
	1		2		3		4		5		6		7		8		9		10		11	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Breed drought tolerance Crop varieties	218	61	32	9	16	4	0	0	0	0	15	4.2	16	4	16	4	31	9	0	0	16	4
Breed short maturity/high yielding crop varieties	79	22	110	31	46	13	0	0	0	0	0	0	31	9	0	0	16	4	16	4	62	17
Reduce cost of weed control	0	0	46	13	61	17	80	22	48	13	0	0	0		16	4	16	4	77	21	16	4
Disease/pest resistance varieties of crops	0	0	31	9	64	18	123	34	32	9	16	4	0	0	16	4	47	13	16	4	15	4
Improve nutrition	0	0			30	8	32	9	155	43	80	22			47	13	16	4	0	0	0	0
High economic return			16	4	48	13	30	8	64	18	123	34	63	18	16	4	0	0	0	0	0	0
Reduce labour intensity	15	4	46	13	16	4			46	13	48	13	93	26	16	4	0	0	0	0	80	22
Improve seed viability	0	0	15	4	0	0	32	9	32	9	30	8	31	9	77	21	16	4	80	22	47	13
improve food security	16	4			31	9	32	9	16	4	0	0	30	8	32	9	157	43	31	9	15	4
Reduce environmental risks	16	4	32	9	32	9	15	4	0	0	16	4			109	30	32	9	92	26	16	4
Meet consumer taste	16	4	48	13	16	4	0	0	15	4	0	0	96	27	31	9	45	13	16	4	77	21

Source: Analysis of field survey Data, 2016

Table 4.20b: Perceived Prospects of GM technology

Items	Mean	SD	Mean Rank	Rank
Breed drought tolerance Crop varieties	3.10	3.27	3.10	1st
Breed short maturity/high yielding crop varieties	4.55	3.87	4.58	2nd
Reduce cost of weed control	5.84	3.09	5.93	6th
Disease/pest resistance varieties of crops	5.22	2.63	5.28	3rd
Improve nutrition	5.54	1.50	5.58	5th
High economic return	5.34	1.53	5.39	4th
Reduce labour intensity	6.57	3.14	6.59	7th
Improve seed viability	7.76	2.49	7.80	11th
improve food security	7.42	2.66	7.44	10th
Reduce environmental risks	7.19	3.05	7.17	9th
Meet consumer taste	7.13	3.20	7.15	8th

N = 360; Chi-Square (df = 10) = 651.147; Asymp. Sig = .000; Kendall's W = 0.47
Source: Analysis of field survey Data, 2016

4.7.2 Farmers' Perceived Constraints of GM Technology

Tables 4.21a and 4.21b present results of analysis of respondents' perceived constraints towards GM crop cultivation. Eleven (11) common issues identified by respondents as possible constraints to the cultivation of GM crops were analysed using Kendall's coefficient of concordance. The issues identified as possible constraints include high cost of GM seed, unreliable supply of GM seed, possible failure of regulatory agencies and possible environmental and health risks among others.

Results of Kendall's coefficient of concordance conducted established significant agreement among respondents' ranking score of their perceived constraints to the cultivation of GM crops. As shown in Table 4.21b, the Chi-Square (df = 10) = 936.664. Asymp. sig = .000 thus indicating significant agreement among respondents ranks scores at 1%. A Kendall's efficient of concordance (W) = 0.60, implies that 60% of the ranking scores assigned by respondents are in agreement.

Analysis of the distribution of the rank scores with 1 as the most severe constraints and 11 the least severe constraints shows that high cost of GM seed is perceived by respondents as the most severe constraint to the cultivation of GM crops with 50% of the respondents ranking it as the one most severe constraint. This was followed by possibility of unreliable GM seed supply which comes as the second most severe constraint perceived by respondents towards the cultivation of GM crops. Fear of possible environmental risks and failure of regulatory agencies were ranked as the third and fourth most severe constrain to the cultivation of GM crops respectively.

This clearly demonstrates that cost of GM seeds and unreliability of its supply are the biggest concerns respondents have regarding GM crops cultivation. They are obviously worried they might not be able to benefit from the commercialization of GM crops because of the high cost involve in obtaining GM seeds. Participants at the various FGD sessions expressed concerns about possible high cost of GM seeds and unreliability of its supply should they adopt the cultivation of GM crops. A participant at one of the focus group discussion expressed the following concern;

> '*This new crop seeds, can we buy the seeds?, I hear they are very expensive and how sure are we that this white people will supply us the seeds at the time we need them and will they even be good ones*'(Verbatim comments of a participant).

Table 4.21a: Perceived Challenges/constraints of GMO technology

Items	Rank Score																					
	1		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**		**10**		**11**	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
High cost of GM seed	181	50	54	15	0	0	36	10.	0	0	17	5	18	5	18	5	18	5	0	0	18	5
Unreliable supply of GM seed	72	20	72	20	54	15	53	15	18	5	18	5	19	5	18	5	18	5	0	0	18	5
Possible failure of regularity agencies	18	5	90	25	54	15	90	25	17	5	19	5	18	5	18	5	18	5	18	5	0	0
Possible environmental risk	18	5	54	15	125	35	72	20	19	5	18	5	18	5	0	0	18	5	18	5	0	0
Possible health risks	0	0	17	5	0	0	18	5	144	40	54	15	18	5	37	10	18	5	18	5	36	10
possible destruction of local seeds	0	0	0	0	0	0	0	0	108	30	90	25	53	145	18	5	37	10	36	10	18	5
Dependence on biotech company	0	0	0	0	0	0	36	10	0	0	90	25	108	30	35	10	36	10	18	5	37	10
Possible consumer rejection	18	5	0	0	18	5	0	0	18	5	18	5	54	15	144	40	17	5	37	10	36	10
Possible emergency of superweeds and bugs	0	0	73	20	0	0	18	5	0	0	36	10	54	15	18	5	72	20	71	20	18	5
Possible labelling conflict and coexistence with convention crops	0	0	0	0	54	15	19	5	36	10	18	5	0	0	18	5	72	20	90	25	53	15
Incompatibility with smallholder farming system	17	5	18	5	55	15	36	10	18	5	18	5	0	0	36	10	18	5	54	15	90	25

Source: Analysis of field survey Data, 2016

Table 4.21b: Ranks of perceived constraints to GM crops cultivation

Items	Mean	SD	Mean Rank	Rank
High cost of GM seed	3.24	3.12	3.34	1st
Unreliable supply of GM seed	4.00	2.83	4.05	2nd
Possible failure of regularity agencies	4.25	2.47	4.30	4th
Possible environmental risk	4.05	2.27	4.06	3rd
Possible health risks	6.42	2.32	6.39	5th
possible destruction of local seeds	6.91	1.90	7.01	7th
Dependence on biotech company	7.31	1.91	7.43	9th
Possible consumer rejection	7.55	2.38	7.55	10th
Possible emergency of superweeds and bugs	6.98	3.01	6.90	6th
Possible labelling conflict and coexistence with convention crops	7.78	2.86	7.81	11th
Incompatibility with smallholder farming system	7.05	3.50	7.16	8th

N = 360; Chi-Square (df = 10) = 936.664; Asymp. Sig = .000; Kendall's W = = 0 .60

Source: Analysis of field survey Data, 2016

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter is made up of three sections covering summary of the study, conclusions drawn from the study and recommendations made from the major findings of the study.

5.1 Summary of the Study

This section presents summary of the study highlighting background, methodology and major findings of the study.

5.1.1 Summary of background of the Study

Notwithstanding the steady progress Ghana had made in her agrobiotechnology agenda through research and putting in place Biosafety law (Act 831; 2011), institutional frameworks (National Biosafety Authority and Institutional Biosafety Committees) amidst mounting opposition (Ashitey, 2013; Bennett et al, 2013), very little is known about farmers' perceptions, knowledge and adoption decision towards GM crops.

However, the prospects of adoption of GM crops by Ghanaian farmers depend largely on stakeholders', especially farmers' knowledge and perceptions about the technology. A study by Ademola, et al (2014) on potential benefits of biotechnology on food security in West Africa, identified challenges such as lack of awareness, inadequate training, low level of education and poor extension services among others as the main challenges facing the introduction of GM technology to resource poor farmers. The study call on governments to put in place policy measures to address these challenges. Their study highlighted important policy issues regarding farmers' perceptions about GM crops in Ghana and Nigeria but they did not thoroughly examined farmers' adoption decision.

As the debate on application of GMOs technology in commercial agriculture intensifies in the country, it is important to add to existing knowledge and expand the scope of literature on smallholder farmers' knowledge, perceptions and adoption decision towards GM Crops. As such this study examined underlying construct characterising smallholder farmers in the Northern Ghana perceptions and adoption decision towards GM crops.

5.1.2 Summary of Methodology

Descriptive survey design was employed in carrying this study with Q Methodological procedure applied in guiding data collection. Through Multi – stage sampling techniques 360 smallholder farmers were sampled from the 120 FBOs surveyed across the three regions in the northern Ghana. Also five focus group discussions, three in northern region and one each in the upper east and west regions were held with an average of 9 participants per focus group discussion. In all forty seven (47) participants took part in the focus group discussions.

In addition, in-depth interviews prior to the actual field survey were conducted with thirteen (13) key informants comprising of ten (10) leaders of FBOs and three (3) commercial farmers across the three regions. Thus the total number of participants who took part in this study was four hundred and ten (410) comprising of 360 smallholder farmers who responded to the personal interviews, forty seven (47) participants of the five focus group discussions held and thirteen (13) key informants interviewed in gathering concourse of farmers' narratives on GM crops.

The study adopted multi - approach in collecting, verifying and analysing data. These are (i) discourse analysis, (ii) an application of the Theory of Planned Behaviour (TPB) and associated statistical analysis; and (iii) an application of Q-Methodology and Q factor analysis in analysing perceptions and attitudes. Also, a probit regression model was adopted in analysing factors influencing farmers' adoption decision.

5.1.3 Summary of Major Findings

Analysis of respondents' knowledge on GM crops revealed general lack of accurate understanding of GM crops in particular and the GMOs technology in general among smallholder farmers surveyed. Examination of respondents' narratives on what they know about GM crops revealed a wide array of ideas ranging from basic knowledge to wild, absurd and mythical understanding of GM crops. Farmers who sourced their information on GM crops from the mass media were more likely to rank their knowledge on GM crops as 'very well informed' than otherwise.

Four factors were identified through exploratory factor analysis as the main underlying constructs characterising farmers' perception towards GM crops. These factors were ''progressive **views on GM crops**'', ''**negative views on GM crops**'', ''**cynical views on GM crops**'' and ''**dispassionate views on GM crops**''. However, some (41%) of the farmers surveyed intended adopting GM crops cultivation when commercialization commences in Ghana.

Result of the probit analysis identified some selected socioeconomic characteristics such as age, household size and marital status and farm characteristics such as farm seize, ratio of crop income to Household income and experience in crop farming as significant determinants of farmers adoption decision towards GM crops cultivation.

