ACCESS TO AND UTILIZATION OF SCIENTIFIC INFORMATION ON GENETICALLY MODIFIED FOOD CROPS AMONG MAIZE FARMERS IN WESTERN KENYA

BY

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DECLARATION

Declaration by Candidate

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DEDICATION

To my beloved wife

Perpetua

For all the love and care

and

For supporting and encouraging me to be the best

To my sons

AJ and CJ

For your smiles which kept me going

ABSTRACT

The rising challenge of food insecurity occasioned by changing weather patterns, crop pests, and diseases has inspired research initiatives among scientific communities, leading to the development of Genetically Modified (GM) food crops. Whilst these new farming technologies have been adopted in many countries, a polarizing public debate rages in Kenya regarding the safety of GM foods. There seems to be a lack of scientific facts informing this debate, begging the question, what is the nature of the communication of scientific information about GM food crops to the public? This study aimed to explore the crop scientists' communication of GM food information to maize farmers in Western Kenya and its impact on their attitudes toward GM food crops. The study sought to answer four research questions: How do the scientists conceptualise and frame the communication of GM food crop information to the farmers in Western Kenya? What information is available to farmers in Western Kenya about GM food crops? How do farmers in Western Kenya access and make sense of information on GM food crops? How does the accessible information influence the farmers' attitudes toward GM food crops? This study was guided by the four models of science communication – the deficit, contextual, lay expertise, and public participation. It adopted a mixed methods approach and a convergent mixed methods design, concurrently generating and integrating quantitative and qualitative data. A purposive sampling technique was used to select Uasin Gishu and Trans-Nzoia counties. Three sub-counties were purposively sampled from each county, and a systematic random sampling technique was used to sample 298 farmers from the resulting six sub-counties. The snowball sampling technique was also used to identify eight key informants from crop scientists researching GM food crops in Kenya. A semi-structured questionnaire and interview guide were used to collect data from maize farmers and crop scientists, respectively. The quantitative data were analysed using descriptive statistical analysis, whereas the qualitative data were thematically analysed. Findings reveal that crop scientists applied direct and indirect communication approaches to communicating with farmers to achieve three key objectives: enhancing farmers' awareness and knowledge of GM food crops, addressing farmers' concerns and questions about GM crops, and debunking misinformation surrounding GM food crops. Farmers were found to have inadequate knowledge of GM food crops, owing to access to limited and sometimes misleading information. Farmers access information from multiple sources, often with conflicting messages, making them skeptical about GM food crops. Findings further revealed that 51% of the farmers often failed to understand the information they accessed, 60.7% were not satisfied with the amount of the information, whereas 80.2% shared the same information with others, possibly contributing to further misinformation and uncertainty among farmers. Nevertheless, the information accessible made farmers more optimistic (63.1%) than negative about GM food crops. I argue that the negative perception associated with GM food crops among maize farmers in Kenya is largely attributed to the scarcity of correct scientific information and the inadequate engagement between crop scientists and farmers. It is recommended that crop scientists develop a community engagement framework as a vehicle for sharing accurate scientific information with farmers and general society to address misinformation/disinformation associated with the genetic modification of food crops.

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ABBREVIATIONS AND ACRONYMS

AAAS:	American Association for the Advancement of Science
BT:	Bacillus Thuringiensis
CBSD:	Cassava Brown Streak Disease
CGA:	Cereal Growers Association
DNA:	Deoxyribonucleic acid
GE:	Genetic Engineering
GM:	Genetic Modification or Genetically Modified
GMO:	Genetically Modified Organism
ISAAA:	International Service for the Acquisition of Agri-biotech Applications
KALRO:	Kenya Agricultural and Livestock Research Organisation
KEPHIS:	Kenya Plant Health Inspectorate Service
NBA:	National Biosafety Authority
NGOs:	Non-Governmental Organisations
PCST:	Public Communication of Science and Technology
PUS:	Public Understanding of Science
WHO:	World Health Organisation

OPERATIONAL DEFINITION OF TERMS AND CONCEPTS

Science Communication

According to Burns et al. (2003), science communication is the use of appropriate skills, media, activities, and dialogue to produce one or more of the five broad personal responses to science: awareness of science, enjoyment, or other affective responses to science; interest in science; the forming, reforming or confirming of science-related opinions or attitudes, and understanding of science. These responses to science are considered the aims of science communication and a means for evaluating science communication initiatives.

In this study, I use science communication or communication of scientific information when referring to the communication of scientific information (about GM food crops) to the public. It is important to note that the term "*public*" as used in science communication is loaded and, according to Burns et al. (2003), may refer to at least six overlapping groups: (i) scientists, (ii) mediators or communicators, including science communicators and journalists, (iii) decision-makers (iv) general public, including the three above and other sectors and interest groups, (v) attentive public which represents the part of the general community already interested in science and scientific activities, and is well informed about it, and (vi) interested public (those interested but not necessarily well informed about science and technology. In this study, I focus on maize farmers (who may be interested in GM food crops but may or may not be well informed about them) and crop scientists researching GM food crops in Kenya.

Therefore, I explore science communication by examining the communication of scientific information about GM food crops by crop scientists and the maize farmers' reception of this information and its impact on their attitudes toward GM food crops. The study's research questions are designed to help highlight the science communication aims (i.e., through scientists' conceptualisation and framing of communication of GM food information). At the same time, they allow for evaluating these aims (i.e., through farmers' reception of information and its impact on their attitudes toward GM food crops). I explain more about science communication in Chapter 2.

Genetically Engineered or Genetically Modified Food

In order to understand GM/GE food more clearly, defining some terms associated with the GM process is essential. "*Genetic engineering/modification*" is a technology that allows for the modification of crops by selecting novel genes from other crops or organisms and incorporating these into the gene of interest of distantly related species (Weebadde and Maredia, 2011). WHO explains that this technology is also called "modern biotechnology" or "gene technology," sometimes also "recombinant DNA technology." *"Gene*" is a part of DNA in a cell that controls the inheritance of a specific characteristic or physical form of living organisms. On the other hand, *DNA is* the chemical at the centre of living things, which controls the structure and purpose of each cell and carries genetic information during reproduction. Therefore, GM/GE food is the food that results from the GM/GE process. According to the World Health Organisation (WHO), "*genetically modified (GM) food"* represents foods derived from organisms whose genetic material (DNA) has been modified in a way that does not occur naturally, such as through the introduction of a gene from a different organism.

In this study, which involved maize farmers and crop scientists, I interchangeably used genetically modified (GM) food crops and genetically modified (GM) food to refer to the food resulting from the above process. I also use genetic modification (GM) technology to refer to the process.

Crop Scientists

According to encyclopedia.com, crop scientists refer to scientists whose training provides them with skills for increasing the yield of field crops through improving farming methods and developing new plant strains. They may be experts in farming production or crop development, while others may also specialise in specific crops, such as maize or cotton. Crop scientists' jobs include conducting research or consulting for corporations, farmers, and farm cooperatives.

In this study, I studied the crop scientists researching GM food crops in Kenya to help understand the nature of the communication of scientific information on GM food crops to maize farmers in western Kenya and, thus, the farmers’ access and utilization of this information. In Chapters Four and Five, *crop scientists* and *scientists* are used almost interchangeably, but they all refer to the crop scientists researching GM food crops in Kenya.

Misinformation

In this study, I use misinformation to mean false or inaccurate information communicated as though it was correct. When misinformation is spread in the absence of or even alongside accurate information, the targeted audience becomes confused or does not know what to believe. Sometimes, the target audience believes the misinformation, especially when accurate information is not communicated as often or is not communicated entirely. Generally, misinformation tends to flourish more in the absence of accurate information or when it is insufficient. Misinformation tends to make the public unable to make an informed decision about important societal issues. I use misinformation to refer to information about GM food that is not accurate and contradicts scientific facts about GM food crops, fueling confusion among the public.

Miscommunication

Miscommunication entails the failure to communicate effectively the information intended. I use miscommunication in this study to refer to the failure to communicate GM food crop information to the targeted audience clearly/effectively.

Public Engagement with Science

Public engagement with science is used in this study to refer to what the American Association for the Advancement of Science (AAAS) describes as intentional, meaningful interactions that provide opportunities for mutual learning between scientists and public members. AAAS explains that public engagement with science is vital because the interaction between interested stakeholders is critical to finding common ground on scientific issues affecting society. Public engagement can provide a constructive platform for public views to be combined with scientific expertise in decision-making contexts.

In this study, I use public engagement with science to refer to (public) maize farmers' involvement in GM food crop affairs by crop scientists researching GM food crops in Kenya, allowing them to provide their opinions and concerns about GM food actively. It also entails creating an inclusive environment where the scientists hear and act upon farmers' feedback. I also use public engagement and public participation interchangeably to refer to public engagement with science.

CHAPTER ONE

INTRODUCTION

1.1 An Overview

In this chapter, I introduce the study by offering background information on the problem: public access and utilization of scientific information on genetically modified (GM) food crops. I then narrow the focus by briefly discussing the communication of GM food information to the maize farmers, how it may influence the kind of information they access, and, in turn, their attitudes toward GM food crops. I then problematize this further in the problem statement. I further state the aim, research questions, the study's scope, justification, and significance. I conclude this chapter by providing the organisation of the whole thesis.

1.2 Background to the Study

1.2.1 Communication of Scientific Information to the Public

Scientists spend most of their time researching to address various societal challenges ranging from environmental to health to socio-economic problems. In conducting research, scientists provide recommendations to different key players informed by their findings. Some scientists' suggestions advise the role the stakeholders, like policymakers or ordinary public members, should play in addressing various challenges and making important decisions. At the same time, some research findings may inform people's everyday practice. For science to solve the various challenges or address various issues that the world is facing today, there is a need to make the scientific results known to the broader public to influence public debate, opinion, policy discussion, and decisions, or human behaviours. As Nancy Baron explained more than a decade ago, there was [and there still is] a growing demand for scientists to "talk to decision-makers, provide testimony, answer journalists' questions, and help inform the public on issues of societal urgency" (2010, p. 3). This call is for researchers (scientists) to ensure that science benefits the general public and the decision-makers by sharing their research findings. For this to materialize, scientists need to move beyond scientific publication to communicate their results in a manner easily accessible to the broader public (Baron 2010). This demand has become more relevant today, where many scientific discoveries should inform societies' everyday practices. Currently, many more issues, such as COVID-19 vaccines, artificial intelligence, nanotechnology, and genetic modification of food crops, need scientists' explanations so the public can understand the potential benefits and risks for them to make informed decisions when called upon to do so. Indeed, Fleming (2009) states that communication of scientific results is crucial in helping the public access impartial and accessible scientific information.

Simply put, scientists must communicate their findings to society (Barbour et al., 2008). Pully (1995, cited in Baron, 2010, p. 23) labels this obligation a "moral obligation," whereas Willinsky (2006, p. 439) refers to it as an “ethical responsibility.” For similar reasons, research funders increasingly demand that scientists explain their public engagement framework to have scientific results inform the public's everyday debate and decisions. Despite the demands that scientists communicate their findings to the end-users to inform their decision regarding scientific issues, scientific phenomena, such as genetic modification of food crops, continue to attract polarizing debate characterised by a lack of scientific facts. This situation necessitated this study about access to and utilization of scientific information on GM food crops among maize farmers in western Kenya.

1.2.2 Status of Genetically Modified Foods in Kenya

According to the World Health Organisation (WHO), genetically modified (GM) foods are foods derived from organisms whose genetic material (DNA) has been modified in a way that does not occur naturally, such as through the introduction of a gene from a different organism. WHO explains that the technology used in developing GM foods is often called "modern biotechnology" or "gene technology," sometimes also "recombinant DNA technology" or "genetic engineering." The genetic engineering (GE) process involves identifying the genetic information—or "gene"—that gives an organism (plant, animal, or microorganism) the desired trait; copying that information from the organism that has the trait; inserting that information into the DNA of another organism; and then growing the new organism (U.S. Food and Drugs Administration, FDA). Currently available GM foods, according to WHO, stem primarily from plants, but in the future, foods derived from GM microorganisms or GM animals will likely be introduced on the market. Most existing genetically modified crops have been developed to improve yield by introducing resistance to plant diseases, increased herbicides, or increased tolerance to droughts. This scientific initiative is championed as one of the possible solutions to global food insecurity.

Like the rest of the world, Kenya has experienced a critical debate on whether to adopt GM technology and foods, mainly because evidence from literature hints at the possibility of GM technology providing a means of attaining food security in the country. On the other hand, the anti-GMO groups constantly highlight the perceived adverse effects on human health and the environment. Generally, the debate seems to lack enough scientific input about the genetic modification process and the resulting GM foods.

GM field trials in the country began in 2004 and have continued ever since. However, in 2012, GM researchers suffered a blow following a ban on GMOs, which the government imposed after a publication of Seralini et al. (2012) that linked GMOs with cancer and other adverse effects on human health (Gheysen et al., 2019). Although this publication was later retracted following heavy criticism of its experimental design and conclusions, the ban on GMOs persisted until the current study was conducted. There is, however, still active research on GM crops, including BT Maize, cotton, sorghum, sweet potato, and pigeon peace.

By the time this study was conducted, Kenya had approved genetically modified cotton for commercialization. On the other hand, the National Biosafety Authority (NBA) had approved the environmental release of genetically modified cassava, cassava event 4046, resistant to cassava brown streak disease (CBSD). The approval was hailed to pave the way for conducting national performance trials before registration and release to the farmers (ISAAA 2022). It is important to note that mixed public perceptions and opinions remain about GM technology and food, as I will highlight in the literature review in the following chapter. These diverse opinions beg the question regarding the communication of scientific information on GM food crops to the public and, in turn, the kind of information the public access. Understanding the communication of GM food crop information will help determine the kind of information the public (maize farmers in this study) access and how it informs their attitude toward GM food crops. Therefore, critical to this study was the nature and quality of information the public (farmers) access and its impact on the current mixed perceptions and attitudes toward GM technology and food.

1.2.3 Communication of Genetically Modified Food Crop Information

Critical scientific results and recommendations regarding scientific issues, such as GM food crops, which was central to this study, do not seem to inform public debate, policy discussions, or political discussions regarding whether to adopt GM food. One wonders about the nature and quality of information the public receives regarding GM food and what role the scientists play in communicating their scientific research findings on GM food crops to the public to influence public debate and policy decisions. Regarding this, Kosgey and Cyrus (2019) observed that scientists do not engage in public debate about GM, which warrants public non-scientific debate, hence the misconception about GM food. Similarly, Baron (2010) noted a lack of scientists who can deliver their information effectively and are willing to share their scientific results with the public. That is, to "reach beyond their research articles to communicate what they are observing to the wider public so that they can understand why it matters, the potential risks, and the possible solutions" proposed by science (p. 5). Sharing scientific results is the best way science can benefit society because science has limited value if not used or communicated to others (O'Hair and O'Hair, 2021). Therefore, society needs science to inform their decision, while science needs to be shared with society for its value to be realised.