Farmers' expectations of GMOs technology gathered from farmers' narratives on GM crops can be broadly categorized into five broad themes, namely, varietal improvement, food and nutrition security, consumer satisfaction and patronage, economic and income gains, and improved research and development (R&D). However, their narratives also contain some reservations and misgivings about the impending commercialization of GM crops in Ghana. These include the fear of possible shift of local seeds sovereignty, research neglect and possible destruction of indigenous crop varieties, possible loss of viability of GM seeds, fear of health and environmental risks and possible consumer rejection.

Generally respondents were optimistic that GM technology can be used to breed drought tolerant, early maturing and high yielding local crop varieties and help reduce cost of weed, pest and disease control. However, they identified constraints to GM crops cultivation as high cost of GM seed, unreliable supply of GM seed, possible failure of regulatory agencies and possible environmental and health risks among others.

5.2 Conclusions

Smallholder farmers in northern Ghana have very little knowledge and understanding about GM crops and the country's agrobiotechnology agenda. Their knowledge on GM crops was patchy, vague and mythical. Their knowledge and understanding on GM crops could be described as partly factual, fictitious, mythical, misconception and mixture of factual, mythical and fictitious. Source of information on GM crops was found as significant driver of smallholder farmers' knowledge, perception and decision to adopting the cultivation of GM crops.

Four underlying constructs characterised the perceptions of smallholder farmers in northern Ghana towards GM crops were 'positive and progressive perceptions', 'negative perceptions', ' cynical perceptions' and 'dispassionate perceptions'. Thus smallholder farmers surveyed in this study can be segregated into positive perceivers, negative perceivers, cynical perceivers and dispassionate perceivers of GM crops and GMOs technology.

Smallholder farmers' adoption decision towards GM crops was significantly influenced by some selected socioeconomic characteristics such as age, household size and marital status and farm characteristics such as farm seize, ratio of crop income to household income and experience in crop farming.

Generally the smallholder farmers surveyed were optimistic of the prospects of GM technology being used to breed drought tolerant, early maturing and high yielding local crop varieties and also helping reduce cost of weed, pest and disease control. However, they foreseen constraints to GM crops cultivation as high cost of GM seed, unreliable supply of GM seed, possible failure of regulatory agencies and possible environmental and health risks.

5.3 Recommendations

Based on the major findings of this study, the following recommendations are made for research and policy consideration.

1. For the agrobiotechnology agenda in Ghana to be successful, there is the need for conscious efforts to be made by the Ministry of Food and Agriculture (MOFA) to involve grassroots level farmer groups, such as Farmer Based Organizations, in shaping the biotechnology policies and designing implementation strategies.

2. National Biosafety Authority should strengthen their public education, sensitisation and advocacy on biotechnology activities to help create awareness of biosafety act and regulations, and agrobiotechnology research activities in the country.

3. It is recommended that educational and information programmes aimed at providing accurate information on GM crops and Ghana's agrobiotechnology policy to smallholder farmers be embarked upon by the extension service department of the MOFA.

4. MOFA and other relevant stakeholders should institute training programmes to build the capacity of smallholder farmers to enable them take appropriate decision regarding the adoption of GM crops

5. Farmers' expectations on GM technology being used to improve local varieties through breeding of drought and herbicide tolerant, and insecticide resistant varieties of local staple crops, as uncovered in this study, should be given attention by research institutions.

6. The mass media, particularly radio and TV should be used by MOFA, OFAB, and NBA to provide information aimed at addressing farmers' concerns on GM crops.

REFERENCES

Acquaah G (2007). Principles of Plant Genetics and Breeding. Blackwell Publishing 350 Main Street, Malden, MA USA.

Ademola A.A (2011). Global capture of crop biotechnology in developing world over a decade. *Journal of Genetic Engineering and Biotechnology. (2011) 9, 83–95.*

Ademola AA, Walter SA and Bamidele O (2014). Potential benefits of Genetic Modification (GM) technology for food security and health improvement in West Africa: Assessing the perception of farmers in Ghana and Nigeria. African Journal of Biotechnology. Vol. 13(2), pp. 245-256, 8 January, 2014.

Adenle AA (2011). Response to issues on GM agriculture in Africa: Are transgenic crops safe? BMC Research Notes 2011, 4:388.

AgSSIP (2007). Implementation completion and results report of Agricultural Services Sub-sector Investment Project (AgSSIP). A World Bank document presented to the Republic of Ghana. Washington, D.C

Ajzen, I (1991). The Theory of Planned Behavior. Organization Behavior and Human Decision Processes, Academic Press, Inc. 179-211.

Ajzen, I (2005). Attitudes, personality, and behavior (2nd. Edition). Milton-Keynes, England: Open University Press / McGraw- Hill.

American Heritage Abbreviations Dictionary (2005). Third Edition, Houghton Mifflin Company.

Amikuzuno J (2012). Climate Variability and Crop Yields in Northern Ghana: What Role for Crop-Livestock Integration. Conference Paper presented at the 8th AFMA Congress on the theme “Repositioning African Agriculture by Enhancing Productivity, Market Access, Policy Dialogue and Adapting to Climate Change”. MOI University Press.

Anderson TW (2003). An Introduction to Multivariate Statistical Analysis. Third ed. Hoboken, New Jersey: Wiley

Bakshi A (2003). Potential Adverse Health Effects of Genetically Modified Crops. Journal of Toxicology and Environmental Health, Part B, 6:211–225, 2003

Annette LV (1997). Q-methodology: Definition and Application in Health Care Informatics. Journal of the American Medical Informatics Association. Volume 4 Number 6 Nov / Dec 1997

Antwi et al (2014). Developing a Community-Based Resilience Assessment Model with reference to Northern Ghana. Journal of Integrated Disaster Risk Management. 4(1)

Areal FJ, Riesgo L and Rodrı´guez-Cerezo E. (2011). Attitudes of European farmers towards GM crop adoption. Plant Biotechnology Journal. (2011) 9, pp. 945–957.

Aref F (2011). Farmers' participation in agricultural development: The case of Fars province, Iran. Indian Journal of Science and Technology, 4(2): 155- 158.

Ashitey E (2013). Ghana Agricultural Biotechnology Annual Report. Global Agriculture Information Network. USDA Foreign Agricultural Services

Azadi H and Ho P (2010). Genetically modified and organic crops in developing countries: A review of options for food security. Biotechnology Advances 28 (2010) 160–168

Azadi H, Samiee A, Mahmoudi H, Jouzi Z, Khachak PR, De Maeyer P, Witlox F. (2015). Genetically modified crops and small-scale farmers: main opportunities and challenges. Crit Rev Biotechnology. 2016; 36(3):434-46.

Barbara KG and Viswanath KRK (2008). Health Behaviour And Health Education Theory, Research, and Practice. 4TH Edition Copyright © 2008 by John Wiley and Sons, Inc. San Francisco, USA

Barrows G, Sexton S, and Zilberman D (2014). Agricultural Biotechnology: The Promise and Prospects of Genetically Modified Crops. Journal of Economic Perspectives—Volume 28, Number 1—winter 2014—Pages 99–120

Bartlett MS (1950). Tests of significance in factor analysis. British Journal of Psychology. 1950; 3(Part II):77-85.

Baulcombe D, Dunwell J, Jones J, Pickett J and Puigdomenech P (2014). 'GM Science Update; A report to the Council for Science and Technology'

Beever, D.E., and Kemp, C.F (2000). Safety Issues Associated with the DNA in Animal Feed Derived From Genetically Modified Crops: A Review of The Scientific and Regulatory Procedures, 70 NUTR. ABSTR. REV. SER. A, 197 (2000).

Bengt OM and Kaplan D (2011). A Comparison of Some Methodologies for the Factor Analysis of Non-Normal Likert Variables: A Note on the Size of the Model. British Journal of Mathematics and Statistical Psychology. 38 171 – 189.

Bennett DJ and Jennings RC (2013). Successful Agricultural Innovation in Emerging Economies: New Genetic Technologies for Global Food Production. Cambridge University Press, Mar 7, 2013 - Business and Economics - 427 pages

Bhuiya SN (2012). Ethical Concerns in Development, Research and Consumption of Genetically Engineered Crops. Synesis: A Journal of Science, Technology, Ethics, and Policy 2012 © 2010-2012 Potomac Institute Press

Binimelis R., Pengue W and Monterroso I (2009). ''Transgenic treadmill'': Responses to the emergence and spread of glyphosate resistant Johnson grass in Argentina. Geoforum 40: 623–633.

Biosafety Act (2011). Act 831. An ACT to regulate biotechnology and to provide for related Matters. Date of assent: 31st December, 2011.

Bowling A and Ebrahim S (2005). Handbook of Health Research Methods: Investigation, Measurement and Analysis. Open University Press.

Boyce C and Neale P (2006). Conducting In-Depth Interviews: A Guide for Designing and Conducting In-Depth Interviews for Evaluation Input Pathfinder

Breustedt G, Muller-Scheesel J and Latacz-Lohmann U (2008). Forecasting the adoption of GM oilseed rape: Evidence from a discrete choice experiment in Germany. Journal of Agricultural Economics, 59(2), 237-256.

Brookes G and Barfoot P (2017). Farm income and production impacts of using GM crop technology 1996–2015, GM Crops & Food, 8:3, 156-193.

Brookes G and Barfoot P (2009). Global impact of biotech crops: socio-economic and environmental effects 1996-2007, Outlooks on Pest Management, 20 (6), October 2009

Brookes G and Barfoot P (2012). GM crops: global socio-economic and environmental impacts. UK: PG Economics.

Brown J.D (2009a). Statistics Corner. Questions and answers about language testing statistics: Principal components analysis and exploratory factor analysis—Definitions, differences, and choices. Shiken: JALT Testing & Evaluation SIG Newsletter, 13(1), 26-30

Brown JD (2009b). Questions and answers about language testing statistics: Choosing the Right Type of Rotation in PCA and EFA. JALT Testing & Evaluation SIG Newsletter. 13 (3) November 2009 (p. 20 - 25)

Brown SR (1997). The history and principles of Q methodology in psychology and the social sciences. British Psychological Society symposium on "A Quest for a Science of Subjectivity: The Lifework of William Stephenson," University of London; and conference on "A Celebration of Life and Work of William Stephenson (1902-1989)," University of Durham, England.

Brown SR and Good JMM (2013). Encyclopaedia of Research Design Q Methodology. SAGE Publications, Inc. Thousand Oaks. Print ISBN: 9781412961271.

Brown S (1980). Political subjectivity: applications of Q methodology in political science. New Haven: Yale University Press.

Brown S (1996). Q methodology and qualitative research, Qualitative Health Research, 6:4:561-567.

Brown, SR (1993). A primer on Q methodology Operant Subjectivity. 16(3/4): 91-138.

Brown SR (2008). Q methodology. In L. M. Given, (Ed.), The Sage encyclopaedia of qualitative research method. Thousand Oaks, CA: Sage, pp. 700–704.

Brown SR (1996). Q methodology and qualitative research. Qualitative Health Research. 6: 561-567.

Brown, SR (2008). Q methodology. In L. M. Given, (Ed.), The Sage encyclopaedia of qualitative research method. Thousand Oaks, CA: Sage, pp. 700–704.

Bruce T (2004). Exploratory and confirmatory factor analysis: Understanding concepts and applications. Washington, DC, US: American Psychological Association.

Bruening G, Lyons JM (2000). The case of the FLAVR SAVR tomato. California Agriculture 2000, 5(4):6-7.

Bryant, FB and Yarnold PR (1995). Principal-components analysis and confirmatory factor analysis. In L. G. Grimm & P. R. Yarnold (Eds.), Reading and understanding multivariate statistics (pp. 99-136). Washington, DC: American Psychological Association.

Bulik C and Sullivan PF (1993). Comorbidity of bulimia and substance abuse: Perceptions of family origin. International Journal of Eating Disorders, 13(1), 49–56.

Carpenter JE (2010). Peer-reviewed surveys indicate positive impact of commercialized GM crops. Nat Biotech 2010; 28:319-21.

Cascetta E (2009). Random Utility Theory. Transportation Systems Analysis. Volume 29 of the series Springer Optimization and Its Applications pp 89-167.

Cattell (1978). The scientific use of factor analysis. New York Plenum.

Paredes C and Martin MA. (2007). Adoption of Transgenic Crops by Smallholder Farmers in Entre Rios, Argentina. Selected Poster Presented at the 2007 AAEA Annual Meeting Portland, on July 29, 2007 – August 1, 2007.

Chambers JA, Zambrano P, Felick-Zepada J, Gruere G, Sengupta D and Hokason K, (2014). GM Agricultural Technologies for Africa: A state of Affairs. International Food Policy Research Institute (IFPRI) and African Development Bank (AfDA). Copyright © 2014

Charles HD (2011). Q Methodology in Audience Research: Bridging the Qualitative and Quantitative 'Divide'? Journal of Audience and Reception Studies. Volume 8, Issue 2 November, 2011

Chau, P. Y. K., and Hu, P., J (2002). Examining a model of information technology acceptance by individual professionals: An exploratory study. Journal of Management Information Systems, 18 (4), 191-229.

Chikoye, D., Ellis-Jones, J., Riches, C., and Kanyomeka, L (2007). Weed management in Africa: experiences, challenges and opportunities. XVI International Plant Protection Congress. 652-653.

Clark N, Stokes K and Mugabe J (2002). Biotechnology and development: threats and promises for the 21st century. Futures, 34(9-10) pp. 785–806.

Cochran WG (1977). Sampling techniques (3rd ed.).New York: John Wiley & Sons

Costello AB and Osborne JW (2005). Best Practices in Exploratory Factor Analysis: Four Recommendations for Getting the Most From Your Analysis. Practical Assessment, Research & Evaluation. 2005;10(7):1-9.

Creswell JW (2010). Mapping the field of mixed methods research. In A. Tashakkori, & C. Teddlie (Eds.), Handbook of mixed methods in social & behavioural research (Second ed., pp. TBD). Thousand Oaks, Calif.: SAGE Publications.

Global Food Security (CSIS) (2010). African Perspectives on Genetically Modified Crops Assessing the Debate in Zambia, Kenya, and South Africa. © 2010 by the Center for Strategic and International Studies.

Dadson JA (1988).The need for cooperative reorientation: The Ghanaian In Hans G. B. Hedlund, Seminar Proceedings No. 21, Scandinavian Institute of African Studies, 1988 Nordiska Afrikainstitutet

Dalecky A, Bourguet D and Ponsard S (2007). Does the European corn borer disperse enough for a sustainable control of resistance to Bt maize via the High Dose/Refuge strategy? Cahiers d'Etudes et de Recherches Francophones / Agricultures 16: 171–176.

Dasgupta P and Vira B (2005). "Q Methodology" for mapping stakeholder Perceptions in Participatory Forest Management. Cambridge: UK Department for International Development (DFID).

Davis FD, Bogozzi RP and Warshaw PR (1989). User acceptance of computer technology: A comparison of two theoretical models. Management Science, 35, 982-1003.

Davis FD (1986). A technology acceptance model for empirically testing new end-user information systems: Theory and results. Massachusetts, United States: Sloan School of Management, Massachusetts Institute of Technology.

Dennis K.E (1986). Q methodology: Relevance and application to nursing research. Advances in Nursing Science, 8(3), 6-17.

Denzine GM (1998). The use of Q-methodology in student affairs research and practice. Student Affairs Journal Online

DG Research (2010). A decade of EU-funded GMO research. European Commission EUR 24473 EN

Domingo JL (2007). Toxicity studies of genetically modified plants: a review of the published literature. Critical Reviews in Food Science and Nutrition, 47:8, 721 – 733.

DTMA (2013). A Quarterly Bulletin of the Drought Tolerant Maize for Africa Project. Vol. 2

Du Plessis TC (2005). Q Methodology. In A Theoretical Framework of Corporate Online Communication: A Marketing Public Relation Perspective (pp. 140-174). Johannesburg: National Research foundation.

Dziopa F and Ahern K (2011). A systematic literature review of the applications of QTechnique and its methodology .European Journal of Research Methods for the Behavioral and Social Sciences, 7, 2 (2011), 39-55.

EASAC (2013). Planting the future: opportunities and challenges for using crop genetic improvement technologies for sustainable agriculture. European Academies Science Advisory Council policy report 21 June 2013. ISBN: 978-3-8047-3181-3

ECOWAS (2008). Regulation C/Reg.4/05/2008 on harmonization of the rules governing quality control, certification and marketing of plant seeds and seedlings in ECOWAS Region.

ECT Group (2008). Who Owns Nature? Corporate Power and the Final Frontier in the Commodification of Life. November 2008 Issue #100

Etwire PM, Ibrahim DK.A, Samuel SJB, Alhassan LA, Karikari AS. and Asungre P (2013). Analysis of the seed system in Ghana. International Journal of Advance Agricultural Research. IJAAR 1 (2013) 7-13

European Association of Bioindustries (2011). GM crops: Reaping the benefits, but not in Europe; Socio-economic impacts of agricultural biotechnology. EuropaBio Avenue de l’Armée, 6 – B-1040 Brussels. Available online at:

http://www.europabio.org/sites/default/files/position/europabio_socioeconomics_ma_2011.pdf (accessed on 20th December, 2014)

Fabrigar LR, Wegener DT, MacCallum RC and Strahan EJ (1999). Evaluating the use of exploratory factor analysis in psychological research. Psychological Methods, 3, 272-299.

Fagerstrom T, Dixelius C, Magnusson U and Sundstrom JF (2012). Stop worrying, start growing. EMBO Reports 13, 493–497

FAO (2009). Responding to the challenges of a changing world: The role of new plant varieties and high quality seed in agriculture. Proceedings of the Second World Seed Conference. FAO Headquarters, Rome, September 8-10, 2009. Available online at: http://www.fao.org/docrep/014/am490e/am490e00.pdf (accessed on 20th January, 2015)

FAO (2009). Responding to the challenges of a changing world: The role of new plant varieties and high quality seed in agriculture. Proceedings of the Second World Seed Conference. FAO Headquarters, Rome, September 8-10, 2009. Available online at: http://www.fao.org/docrep/014/am490e/am490e00.pdf (accessed on 20th January, 2015)

FAO (2012). Gender Inequalities in Rural Employment in Ghana: An Overview. Prepared by the Gender, Equity and Rural Employment Division of Food and Agricultural Organization (FAO), Rome.

FARA (2012). Africa in search of safe and high-quality biotech crops; 1st Pan-AfricanM Conference on Stewardship of Agricultural Biotechnology, Accra, Ghana, 29-30 November 2011. Available on: http://www.syngentafoundation.org/__temp/STEWARDSHIP_CONFERENCE_

NOV _2011_ABRIDGED_REPORT-_WSA__FINAL-emm-revised.pdf (Accessed on 12th October, 2014)

Fearon J, Adraki PK and Boateng VF (2015). Fertilizer Subsidy Programme in Ghana: Evidence of Performance after Six Years of Implementation. Journal of Biology, Agriculture and Healthcare. Vol.5, No.21, 2015

Field A (2000). Discovering Statistics using SPSS for Windows. London – Thousand Oaks – New Delhi: Sage publications.

Finger R, Benni N, Kaphengst T, Evans C, Herbert S, Lehmann B, Morse S and Stupak N, (2011). A meta-analysis on farm-level costs and benefits of GM crops. Sustainability 3(5): 743-762..

Fishbein M and Ajzen I (1975). Belief, attitude, intention, and behavior: An introduction to theory and research. Reading, Mass; Don Mills, Ontario: Addison-Wesley Pub. Co.

Fisher, R.A. (1960). The Design of Experiments, 7th edition. Edinburgh: Oliver & Boyd.

Fukuda-Parr S and Orr A (2012). GM Crops for Food Security in Africa –The Path Not Yet Taken. United Nations Development Programme (UNDP) working paper. WP 2012-018: January 2012

Gabor MR. and Lorga N (2013). Q Methodology (Factor Analysis) – Particularities and Theoretical Considerations for Marketing Data. International Journal of Arts and Commerce. Vol.2 No 4 Arpil 2013 issue.

GNA (2011). Northern farmers complain of high cost of farming. Ghana News Agency (GNA) Report Saturday 12th November, 2011, Accra, Ghana.

GNA (2015). National Biosafety Authority board inaugurated.17 February 2015. Ghana News Agency, Accra.

GoG (2010). The Savannah Accelerated Development Initiative (SADA); A Comprehensive, Long-term Development Strategy (2010 to 2030). Government of Ghana (GoG), Accra.

Goldman I (1999). Q-Methodology as Process and Context in Interpretivism, Communication, and Psychoanalytic Psychotherapy Research. The Psychological Record, 49, 589-604

Gorsuch RL (1983). Factor analysis (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Greenpeace (2011). Environmental and health impacts of GM crops - the science

GSS (2014). Ghana Living Standard Survey Round Six. Ghana Statistical Services, August, 2014, Accra.

GSS (2016). 2015 Ghana Labour Force Report, Ghana Statistical Service (GSS). GOG, Accra.

GSS (2012). Ghana Population and Housing Census. Ghana Statistical Service (GSS), GoG, Accra.

GSS (2007). Patterns and Trends of Poverty in Ghana, 1991-2006. Ghana Statistical Service, Government of Ghana, Accra

Guadagnoli E, Velicer WF (1988). Relation of sample size to the stability of component patterns. Psychological Bulletin. 1988;103(2):265-75.

Gujarati D (2004). Basic Econometrics 4th Edition McGraw-Hill, New York.