It seems evident that the nature of communication surrounding scientific issues, particularly GM food, might influence the general public and the policymakers' discussions and decisions. Therefore, ineffective (scientific) communication or lack thereof could result in the public relying on misconceptions or misinformation surrounding GM technology and foods in their decision-making. Indeed, the public may engage in what Kosgey and Cyrus (2019) termed non-scientific debate and consequently become non-receptive to scientific facts regarding GM food crops.

Where the scientific community does not share enough factual information, the public may rely on communication from the "opponents of science." Such opponents tend to focus on the most controversial and sometimes immeasurable issues (about GM foods) that appeal to feelings and emotions rather than facts (Oloo et al., 2020a, p. 698) instead of communicating adequately about the potential risks and benefits to help the public make informed decisions. These opponents are also constantly looking to exploit the communication gaps left by scientists (Oloo et al., 2020b) to push their anti-GMO agenda to the public. The possible result of all these is public confusion and scepticism about GM food crops, which is evident in the current GM food crop debate in Kenya and around the globe. This confusion may contribute to the slow adoption of GM food crops and increased public concerns regarding the potential risks of the food to human health and the environment. One possible explanation for this confusion could be the lack of reliable scientific information on GM food to the public. For example, Klumper and Qaim (2014) note that although there is robust evidence of GM crop benefits, which may help gradually increase public trust in the technology, NGO reports and other publications without scientific peer review seem to bias these impact estimates downward. This seems to imply that the communication about these benefits to the general public may not have been inadequate and is probably overshadowed by the ati-GMO communication. This results in increased public suspicion and uncertainty towards GM food crops and GM technology. This situation is especially evident in Africa, where reports indicate that close to 70% of the population engages in agriculture, mainly smallholder farmers, but the production is lower than in other continents (Gheysen et al., 2019) owing to changing weather patterns, and crop pests and diseases. Nonetheless, only Burkina Faso and South Africa have fully commercialised GM crop cultivation in sub-Saharan

Africa, followed by Kenya's recent decision to commercialise BT cotton despite the existing GMO ban in the country. Therefore, it is important to explore the communication of scientific information on GM food to the public (farmers in this study) to understand its contribution to the current debate in Kenya.

1.2.4 Need and Access to Scientific Information about GM Food Crops

Accessibility to reliable information about GM food crops is essential for the public to make informed decisions regarding whether to adopt GM technology. For the public to access enough reliable information about GM food crops, the experts involved (including GM food crop scientists) ought to communicate GM food crop information adequately and in a manner easily accessible to the public.

The public (farmers in this study) needs to understand what genetic modification of food crops is, why it matters to them, and the possible risks associated with adopting the technology. Indeed, the only way to make an informed decision is by adequately understanding GMOs' potential risks and benefits (Oloo et al., 2020a, p. 698). Obviously, the best candidate for a reliable source of information about these aspects seems to be the GM food crop scientists. The scientists have a privileged and influential contribution, and their voices are rightly regarded as having a particular authority (Cook et al., 2004). Still, as I already noted above, they seem not to have done an excellent job convincing the political decision-makers about GM crops' safety and attending benefits (Oloo et al., 2020a). This may have contributed to public confusion and scepticism portrayed in the controversial debate about GM technology and food.

The reluctance to adopt the technology and polarized debate about GM food could imply a scarcity of reliable information on GM food's potential risks and benefits, influencing the GM food debate and decisions among the public and policymakers. Cook et al. (2004) note the involvement of various groups in the GM food debate, including anti-globalization campaigners, environmentalists, doctors, farmers, food retailers, lawyers, religious leaders, and scientists, each bringing their own genre and style to the debate. The contribution from all these groups to the public debate about GM food crops begs the question about the kind of information the farmers ultimately end up accessing and its impact on their attitude towards GM food crops. It is important to reiterate that evidence shows a lack of scientists willing to share their scientific findings with the public (Baron 2010) or involve the public in GM food crop affairs (Kosgey and Cyrus 2019). The latter warrants non-scientific public debate about GM food crops, ending in misconceptions and public confusion about GM food crops.

Underscoring the importance of ensuring the public access to reliable information about GM food crops, Kimenju (2006) noted that it is essential that the public be informed about GM technology to participate effectively in the debate. Effective public participation can only happen when those involved in GM are willing to share the knowledge generated by their GM food crop research for the public to access factual information on the technology. This information will help the public understand GM food crops clearly and thus make an informed decision about them. However, based on the diverse public opinion, it is not clear how scientific information generated from GM food crop research is communicated to the general public in Kenya and whether it is in a manner that can be easily accessible to them. Therefore, in this study, I was interested in exploring the nature of GM food crop scientists' communication of GM food crop information to maize farmers in western

Kenya and the impact of the accessible information on farmers' attitudes towards GM food crops.

1.3 Statement of the Problem

The rising challenge of food insecurity occasioned by changing weather patterns, crop pests, and diseases has inspired research initiatives among scientific communities, leading to the development of GM food crops. These new farming technologies have been adopted in many countries, and literature indicates that research has not found GM food to cause any new risks to human health or the environment (cf., Nicolia et al., 2013; Wong and Chan, 2016). Nonetheless, a polarizing public debate rages in Kenya regarding the safety of GM foods. There seems to be a lack of scientific facts informing this debate; scholars have reported that the public tends to have a non-scientific debate about GM food because scientists do not engage in public debate about GM food (e.g., Kosgey and Cyrus, 2019). This situation may contribute to misconceptions about GM food and the slow adoption of GM technology.

Despite GM technology being around for nearly three decades and attracting substantial research on its application and products, it is unclear whether the scientific information on GM food crops is communicated in a manner that the farmers can easily access. The nature and quality of information accessible to farmers and its impact on their attitude toward GM food crops is also unclear. In Kenya, available literature focuses on the public reaction to GM food and the factors influencing this reaction, such as awareness, knowledge, perception, and socio-demographic factors (e.g., Kimenju, 2006; Kimenju and De Groote, 2008; Anunda et al., 2010; Kagai, 2011, Mbugua, 2016). However, there is little knowledge of the GM food crop scientists' communication of scientific information on GM food crops to the farmers, their access to this information, and how the accessible information shapes their attitudes toward GM food crops.

In that regard, this study explored the GM food crop scientists' communication of GM food information to maize farmers in western Kenya and its impact on their attitude towards GM food crops. Specifically, I examined the scientists' conceptualisation and framing of the communication of GM food crop information to the maize farmers and how the farmers access and make sense of GM food crop information. Additionally, I assessed the impact of the accessible information on the farmers' attitudes toward GM food crops.

1.4 Aim of the Study

This study explored crop scientists' communication of GM food information to the maize farmers in western Kenya and its impact on the farmers' attitude towards GM food in view to recommend ways to improve the communication of scientific information about GM food to the public.

1.5 Research Questions

To achieve the above aim, this study set out to answer the following research questions:

i. How do the crop scientists conceptualise and frame communication of GM food information to the farmers in western Kenya?

ii. What information is available to farmers in Western Kenya regarding GM food crops?

iii. How do farmers in Western Kenya access and make sense of information on GM food crops?

iv. How does the accessible information influence the farmers' attitudes toward GM food crops?

1.6 Assumptions of the Study

This study made the following assumptions about the communication of and farmers' access to GM food crop information:

i. Scientists' conceptualisation of the communication of GM food information to the farmers will influence their framing of GM messages for the farmers;
ii. Accessibility of adequate scientific information about the benefits and the potential risks of GM foods shall lead to positive attitudes toward GM food crops and vice versa;
iii. The sources of information may influence the nature and quality of GM food crop information the public access; scientific information might compete with non-scientific communication about GM food crops.

1.7 Scope of the Study

This study was about access to and utilization of scientific information on GM food crops among maize farmers in Western Kenya. It achieved this by studying scientists' communication of GM food crop information to farmers in Western Kenya on the one hand and the farmers' reception of GM food information on the other. The study confined itself to the scientists' conceptualization and framing of the communication of GM food crop information to the farmers, the kind of information the farmers need and access, and the role of the accessible information in shaping farmers' attitudes towards GM food crops. Only crop scientists[1] researching GM food crops in Kenya

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[1] When negotiating access to the crop scientists researching GM food crops in Kenya, they requested that their identities be kept strictly confidential since some had signed a non-disclosure agreement with the institutions they worked for. Thus, in this study, the GM crop scientist participants are only referred to as *Crop scientists researching GM food crops in Kenya* or *GM food crop scientists*.

were involved in the study. On the other hand, only maize farmers[2] from two counties of Western Kenya, Uasin Gishu and Trans-Nzoia, were involved in the study to help understand the nature and quality of the GM food crop information they access and its impact on their attitude toward GM food crops. Maize farmers in this study had heterogeneous characteristics. They ranged from those who self-reported having no education to those who reported having a university education, as summarised in Figure 1.1 below.

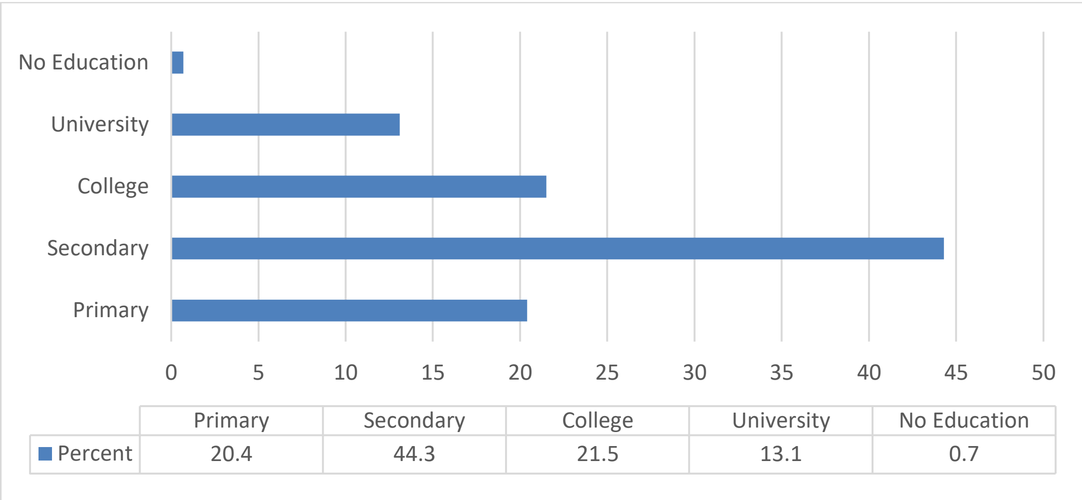

Figure 1.1 Distribution of Maize Farmer Participants According to Level of Education

The maize farmer participants also ranged from smallholder to large-scale farmers. They self-reported farming between less than one acre of land and more than 100 acres of land, as summarised in Figure 1.2 below. I provide more demographic information on maize farmer participants in Chapter Three – methodology.

However, they came from different research institutions dealing with GM food crops in Kenya. Their names and the institutions they work for shall not be mentioned.

[2] The sample of maize farmers who participated in this study was obtained using two sample frames: a list of maize farmers registered with Cereal Growers Association (for farmers from Uasin Gishu) and a list of maize farmers registered with county's directorate of agriculture (for farmers from Trans-Nzoia County). I provide more details on sampling procedure in Chapter three.

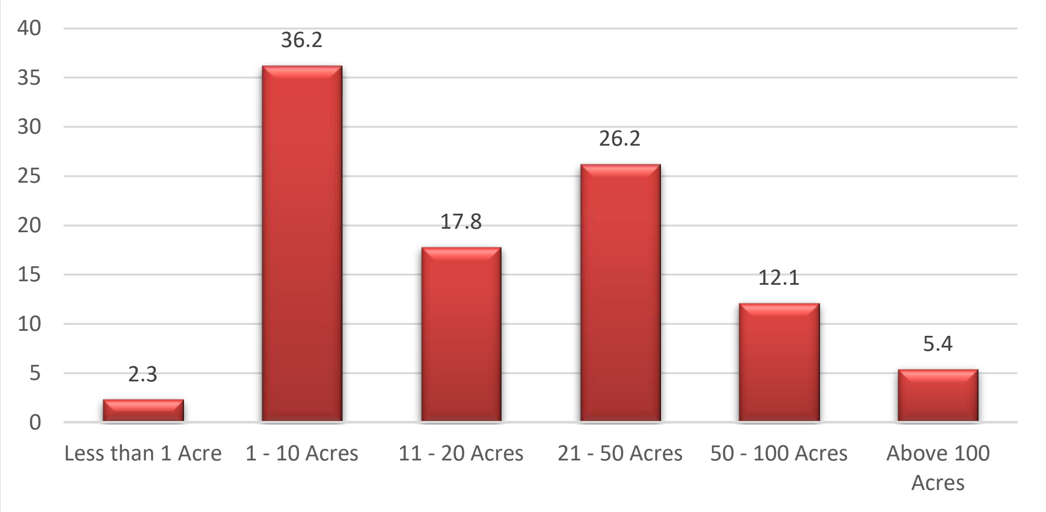

Figure 1.2: Distribution of Maize Farmer Participants According to the Farm Size

The study focused only on the issues related to the communication of GM food crop information and the role of this information in shaping the farmers' attitudes toward GM food crops. Other issues related to GMOs and GM technology were not the focus of this study.

1.8 Justification of the Study

The public's acceptance and attitude towards GM food crops depend on the nature and quality of information accessible to them. The quality of the accessible information may determine the public's knowledge and attitude toward GM food crops. Reliable information about the genetic modification of food crops is expected to inform the public's debate and policy discussion and, consequently, help them make informed decisions about GM food crops when required. There are many mixed opinions about GM technology and the resulting GM food. Studies have reported that the public tends to be aware of GM technology and food, which can influence their perception and acceptance of GM products. However, what information the public receives leading to the reported awareness is unclear. It is also unclear whether crop scientists communicate scientific information on GM food crops in a manner that can be easily accessible to the public. In fact, some public members report having heard of GMOs but most often fail to provide a simple concrete definition of GMOs when asked to do so (cf., Changwena et al., 2019; Karau et al., 2020), which calls for the exploration of the nature of the communication of GM food crop information to determine the information farmers access and the role of this information in shaping their attitude and action toward GM food crops. Therefore, this study is critical because it explores the crop scientists' communication of scientific information about GM food crops to maize farmers in western Kenya and its impact on their attitudes toward GM food crops. The study will highlight the information farmers need, what they access, how they make sense of it, and the role of access to reliable information on farmers' attitudes toward GM food crops.

1.9 Significance of the Study

The significance of this study is threefold: first, the study findings will add to the existing knowledge base in science communication. Specifically, the results will shed light on the nature of the communication surrounding GM food crops from the perspectives of the crop scientists researching GM food crops and the maize farmers, who are the prospective beneficiaries of GM technology. Additionally, the study will explore this communication in light of the four models of science communication: deficit, contextual, lay expertise, and public participation; thus, the findings will have a specific implication on the science communication models' assumptions in communicating scientific information on GM food crops. Secondly, the findings will shed light on the role of reliable scientific information in shaping the public's (in this study, maize farmers) attitude and actions towards new technologies or their products (in this study, GM technology and food crops). Findings will inform the scientists (and other stakeholders involved) regarding the importance of communicating scientific results to the intended end-users and the potential challenges that might be encountered. Lastly, the study will benefit the scientific community since it intends to propose ways to improve the communication of scientific information about GM food crops to the public.

1.10 Organisation of the Thesis

This thesis is organised into five chapters: In Chapter 1, I introduce the study by giving background information on the communication of scientific information to the public. Specifically, I focus on the importance of the accessibility of reliable information in the public acceptance of new technologies and their products, such as GM food crops. I note that public debate about GM food crops is non-scientific, which may result in uninformed decisions about scientific issues, particularly GM food crops. I problematize this further in the statement of the problem by noting the lack of scientific facts informing the public debate about GM food and a lack of clarity on whether the crop scientists communicate scientific information on GM food in a manner easily accessible to the public (farmers). I then give the aim of the study, the research questions that the study sought to answer, and the study assumptions. I explain the study's scope, justification, and significance and end the chapter with the organisation of this thesis.

In Chapter 2, I present the review of literature relevant to this study, the gaps, and the theoretical framework that guided the presentation, analysis, and interpretation of the findings. Specifically, I discuss science communication as a field of study and research and link this study (science communication) with communication studies. I also discuss various studies on public involvement in GM food crops and note that no studies have explicitly focused on the communication of information about GM food crops to the public in its own right, especially in Kenya. I further note that this communication has not been explored in light of the models of science communication, which this study used as its theoretical framework. I then discuss the deficit, contextual, lay expertise, and public participation models of science communication that guided this study and justify my choice of the four models of science communication as the framework.

In Chapter 3, I present the philosophical research paradigm and give insights into the choices of research approach, design, and methods used in data generation. I also explain the population of the study and sampling techniques, data generation methods and procedures, and data analysis. In Chapter 4, I analyse, present, and discuss the study findings. I also discuss the implication of the findings on science communication and the application of models of science communication. Lastly, in Chapter 5, I give a general summary of the study and the findings of the study and provide the study conclusion. I also make recommendations on improving the communication of GM food crop information to the farmers and the wider public and recommendations for further research.

CHAPTER TWO

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

This chapter provides the theoretical framework for the study by reviewing literature related to science communication and the communication of GM food information to the public, in particular. First, I discuss science communication as a field of study and research. Specifically, I discuss the meaning and objectives of the science communication process, discuss research in science communication, present paradigms of science communication, and then link this study with communication studies. I then review studies relevant to this study, with a specific focus on studies from Africa and Kenya, before presenting the synthesis of the review and identifying the research gap this study aimed to fill. Finally, I discuss the issues surrounding the models of science communication as the theoretical framework in science communication and justify the relevance of the deficit, contextual, lay expertise, and public participation models of science communication for this study.

2.2 Science Communication as a Field of Study and Research

The need for science to benefit society has been a subject of discussion among scholars for a considerable time now. As I have noted in the previous chapter, Nancy Baron (2010) noted, there had been calls [and there still are calls] for scientists to inform the public about their research findings on issues of societal concern and explain why it matters to the public. The public needs this information to help them to act wisely and intelligently, whether about "high technology or garbage collection" (Hartz and Chappell, 1997, cited in Treise and Weigold, 2001). These needs and calls necessitated the emergence of a field of research known as science communication over 50 years ago. Science communication has since matured as a field of academic inquiry (Guenther and Joubert 2017).

Scholars have attempted to define science communication, with the general theme being the communication of scientific information within the scientific community and between the scientific community and the non-scientific community. Generally speaking, researchers/scientists are expected to conduct two communication activities: scholarly communication and research/science communication. According to Mason and Merga (2021), scholarly communication covers a wide range of activities that relate to the system through which research and other scholarly writings are created, evaluated for quality, disseminated to the scholarly community, and preserved for future use. It entails the communication among the scientific community members. On the other hand, science communication is "…… the processes by which the culture and knowledge of science are absorbed into the culture of the wider community" (Bryant, 2003, p. 357). Other scholars (e.g., CRU 2010) refer to science communication as research communication. To them, research communication is a two-way process whereby researchers interact and communicate with potential or actual intermediate and end-users of research, intending to make research more relevant for users and to facilitate the understanding and application of research by users.

On the other hand, Trench and Bucchi (2010) consider science communication to be near-synonymous with Public Communication of Science and Technology (PCST). They observed that technology had been given less attention in science communication initiatives despite its relevance in setting the context of communication practice, including communication practices in and about science.

Clearly, science communication involves sharing scientific findings within and without the scientific community. While many definitions consider science communication a process, Burns et al. (2003) clarified what the science communication process should aim to achieve. They introduced the vowel analogy (Figure 2.1) in defining science communication. They stated that science communication is using appropriate skills, media, activities, and dialogue to produce one or more responses summarised by the label AEIOU (p. 190). Their main argument is that specific aims should lead the science communication process and that these aims become the means for evaluating the effectiveness of the process.

SCIENCE COMMUNICATION (SciCom) may be defined as the use of appropriate skills, media, activities, and dialogue to produce one or more of the following personal responses to science (the vowel analogy)

- **A**wareness, including familiarity with new aspects of science
- **E**njoyment or other affective responses, e.g. appreciating science as entertainment or art
- **I**nterest, as evidenced by voluntary involvement with science or its communication
- **O**pinions, the forming, reforming, or confirming of science-related attitudes
- **U**nderstanding of science, its content, processes, and social factors

Science communication may involve science practitioners, mediators, and other members of the general public, either peer-to-peer or between groups.

Figure 2.1: The AEIOU Definition of Science Communication
Source*: Burns et al., (2003)*

Accordingly, the science communication process should aim to achieve one or more of the purposes under the AEIOU analogy. These aims are improving individuals' *awareness* of science, *enjoyment*, or other affective responses to science; *interest* in science, the forming, reforming, or confirming science-related *opinions* (or attitudes); and *understanding* of science.

This definition best summarises the purpose and characteristics of science communication and provides the basis for evaluating its effectiveness. Burns et al. (2003) elaborated that this definition gives important personal responses to science communication. These responses summarise the aim of science communication: to enhance public scientific awareness, understanding, literacy, and culture. It is important to note that the aims/objectives of science communication have emerged in several other studies. For example, Sánchez and Mora (2016) proposed four objectives: communicating that science exists, feeling that science is attractive, understanding that it is interesting, or being aware that science is part of one's identity (p. 2). On the other hand, The National Academies of Sciences, Engineering, and Medicine identified five general goals for science communication in their 2017 report. These objectives include: sharing recent findings and excitement for science, increasing public appreciation of science, increasing knowledge and understanding of science, influencing the opinions, policy preferences, or behaviour of people, and ensuring that a diversity of perspectives about science held by different groups are considered when solutions to societal problems are pursued (National Academies of Sciences, Engineering, and Medicine, 2017).

Therefore, it is essential that science communication initiatives begin with identifying the goals/objectives that the communicators aim to achieve and, by so doing, provide the criteria for evaluating its effectiveness. The idea of the science communication process having specific aims is well advanced by Burns et al. (2003), who agree that science communication is a process but caution:

> Science communication] is not just a process. It should never be done in an ad hoc or inappropriate manner for its own sake. For science communication to be effective – in fact, to allow any valid assessment of its effectiveness – it must always have pre-determined aims (p. 191).

This study was partly devoted to understanding the crop scientists' goals/objectives for communicating GM food crop information to the farmers and understanding the effectiveness of this communication by studying farmers' reception of information. As I have explained in chapter one, the first research question was intended to help me understand the scientists' conceptualisation and framing of the communication of GM food crop information to the farmers. In so doing, I hoped to understand what (objectives) they wanted to achieve through their communication. The rest of the study's research questions were meant to help me evaluate the scientists' communication aims by assessing the dynamics of the farmers' reception of this information.

Burns et al. (2003) further explained the science communication process using a mountain climbing analogy (Figure 2.2 below). This analogy clarifies the purpose and characteristics of science communication described earlier in their AEIOU definition. The mountain-climbing analogy is a structure that fits public awareness of science, public understanding of science, scientific culture, scientific literacy, and science communication together in one big picture of science and society (p. 193). It is important to note that "science" may have several aspects represented in the analogy by mountains. As Burns et al. (2003) argued, developing literacy in one particular area of science may be likened to climbing a mountain.

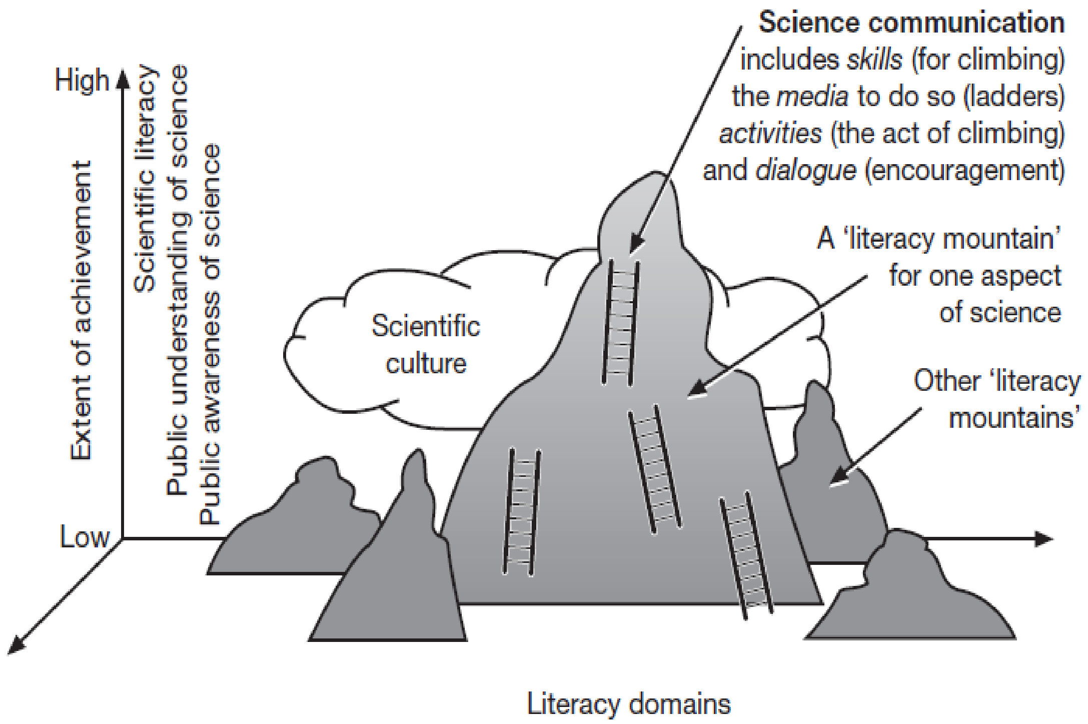

Figure 2.2: A mountain-climbing analogy
Source*: Burns et al. (2003)*

The mountain climbing process is dynamic and participatory, inevitably changing the participant's view of the world. The authors explained that this climbing process is facilitated by science communication whereby appropriate skills, media, activities, and dialogue are used to improve individuals' awareness, enjoyment, interest, opinion, or understanding (AEIOU) of science.

Generally, according to Burns et al., the science communication process is likened to the process of mountain climbing. In this process, science communicators (who act as mediators) are thought of as mountain climbing guides because they teach people how to climb (skills) and provide ladders (media). They also assist with the actual climbing events (activities) and keep climbers informed about progress, possible dangers, and other issues related to the climb (dialogue). The authors further clarified that ladders in science communication work in two ways, for ascent and descent, allowing access between people at different levels. Scientists, mediators, and other groups with a higher level of scientific literacy can learn something from groups at lower levels of scientific literacy. This knowledge-sharing may develop scientists' communication skills, clarify their understanding, and provide helpful feedback and a fresh perspective on various issues. Of interest to note here is the argument that scientists, communicators, and the public learn with and from each other. This argument means science communication should not be understood only as the dissemination of information from experts to non-experts but as the process of learning with and from each other. Burns et al. (2003) concluded that once a mountain has been tackled, even if the summit was not reached (maybe because of increased scientific awareness in some aspects of science), the prospect of climbing the next peak is not so difficult. The climber may even find the experience enjoyable (p. 194). This conclusion means with every science communication initiative, any achievement provides the basis for subsequent science communication activities.

Burns and his colleagues caution on some common misconceptions about science communication process as depicted by the mountain climbing analogy (p. 193):

1. Science communication will not always cause an immediate increase in scientific literacy. There might be increased interest in, or a change of attitude toward, science that may (later) lead to enhanced scientific literacy. Indeed, this seems very important when assessing science communication's effectiveness in achieving the AEIOU analogy's aims.
2. It is often incorrect to assume science communication is solely for the lay public's benefit. Many other groups may benefit from using science communication tools to share scientific messages—for example, science

practitioners and mediators, scientific businesses, politicians, decision-makers, and media members.

3. Science is not a single mountain peak; it is an expansive mountain range with many peaks because it includes multiple literacies. There are many different areas of science and technology, and each can be considered a mountain in its own right.
4. A person's mountain range profile (the extent of literacy in various domains) is unique. Still, it will change over time as the individual learns, forgets science skills, and acknowledge or comes to value different areas in new ways.
5. Scientists are not at the top of the mountain and lay public at the bottom. Scientists may be at the top of one or two mountains but at the foot of many more because of the current state of scientific specialization. All people are somewhere between a plain and the peak.

Evidently, the primary purpose of science communication is to have the scientific facts reach the end-users to allow them to have a meaningful debate on societal issues addressed by science and help inform their decision regarding the same issues. Scientists and science communicators have a role in acting as mountain climbing guides and providing ladders to help the public climb the Literacy Mountains. It is important to stress that scientists and communicators may also learn from the public during the science communication process.

Generally, literature seems to agree with the importance of communicating scientific information to the public, as summarized by Treise and Weigold (2001), who observed:

> This idea that science knowledge permits the public to make effective decisions about science policy is a common theme in science communication

> literature. An educated public should be better equipped to choose from among competing technical arguments on topics such as energy conservation, solid waste disposal, pesticide risk, and social welfare policy (p. 311).

For this to happen, the communication process has to have clear aims to determine appropriate activities for the science communication process, approaches to these activities, and the criteria for evaluating its effectiveness.

In this study, I adopted the AEIOU definition by Burns et al. (2003) and their mountain climbing analogy because they best explain the science communication process. I, therefore, argue, similar to the authors, that crop scientists' communication of GM food crop information to maize farmers in western Kenya would be aimed at producing some or all of the responses stipulated by the AEIOU analogy. Indeed, I explored the crop scientists' communication of GM food information to maize farmers in western Kenya in terms of the farmers' elicitation of three of the responses: Awareness of science (in this study, GM food crops); the forming, reforming or conforming of science-related Opinions (in this study, attitudes toward GM food crops), and understanding of science (in this study, making sense of GM food crop information). Furthermore, the mountain climbing analogy best summarises the science communication process, facilitated by appropriate skills, media, activities, and dialogue to improve an individual's AEIOU responses to science. I acknowledge that this process may take a long time and that desired changes (responses) may equally take a long time to arrive. Still, every communication of the GM food crop information initiative will set the pace for the subsequent ones.