Gulati A, Minot N, Delgado C and Bora S (2007). "Growth in High-value Agriculture in Asia and the Emergence of Vertical Links with Farmers." In Global Supply Chains, Standards and the Poor: How the Globalization of Food Systems and Standards Affects Rural Development and Poverty, edited by J. F. Swinnen. Oxford: CAB International.

Hair J, Anderson RE, Tatham RL, Black WC (1995). Multivariate data analysis. 4th ed. New Jersey: Prentice-Hall Inc; 1995.

Hair JF, Black WC, Babin, BJ, Anderson RE and Tatham RL (2006). Multivariate Data Analysis (6th ed.). Upper Saddle River, N.J.: Pearson Education Inc.

Hall C (2010). Identifying farmer attitudes towards genetically modified (GM) crops in Scotland. Land Economy Working Paper Series Number 6. Land Economy Research Group SAC Edinburgh EH9 3JG.

Hanrahan C (2010). "Agricultural Biotechnology: The U.S. – EU Dispute, " CRS Report for Congress RS21556, 8 April, http://digitalcommons.unl.edu/crsdocs/69/ (accessed on 28th April, 2014)

Haroon F, Ghazanfar M (2016). Applications of Food Biotechnology. J Ecosys Ecograph 6:215. doi:10.4172/2157-7625.1000215.

Harrison RW, Boccaletti S, House L (2004). Risk perceptions of urban Italian and United States consumers for GM foods. AgrobioForum, 7 (4), 195-201.

Hasson D and Arnetz B (2005). Validation and Findings Comparing VAS vs. Likert Scales for Psychosocial Measurements. International Electronic Journal of Health

Hayton JC, Allen DG and Scarpello V (2004). Factor Retention Decisions in Exploratory Factor Analysis: A Tutorial on Parallel Analysis. Organizational Research Methods, 7, 191-205.

Heiser CB Jr (1990). Seed to Civilization: The Story of Food. Harvard University Press, Cambridge, MA

Helander M, Saloniemi I and Saikkonen K (2012). Glyphosate in northern ecosystems. Trends in Plant Sciences 17, 569–574

Henson RK, Roberts JK (2006). Use of Exploratory Factor Analysis in Published Research: Common Errors and Some Comment on Improved Practice. Educational and Psychological Measurement. 2006; 66(3).

Hill RC, Griffiths WE, Lim GC (2008). Principles of Econometrics, New York, John Wiley and Sons, Inc.

Ho P, Zhao JH and Xue D (2009). Access and control of agro-biotechnology: Bt cotton, ecological change and risk in China. The Journal of Peasant Studies Vol. 36,

Hogarty K, Hines C, Kromrey J, Ferron J, Mumford K (2005). The Quality of Factor Solutions in Exploratory Factor Analysis: The Influence of Sample Size, Communality, and Over determination. Educational and Psychological Measurement. 2005;65(2):202-26.

Hsieh H and Shannon SE (2005). Three Approaches to Qualitative Content Analysis. Qualitative Health Research, Vol. 15 No. 9, November 2005 © 2005 Sage Publications.

Icoz I and Stotzky G (2008). Fate and effects of insect-resistant Bt crops in soil ecosystems. Soil Biology and Biochemistry 40: 559–586.

Idowu PE, Ibitoye DO and Ademoyegun OT (2009). Tissue culture as a plant production technique for horticultural crops. African Journal of Biotechnology. Vol 8, No 16 (2009). Available online: http://www.ajol.info/index.php/ajb/article/view/62060 (accessed on 19th December, 2014)

IFAD (2010). Rural Poverty Report 2011. International Fund for Agricultural Development (IFAD).

IFPRI (2013). Genetically Modified Crops in Africa: Economic and Policy Lessons from Countries South of the Sahara. Internal Food Policy Research Institute (IFPRI) issue brief November 2013 80.

Tripp R and Mensah-Bonsu A (2013). Ghana’s commercial seed sector: New incentives or continued complacency? GSSP Working Paper 32. Washington, D.C.: International Food Policy Research Institute (IFPRI)

Krausova M and Banful AB (2010). Overview of the Agricultural Input Sector in Ghana. International Food Policy Research Institute (IFPRI) Discussion Paper 01024, September, 2010

IMF (2017). GDP per Capita by Country | Statistics from International Monetary Funds (IMF), 2017.

Iqbal M (2007). Concept and implementation of participation and empowerment: Reflection from coffee IPM-SECP. Makara, Sosial Humaniora, 11 (2): 58- 70.

ISAAA (2016). Global Status of Commercialized Biotech/GM Crops: 2016. ISAAA Brief No. 52. ISAAA: Ithaca, NY.

ISAAA (2013). Report on global status of biotech/GM crops. ISAAA Brief 44-2012.

ISAAA (2006). Genetic Engineering and GM Crops. Pocket K No. 17. Global Knowledge Center on Crop Biotechnology.

ISAAA (2004). Cartagena Protocol on Biosafety. Pocket K No. 8 http://www.isaaa.org/kc

IUNS (2012). Statement on Benefits and Risks of Genetically Modified Foods for Human Health and Nutrition. International Union of Nutrition Sciences. Available online at: http://www.iuns.org/statement-on-benefits-and-risks-of-genetically-modified-foodsfor-human-health-and-nutrition (accessed on 17th December, 2014)

James C (2014). Global Status of Commercialized Biotech/GM Crops: 2014. ISAAA Brief No. 49. ISAAA: Ithaca, NY.

James C (2013). Global Status of Commercialized Biotech/GM Crops: 2013. ISAAA Brief No.46. ISAAA: Ithaca, NY. ISBN: 978-1-892456-55-9

James C (2010). Global Status of Commercialized Biotech/GM Crops: 2010. ISAAA-brief 42/ Ithaca, NY

James C (2012). Global status of commercialized biotech/GM crops. ISAAA Brief No. 44. Ithaca, NY: ISAAA

James C (2008). Global status of commercialized biotech/GM crops 2008. ISAAA Brief no. 39, ISAAA, Ithaca, NY.

Johnson R (2004). Marker – assisted Selection. Plant Breeding Review, vol. 24, part 1, Edited by Jules Janick ISBN-0-471-35316-7 John Wiley and Sons. Inc., USA

Joilo CB, Paula W, Do, Craig R and Robert G.M (2008). Statistical Methodology: VII. Q-Methodology, a Structural Analytic Approach to Medical Subjectivity. Academic Emergency Medicine. Volume 5, Issue 10.

Jolliffe J (2014). Principal Component Analysis. Wiley StatsRef: Statistics Reference Online, 2014. Published Online: 29 SEP 2014.

Jyotsna H, 2012. Measuring Internal Customers' Perception on Service Quality Using SERVQUAL in Administrative Services. International Journal of Scientific and Research Publications, Volume 2, Issue 3, March 2012 1 ISSN 2250-3153

Kaiser HF (1970). A Second-Generation Little Jiffy. Psychometrika. 1970; 35(4):401-15.

Kaiser HF. Little Jiffy, Mark IV (1974). Educational and Psychological Measurement. 1974; 34:111-7.

Kameri-Mbote, P., Wafula, D. and Clark, N (2001). Public/Private Partnerships for Biotechnology in Africa: The Future Agenda. International Environmental Law Research Centre. Published by Africa Centre for Technology Studies, Nairobi

Karapinar B and Temmerman M (2007). Benefiting from Biotechnology: Pro-poor IPRs and Public-Private Partnerships. Working Paper No. 2007/35. NCCR-International Trade Regulation.

Karim K (2001). Q methodology—advantages and the disadvantages of this research method. Journal of Community Nursing. 15(4): 8-10.

Kariyawasam K (2010). Legal Liability, Intellectual Property and Genetically Modified Crops: Their Impact On World Agriculture. Copyright © 2010 Pacific Rim Law & Policy Journal Association.

Katiraee L (2014). Patents and GMOs: Should biotech companies turn innovations over to public cost-free? Genetic Literacy Project publication. April 22, 2014.

Keelan C, Thorne FS., Flanagan P, Newman C and Mullins E (2009). Predicted Willingness of Irish Farmers to Adopt GM Technology. AgBioForum, 12(3&4): 394-403.

Kelley K, Clark B, Brown V and Sitzia J (2003). Good practice in the conduct and reporting of survey research. International Journal for Quality in Health Care. Volume 15, issue 3, May 2003, Pp 261-266. Online ISSN; 1464-3677 print 13534505. Oxford University press.

Kendall MG and Babington SB (1939). The problem of m rankings. Annals of Mathematical Statistics, 10: 275–287.

Khush GS (2012). Genetically modified crops: the fastest adopted crop technology in the history of modern agriculture. © 2012 Khush.; licensee BioMed Central Ltd. Khush

Kieffer KM (1999). An introductory primer on the appropriate use of exploratory and confirmatory factor analysis. Research in the Schools. 1999;6(2):75-92.

King DK (2003). GM Science Review: First Report, Prepared by the GM Science Review Panel under the chairmanship of Sir David King for the UK Government, July.

Kitzinger J (2005). Focus Group Research: using group dynamics toexplore perceptions, experiences and understandings. Holloway I. (ed.) (2005) Qualitative Research in Health Care Maidenhead: Open University Press pp.56-6IS BN 0-335-21293-x

Kline P (2002. An easy guide to factor analysis. London: Routledge.

Kline P (1994). An easy guide to factor analysis. London, Routledge.

Kremer RJ and Means NE (2009). Glyphosate and glyphosate-resistant crop interactions with rhizosphere microorganisms. European Journal of Agronomy 31: 153-161.

Kryder R.D, Kowalski SP and Krattiger A.F (2000). The intellectual and technical property components of pro-vitamin A rice (Golden rice TM): A preliminary freedom to operate review. ISAAA Briefs No. 20, ISAAA:Ithaca, N.Y.

La Rovere, R, Kostandini, G, Abdoulaye, T, Dixon, J, Mwangi, W, Guo, Z, and Banziger, M (2010). Potential Impact of Investments. In Drought Tolerant Maize in Africa. CIMMYT, Addis Ababa, Ethiopia.

Lai PC and Zainal AA (2015). Perceived Risk as an Extension to TAM Model: Consumers' Intention To Use A Single Platform E-Payment. Australia Journal Basic and Applied Science, 9(2): 323-330.

Lai, P. C (2014). "Factors influencing consumers' intention to use a single platform E-payment System." UNITEN.

Laird NM and Lange C (2011). The Fundamentals of Modern Statistical Genetics, Statistics for Biology and Health, DOI 10.1007/978-1-4419-7338-2_2, Springer Science+Business Media, LLC 2011 ISBN: 978-1-4419-7337-5

Lamichhane SA (2014). Genetically Modified Foods-Solution for Food Security. International Journal of Genetic Engineering and Biotechnology. ISSN 0974 3073 Volume 5, Number 1 (2014), pp. 43-48

Lang A and Otto M (2010). A synthesis of laboratory and field studies on the effects of transgenic Bacillus thuringiensis (Bt) maize on non-target Lepidoptera. Entomologia Experimentalis et Applicata 135: 121–134.