2.2.1 Research in Science Communication

Trench and Bucchi (2010) observed that science communication grew as advocacy by scientists for more public communication and particular approaches to that activity.

As a field of research, science communication is dynamic and interdisciplinary; it draws from a wide range of disciplines and encompasses a broad spectrum of scientific approaches (Schiele et al., 2012, cited in Guenther and Joubert, 2017, p. 1). Since its emergence, the field has benefited from substantial research. It has continued to mature into the field of scholarly inquiry. However, Guenther and Joubert note that scholars from Western, English-speaking countries dominate research activities and output distribution in science communication. The authors cite Horning Priest (2007; 2010), who explains that scholars in science communication are trained in "social science disciplines such as sociology, communication studies, media studies, or in the related field of humanities such as philosophy or rhetoric. These scholars employ tools and techniques from social and behavioural science and humanities (p. 1). This explanation implies that scholars from any of these disciplines may undertake research in science communication.

Concerning the theories, research in science communication has been conducted through the lens of the models of science communication. These models can generally fall under two paradigms of science communication. According to Kappel and Holmen (2019), the dissemination and public participation paradigms of science communication are the two paradigms. Below, I present a summary of the paradigms of science communication as discussed by Kappel and Holmen (2019, p. 2 &3).

Paradigms of Science Communication

Science communication activities and research have been conducted under the lens of various models of science communication. These models provide the assumptions and views about the science communication initiatives, the aims of the process, and the direction of the flow of scientific information. The models of science communication are evolving, with some new models being proposed to explain better and improve science communication efforts (the models of science communication are discussed in detail under the theoretical framework). In their discussion of science communication, Kappel and Holman (2019) grouped the model of science communication into two paradigms of science communication: the dissemination paradigm and the public participation paradigm. The authors explain that the two paradigms differ in terms of the aims of science communication they intend to fulfill and the methods used to attain such aims.

The dissemination paradigm of science communication

Kappel and Holman explain that the dissemination paradigm of science communication encompasses the science communication models, which propose a one-way transmission of science information from experts to the public (p. 2). Scholars who subscribe to this paradigm believe science communication should aim at informing the public about science; therefore, the linear transmission of information is the best way to communicate science. The central assumption of the dissemination paradigm is that the transmission of information about science can be done in two approaches: formal education (in a school setting) or "re-education" through the use of mass media (The Royal Society, 1985; Ziman, 1991; Bauer, 2007, cited in Kappel and Holman, 2019: 2). Kappel and Holman point out that because of recent movement by scholars to acknowledge the role of context in public understanding of scientific information, some models in this paradigm recognize the heterogeneity of multiple publics in society and the influence that it may have on people's response to science communicative initiatives. Such models emphasise the role of factors like cultural context, individuals’ previous experiences, and personal circumstances in shaping the public's response to science communication efforts (Brossard and Lewenstein, 2010).

Generally, the dissemination paradigm views linear transmission of information about science from experts to the public as the right approach to communicating science. However, it acknowledges the influence of factors such as cultural context and personal experiences in the success of science communication initiatives. Therefore, although science communication under this paradigm assumes that one-way transmission is the best approach, scholars agree that science may relate differently to different public groups in different cultural contexts. These differences may yield variation in the public's responses to science communication efforts. The central belief in the dissemination paradigm is that science communication should focus on feeding the public with scientific information.

The public participation paradigm of science communication

The public participation paradigm includes models of science communication that break away from the belief that one-way transmission of scientific information from experts to the public is ideal. The models assume that non-linear transmission is the best approach to science communication initiatives. Therefore, the models in this paradigm emphasise public participation and deliberation in the two-way and three-way transmission of scientific information. According to Kappel and Holman, this paradigm assumes that dialogue and deliberation between the public, experts, and decision-makers is the proper way of engaging in science communication. The authors acknowledge that dialogue and deliberation may differ, clarifying that they are included in the public participation paradigm because they differ in the degree of participation and not the kind of participation. They further explain that dialogic and deliberative science communication can be considered participatory, but participation could be more significant in deliberation than in dialogue (p. 2).

Science communication initiatives under the public participation paradigm may take various forms, such as public hearings and referendums, citizen juries, deliberative polls, consensus conferences, and citizen science. According to Bubela et al. (2009), each form places a different weight on extended peer review, whereby the public or groups of individuals affected by the product of science are invited to become a part of a community of evaluators and decision-makers (p. 515). Bubela et al. (2009) further explained that the participants in these initiatives learn directly about the technical aspects of the subject and the social, ethical, and economic implications of science. However, each initiative differs in terms of the involvement of the participants, for instance, how they are asked for feedback, how much their feedback influences the final decision, and the timing of consultation (Einsiedel, 2008; Bubela et al., 2009).

Generally, the public participation paradigm of science communication encompasses science communication models that encourage science communication approaches that allow for public participation through dialogue and deliberation. The degree of participation may vary from one approach to another, but the main aim is dialogue and deliberation about science between the public, experts, and decision-makers. Obviously, for the science communication process to attain the AEIOU responses (in the definition adopted in this study), models from the two paradigms must be applied as appropriate to achieve the intended aims of a science communication activity. This chapter discusses the science communication models later under the theoretical framework.

2.2.2 Science Communication and the Present Study

The present study– *access to and utilization of scientific information on GM food crops among maize farmers in western Kenya*–concerns scientists' communication of the knowledge generated by their research on GM food crops to the farmers. It also concerns farmers' reception of GM food information and how this information shapes their attitudes toward GM food crops. The study falls under communication studies and science communication, mainly because it explored communication between crop scientists researching GM food and the public (maize farmers) in western Kenya. The study explored the communication of scientific findings about GM food to the public (farmers). I examined scientists' conceptualization of the communication of scientific knowledge about GM food with maize farmers, the framing of this communication (GM food messages), and how the farmers access and make sense of the information. The study also sought to determine how the information communicated shapes the (farmers') attitudes toward GM food crops. The remaining part of this chapter is devoted to reviewing the literature on communicating GM food information to the public and the models of science communication, which served as the theoretical framework for the study.

2.3 Communication of GM Food Information to the Public

2.3.1 Need and Access to GM Food Information

Scholars generally agree that the public needs information about new scientific phenomena to inform their debate and opinion about the science and help inform their decisions. There is mixed public opinion and polarizing debate coupled with a low level of acceptance of GM technology and food. These diverse public opinions, mainly rooted in GM food's perceived adverse health and environmental effects, can be attributed to factors such as access to information and general public engagement in GM research through communication. Indeed, literature shows that the information available contributes significantly to the public's attitudes and actions towards issues such as climate change, nanotechnology, vaccination, GM technology, etc. For example, Smale et al. (2009) noted that consumer attitudes toward GM crops change as consumers are exposed to new information, especially negative information.

Similarly, Kagai (2011) and Chagwena et al. (2019) observed that information, awareness, and basic knowledge of GM technology are essential because they determine the technology’s acceptance; therefore, there is a need to provide more information to the public about GM through established sources (Kimenju and De Groote, 2008). There seems to be a direct association between increasing knowledge of GM technology and increasing support for GM applications (Koivisto-Hursti and Magnusson, 2003). However, as discussed later, how public knowledge is increased can make a difference. Most people do not have scientific knowledge about GM crops and, therefore, have wrong perceptions about them (Ezezika et al., 2012; Kosgey and Cyrus, 2019). Kosgey and Cyrus observe that this lack of scientific information results from the fact that most scientists do not engage the public on issues concerning genetic modification, leading to non-scientific public debate. They further observe that, given the lack of scientific information about genetic modification, public debates tend to be skewed towards precautionary principles while ignoring the principle of substantial equivalence (p. 13951). Both Buah (2011) and Changwena et al. (2019) call for public education on GM foods to help the public better understand the issues involved and empower the public to make informed decisions. These calls cement the role of access to information in influencing public acceptance of new issues, such as GM food. The calls also imply that the nature and quality of the information that the public receives regarding what it contains and its accessibility can contribute significantly to the public's attitude and actions regarding GM foods.

Therefore, information is a much-needed commodity for the public to make informed decisions regarding GM foods. However, reliable communication should originate from the people who understand GM technology and foods, i.e., the scientists involved in GM food research. Suppose there is not enough information from these scientists. In that case, the public will likely believe any communication available to help fill their hunger for information they need to inform their decision about GM foods. As Wedding and Tuttle (2013) observed, the significant communication gaps among key stakeholders partly cause all the confusion [regarding GM food]. Policymakers, food companies, and retailers should pay attention to the [scientific] research results instead of teaming up with "a small group of anti-biotech activists" (Gheysen et al., 2019, p. 55) and some non-governmental organisations who are running negative campaigns about GMOs (Kosgey, 2019). It is important to note that the only way the public can pay attention to scientific findings, as suggested, is if they are adequately communicated by those concerned, including the scientists.

It has become apparent that effective public participation in the debate regarding GM food can only happen when the public has factual information on the technology (Kimenju et al., 2005). However, considering the current status of the debate about GM food, one wonders what kind of information the public access regarding GM foods and how much the information is reliable. This issue is partly what this study sought to address.

2.3.2 Public Awareness of GM Food and Sources of Information

Generally, studies have reported that the public self-reported being aware of GM food. However, there is no report of what information is communicated to the public, influencing their awareness. In fact, some studies have reported that it is not enough for the public to indicate that they have heard about GMOs because they might have heard wrong information from unreliable sources or sources intending to spread inaccurate information. For example, Changwena et al. (2019) noted that out of 92% of respondents who reported having heard of GMOs before in their study, only 38% could give a simple, accurate definition of a GMO. A similar case is reported by Karau et al. (2020), in which despite most of the respondents in their study claiming to be aware of GMOs, only a small portion could correctly explain what GMOs meant. These two examples imply that although the public may report being aware of GM technology and foods or any other new technology, their knowledge may be limited; there could be chances that they received information (which informs their awareness) from both scientific and non-scientific sources alike. Literature has shown that there is a scarcity of communication of information regarding GM food from scientists and other reliable sources. As noted in the preceding section, Kosgey and Cyrus (2019) think scientists do not engage the public on GM crops issues. A situation like this may leave the public members struggling with conflicting information from multiple sources, hence room for misinformation. Indeed, Kosgey and Cyrus noted that leaders and policymakers could complicate this situation more by passing wrong information to the public without clear information about GM crops (p. 13951). Oloo, Maredia, and Mbabazi (2020a) call for developing countries to make science-based decisions on GMOs. They also observed that the scientific community seems not to have done an excellent job convincing the political decision-makers about GM crops' safety and attending benefits for these nations' people and the economy. The only way to make an informed decision is by adequately understanding GMOs' potential risks and benefits (p. 698). To achieve this, scientists must share their GMO research findings with the general public and decision-makers. As Kosgey and Cyrus (2019) put it, scientists must engage the public on matters regarding GM food crops.

The shortage of communication of scientific information regarding GM food may warrant the public to rely on communication from the "opponents of the technology." These opponents tend to ″lure the public to most controversial and sometimes immeasurable issues which appeal to feelings and emotions rather than facts″ (Oloo et al., 2020a, p. 698). An excellent example of such communication is when ActionAid-Uganda (a UK-based organisation) communicated through local radio that GM foods cause cancer and infertility (Karembu, 2017; Gheysen et al., 2019). Although the organisation later apologized for the message (which they admitted carried incorrect information about GM), the communication had already caused damage. It fueled anti-GMO activism and consequently delayed the country's (Uganda) national biosafety bill for GM crop cultivation (Gheysen et al., 2019). As Changwena et al. (2019) explained in their study, the reason the respondents failed to give a simple definition of GMOs despite reporting to have heard about it could have been that the subject (GMO) had been misleadingly presented to the public. They also attributed the possible misrepresentation of GMO information to the negative attitudes and perceptions demonstrated by most respondents in their study, hence the rejection of GM foods. It is evident that the importance of scientific communication on new scientific phenomena cannot be over-emphasised, and lack of it warrants dependence on unreliable sources of information, rendering the public unable to make informed decisions.

Generally, there seems to be a direct connection between the nature of public awareness of GM food and the sources of information that inform their awareness. The literature agrees scientists must engage the public and decision-makers in GM food issues. As noted later in this chapter, most studies in Kenya only identified the sources of GM food information available to the public: radio, Newspapers, TV, fellow farmers and friends, schools, the internet, and extension officers. In this study, I further interrogated the sources of information to understand the nature and quality of GM food information accessible to the farmers and its impact on their attitudes toward GM food crops.

2.3.3 GM Food Information and Public Perception of GM Food Crops

Effective science communication is the only way scientists can contribute to the public knowledge of scientific phenomena and help them make informed decisions. Communication can also help to shape public opinion about solutions proposed by science, such as GM food. Therefore, the public deserves adequate information on the potential risks and benefits of such new phenomena and needs this information from reliable sources. Undoubtedly, adequately communicating scientific knowledge to the public can help them build a positive perception of a scientific phenomenon and consequently help make informed decisions about everyday human problems. As noted earlier, Baron (2010) called for scientists to move beyond their publications to share their scientific findings with the broader public for them to know why it matters. Nonetheless, more than a decade later, we still have reports from the literature that scientists do not engage the public in the issues related to GM food, calling for the need to understand the nature of communication surrounding GM food.

GM technology and GM food have been around for nearly three decades. The food is not necessarily harmful and has been used in many countries as feed for livestock and as food for people. There is a considerable amount of scientific research on GMOs with no evidence that GMOs have brought new risks to either human health or the environment (Snell et al., 2012; De Francesco, 2013; Nicolia et al., 2013; Klumper and Qaim, 2014; Gheysen et al., 2019; Sanlier and Sezgin, 2020). These findings are also supported by science academies and medical associations worldwide. Policymakers from developing countries have increasingly considered GM crops a potential tool for increasing agricultural productivity (Racovita et al., 2013) by addressing pest attacks and small yield challenges. However, there has been a lot of polarized debate and mixed public perceptions globally and specifically in Kenya. These diverse opinions imply that the nature of communication that goes to the public regarding GM food needs to be scrutinized. As I noted earlier, where science communication is inadequate, the public will likely rely on communication from GM opponents, resulting in misinformation (Gheysen et al., 2019), fueling the public's negative perception of GM food (Kosgey and Cyrus, 2019) and uncertainty, especially regarding GM food safety issues.

Scholars agree that to change public perception of GM technology or its products, scientists researching in the area should share their findings with the public so that facts can inform public debate about the technology or its products. Anunda et al. (2010) noted the need for scientists to communicate complete information regarding GM crops and foods to the public. Disseminating credible information to the public about the risks and benefits of GM crops and facilitating their input into decision-making is essential (Racovita et al., 2013). As discussed later, the question of public perception of GM technology or its products has received substantial attention from researchers, especially in Kenya. Their primary focus has been on explaining the factors that influence public perception. The general conclusion is that it is important to provide the public with more information and education regarding GM technology and its products. Nonetheless, there is little knowledge regarding how the nature and quality of GM information the public access helps shape their perception/attitude of GM technology and food. Hence the focus of this study.

2.4 Selected Studies on GM Food and Public Engagement

2.4.1 Studies from Africa

As mentioned in the previous sections, there have been a handful of studies on GM technology and products. Most of these studies have focused on the issues of public perception, awareness, and issues of public acceptance of the technology or its products. In Africa, most studies focus on the readiness of the public to accept GM technology and food, factors that may influence this, and the public's concerns about the technology and food. Communication of GM food information to the public (the concern of this study) has been only indirectly hinted at in most studies in Africa but has not been the subject of concern in its own right. Below, I summarise a few studies from Africa that have featured public engagement with GM food.

Oladipo et al. (2020) sought to investigate the readiness of potential consumers in Nigeria for the possible introduction of GM crops into the food market by surveying 335 potential consumers. The authors designed a survey to investigate the participants' knowledge, attitudes, and concerns about GMOs and their willingness to consume GM crops. The researchers reported that 88% of the respondents had previous knowledge about GMOs, and most had medium-level knowledge about GMO/GM crops. Respondents' desire to consume GM food varied in that 44% were willing to consume GM crops when eventually introduced, whereas 30% were not willing to consume them, and 23% were uncertain. Generally, the findings of their study indicated that many respondents indicated that they had concerns about GM crops primarily related to potential risks to health. The authors also found that the internet and the media (such as newspapers, television, etc.) were the primary means of previous knowledge about GMOs reported by the respondents. The respondents also indicated the need for further information about GMOs and requested the internet as a means to attain that further.

Lewis et al. (2010) conducted qualitative research involving farmers as both producers and consumers in three areas of Tanzania: Rufiji, Bagamoyo, and Michi-Unguja. They aimed to assess farmers' knowledge of GM crop technology, their attitude (in terms of receptivity), and their areas of concern about GM crop technology. The authors conducted individual interviews with 19 farmers and five focus group discussions involving the same farmers. The findings indicated that farmers had poor understanding, awareness, and knowledge of GM crop technology. The results also showed that there was high receptivity to the potential use of GM crops and a tendency of the farmers in their study to focus on the benefits rather than long-term health risks. The study recommended a continued assessment of the public's perception and attitudes toward the potential use of GM crop technology in Sub-Sahara Africa. It also called for the training of agricultural extension officers in the advantages and disadvantages of GM technology to enable them to provide better information to farmers and other community members. They believed that information would help public members make an informed decision regarding GM crop technology.

Deffor (2014) used a qualitative choice (Logit) model survey conducted in three districts of Accra, Ghana: Accra Metropolitan Assembly, Ga East, and Tema Metropolitan Assembly, to estimate the effect of various factors on consumer acceptance of GM foods. The author collected data by administering questionnaires to 240 purposively sampled respondents with "some level" of education. The study results showed that most respondents (90%) had heard or read something about GM foods, indicating a high level of awareness among respondents. The author also found that 85% of the respondents were willing to accept GM foods. Specifically, the findings of Deffor’s study indicated that consumers with age groups 31 - 40 and above 50 years were more likely than other age groups to accept GM foods. In addition, male respondents were also found to be less likely than female respondents to accept GM foods. Regarding the factors influencing acceptance, the author found that education and understanding of science and technology influenced the level of acceptance of GM foods, leading to the study’s conclusion that awareness and education are necessary for the acceptability of GM foods. The author recommended that effective education about the benefits of GM foods should be promoted to increase potential acceptance.

Changwena et al. (2019) conducted a descriptive cross-sectional survey among 301 participants attending a country-wide Traditional and Organic Foods Festival in Harare, Zimbabwe. They aimed to describe the general public's level of knowledge and perception of GM food. The authors used a self-administered questionnaire to collect data. The result indicated a poor level of knowledge associated with the level of education; a lack of understanding of the genetic engineering process in food production was common among respondents. Only 38% out of 92% of the respondents who reported being aware of GM food could give a simple, meaningful definition of GMOs. The results also indicated that participants had negative attitudes toward GM foods and low intention to consume GM foods. The authors also reported that people with increased knowledge of genetic engineering and GM foods were more receptive to GM foods in their diets. Therefore, they concluded there was a need to improve consumer awareness of genetic engineering in food production to empower consumers to make informed choices regarding GM food. Consumers in resource-limited settings were sceptical of genetic modification of food and, thus, should be consulted during policy formulations on GM foods.

Nyinondi et al. (2017) used a cross-sectional survey to assess the perception of GM Crops among farmers, journalists, and scientists in Tanzania and determine the factors influencing their perception. The authors collected data using a questionnaire, focus group discussion, and observation guide from 265 respondents. The findings of their study indicated that 70.5% of the respondents had a positive perception of GM crops, while 23.8% and 5.7% had neutral and negative perceptions, respectively. The findings also indicated that a mixture of multiple factors such as age, gender, educational level, marital status, religion, occupation, and basic knowledge of science and technology influenced respondents' perceptions of GM crops in Tanzania. Nyinondi et al. concluded that stakeholders in the agricultural sector should strive to institute policies and legislations that are informed by scientific evidence. They observed that these policies and legislations would, in turn, support scientific advancement in the country.

2.4.2 Studies from Kenya

In Kenya, like in the rest of Africa, the available literature regarding GM technology or its products focuses mainly on the public reaction to the technology and food and factors influencing this reaction, such as public awareness, knowledge, and socio-demographic factors. Very few exceptions are like Lore et al.'s (2013) *A framing analysis of Newspapers coverage of genetically modified crops in Kenya*. Although farmers are very crucial when it comes to adopting GM food crops, most studies in Kenya mainly focus on consumers' reactions. Nevertheless, issues regarding the communication of GM food information are only hinted at in the conclusions or recommendations of most studies in Kenya. A few of these studies are highlighted below.

Lore et al. (2013) used quantitative content analysis to analyse media framing of GM crops during the parliamentary process toward enacting a biosafety bill on GM crops in Kenya. Their main objective was to examine the principal frames used in the coverage of GM crops by three daily newspapers in Kenya: The Daily Nation, The Standard, and Taifa Leo. They also examined the tone of the articles and the sources used in articles on GM crops in these newspapers. The authors sampled 95 articles about GM crops published in the three newspapers between June 2007 and August 2009, when there was increased public debate around the development of the biosafety law. Their results indicated that eight frames were identified: agriculture, controversy, environment, ethics, public awareness, regulation, research, and safety frames. Daily Nation and The Standard were found to be dominated by agriculture frames in their articles about GM crops. On the other hand, Taifa Leo framed their articles about GM crops in line with safety and regulation.

Regarding the tone of the articles, their study reported that the agriculture frame was largely positive toward GMOs. The main focus in this frame was on the potential benefits of GM crops, including drought tolerance, pest resistance, and high yields. Conversely, the safety frame was found to have a negative tone. Articles under this frame gave a negative presentation of GM food and crops, focusing on the likelihood of risk and framing GM food and crops as potentially harmful to human health. The study found that, generally, 27.4% and 37.9% of all the 95 articles analysed had positive and negative tones, respectively, whereas 34.7% were neutral toward GM crops. Concerning the sources quoted in these articles, scientists and government officials who spoke positively about GM crops were the most frequently quoted. Lore et al. concluded that there was low coverage of GMOs in Kenyan media and that the overall coverage of GMOs was not balanced. Most articles analysed were either positively or negatively biased, and more articles had negative than positive bias. The authors recommended that journalists be trained to become more objective and balanced in their coverage.

Kimenju et al. (2005) sought to determine consumer awareness and attitudes toward GM foods by surveying 604 consumers in Nairobi, Kenya, at three points of sale: supermarkets, kiosks, and posho mills. The authors reported that 38% of the respondents were aware of GM crops and that their awareness mainly came from newspapers, television and radio, and schools. They also reported that Newspapers and television were more important sources of information to higher-income and more educated consumers. The results also indicated that consumers acknowledged the technology's potential positive impacts, with more than 80% agreeing that it increases productivity. On the other hand, 68% reported they would buy GM maize at the same price as their favourite brands, although many had concerns.

Regarding concerns, half of the respondents feared that GM technology could lose biodiversity and affect non-target insects. At the same time, 37% were concerned about GM food's effects on human health. The authors concluded that GM technology plays a role in food security in Kenya. However, the authors argued that consumers needed more information about the technology, which could be provided through established sources of information.

Kagai (2011) conducted a cross-sectional survey to assess public perceptions of GM crops and foods in Trans-Nzoia County, Kenya. The study specifically aimed at achieving three objectives: (i) assessing public perceptions of and knowledge about GM products and their impact on decisions to adopt and consume these products; (ii) investigating consumers' willingness to purchase GM crops and foods and factors influencing consumer purchasing behaviour, and (iii) identifying the factors that influence consumers' attitudes and perceptions towards GM crops and foods. The study found that farmers' and customers' perceptions influenced their approval of GM technology and that gender, basic knowledge of GM technology, and information access and dissemination were likely to influence farmers' adoption of GM technology. The author also found that consumers who were familiar with government policy and had a basic knowledge of GM crops were more likely to approve of the technology than those who had not.

The study also revealed that farmers were concerned about the environmental risks associated with GM technology and its possible effect on the marketing of crops both locally and abroad. At the same time, consumers expressed concerns about potential health risks, the ability of the government to protect them, and the acceptance of GM products in the local market. The author concluded that the disapproval of GM products by both farmers and consumers in his study was influenced by the perception of the products' high risks and low benefits. Therefore, he observed a need for increased public awareness and participation in GM technology at all levels.

Karau et al. (2020) conducted a cross-sectional study to investigate the knowledge, perception, and attitude of residents in Kiambu regarding the safety of GM food and feeds. The study's participants were drawn from rural and urban residents in several areas of Kiambu County. The rural residents were sampled from Limuru, Kikuyu, North Gatundu, and South Gatundu, whereas the urban residents were sampled from Thika and Kiambu towns. The authors collected data through a semi-structured questionnaire administered to a total of 384 respondents, which included small-scale farmers and university and tertiary students. The small-scale farmers were considered the main producers of food crops in Limuru, Kikuyu, and Gatundu North and South. The study results indicated that 89.3% of the respondents were aware of GMOs and received information from various sources, including the media, educational institutions, agricultural shows, biotechnology companies, public grapevine, government sectors, seminars, and workshops. However, only a small portion of the respondents in this study could explain what genetic modification meant.

The study also found that 60.3% of respondents trusted scientists to apply agricultural biotechnology appropriately. Regarding the perception of GMOs, 54.6% of the respondents were reported to have negative perceptions by presuming that GMOs are harmful to human health, while 68.8% thought GMOs would reduce indigenous crops. Concerning protection by the government from risks, 49.6% believed that the government had enough capacity to protect farmers and the general public from risks associated with GMOs. The author also found that 66.1% of the respondents believed that Kenyans did not have enough knowledge to make an informed decision on the placement of GM in the market.

Regarding how often they got information about GMOs, more than half (58.1%) of the respondents reported getting information monthly. Respondents of this study also indicated that they shared information they received with others, including family members, neighbours, and other groups in their society. Karau et al. concluded that appropriate policies, regulation, funding, and effective communication would help shape consumers' expectations and demands, hence driving acceptance of GM products into the local market. Media play a critical role in informing perception and influencing the acceptance of biotechnology. The authors called for improvement in the government's and concerned bodies' information delivery to ensure easy adoption and acceptance of GM technology.

Anunda et al. (2010) conducted a cross-sectional survey involving 702 adults from 8 provinces in Kenya to assess how risk/benefit perceptions differed across agro-ecological regions, individual ages, academic qualifications, and gender in Kenya. The finding indicated that 58% of the respondents had positive perceptions and believed that the genetic engineering of crops would alleviate hunger and malnutrition and reduce poverty in Kenya. The study also reported that public acceptance of genetically engineered food crops was related to their demographic characteristics and value attributes. Respondents in high-potential regions (areas with high rainfall, fertile soils, and good infrastructure) were more negative towards GM crops and foods than those from medium and low-potential regions (arid/semi-arid areas with poor soils). Regarding age and education, the finding indicated that the more senior one became in age, the more negative they were likely to be towards GM crops. At the same time, more-educated individuals and those with higher scientific knowledge were more optimistic about introducing GM crops and foods in Kenya. The study concluded that there was a need for a well-designed and effective program to educate the public about various issues relating to the use of genetic engineering in agriculture and food production. The authors observed that scientists needed to communicate with the public with complete information proactively.

2.5 Synthesis of the Literature and Research Gap

My analysis has revealed that literature has generally focused on public involvement with GM technology or its products. The general theme in most studies has been public knowledge and awareness, perception, attitude, and acceptance of GM technology and food. The literature agrees that information to the public regarding GM technology and food will contribute toward a more positive attitude towards GM and, thus, acceptance of the technology or its products. The literature analysis revealed an obvious need to increase public awareness and participation in GM technology and educate the public by providing factual information about GM technology and food. The analysis also revealed the need for scientists to communicate with the public with complete information and proactively. Most of the reviewed literature (specifically from Kenya) has focused more on consumers primarily based in urban areas than producers (farmers). A few exceptions are Kagai (2011), who studied both the producers and customers in rural and urban areas, and Karau et al. (2020), who surveyed consumers in rural and urban areas of Kiambu.

The literature review has further shown that public perceptions toward GM food are mixed and different across countries and that their awareness needs to be improved for them to make an informed decision. The lack of information [reliable] is making them more sceptical and confused; the public needs more information about GM food to improve their understanding of GM. The literature has also shown that importance is accorded to improving public education and communication of GM food information. Nonetheless, no study, especially in Kenya, has focused exclusively on exploring the nature of the communication of GM food information to the general public and, in so doing, determining the kind of information accessible to the public. Specifically, the literature has not shown how crop scientists communicate to the public, how the public accesses and makes sense of information, or how the information accessible to the public influences their attitudes toward GM foods. These were the concerns of this study.

Lore et al.'s (2013) analysis of the framing of GM crops by Newspapers in Kenya is the closest the literature has come to the present study. However, unlike this study, which studied crop scientists (as sources of GM food information and communicators) and maize farmers (as receivers of GM food information), their study investigated the communication of GM food information from the perspective of the media (Newspaper framing GM crop information). Generally, the analysis revealed the following gaps:

a) There is a lack of research on the communication of GM food information to the public in its own right. However, most available studies indirectly hint at this by indicating what the public identifies as the sources of GM food information, which they said informed the public awareness of GM technology and food;
b) Most studies have investigated public engagement in GM food from a producer and/or consumer point of view. No study in Kenya [to my

knowledge] has studied the crop scientists researching GM food crops and the farmers concerning sharing information on GM food between them. It is unclear how the scientists conceptualise the communication of GM food information to the farmers and, consequently, how they frame GM food messages for the farmers;

c) No study in Kenya has explored how the public access and make sense of GM food information;
d) Studies have attributed the public's attitude toward GM food to socio-economic factors such as age, education level, economic status, etc. No study has examined the role of information the public receives about GM food in shaping their attitudes toward GM food;
e) No study in Kenya has assessed the communication of GM food information in light of the assumptions of the models of science communication.