Laura MZ, Pamela JH, Elizabeth P and John T (2008). Green genes. Science 320 (5875), 465.

Leary KO, Jacob OW and Eve AR (2013). Q-Methodology as a Research and Design Tool for HCI. CHI 2013, April 27–May 2, 2013, Paris, France. Copyright © 2013 ACM 978-1-4503-1899-0/13/04.

Ledesma R. D. and Valero-Mora P (2007). Determining the Number of Factors to Retain in EFA: an easy-to-use computer program for carrying out Parallel Analysis. Practical Assessment, Research & Evaluation. Volume 12, Number 2, February 2007 ISSN 1531-7714.

Lefin AL (2009). Towards integrated sustainable food consumption strategies: a Q Methodology study. Institut pour un Développement Durable

Legendre, P (2010). Coefficient of concordance. Pp. 164-169 in: Encyclopedia of Research Design, Vol. 1. N. J. Salkind, ed. SAGE Publications, Inc., Los Angeles.

Li E, Dearing M. (2014). Genetic Modification: Utopia or Dystopia? 13 November 2014. Available at: https://www.scribd.com/doc/250056269/genetic-modification-utopia-or-dystopia (accessed 20th June, 2016)

Li GP, Wu KM, Gould F, Wang JK, Miaoi J, Gao XW and Guo YY (2007). Increasing tolerance to Cry1Ac cotton from cotton bollworm, Helicoverpa armigera, was conirmed in Bt cotton farming area of China. Ecological Entomology 32: 366–375.

Louwaars NP and De Boef WS (2012). Integrated seed sector development in Africa: A conceptual framework for creating coherence between practices, programs, and policies. J. Crop Imp. 26:39–59.

Lu B (2008). Transgene Escape from GM Crops and Potential Biosafety Consequences: An Environmental Perspective. Collection of Biosafety Reviews Vol. 4 (2008)

Mampuys R, Frans W. A. Brom (2015). Ethics of Dissent: A Plea for Restraint in the Scientific Debate About the Safety of GM Crops. Journal of Agricultural and Environmental Ethics October 2015, Volume 28, Issue 5, pp 903-924.

Manly BFJ (2005). Multivariate Statistical Methods: A primer, Third edition, Chapman and Hall.

Manly BFJ. 2005. Multivariate Statistical Methods: A primer, Third edition, Chapman and Hall.

Mannion AM and Morse S (2012). Biotechnology in agriculture: agronomic and environmental considerations and reflections based on 15 years of GM crops. Progress in Physical Geography 36, 747–763

Marianne J and Louise P (2002). Discourse Analysis as Theory and Method. SAGE Publications London • Thousand Oaks • New Delhi.

Marra M and Carlson G (1987). The role of farm size and resource constraints in the choice between risky technologies. Western Journal of Agricultural Economics, 12(2), 109118.

Marshall G (1998). A dictionary of sociology. Oxford University Press, New York

Mathieson, K (1991). Predicting user intentions: Comparing the technology acceptance model with the theory of planned behavior. Information Systems Research, 2(3), 173-191.

McDonald RP (1985). Factor analysis and related methods. Hillsdale, NJ: Lawrence Erlbaum Associates.

McFadden, D. 1974. Conditional logit analysis of qualitative choice behaviour.

McKeown B and Thomas D (2013). Q-Methodology. Sage Publications, London, 2013. [p164, 165]

McKeown BF, Thomas BD (1988). Q-methodology. Newbury Park, CA: Sage Publications.

McKeown M, Hinks M, Stowell-Smith M, Mercer D, Forster J (1999). "Q methodology, risk training and quality management", International Journal of Health Care Quality Assurance, Vol. 12 Iss: 6, pp.254 - 266

Meinzen-Dick R, Di Gregorio M and McCarthy N (2004). Methods for studying collective action in rural development. Agricultural System 82(3):197–214

Mercer KL, Andow DA, Wyse DL and Shaw RG (2007). Stress and domestication traits increase the relative fitness of crop-wild hybrids in sunflower. Ecology Letters

MES/UNEP-GEF (2004). National Biosafety Framework for Ghana. United Nations Environment Programme – Global Environment Facility (UNEP-GEF).

MOFA (2016). Agricultural Sector Progress Report 2015. Ministry of Food and Agriculture (MOFA), GOG, Accra.

MOFA (2015). Web Portal for Farmer Based Organisations in Ghana. Ministry of Food and Agriculture, Ghana, Accra (Available online at: http://fboghana.com/ accessed on 15th July, 2015)

MOFA (2012). Performance Of The Agricultural Sector In Ghana: 2006-2012. Gross Domestic Product (GDP) At 2006 Prices By Economic Activity: 2006-2012

MOFA (2011a). Agricultural in Ghana Facts and Figures 2010. Ministry Of Food and Agriculture Statistics, Research and Information Directorate (SRID). Government of Ghana (GOG). Accra.

MOFA (2011b). Ghana Commercial Agriculture Project (GCAP): Pest Management Plan (PMP) final report. November 2011. Ministry Food and Agriculture, Government of Ghana, Accra

MOFA (2010). 'Medium Term Agriculture Sector Investment Plan (METASIP) 2011 – 2015. Ministry of Food and Agriculture, Government of Ghana, Accra

Murphy DJ (2007). Plant Breeding and Biotechnology: Societal Context and the Future of Agriculture. Published in the United States of America by Cambridge University Press, Mwamahonje A. and Mrosso L (2016). Prospects of genetic modified maize crop in Africa. African Journal of Biotechnology. Vol. 15(15), pp. 571-579, 13 April, 2016

Namara R.E., Horowitz L. Nyamadi B. and Barry B (2011. Irrigation Development in Ghana: Past experiences, emerging opportunities, and future directions. Ghana Strategy Support Program (GSSP).GSSP Working Paper No. 0027, March 2011. International Food Policy Research Institute (IFPRI).

National Campaign against UPOV/Plant Breeders' Bill (2014). Faith-Based Organizations' Position on the Plant Breeders' Bill And Genetically Modified Organisms In Accra On 19th June 2014 (Available on http://foodsovereigntyghana.org/ accessed on 20th June, 2014)

Newman I and Ramlo S (2010). Using Q methodology and Q factor analysis to facilitate mixed methods research. In A. Tashakkori, & C. Teddlie (Eds.), Handbook of mixed methods in social and behavioural research (2nd ed., pp. 505-530). Thousand Oaks, CA: Sage Publications.

Newman I, and Newman C (1994). Conceptual statistics for beginners (2nd ed.). Lanham, Md.: University Press of America.

Newman I. and McNeil, K (1998). Conducting Survey Research in the Social Sciences.

Nicolia A., Manzo A., Veronesi F, and Rosellini D (2014). An Overview of the Last 10 Years of Genetically Engineered Crop Safety Research. Crit Rev Biotechnol, 34(1), 77-88

Njoroge KT and Orodho JA (2014). Secondary School Students' Perception Towards Agricultural Science in Public Secondary Schools in Nairobi County, Kenya. Journal of Humanities and Social Science 19(7), 30-36.No. 1.

Todua N, Gogitidze T and Phutkaradze B (2017). Georgian Farmers' Attitudes towards Genetically Modified Crops. Economics World, July-Aug. 2017, Vol. 5, No. 4, 362-369.

Nxumalo KKS. and Oladele OI (2013). Factors Affecting Farmers' Participation in Agricultural Programme in Zululand District, Kwazulu Natal Province, South Africa. Kamla-Raj 2013 J Soc Sci, 34(1): 83-88 (2013).

Oliveira AR, Castro TR, Capalbo DMF and Delalibera I (2007). Toxicological evaluation of genetically modiied cotton (Bollgard®) and Dipel ® WP on the non-target soil mite Scheloribates praeincisus (Acari: Oribatida). Experimental and Applied Acarology 41:

Onumah GE., Davis JR., Kleih U and Proctor FJ (2007). Empowering smallholder farmers in markets: Changing agricultural marketing systems and innovative responses by producer organizations. ESFIM Working Paper 2: IFAD, CTA, AGRICORD.

Ostrom E (2004). Collective Action and Property Rights for Sustainable Development Understanding Collective Action, FOCUS 11 Brief 2 of 16, Vision 2020.

Paarlberg R (2010). GMO foods and crops: Africa's choice. New Biotechnology Volume 27, Number 5 November 2010 Elsevier

Perlak FJ, Deaton RW, Armstrong TA, Fuchs R.L, Sims SR, Greenplate JT and Fischhoff, DA (1990). Insect resistant cotton plants. Bio/Technology, 8, 939-943.

Petit OD, Heather W and Richard W (2012). Exploring the underlying factors influencing e-learning adoption in nurse education. Journal of Advanced Nursing, © 2012 Blackwell Publishing Ltd

Pett MA, Lackey NR, Sullivan JJ (2003). Making Sense of Factor Analysis: The use of factor analysis for instrument development in health care research. California: Sage Publications Inc; 2003.

Pett MA, Nancy RL, and John JS (2003). Making sense of factor analysis: The use of factor analysis for instrument development in health care research. Thousand Oaks, CA: Sage Publications.

Prakash CS (2001). The Genetically Modified Crop Debate in the Context of Agricultural Evolution. Plant Physiology, May 2001, Vol. 126, pp. 8–15

Purnamita D and Bhaskar V (2004). Adapting Q-methodology to investigate stakeholder perceptions in participatory forestry in India. Submission for ISEE Montreal 2004

Qaim KW M (2014). A Meta-Analysis of the Impacts of Genetically Modified Crops. PLOS ONE, Vol. 9, No. 11, e111629. doi:10.1371/journal.pone.0111629.

Qaim M and Kouser S (2013). Genetically Modified Crops and Food Security. PLoS ONE8(6).

Qaim M (2009). The economics of genetically modified crops. Annual Review Resource Economics 1, 665–693

Qaim M (2015). Genetically Modified Crops and Agricultural Development. Copyright © Martin Qaim. Printed by Hardcover ISBN 978-1-137-40571-5

Ramlo S and Newman I (2011). Classifying individuals using Q Methodology and Q Factor Analysis: Applications of Two Mixed Methodologies for Program Evaluation. Journal of Research in Education. Volume 21, Number 2

Ranllo S (2008). Deterillining the various perspectives and consensus within a classroom using Q methodology. Physics Education Research Conference Proceedings, 1064(1), 179182.

Rausser, G., Simon, L. and Ameden, H (2000). ‘Public–private alliances in biotechnology: Can they narrow the knowledge gaps between rich and poor?’ Food Policy, 25, 2000, 499–513.

Rees, M (2005). Response to the question "What is your dangerous idea". Featured on The Edge. Available at http://www.edge.org/q2006/q06_12.html#rees Accessed on 21st December, 2014)

Rencher AC (2002). Methods of Multivariate Analysis, Second edition, Wiley.

Rietveld T and Van HR (1993). Statistical Techniques for the Study of Language and Language Behaviour. Berlin – New York: Mouton de Gruyter.

Rogers, E.M (1995). Diffusion of Innovations. 4th ed., New York: The Free Press

Rogers, E.M (2003). Diffusion of innovations (5th ed.). New York: Free Press.

Robert M Yawson, Wilhelmina Quaye, Irene Entsi Williams & Ivy Yaws, (2008). A Stakeholder Approach to Investigating Public Perception and Attitudes towards Agricultural Biotechnology in Ghana. Tailoring Biotechnologies Vol. 4, Issue 1/1, pp: 55-70

Rosi-Marshall EJ, Tank JL, Royer, TV, Griffiths NA, Evans-White, MA and Stojak, AR, (2010). Responses of stream macroinvertebrates to Bt maize leaf detritus. Ecological Applications 20:1949–1960

Saheed M (2014). An Assessment of Q Methodology for Social Research. A study project submitted to Brandenburg University of Technology for the Degree of MSc. Environmental and Resource Management

Salifu, A., Francesconi, G. N., and Kolavalli, S. (2010). "A review of collective action in rural Ghana".

Sandbrook C., Scales IR., Vira B and Adams WM (2011). Value plurality among conservation professionals. Conservation Biology, 25(2):285–94, 2011.

Sanvido O, Romeis J, Gathmann A, Gielkens M, Raybould A and Bigler F (2012). Evaluating environmental risks of genetically modified crops: ecological harm criteria for regulatory decision-making. Environmental Science and Policy 5, 82–91

Sapnas KG, Zeller RA (2002). Minimizing sample size when using exploratory factor analysis for measurement. Journal of Nursing Measurement. 2002;10(2):135-53.

SARI (2010). A Brief Overview of Savannah Agricultural Research Institute. SAR of CSIR, Ghana.

Sarpong GA (2004). The Legal Regime for the Control of Invasive Alien Species (IAS) In Ghana: Some Lessons in the Implementation of Treaty Norms. FAO Legal papers on-line number 40, December, 2004.

Schlinger MJ (1969). Cues on Q-technique. Journal of Advertising Research, 9(3), 53-60.

Séralini, G. E., Claira, E., Mesnage, R., Gress, S., Nicolas Defarge, N., Malatesta, M., et al. (2012) .Long Term Toxicity of a Roundup Herbicide and a Roundup-Tolerant Genetically Modified Maize. Food and Chemical Toxicology, 50(11), 4221-4231 SERVQUAL in Administrative Services. International Journal of Scientific and Research Publications, Volume 2, Issue 3, March 2012 1 ISSN 2250-3153

Sesabo JK, Lang H. and Tol RSJ (2006). Perceived Attitude and Marine Protected Areas (MPAs) establishment: Why households' characteristics matters in Coastal resources conservation initiatives in Tanzania: Journal of Anthropology vol. 28: 230-254.

Shiferaw BJH, and Muricho G (2011). Improving Market Access and Agricultural Productivity Growth in Africa: What Role for Producer Organizations and Collective Action Institutions? Food Security: 475–489.

Shinebourne P and Adams M (2007). Q Methodology as a Phenomenological Research Method. Existential Analysis 18.1: January 2007. Available on: www.academia.edu/8428834/Q- (Accessed on 20th May, 2014).

Shinebourne P (2009). Using Q Method in Qualitative Research. International Journal of Qualitative Methods 2009, 8(1). © 2009 Shinebourne

Shiva V (2006). The manifesto on the future of seeds. The International Commission on the Future of Food and Agriculture. Available online at: http://www.arsia.toscana.it/petizione/documents/semi/futurosemi_eng.pdf (Accessed on 22nd December, 2014)

Yang S, Vanderbeld B, Wan J and Huang Y (2010). Narrowing Down the Targets: Towards Successful Genetic Engineering of Drought-Tolerant Crops Performance Plants .Molecular Plant. Volume 3 Number 3 Pages 469–490 Inc., 700 Gardiners Road, Kingston, Ontario, K7M 3X9, Canada May 2010 Review Article

Sipalla F, Cairns J (2015). CIMMYT – CCAFS Scientists Identify Maize Varieties that can withstand drought and high temperatures in Zimbabwe, Nairobi and Kenya. CMMYT Feature article. (Available on: http://www.cimmyt.org/drought-and-heat-tolerant-maize-tackles-climate-change-in-southern-africa/ accessed on 12th December, 2016)

Smith J (2007). Genetically modified foods unsafe? Evidence that links GM foods to allergic responses mounts. Global Research. 8 Nov 2007.

Specter M (2014). Seeds of Doubt an activist’s controversial crusade against genetically modified crops. Annals of Science August 25, 2014 Issue. The New Yorker. Available online on: http://www.newyorker.com/magazine/2014/08/25/seeds-ofdoubt (Accessed on 21st December, 2014)

Stephenson W (1935). Correlating persons instead of tests. Character and Personality 1935;4: 17-24

Stockbridge, M., A. Dorward, and J. Kydd (2003). Farmer Organizations for Market Access: A Briefing Paper. UK Department of International Development, London.

Stricklin, M. & Almeida, J (2001). PCQ: analysis software for Q-technique (Academic edition revised.

Sullivan B.D (2017). Mega-mergers in agribusiness raise concerns about food costs, biodiversity. USA TODAY Published 11:28 a.m. ET Aug. 29, 2017

Surendran P (2012). Technology Acceptance Model: A Survey of Literature. International Journal of Business and Social Research (IJBSR), Volume -2, No.-4, August 2012.

Sutton S (2002).Testing attitude–behaviour theories using non-experimental data: An examination of some hidden assumptions. European Review of Social Psychology, 2002, 13, 293 – 323

Swisher LL, Beckstead JW, Bebeau MJ (2004). Factor Analysis as a Tool for Survey Analysis Using a Professional Role Orientation Inventory as an Example. Physical Therapy. 2004; 84(9):784-99.

Tabachnick, B. G., & Fidell LS (2001). Using Multivariate Statistics (4th Ed.). Needham Heights, MA: Allyn & Bacon.

Tabachnick B. G., & Fidell LS (2007. Using multivariate statistics (5th ed.). Upper Saddle River, NJ: Pearson Allyn & Bacon

Taylor S. and Todd PA (1995). Understanding Information Technology Usage: A Test of Competing Models. Information Systems Research, 6, 144-176.

Teun AD (2014). Discourse & Society. An International Journal for the Study of Discourse and Communication in their Social, Political and Cultural Contexts

Thomas D and Larry B (1992). 'The issue of generalization in Q Methodology: "Reliable schematics" revisited', Operant Subjectivity, 16(1), 1992, pp. 18-36.

Thompson B and Daniel LG (1996). Factor analytic evidence for the construct validity of scores: A historical overview and some guidelines. Educational and Psychological Measurement. 56(2):197-208.

Thompson B (2004). Exploratory and confirmatory factor analysis: understanding concepts and applications. Washington, DC: American Psychological Association; 2004.

Thomson MJ, Ismail AM., McCouch SR and Mackill DJ (2010). Abiotic Stress Adaptation in Plants – Physiological and Genomic foundation, pp 451469

Timpo SE (2011). Harmonizing Biosafety Regulations in Africa: Surmounting the Hurdles. Socio-Economics Policy Brief No. AU-NEPAD African Biosafety Network of Expertise (ABNE)

Vain, P (2007). Trends in GM crop, food and feed safety literature. Nature Biotechnology Correspondence 25: 624-626.

Van Exel, N.J.A.; de Graaf, G (2005). Q methodology: A sneak preview. Available online at: http://qmethod.org/articles/vanExel.pdf (Accessed on 20th June, 2015)

Vanni F 2014. The Role of Collective Action. Springer Science+Business Media Dordrecht 2014

Venkatesh, V. and Bala, H (2008). Technology Acceptance Model 3 and a Research Agenda on Interventions. Decision Science, 39 (2), 273-312.

Venkatesh V and Davis FD (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. Management Science, 46 (2), 186-204.

Venkatesh V, and Morris MG (2000). Why Don't Men Ever Stop to Ask For Directions? Gender, Social Influence, and Their Role in Technology Acceptance and Usage Behavior. MIS Quarterly (24:1), 115-139.

Venkatesh V, Morris MG, Davis FD and Davis, G.B (2003). User Acceptance of Information Technology: Toward a Unified View. MIS Quarterly, 27, 425-478.

Vigani M and Olper A (2013). GMO standards, endogenous policy and the market for information. ScienceDirect Food Policy 43 (2013) 32–43. Elsevier

Vogt WP (1993). Dictionary of statistics and methodology: A nontechnical guide for the social sciences. Newbury Park, CA: Sage.

Vorley BA. Fearne and Ray D (2007. Regoverning Markets: a Place for Small-Scale Producers in Modern Agrifood Chains? Aldershot, Hants, England: Growers Publishing Limited.

Wanyama FO,Develtere P and Pollet I (2008). Reinventing the wheel? African cooperatives in a liberalized economic environment. Working paper for the Belgian Federal Ministry for Social Integration. Leuven, Belgium: University of Leuven.

Warner RM (2009). Applied statistics from bivariate through multivariate techniques. California, America: Sage.

Watts S and Stenner P (2012). Doing Q Methodological Research Theory, Method & Interpretation. 248 pages SAGE Publications Ltd. Available online at: http://www.uk.sagepub.com/booksProdDesc.nav?prodId=Book234368 (Accessed on 17th June, 2015)

Wen S. Chern (2006). Genetically Modified Organisms (GMOs) and Sustainability in Agriculture. Contributed paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 1218, 2006

Whitman D (2000). Genetically Modified Foods: Harmful Or Helpful? CSA Discovery Guides, 2000.

Ward W (2009). Q And You: The Application of Q Methodology in Recreation Research. Proceedings of the 2009 Northeastern Recreation Research Symposium GTR-NRS-P66

Williams, B, Brown, T and Onsman A (2012). Exploratory factor analysis: A five-step guide for novices. Australasian Journal of Paramedicine, 8(3).

Wittink L.T (2011). Choice modelling: An overview of theory and development in individual choice behaviour modelling. BMI Paper. August, 2011.

Wolf, A (2009). In Ramlo S. (Ed.), Personal communication re: Operant subjectivity

Wolf A (2010). Orientations to academic workloads at department level. Educational Management Administration & Leadership, 38(2), 246–262.

Wongkaew P and Jacqueline F (2004). Sugarcane white leaf phytoplasma in tissue culture: long-term maintenance, transmission, and oxytetracycline remission. Plant Cell Reports. November 2004, Volume 23, Issue 6, pp 426-434.

World Bank (2011). World Development Report 2012; Gender Equality and Development. World Bank publication 20433. Washington DC.