In this study, therefore, I intended to address the gaps by studying access to and utilization of scientific information on GM food crops among maize farmers in western Kenya. I achieved this by exploring the crop scientists' communication of GM food information to the farmers and the farmers' reception of this information.

2.6 Theoretical Framework

This section explains the theoretical framework that steered this study. As I have established earlier in this chapter, the present study falls under communication studies and science communication in particular because it studies the communication of scientific information about GM food to farmers (i.e., scientists-farmers interaction). Therefore, the study was guided by the models of science communication, the lens under which science communication research is conducted. Various scholars have discussed these models, with different scholars coming up with varying numbers of models but with similar intentions. The most common models identified are the science literacy model, famously known as the deficit model; the contextual Model; the lay expertise model; and the public participation/engagement model.

Generally, the choices made when communicating scientific findings to the public, such as communicating GM food information to maize farmers, which this study sought to explore, could be explained by assumptions from the four models of science communication. Thus, this study was guided by the four models: deficit, contextual, lay expertise, and public participation. In other words, I envisaged that GM food is relatively new to the public (and the farmers in this study). As such, the communication surrounding this area might aim to improve farmers' understanding of GM food and simultaneously engage them in knowledge creation about GM food. This thinking aligns with Brossard and Lewenstein (2010), who look at the models in terms of projects aiming to improve the understanding the public(s) have of a specific area of science and projects aiming at exploring the interaction of the public and science (p. 12). The authors argue that recent efforts have focused on integrating the two categories by linking research findings with outreach activities. Indeed, the decision to use the four models of science communication in this study aligns with Trench (2008), who argues that the various models of science communication can coexist. Also, the definition of science communication I adopted from Burns et al. (2003), earlier in this chapter, clearly specifies that the science communication process aims to achieve one or more of the aims in the vowel analogy (AEIOU): Awareness, enjoyment, interest, opinions, and understanding of science. These five aims of science communication fall under different assumptions of the four models. Therefore, the four models of science communication explained in this chapter enlightened the presentation and discussion of findings on access to and utilization of scientific information on GM food crops among maize farmers in western Kenya. I first discuss the four models and then present the various alternative discussions to the models of science communication by different authors to synthesize the discussion and cement the relevance of the four models with the present study.

2.6.1 The Models of Science Communication

2.6.1.1 The Science Literacy Model of Science Communication (the Deficit Model)

According to an editorial by Scidev net (2005), the term deficit was coined in the 1980s by social scientists studying the public communication of science to characterise a widely held belief that underlies much of what is carried out in the name of science communication rather than to describe a mode of science communication. This belief has two aspects: the first is that public scepticism towards modern science and technology is caused primarily by a lack of adequate knowledge about science. The second is that providing sufficient information about modern science and technology will help overcome this 'knowledge deficit,' and consequently, the public will become positive towards science and technology. Similarly, Ziman (1991, 1992), cited in Brossard and Lewenstein (2010), pointed out that the 'deficit' model, which describes the deficit of knowledge that must be filled, presumes that after fixing the deficit, everything will be better. Figure 2.3 below summarises the aim of the deficit model of science communication.

The science literacy (the deficit) model of science communication aims to disseminate scientific information to the public to give citizens information needed to make decisions about their daily lives and gain popular support for science (Secko et al., 2013). This aim implies the deficit model assumes a linear (one-way) information delivery whereby scientific information flows from the scientists, who are considered to have the required knowledge, to the public, who are considered to have a knowledge deficit. The public is treated as scientifically illiterate and passive in the communication process. The Model is, therefore, sometimes referred to as the public education model since it intends to educate the public about scientific issues because of the tendency of scientists to think that the public suffers from a deficit of knowledge and is incapable of grasping the complexity of science (Pouliot and Godbout, 2014, p. 1)

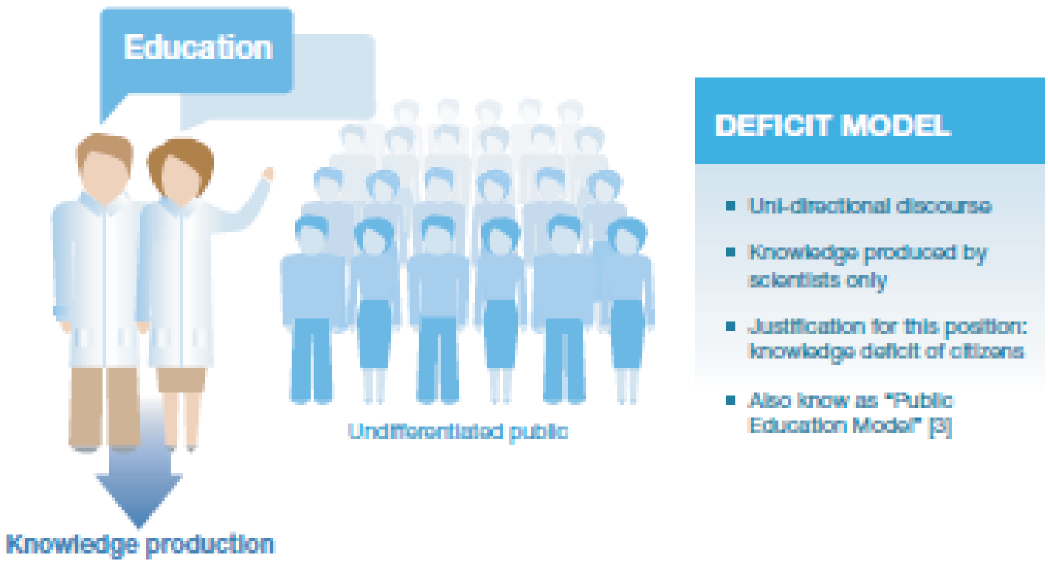

Figure 2.3: The Deficit Model of Science Communication
***Source**: Pouliot and Godbout (2014)*

The deficit model of science communication has been heavily criticized for treating the public as a passive receiver of scientific information, treating science as the only legitimizing knowledge, and ignoring other forms of knowledge. Other criticisms are lack of context and failure to connect scientific information to personal relevance, and uneven power relations between scientists who have the knowledge and audiences who are viewed as lacking the knowledge (Brossard and Lewenstein, 2010; Jasanoff, 2011; Secko et al., 2013). It is important to note that these criticisms notwithstanding, studies have indicated that most scientists still use the deficit model when interacting with non-scientist audiences (Pouliot and Godbout, 2014). It is also important to note that, despite the criticisms of the deficit model, where new scientific issues are concerned (such as GM food crops in the context of this study), public education may be necessary to aid understanding of the issue. However, the difference could lie in how such education is provided. I considered the deficit model relevant in this study because GM technology and food are relatively new, and the public could need the information to help improve their awareness and knowledge. Scientists might also share this assumption when framing GM messages for the farmers. Thus, the model would help explain the choices made in communicating GM food messages to the farmers.

According to Brossard and Lewenstein (2010), these criticisms gave rise to three Models of science communication to respond to the deficit model: the contextual Model, the lay expertise model, and the public engagement model. The authors explain that these models are the frameworks for understanding what "the problem" is, how to measure the problem, and how to address the problem (p. 13).

2.6.1.2 The Contextual Model of Science Communication

Although the contextual Model of science communication carries some similarities to the deficit model in that it assumes the top-down linear approach to science communication, its uniqueness is that it addresses scientific information in specific, audience-linked contexts (Secko et al., 2013). The Model acknowledges the role of context (both geographical and social) in shaping the public's understanding of scientific information and that the context in which information is received helps individuals process and respond to such information (Brossard and Lewenstein, 2010; Secko et al., 2013). Brossard and Lewenstein explain that the contextual Model of science communication acknowledges that "individuals do not simply respond as empty containers to information, but rather they process information according to social and psychological schemas that their previous experiences, cultural context, and personal circumstances have shaped" (2010, p. 13). The Model also acknowledges the ability of social systems and media representations to either reduce or increase public concern about specific issues (Kasperson et al., 1988, cited in Brossard and Lewenstein, 2010). Generally, the contextual Model focuses on tying scientific information to a particular audience while recognizing that science has a different meaning in different contexts. The Model is said to have a more cooperative relationship between scientists and the public (Irwin, 2009; Secko et al., 2010).

The contextual Model is not free of criticism. Although it was seen as a means to step away from the deficit model, it has been criticized for maintaining a top-down information delivery approach to communicating scientific information. According to Wynne (1995), cited in Brossard and Lewenstein (2010), the contextual model is a sophisticated version of the deficit model. This is because, despite acknowledging that the audience is not mere empty vessels, it conceptualizes a problem in which individuals respond to information in ways that seem inappropriate to scientific experts (p. 14). Similarly to the deficit model, the contextual Model still views the public (audience) as unable to understand science's complexities. This model was relevant to this study since it was expected that the communication of GM food information would be done as it related to the targeted audience (maize farmers). The assumption was that crop scientists would communicate to inform maize farmers and contextualise their communication to suit specific audiences in specific contexts. I also assumed that maize farmers would not be passive audiences but somewhat concerned and questioning.

2.6.1.3 The Lay-expertise Model of Science Communication

The lay-expertise Model of science communication emerged as a response to criticisms placed on the deficit and contextual models, especially on using a top-down information delivery approach and thus failing to have public participation. The lay-expertise Model encourages public engagement and considers scientific knowledge as not solely scientific, and lay people may have as much to learn as to communicate (Irwin 2009).

According to Brossard and Lewenstein (2010), under the lay-expertise model, knowledge is valued in its own right and is validated through other social systems. Science is promoted as limited and uncertain and, therefore, requires expertise from sources outside science to examine issues. They clarify that:

> The Lay Expertise Model argues that scientists are often unreasonably certain—even arrogant—about their level of knowledge, failing to recognize the contingencies or additional information needed to make real-world personal or policy decisions (p. 14)

Despite the lay-expertise Model being seen as encouraging more public involvement by considering the public to have as much to learn as to communicate, it is not free of criticism. The Model has been termed anti-science because it privileges local knowledge over reliable knowledge about the natural world produced by the modern scientific system (Brossard and Lewenstein, 2010). The authors observed that a political commitment drives the lay expertise to the empowerment of local communities. They added that it is unclear how a model of public understanding based on lay expertise guides practical activities that can enhance public understanding of particular issues.

I considered this Model useful in explaining the crop scientists' communication of GM food information to farmers in this study because it emphasizes the lay expertise or knowledge based on the lives and histories of real communities. This emphasis implies that communication of scientific information should consider the audiences' lives and histories, in this case, farming – the economic activity in which the "audience" (maize farmers) engaged. This communication initiative should also consider that science may have its way of explaining food, yet the farmers' understanding may be different based on their social systems. Indeed, as stipulated by the mountain climbing analogy earlier in this chapter, local knowledge is necessary; therefore, crop scientists might have as much to learn from the farmers as to communicate.

2.6.1.4 The Public Engagement/participation Model of Science Communication

In search of a model of science communication that would address the criticisms placed on the three previously discussed models, the public engagement/participation model of science communication emerged. According to Brossard and Lewenstein (2010), this model of science communication focuses on activities that enhance public participation in science, especially regarding policy issues. These participation activities are meant to democratize science by taking control from the hands of elite scientists and placing it on the public groups through some forms of empowerment and political engagement (Sclove, 1995, cited in Brossard and Lewenstein, 2010). The public engagement model encourages public participation through debate surrounding various scientific issues by using a two-way information flow from the scientists to the laypersons and vice versa.

The public engagement model has also received a fair share of criticism. For example, it is criticized for focusing more on politics and policy than on the public understanding of science, failing to address a wider audience at a time, and emphasising the process of science while discounting the actual science content (Brossard and Lewenstein, 2010). Evidently, the question of public knowledge of science lingers. The public needs scientific knowledge to help them make informed decisions and participate more effectively in scientific debates. The participation model was considered relevant in this study because scientists and communicators may need to involve the farmers more in GM technology and food issues for effective communication of GM food. I assumed that dialogue between scientists and farmers and among farmers could be a more welcome approach by the maize farmers in this study since farmers might have specific issues that they wish this communication addresses.

2.6.2 Synthesis of the Models of Science Communication

As pointed out earlier, the four models of science communication discussed above can be grouped into two categories, courtesy of their primary focus. Whereas Secko et al. (2013) group them into traditional and non-traditional models of science communication, Brossard and Lewenstein (2010) group them into information delivery and engaging the public (Figure 2.4), in what they called the conceptual models of Public Understanding of Science. Secko et al.'s grouping is based on the argument that the deficit and contextual models are traditional in their information delivery style. These models assume one-way information delivery from scientific experts to laypersons and align with Brossard and Lewenstein's information delivery models. The authors focus their categorization on the main focus of the two models – delivering scientific information to the layperson.

Main focus: Information delivery	Main focus: engaging the public
A. Contextual model • Tied to particular audiences(s) • Pays attention to needs and situations that may be time, location, disease, language-dependent, etc. • Highlights the ability of audiences to quickly become knowledgeable about relevant topics	**B. Lay expertise model** • Acknowledges limitations of scientific information • Acknowledges potential knowledge of particular audiences • Highlights the interactive nature of the scientific process • Accepts expertise away from scientists
C. Deficit model • Linear transmission of information from experts to the public • Belief that good transmission of information leads to reduced "deficit" in knowledge • Belief that reduced deficit leads to better decisions and often better support for science	**D. Public engagement model** •Focuses on policy issues involving scientific and technical knowledge • Tied to the democratic ideal of wide public participation in the policy process • Builds mechanisms for engaging citizens in active policy-making • Real public authority over policy and resources

Figure 2.4: Information Delivery and Public Participation Models of Science Communication
Adapted from *Brossard and Lewenstein (2010)*

On the other hand, the lay-expertise and public engagement models are non-traditional because they strive for more bi-directional information delivery from the experts to the public and vice versa. Similarly, Brossard and Lewenstein think of these two models in line with the end goal of enhancing public participation in science. The obvious takeaway from these groupings of the four models is that in choosing a specific model category, the science communicator presumes to attain a particular purpose (of delivering knowledge or engaging their audience). The aim will inform the information delivery style (either one-way or bi-directional). This fact was key in this study, which sought to explore crop scientists' communication of scientific information on GM food to maize farmers and its impact on their attitudes and actions toward GM food crops. These models helped explain how the scientists researching GM food crops in Kenya conceptualise communication of the knowledge generated by their research to the farmers and how this conceptualisation, in turn, informed the framing of GM food messages and the reception by the farmers.