World Bank (2012). Agribusiness Indicators: Ghana. Economic Sector Work. 1818 H Street NW Washington DC 20433. Internet: www.worldbank.org World Bank document presented to the Republic of Ghana. Washington, D.C.: World Bank.

Wu KM (2007). Monitoring and management strategy for Helicoverpa armigera resistance to Bt cotton in China. Journal of Invertebrate Pathology 95: 220–223. DOI: 10.1016/j.jip.2007.03.012

Yankson PWK, Owusu AB., and Frimpong S (2016). Challenges and Strategies for Improving the Agricultural Marketing Environment in Developing Countries: Evidence from Ghana. Journal of Agricultural & Food Information Vol. 17, 1, 2016.

Yaremko, R. M., Harari, H., Harrison, R. C., & Lynn, E (1986). Handbook of research and quantitative methods in psychology: For students and professionals. Hillsdale, NJ: Lawrence Erlbaum Associates.

Zabala A (2014). qmethod: A Package to Explore Human Perspectives Using Q Methodology. The R Journal. Vol. 6/2, December 2014 ISSN 2073-4859

Zakaria H (2016). Underlying Constructs of Farmers' Perceptions towards Bt Cotton Among Former Cotton Farmers in Northern Ghana: Empirical Application of Q Methodology. International Journal of Agricultural Science, Research and Technology in Extension and Education System. Article 6, Volume 6, Issue 1, Spring 2016, Page 35-4

Zakaria H (2014). Farmer Based Organizations in Northern Region of Ghana Intention to Adopt GM Crop: Empirical Application of Theory of Planned Behaviour. International Journal of Innovation and Applied Studies Vol. 7 No. 3 Aug. 2014 issue, pp. 1191-1201.

Zakaria H, Adam H and Abujaja AM (2014). Knowledge and Perception of Farmers towards Genetically Modified Crops: The Perspective of Farmer Based Organizations in Northern Region of Ghana. American International Journal of Contemporary Scientific Research. Vol. 1 (2) 2014

Zobiole LHS, Kremer RJ, Oliveira RS, Constantin J (2011). Glyphosate affects microorganisms in rhizospheres of glyphosate-resistant soybeans Journal of Applied Microbiology. 110: 118-127

Zografos. C (2007). Rurality discourses and the role of the social enterprise in regenerating rural Scotland. Journal of Rural Studies, 23(1):38–51, 2007.

APPENDICES

Appendix 1: Questionnaire For Smallholder Farmers

Questionnaire code ……………… Interviewer Name …………………………………….. .Date …………………………… Starting time ………………………………….

Community …………………… District ………………….. Region ……………………… Ending time ………………………………….

Research objectives

The study sought to examine these specific research objectives:

6. To examine the knowledge and understanding smallholder farmers in Northern Ghana have about GM crops.
7. To analyse the underlying constructs characterising the perceptions smallholder farmers in Northern Ghana hold towards GM crops.
8. To determine factors predicting smallholder farmers in Northern Ghana adoption decision towards GM crop cultivation.
9. To analyse the expectations farmers have about Ghana's agrobiotechnology agenda.
10. To examine the likely prospects and constraints of commercialization of GM crop production from the perspective of smallholder farmers in northern Ghana.

INSTRUCTIONS: I hereby assured you that this information you are about to give, is being sought for academic research and will be used only for that purpose. You are further assured that, under no condition will your identity be disclosed nor your personal data and information be shared or transmitted for other purposes apart from the purpose (research) for which it is being sought for.

A: INFORMATION ON FARMER BASED ORGANIZATION

A1. Name of FBO …………………………………………………………………………

A2a. Is your FBO Registered? Yes [ ] or No [ ]

If yes, continue from A2b and if No, skip to question A3.

A2b. Which institutions is it registered with? MOFA [ ]; District Assembly [ ]

Registrar General's Department [ ]; Department of Cooperatives [ ]; other (specify) ………

A3. What is the evidence of existence of your FBO? Certificate of registration [ ]; Minute book [ ]; Meeting/Attendance Book [ ]; Financial Records [ ]; Bye laws, rules and regulations [ ] or others (specify) ……………………………………………

A4. Does your FBO have active functional bank account? Yes [ ] or No [ ]

A5. What is the membership structure of your FBO? (fill in the table below)

Membership structure	**Number of people**
Male members in the FBOs	
Female members in the FBOs	
Total members in the FBOs	

A6a. Which enterprise is your FBO engaged in? Crop production [ ]; livestock [ ]; processing enterprise [ ]; Marketing enterprise [ ]; Aquaculture [ ]

A6b. Why do your FBOs engaged in the above enterprise mentioned in A6a? ………………

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

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

A7a. Has your FBO ever had collaboration with other organizations? Yes [ ] or No [ ]

If yes, continue from question A7b, and if No, skip to A8.

A7b. If yes to question A7a, Which organization? MOFA [ ]; NGO [ ];

District Assembly [ ]; Financial Institution [ ]; other (specify) …………………………
(Multiple choice possible)

A7c. If yes to question A7a, what is/was the nature of collaboration?
…………………………...…………………………………………………………………
………………………………………………………………………………………………

A8a. Has your FBO ever received assistance from any organization? Yes [ ] or No [ ]

If yes, continue from question A8b, and if No, skip to section B.

A8b. If yes to question A8a, which organization provided the assistance? MOFA [ ]; NGO [ ]; District Assembly [ ]; Financial Institution [ ]; other (specify) ………………………… (Multiple choice possible)

A8c. What was/were assistance?

……………………………………………………………………………………………….

……………………………………………………………………………………………….

B: PERSONAL BACKGROUND

B1. Name of respondent ……………………..………………… B2. Position held in the FBO ……………………………………………………………………..……………………………

B3. Sex: Male [ ] or Female [ ] B4. Age of Respondent ……………………….………

B5. How long have you been a member of this FBO? ………………………………………..

B5: Household Status: Male headed [ ] Female headed [ ]

B6: Status of respondent in the Household: [Head] [Member]

B7: Household Size ….............................(fill in the table by providing information on household structure by age and sex)

Household age structure	**Male**	**Female**	**Total**
< 15			
15 - 60			
> 60			
Total			

B8: Is your household membership structure composed of mixed sex or single sex membership? Mixed sex [ ] Single sex [ ]

B9: Marital Status: Married [ ] or Single [ ]

B10. Can you read and/or write Yes [ ] No [ ]

B11. Number of years of formal schooling completed ………………………………..

B13. What is your religious background? Christian [ ]; Muslim [ ]; Traditional religion [ ]

B14. What are your sources of income? (Fill in the table below)

Source of income	Tick if apply	How much did you got from the sources within the last 12 months
Cropping farming		
Livestock rearing		
Off farm activities		
Remittance		
Others (specified		

C: CROPS FARMING ACTIVITIES

C1. What type of crops have you been growing over the years? Food crops [ ]; cash crops [ ]; tree crops [ ] (Multiple choice possible)

C2. What type of seeds have you been using for your crop production? Certified seed [ ] or non-Certified seed/Local [ ]

C3. If you have not being using certified seeds, why? ………………………………………..……………………………………………………… ………………………………………...

C4. Where have you been sourcing your seeds from? From certified seed growers [ ]; from my previous year harvest [ ]; from the open market [ ]; from colleagues/relative farmers [ ]; from input dealer [ ] or others (specify) ………………………..… (Multiple choice possible)

C5a. What is your main source of information on agriculture? MoFA extension officers [ ]; NGO staff [ ]; from the radio and other mass media [ ]; from colleague farmers [ ] others (specify) ………………………………………………………………………..

C5b.what agricultural information have you been receiving from your main source?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

C6a. How frequently did you have extension contact over the last season? Very frequently [ ]; frequently [ ]; fairly frequently [ ] or not very frequent [ ]

C6b. how many extension visits did you received within the last season? ……………………..

C7: How did you access your land for farming? Own [ ]; Family land [ ];

Communal land [ ]; Leased [ ]; Purchased [ ]

C8: What is the size of your land under cultivation? (Please fill in the table below).

Size land under food crops cultivation	Size of land under cash crops cultivation	Size of land left to fallow	Size of land leased/lent out	Total

C9. What quantity of produce did you got from your various crop enterprises in the last farming season? (Please fill in the table below)

Crop	Quantity harvested in the last season (Indicate unit)	Quantity consumed (Indicate unit)	Quantity sold (indicate unit)	Unit price
Maize				
Rice				
Millet				
Sorghum				
Groundnut				
Soybean				
Yam				
Cassava				
Others (specify)				

C11a. Have you ever changed the variety of crops you being growing? Yes [ ] or No [ ]

C1a. If yes to question C11a, why did you change your crop variety? ……………………………………..………………………………………………………
………………………………………………………………………………………………..
………………………………………...

C11b. If no to question C11a, why? ………………………………………………………………

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

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

C12a. What problems are you currently facing regarding your crops?

Varietal problems ………………………………………………………………………..

………………………………………………………………………………………………

……………………………………………………………………………………………..

Farming system problem …………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

Production problem ………………………………………………………………………

………………………………………………………………………………………………

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

Marketing Problem ………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………….

C12b. Any suggested solutions to the above problems……………………………………...

………………………………………………………………………………………………

………………………………………………………………………………………………

C13. What improvement do you want to see in the current variety of crop you are growing?

…………………………………………………………………………………………………

……………………………………………………………………………………………….

C15a. Do you keep livestock? Yes [ ] or No [ ]

C15b. If yes to question C15a, what types of livestock do you rear? (Kindly fill in the table below)

Livestock	Current stock	Number consumed within the last 12 months	Number sold within the last 12 months	Unit price
Goat				
Sheep				
Cattle				
Pig				
Guinea fowls				
Local fowls				
Exotic fowls/birds				
Others				

D: INFORMATION AND KNOWLEDGE ON GM CROPS

D1. Where did you first hear/read about GM crops? Mass media [ ]; Colleague farmers [ ]; Extension officer [ ], Never heard of them [ ]; Others (specify)

……………………………………………………..

D2. What will you say GM crops are? (probe more and deep)

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

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

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

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

D3a. How well informed are you regarding GM crops? Very well informed [ ]; somewhat informed [ ]; not informed [ ] or not sure [ ]

D3a. What inform your description or grading of your knowledge on GM crops in question D3a?

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

D4a. What benefits of GM crops do you know or have you heard of? ....

....

....

D4b. What disadvantages or negative side effects of GM crops do you know or have you heard of?

....

....

D5a. Are you willing to learn more about GM crops Yes [ ] or No [ ]

D5b. If yes to question D5a, what do you want to know about?

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

D5c. If no to question D5a, why? ………………………………………………………

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

D6. What expectation do you have from the introduction of agro-biotechnology in Ghana's agriculture regarding:

Varietal Improvement ………………………………………………………………..

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

Reduce cost of production and income gains ………………………………………………
…………………………………………………………………………..……………………
………………………………………………………………………………………………
…………………………………………………………………………............................