It is important to note that there has been a consistent debate on the persistence and relevance of the deficit model. Recent discussions have focused on providing an alternative to the deficit model by proposing more bi-directional models. Pouliot and Godbout's *Thinking Outside the "Knowledge Deficit" Box* offers two models: the public debate and the co-production of knowledge models (Figure 2.5 below). They argue that the models can enhance public debate about science and involve the public in forming 'research collectives' and producing legitimate knowledge (2014, p. 833).

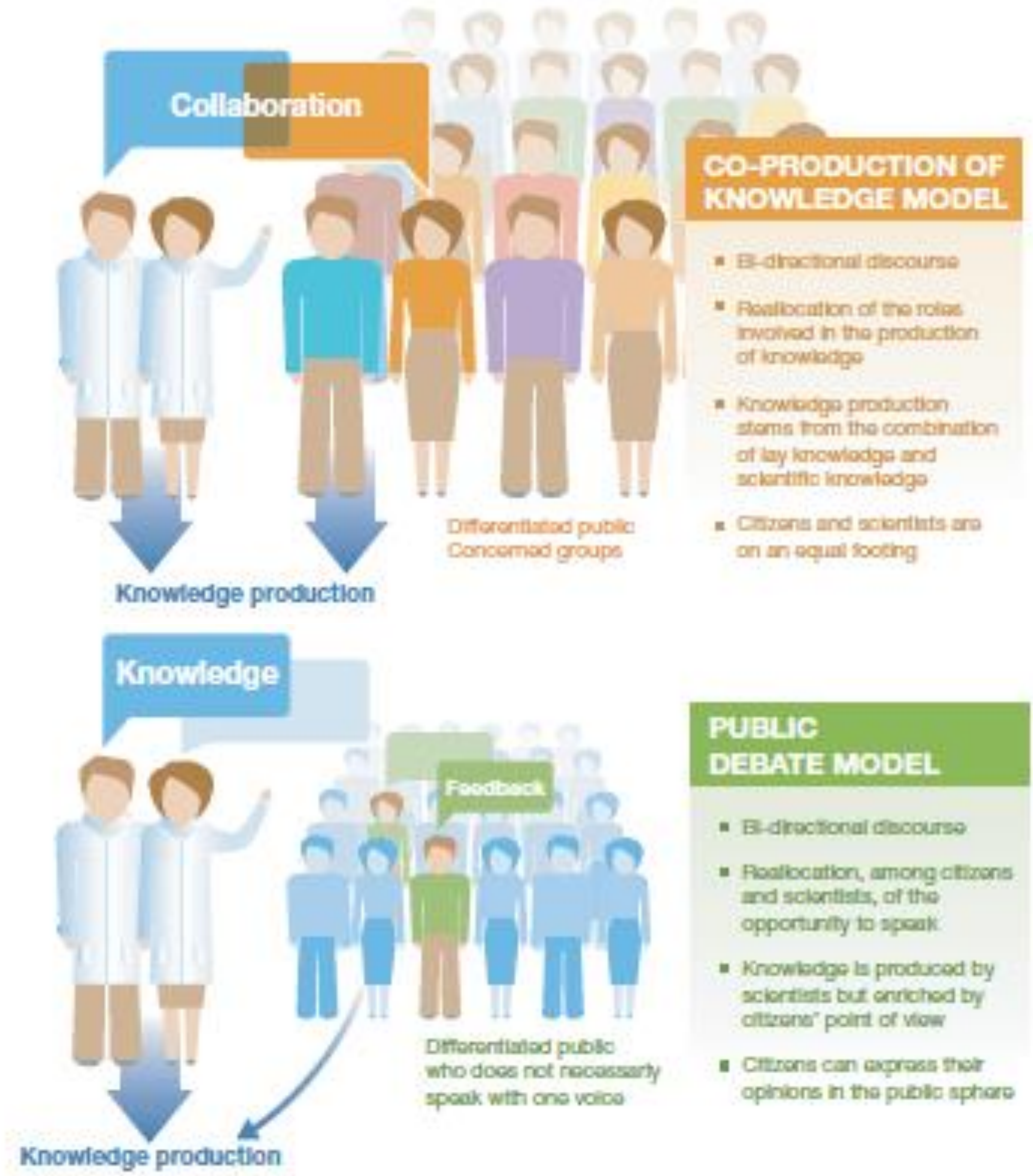

Figure 2.5: The Public Debate and the Co-production of Knowledge Models of Science Communication

***Source**: Pouliot and Godbout (2014)*

Still, the deficit model of science communication cannot be wholly ignored because some of its assumptions, such as the need to provide public education on science, are relevant. This study assumed that since genetic modification of food crops is relatively new, farmers may have limited knowledge about it and, therefore, would need to improve their awareness and understanding of GM technology and food and that if scientists share this perception, they will include a top-down approach to their communication.

Another discussion of the models of science communication is in Trench 2008's *Towards the analytical models of science communication*. The author discusses only three models: the deficit, the dialogue, and the participation models, and argues that the contextual model can be considered to be included in the dialogue model. He aimed to develop what he labelled the analytical framework of the science communication models (Figure 2.6)

Base communication models	**Ideological and philosophical associations**	**Dominant models in PCST**	**Variants on dominant PCST models**	**Science's orientation to public**
Dissemniation	Sceintism Technocracy	Deficit	Defence Marketing	They are hostile They are ignorant They can be persuaded
Dialogue	Pragmatism Constructivism	Dialogue	Context Consultation Engagement	We see their diverse needs We find out their views They talk back They take on the issue
Conversation	Participatory democracy Relativism	Participation	Deliberation Critique	They and we shape the issue They and we set the agenda They and we negotiate meanings

Figure 2.6: Analytical Framework of Science Communication Models
Source: Trench (2008)

Trench explains that the deficit and dialogue models are more linear since they represent one-way and two-way information delivery. In contrast, the participation model is multidirectional since it represents three-way information delivery such that communication occurs between experts and the public and between the public and the public. According to him, the main objective in the dialogue may be the applications of science, while in the participation model, the objective is the implications of science. Regarding the application of and the relevance of the models in science communication projects, he observes that:

> All three will continue to have their uses in particular circumstances. In an extended communication project or in an unfolding public debate, participants may move from one approach to another. However, as a general observation, […..] communication processes become more open-ended and more open to values as well as facts in the transition from deficit to dialogue and participation (p. 13)

His observation aligns with the decision to use the four models of science communication as the theoretical framework in this study, as explained earlier.

It is important to note that, as discussed earlier in this chapter, Kappel and Holman's public participation paradigm of science communication differentiates between dialogue and deliberation in science communication. They argued that both encourage public participation, but the deliberative science communication process can be more participatory than dialogue. Generally, the discussion of the models of science communication continues to centre around the information delivery/dissemination models and public participation/engagement models. Despite the criticisms of each model of science communication, each has some assumptions that are too tangible to ignore.

More recently, Reincke, Bredenoord, and Van Mil (2020) discuss only two models – the deficit model and the dialogue model of science communication- in their publication: From Deficit to Dialogue in science communication. In line with our discussion of the four models, the authors point out that the deficit model assumes a one-way flow of information from the scientists to the laypersons and that more scientific literacy or knowledge will induce a positive attitude concerning science. To them, the alternative to the deficit model, which they claimed is becoming obsolete, is a more bi-directional form of science communication in the form of the dialogue model. The dialogue model discussed by Reincke et al. seems to combine the three other models already discussed in this chapter: the contextual, the lay-expertise, and the public engagement models. Specific to their discussion is the importance of other forms of knowledge apart from scientific knowledge, insisting that different factors such as culture, (religious) beliefs, and personal experiences contribute significantly to how scientific knowledge is understood by a given (audience) public (p. 1).

In providing relevance to the Dialogue model in science communication, Reincke et al. (2020) point out that some complex societal issues, such as human genetic germline modification (HGGM), can impossibly be dealt with by using only scientific knowledge. Science may offer insights into possible risks and benefits of modifying the human germline, but not in the individual or social meaning assigned to its risks and benefits. For example, there may be differences regarding how we value health and disease that are, to some extent, influenced by factors such as culture, (religious) beliefs, and personal experiences. Another example is the introduction of cochlear implants to correct deafness in young children, which was criticised heavily by the deaf community. In its specific culture and social bonding, the community thinks deaf children are perfectly healthy and sees no reason to operate on them. This concern can only be addressed if there is a dialogue/debate between experts and the community involved.

The same can be said regarding the communication of GM food crop information; studies have reported that public perceptions and attitudes toward GM food are influenced by their concerns over perceived risks to human health and the environment and ethical concerns. The dialogue model allows for a scientist–farmers dialogue that may help bring to light the farmers' concerns regarding what science is proposing. A key feature of science communication based on the dialogue model is mutual learning (McCallie et al., 2009).

For this reason, science communication based on the dialogue model foregrounds a two-way flow of information from experts to laypersons and vice versa (p. 2). The authors clarify that the most crucial component of the dialogue model is learning with and from each other by exposing different views, values, experiences, and concerns. These authors explain that the dialogue model requires additional roles from scientists: sharing well-received input, listening to and learning from the input of others, and investing in relationships with others. Still, the dialogue model seems to encompass the assumptions of the contextual, lay expertise, and public participation models; this is also reflected in Trench's analytical framework of the science communication models discussed above.

Generally, the different ways of looking at the models of science communication seem to still zero into the four models earlier discussed. Criticisms for models exist and are justified, but their assumptions may still prove valid in achieving the objectives of science communication reflected in the AEIOU analogy. Thus, it could be argued that all the models can still prove useful depending on science communication's objectives. In this regard, this study used the four models: the deficit, contextual, lay expertise, and public participation as its framework in attaining the purpose of this study: exploring the crop scientists' communication of GM food information to maize farmers and its impact on their attitudes toward GM food. I worked under the assumption that scientists could move between the assumptions of the four models depending on the purpose they intended to achieve when communicating with the farmers.

2.7 Summary

In this chapter, I reviewed the literature on science communication and the communication of GM food information and discussed the theoretical framework that steered the study. I have discussed the various definitions of science communication and adopted the vowel (AEIOU) analogy in defining science communication and the mountain climbing analogy in explaining the process of science communication (both proposed by Burns et al., 2003). I have established that science communication, like the communication of GM food information to farmers, should be aimed at achieving some or all of the aims stipulated in the vowel analogy. I have also discussed science communication as a field of study and research, highlighted the two paradigms in science communication, and linked science communication with the present and with communication studies.

I also reviewed the literature concerning the public need and access to GM food information and public awareness and perception of GM food. The consensus in the literature is on the need to improve public education on GM food to improve their knowledge and awareness. I finally reviewed studies specifically from Africa and Kenya on GM food and public engagement. The general observations were: first, studies have not investigated the crop scientists' communication of scientific information on GM food to the public in its own right; secondly, the public has poor knowledge of GM food, but the role of information they access on their knowledge is unclear; and thirdly, there is a need to improve communication of GM food information to improve public understanding, perception, and acceptance of the technology and its products. I also summarised the gaps identified from the literature, which justified what this study intended to achieve: exploring the crop scientists’ communication of GM food information to maize farmers and its impact on their attitudes toward GM food.

I also discussed the theoretical framework which guided this study. The theoretical framework is based on the four models of science communication: the deficit, contextual, lay-expertise, and public engagement/participation models that were used to analyse the scientists' communication of GM food information to the farmers as well as the influence of this communication on the farmers' attitude and towards GM food crops.

I have noted scholars' consensus on the science communication models in moving away from a one-way flow of information (specifically, the deficit model) to a more bi-directional flow of information in which the public has as much to learn from the experts as to communicate. However, evidence from the literature (as presented in this chapter) shows that the deficit model persists despite criticisms. The deficit model can, therefore, be considered similar to the case of the baby with the bath water. Indeed, the deficit model seems to survive as the effective underpinning of much science communication (Trench, 2008) because there might still exist cases where scientists communicate science to the public intending to pass knowledge. Indeed, the first "A" in our vowel analogy (AEIOU) [which represents what the science communication process should aim to achieve] is awareness. This means science communication may seek, among other purposes, to create awareness among the public members. This was specifically relevant to this study since it helped to explain how the scientists' conceptualisation of the communication of GM food information to the farmers informed their communication initiatives.

Therefore, this study employed all four science communication models to explain the findings. In line with Lewenstein (2003) and Trench (2008), I argue that several models of science communication can coexist in science communication endeavours. As Lewenstein clarifies, these models provide only a schematic tool for understanding public communication of science activities and that, in practice, many activities combine elements of the different models. Indeed science communication process may aim to achieve some or all of the (AEIOU) responses from the public.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, I discuss the methodology used in this study. I first explain the philosophical underpinning adopted in this study. I then present the research approach and design adopted by the study before explaining the study population and the sampling procedures employed in drawing the study participants. I end the chapter by discussing fieldwork procedures, data analysis techniques, and ethical considerations.

3.2 Research Philosophical Paradigm

Krauss (2005) cites Guba and Lincoln (1994:105), who define a paradigm as the basic belief system or worldview that guides the investigation. It is related to the way of looking at the world. It is the worldview – a way of thinking about and making sense of the world's complexities (Patton, 2002, cited in Kaushik and Walsh, 2019). Creswell and Creswell (2018) also use the word worldviews and explain that it is a general philosophical orientation about the world and the nature of research that a researcher brings to a study. The authors explain that Individuals develop worldviews based on their discipline orientations, research communities, advisors and mentors, and past research experiences (p. 44). Creswell and Creswell (2018) further clarify that individual researchers' beliefs based on these factors often lead them to embrace a strong qualitative, quantitative, or mixed methods approach (p. 44).

In this study, I used philosophical research paradigms to refer to the researcher's worldviews (similar to Creswell and Creswell 2018), their conception of reality (ontology), the nature and forms of knowledge/reality (epistemology), and how reality can be comprehended/conceptualized (issues related to why, what, from where, when and how data about reality can be generated, analysed and discussed – methodology). Indeed, Scotland (2012) considers a paradigm to consist of ontology, epistemology, methodology, and methods. According to him, ontological assumptions are concerned with what constitutes reality. On the other hand, the epistemological assumptions are concerned with the nature and forms of knowledge and how knowledge can be created, acquired, and communicated (what it means to know) (Scotland, 2012, p. 9). Scotland considers methodology to be the strategy or plan of action which lies behind the choice and use of particular methods dealing with why, what, from where, when, and how data is collected and analysed. According to him, methods are the specific techniques and procedures used to generate and analyse data (p. 9).