Food security and Consumer satisfaction ………………………………………………...
…………………………………………………………………..……………………………
………………………………………………………………………………………………

Improve research ……………………………………………………………..

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

D7a. Do you intend cultivating GM crops, if they are introduced in Ghana? Yes [ ] or No [ ]

D7b. If yes to question D7a, why do you intend to adopt GM crop cultivation? ……………………………………………………………………………………………….

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

……………………………………………………………………………………………….

D7c. If no to question D7a, why don't you want to adopt GM crop cultivation? ………………………………………………………………………………………………..

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

……………………………………………………………………………………………..

E: PERCEPTION AND ATTITUDE TOWARDS GM CROPS

Use the table below to guide the Q sorting process. Enter the rank score from the Q sort board as sorted by the interviewee on the rank column.

NB: Rank score: 1= Strongly Disagree; 2 = Disagree; 3= Undecided; 4 = Agree or 5 = Strongly Agree

Read careful the following statements and indicate your agreement rank (1 – Strongly Disagree through 3 – undecided to 5 – Strongly agree)

Card No.	**Statements**	**Response category**				
		1	2	3	4	5
1.	All agricultural practices, not only GM crops, affect the environment					
2.	Commercialization of GM crops in Ghanaian will help reduce cost of production					
3.	I will be encouraged to grow GM crops because it can be bred to be resistant to the common plant diseases					
4.	Reduction of chemical use in GM crops cultivation will benefit the environment					
5.	Since US had allowed the cultivation of GM crops, we in Ghana shouldn't have reservation					
6.	Both farmers and consumers stand to benefit from the introduction of GM crops in Ghana					
7.	I will eat GM food because all what is being said are doubts					
8.	GM crops are substantially equivalent to their non-GM counterparts and as such pose no harm					
9.	There wouldn't be problem if GM and conventional crops coexist in Ghana					
10.	Farmers would benefit from improved yields if GM crops are introduced in Ghana					
11.	I am satisfied with the country's progress towards the introduction of GM crops					
12.	I will not mind, if a farm nearby grows GM crops					
13.	I would choose to grow GM crops because technology should be embraced					
14.	With the country's open border system, it is unfair and unwise to prevent Ghanaian farmers from growing GM crops					
15.	The introduction of GM crops in Ghana would enslave Ghanaian farmers and consumers to foreign multinational companies					
16.	Commercialization of GM crops in Ghana will cause emergence of 'difficult to control' weeds					
17.	It will be in the interest of farmers if Ghana is seen to be GM free					
18.	The introduction of GM crops in Ghana will not solve the problems of Ghanaian's agriculture					
19.	GM crops are not compatible with my farming system					
20.	I don't think there is any need for GM crops as we are struggling to get a decent price for what we grow now					
21.	I am discouraged from growing GM crops because of the negative campaign against it					
22.	I would not choose to grow GM crops because the risks are unknown and future generations					

	should not be put at risk					
23.	Ghana risks losing her food sovereignty if the country allows commercialization of GM crops					
24.	My religious belief will not allow me to cultivate GM crops because it is sacrilegious and against nature.					
25.	The introduction of GM crops in Ghana will destroy the indigenous and less economic but important local varieties of crops					
26.	The introduction of GM crops would impact negatively on farmers' and consumers' health					
27.	It will be in the interest of farmers if Ghana is seen to be GM free					
28.	If GM crops will not pose future risk to the environment then is good					
29.	I am not sure of the safety of GM crops, but if proven safe then it would be good for Ghanaian farmers					
30.	I don't think there is a place for both GM crops and non-GM crops					
31.	If Ghanaian consumers demand for GM - food, then I will be encouraged to grow it					
32.	I will choose to grow GM crops if it comes with incentives					
33.	I am not sure Ghanaian research institutions can breed GM crops					
34.	I am not sure Ghanaian regulatory agencies can ensure safe application of GMOs					
35.	If many Ghanaian farmers accept GM crops, then I will also grow it					
36.	I am not sure Ghanaian farmers can manage GM crop farms					
37.	If only 'natural' genes are added to GM plants then it's ok					
38.	Ghanaian consumers might reject GM food if it is introduce in Ghana.					
39.	I am not sure Ghanaian extension services can manage information on GM crops					
40.	If GM crops will not pose future risk to the environment then is good					
41.	I would choose to grow GM crop if it proven to be more profitable					
42.	To grow or not to grow GM crops would depend on the traits modified					
43.	I don't have any opinion for or against the Plant Breeders' Protection Bill in its current form					
44.	Whether GM crops is good or bad depend on the feature produced by genetically modification					
45.	To grow or not to grow GM crops is more of international politics rather than scientific consideration					
46.	I don't think there is any difference between GM-food and conventional food					

47.	Some Ghanaian farmers may or may not have the capacity to adopt GM crops					
48.	Bad publicity is affecting my judgement on the appropriateness of GM crops					
49.	I am not sure whether the introduction of Genetically Modified crops into Ghanaian agriculture would be good or bad for Ghanaian farmers					
50.	I don't believe the introduction of GM crops will bring cost of production down					
51.	I don't know who would benefit if GM crops were introduced in Ghana					
52.	To prevent contamination of our local crops GM crops should not be allowed in					
53.	I might be easy to control common plant diseases with GM crops					
54.	Allowing introduction of GM crops in Ghana will jeopardised Ghana's food image					
55.	The introduction of genetically modified crops into Ghanaian agriculture would be good for Ghanaian farmers in as much as it may reduce costs of production					
56.	The problem of Ghanaian agricultural development is low investment opportunities, poor market and lack of infrastructure like roads, storage facilities among others and not GM crops					
57.	I don't know if I would choose to grow GM crops because I still need to be convinced of its safety and not just commercial and big economic returns					
58.	GM crops are not developed for resource poor farmers					
59.	I have trust in the country's legislative, regulatory and institutional frameworks put in place to ensure safe application of GM crops					
60.	The interference and threats from activist groups against GMOs to destroy trial crops should be dealt with severely in the law courts as the activists are only hindering the interests of Ghanaians					
61.	The throwing out of the case in Ghanaian high court against the possible contained release of GM cowpea and Bt cotton is a clear indication that the proponents of GM crops are right					

Thanks.

Appendix 2: Check List to Guide Focus Group Discussion

INSTRUCTIONS: I hereby assured you that this information you are about to give, is being sought for academic research and will be used only for that purpose. You are further assured that, under no condition will your identity be disclosed nor your personal data and information be shared or transmitted for other purposes apart from the purpose (research) for which it is being sought for.

Check List to guide focus group discussion

1. What is the role of your FBO in securing agricultural services for members?
2. Let's discuss more about your FBOs organization, development and operations.
3. What problems do you usually face with your crop farming?
4. Possible solutions to the problems; source of solution and actions/resources require
5. Where did you first heard/read about Genetically Modified (GM) crops?
6. What do you have to say about Genetically Modified Organisms (GMOs) and GM crops (be open and frank. Probe further):
7. Let's discuss about Ghana's agrobiotechnology policy and commercialization of GMOs in commercial agriculture? (probe more)
8. Comment on Ghana's agrobiotechnology research and GM seed development
9. Discuss the role of GMOs in improving local crop varieties
10. What improved traits or characteristics (such as herbicide tolerant, drought tolerant, disease and pest resistant, nutrient boasting etc) do you want to see in GM crops
11. Comment on the capacity of local farmers, Ghana's research institutions and biosafety agencies (such National Biosafety Authority (NBA) and Environmental Protection Authority (EPA) etc) to ensure safe application and commercialization of GM crops?
12. How do you see your ability and willingness, as members of FBOs, to adopt GM crops
13. Any general comments about GM crops (please express your views freely).

Appendix 3: Interview Guide For Key Informants

INSTRUCTIONS: I hereby assured you that this information you are about to give, is being sought for academic research and will be used only for that purpose. You are further assured that, under no condition will your identity be disclosed nor your personal data and information be shared or transmitted for other purposes apart from the purpose (research) for which it is being sought for.

Check List

1. What role do you think Farmer Based Organizations (FBOs) can or have been playing agricultural development?
2. Please tell me more about FBOs organization, development and operations.
3. What problem do farmers in your locality face with their crop farming activities?
4. What improvement do you want to see in crop farming in your locality?
5. Where did you first heard and/or read about Genetically Modified (GM) crops?
6. What do you have to say about Genetically Modified Organisms (GMOs) and GM crops (be open and frank. Probe further):
7. What is your opinion about Ghana's agrobiotechnology policy and commercialization of GMOs in commercial agriculture? (probe more)
8. Comment on Ghana's agrobiotechnology research and GM seed development
9. What improved traits or characteristics (such as herbicide tolerant, drought tolerant, disease and pest resistant, nutrient boasting etc) do you want to see in GM crops
10. Comment on the capacity of local farmers, Ghana's research institutions and biosafety agencies (such National Biosafety Authority (NBA) and Environmental Protection Authority (EPA) etc) to ensure safe application and commercialization of GM crops?
11. How do you see Ghanaian farmers' ability and willingness to adopt GM crops
12. Any general comments about GM crops (please express your views freely).

Appendix 4: Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	20.967	44.610	44.610	20.764	44.180	44.180
2	6.858	14.592	59.202	6.585	14.011	58.190
3	3.662	7.792	66.994	3.358	7.145	65.335
4	3.625	7.712	74.706	3.266	6.950	72.284
5	1.683	3.582	78.288	1.452	3.088	76.035
6	1.282	2.728	81.016	1.025	2.181	78.217
7	1.185	2.521	83.537	.905	1.925	80.142
8	.944	2.009	85.546			
9	.733	1.559	87.104			
10	.677	1.440	88.544			
11	.603	1.283	89.827			
12	.539	1.146	90.973			
13	.509	1.083	92.055			
14	.412	.876	92.932			
15	.342	.727	93.658			
16	.309	.657	94.315			
17	.291	.619	94.934			
18	.280	.595	95.530			
19	.231	.492	96.022			
20	.222	.473	96.495			
21	.184	.391	96.886			
22	.170	.362	97.248			
23	.144	.307	97.555			
24	.120	.256	97.811			
25	.104	.222	98.033			
26	.100	.213	98.246			
27	.091	.193	98.439			
28	.081	.172	98.611			
29	.076	.161	98.772			
30	.070	.150	98.922			
31	.059	.125	99.047			
32	.056	.119	99.165			
33	.053	.113	99.279			
34	.048	.102	99.380			
35	.042	.089	99.469			
36	.039	.082	99.551			

37	.037	.079	99.631			
38	.031	.066	99.697			
39	.026	.056	99.753			
40	.024	.051	99.804			
41	.021	.044	99.848			
42	.018	.038	99.886			
43	.014	.030	99.916			
44	.012	.026	99.943			
45	.011	.024	99.966			
46	.008	.018	99.984			
47	.008	.016	100.000			
Extraction Method: Principal Axis Factoring.						