The present study adopted pragmatism as a philosophical research paradigm because of its assumption that there can exist one reality but, at the same time, multiple ways of interpreting this reality by an individual. Saunders et al. (2009) explained that pragmatism implies that reality is external and multiple at the same time and that a researcher chooses the view that best serves their research purposes. The pragmatic approach to research is informed by the idea that the practicalities of research are such that it cannot be driven by theory or data exclusively, and a process of abduction is recommended, which enables one to move back and forth between induction and deduction through a process of inquiry (Morgan, 2007). Morgan views pragmatism as a basis for supporting work that combines qualitative and quantitative methods and as a way to redirect our attention to methodological rather than metaphysical concerns. Krauss (2005) argued that pragmatism implies that pragmatic research is "intersubjective," which means being subjective and objective at the same time, accepting both the existence of one reality and that individuals may have multiple interpretations of this reality. As Creswell and Creswell (2018) put it, the researchers focus on the methods rather than the research problem and questions while using all available approaches to understand the problem. The authors explain that this paradigm, which is the philosophical underpinning for mixed methods research, conveys its importance for focusing attention on the research problem in social science research and then using pluralistic approaches to derive knowledge about the problem (p. 48).

It is in light of the above views the farmers' access to and utilization of scientific information on GM food could be better understood by focusing on the problem (i.e., issues surrounding the communication of scientific information on GM food) and using different approaches to understand it. It allows for analyzing the facts and the varying views of those involved (the crop scientists and maize farmers). This study does not give in to the debate between qualitative and quantitative approaches. I instead embrace the two approaches to help understand the crop scientists' communication of GM food crop information to the farmers better and, in turn, the information accessible to the farmers and its impact on their attitudes toward GM food. As Maarouf (2019) noted, pragmatism is all about what works, mainly referring to the pragmatic theory of truth. Pragmatism is oriented toward solving practical problems in the real world rather than being built on assumptions about the nature of knowledge (Creswell, 2014; Hall, 2013; Shannon-Baker, 2016). Similarly, the current study sought to understand the crop scientists' communication of GM food crop information to the maize farmers in western Kenya and suggest means for improving the communication of scientific information about GM food to the farmers and the general public.

3.3 Research Approach

The research approach entails plans and procedures that include steps from broad assumptions to detailed data collection methods, analysis, and interpretation (Creswell 2014). Creswell explains that the research approach should be informed by the philosophical assumptions adopted by the researcher, the procedures of inquiry (research design), and the specific research methods of data collection, analysis, and interpretation. Since this study was rooted in the pragmatism philosophical paradigm, I adopted a mixed-methods approach to data collection, analysis, and interpretation in exploring the crop scientists' communication of GM food information to the farmers in western Kenya. Mixed methods research is a methodological approach that involves the systematic collection, analysis, and integration of both quantitative and qualitative data to develop a more comprehensive understanding of a research question than might be garnered through quantitative or qualitative methods alone (Creswell and Clark, 2017, p. 1). In explaining the rationale for the mixed methods approach, Creswell and Creswell (2018) noted that:

> Early thoughts about the value of multiple methods—called mixed methods—resided in the idea that all methods had biases and weaknesses, and the collection of both quantitative and qualitative data neutralized the weaknesses of each form of data (p. 51).

As I have noted, this study was guided by the pragmatism philosophical paradigm, the philosophy behind the mixed-method approach. Scholars have observed that pragmatism is considered "the philosophical partner" of the mixed research approach because its underlying assumptions provide the essence for mixing research methods (cf., Denscombe, 2008; Mitchell, 2018). Similarly, Johnson et al. (2007) agree that pragmatism is an advanced philosophy that provides the epistemology and the logic for combining quantitative and qualitative approaches and methods. Therefore, in mixed-methods research, qualitative and quantitative research are combined by collecting, analysing, and integrating qualitative and quantitative data to explain better the problem being studied.

In the current study, I share the core assumption of the mixed methods research approach that mixing quantitative and qualitative methods provides a complete understanding of the research problem rather than using only one type of method (Creswell, 2014; Molina-Azorin, 2016; Creswell and Creswell, 2018). Indeed, as already observed earlier, a mixed methods approach to research can help the researcher neutralize the weaknesses of both qualitative and quantitative approaches. This study sought to understand the crop scientists' communication of GM food information to the maize farmers in western Kenya. I believe that a mixed methods approach would aid this better. That is, mixing qualitative and quantitative research methods could aid in gaining a much more in-depth understanding of the scientists' conceptualisation and framing of the communication of scientific information about GM food to farmers in western Kenya and the impact of the information on farmers' attitudes toward GM food crops.

3.4 Research Design

The research design refers to types of inquiry within qualitative, quantitative, and mixed methods approaches that provide specific direction for procedures in a research study (Creswell and Creswell, 2018). As discussed in the previous section, this study adopted a mixed methods approach; thus, it was mixed methods in design since qualitative and quantitative data were generated, analysed, and integrated. Since the study aimed at exploring the crop scientists' communication of GM food information to the farmers, the mixed methods design was deemed more appropriate because it allowed me to generate qualitative data from the scientists researching GM food crops in Kenya and quantitative data from maize farmers in western Kenya.

Regarding the type of mixed methods design adopted by this study, scholars have discussed different typologies of mixed methods design based on the level of integration. Both Creswell and Creswell (2018) and Guetterman and Fetters (2018) discuss *three core designs in mixed methods designs*: convergent mixed methods, explanatory sequential mixed methods, and exploratory sequential mixed methods. The three types of designs are summarised below based on Creswell and Creswell (2018, p. 52).

Convergent mixed methods - a form of mixed methods design in which the researcher converges or merges quantitative and qualitative data to provide a comprehensive analysis of the research problem. Here, the researcher typically collects both forms of data at roughly the same time [concurrently] and then integrates the information in interpreting the overall results.

Explanatory sequential mixed methods – this type of mixed methods design entails the researcher first conducting quantitative research, analysing the results, and then building on the results to explain them in more detail with qualitative research. It is considered explanatory because the initial quantitative data results are explained further with the qualitative data. It is considered sequential because the qualitative phase follows the initial quantitative phase. This type of design is popular in fields with a strong quantitative orientation; hence, the project begins with quantitative research. However, it presents challenges in identifying the quantitative results to explore further because of the unequal sample sizes for each phase of the study.

Exploratory sequential mixed methods – in this type of mixed methods design, the researcher first begins with a qualitative research phase and explores the participants' views. The data are then analysed, and the information is used to build into a second quantitative phase. The qualitative phase may be used to build an instrument that best fits the sample under study, to identify appropriate instruments to use in the quantitative follow-up phase, to develop an intervention for an experiment, to design an app or website, or to specify variables that need to go into a follow-up quantitative study. Particular challenges to this design reside in focusing on the appropriate qualitative findings to use and the sample selection for both phases of research.

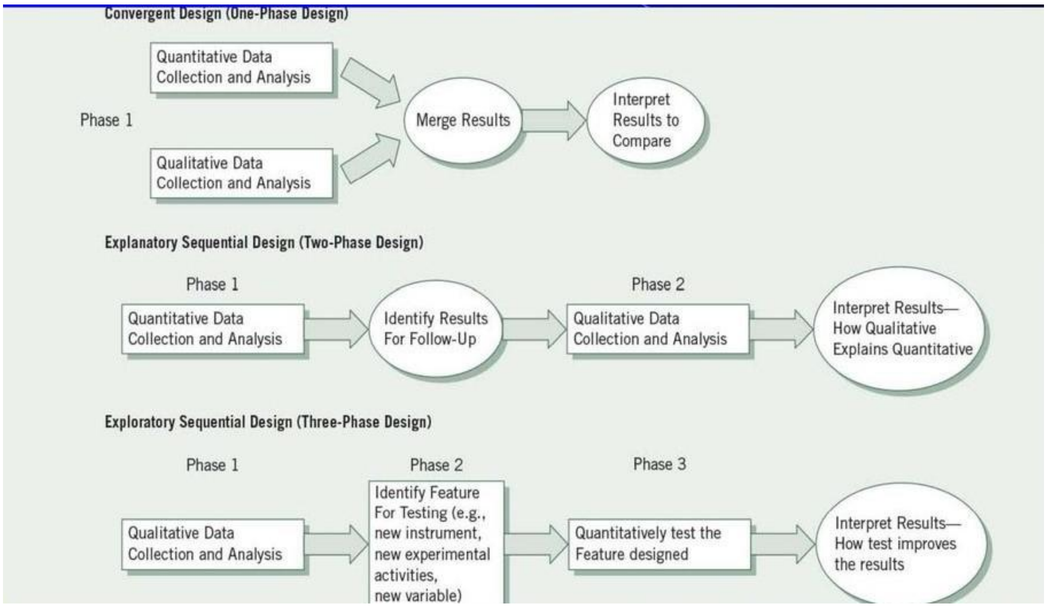

Figure 3.1: Three Core Mixed Methods Designs
***Source**: Creswell and Creswell (2018)*

Therefore, in terms of design, the study adopted convergent mixed methods. I generated, analysed, and integrated qualitative and quantitative data in studying the communication of scientific information about GM food to farmers. In line with the clarification by Guetterman and Fetters (2018), in this study, I generated qualitative and quantitative data concurrently, analysed them, and then integrated them typically to compare or relate results from the two forms of research. In this study, I needed to explore what information is available to maize farmers in western Kenya about GM food, how they access and make sense of GM food information, and how this information influences their attitude towards GM food. This could be better understood if I had a large representative sample of farmers, which could be best studied using a quantitative method (a survey).

On the other hand, I intended to find out how the crop scientists researching GM food in Kenya conceptualise and frame the communication of GM food to the farmers. These scientists are relatively few, and because the study sought their perspective, the qualitative method (key informant interviews) was deemed the most appropriate; hence, my reason for choosing a mixed methods design. Therefore, I concurrently generated quantitative data by administering semi-structured questionnaires to maize farmers in western Kenya and qualitative data by interviewing key informants from crop scientists researching GM food in Kenya. The data were then integrated during the analysis and interpretation phase of the study to provide insights into the issues related to the maize farmers' access to and utilization of scientific information on GM food crops.

3.5 Research Methods

Research methods entail the forms of data collection, analysis, and interpretation that researchers propose for their studies (Creswell and Creswell, 2018: p. 51). Since the study sought to understand how the scientists conceptualize and frame the communication of GM food information to the maize farmers in western Kenya, I chose data collection tools that would allow the generation of relevant data about this communication from the crop scientists researching GM food and the maize farmers in western Kenya. This study used Interviews with the scientists and a survey of the maize farmers as its research methods. Data were presented and analysed using descriptive statistics and thematic analysis. The presentation and analysis were done according to the research question. Additionally, the model of science communication also enlightened the presentation, analysis, and interpretation of the results.

3.6 Population, Sample, and Sampling Techniques

3.6.1 Study Population

The study population refers to all individuals of interest to the researcher, whereas the sample is the subset of the population that the researcher typically studies. This study explored the crop scientists' communication of GM food information to the maize farmers in western Kenya. The study population, therefore, was the crop scientists researching GM food crops in Kenya and the maize farmers in western Kenya. Although GM research in Kenya involves several food crops, I chose to study maize farmers because maize is the staple food crop in Kenya. Still, evidence shows that the production does not meet the country's demand (cf., Mbugua-Gitonga et al., 2016) and that GM technology could partly solve some of the challenges in agriculture (Gheysen et al., 2019). Besides, GM food continues to attract a polarizing debate in Kenya focused on safety concerns, making it important to study the type of information accessible to the farmers. Therefore, maize farmers from western Kenya were surveyed to determine the nature and quality of GM food information they access (communicated to them) and the impact of the information on their attitudes toward GM food crops.

On the other hand, scientists researching GM food were expected to help provide insights into their approaches to communicating GM food information from their research to the farmers. Specifically, the study sought to find out how they conceptualised and framed this communication and the challenges that could be involved. Since the target population was large and I could not study all of it, I chose a representative sample from this target population. More on the sample and the sampling techniques employed are discussed in the following section

3.6.2 Sampling Procedures

A sample is a group of participants the researcher actually examines in an empirical investigation (Dörnyei, 2007, p. 97). I employed probability and non-probability sampling techniques to obtain the relevant participants for this study. In this study, I generated data from two groups of participants: maize farmers from western Kenya and crop scientists researching GM foods in Kenya.

Regarding the first set of participants, the study employed multistage sampling techniques in sampling maize farmers from western Kenya. First, I purposively sampled Uasin Gishu and Trans-Nzoia counties because the counties are termed Kenya’s food basket in maize production (cf., Mbugua-Gitonga et al., 2016). Then, sample frames for farmers in Uasin Gishu and Trans-Nzoia were obtained from the Cereal Growers Association (CGA) and the Trans-Nzoia County’s agriculture department, respectively. Since I could not reach all the farmers in the two counties, I grouped them into clusters according to their sub-counties. Then, from these clusters, three sub-counties with many farmers (from each county) were purposively selected as sampling units to represent the farmers in the two counties. Then, from each of the selected sub-counties (six), the actual sample used in this study was obtained through systematic random sampling. From Uasin Gishu, the actual sample was obtained from

Moiben, Ziwa, and Soy sub-counties. On the other hand, those from Trans-Nzoia were obtained from Cherangany, Kwanza, and Saboti sub-counties (cf., Table 3.1).

Table 3.1: General Farmer Participants' Characteristics in the Six Sub-counties

Sub-county		Moiben	Soy	Ziwa	Cherangany	Kwanza	Saboti
Sample size (n=298)		**48**	**48**	**45**	**61**	**46**	**50**
Age	18 - 23 Years	0	0	0	1	2	2
	24 - 29 Years	1	1	0	13	6	4
	30 - 35 Years	4	0	3	8	5	8
	36 - 41 Years	2	1	1	12	7	8
	42 - 47 Years	12	11	10	14	11	9
	48 - 53 Years	5	16	13	7	6	9
	54 and Above	24	19	18	6	9	10
Gender	Male	44	45	42	47	36	39
	Female	4	3	3	14	10	11
Size of land farmed	<1 Acre	0	0	0	2	3	2
	1 - 10 Acres	2	1	5	35	28	37
	11 - 20 Acres	19	5	8	9	6	6
	21 - 50 Acres	15	17	27	7	9	3
	50 - 100 Acres	9	17	4	4	0	2
	> 100 Acres	3	8	1	4	0	0
Level of Education	Primary	9	15	13	7	6	11
	Secondary	20	21	24	25	19	23
	College	7	9	6	22	12	8
	University	12	3	2	7	7	8
	No Education	0	0	0	0	2	0

Table 3.1 above shows maize farmer respondents' characteristics in the six sub-counties. A larger proportion of farmers (144 out of 298) were 48 years or above. As for their education level, 132 farmers had attained secondary education, whereas 103 out of 298 had attained either college or university education. Sixty-one farmers had attained primary education, whereas only two reported no education. As for the size of land farmers, the respondents consisted of both small-scale and large-scale farmers. One hundred eight farmers reported farming between one and ten acres, whereas 78

and 53 farmers reported farming 21 - 50 acres and 11 - 20 acres, respectively. Thirty-six farmers farmed between 50 and 100 acres, whereas 16 farmers reported farming more than 100 acres. Only seven farmers reported farming less than one acre of land. Generally, most farmers (157 out of 298) reported farming 11 acres or more. As for the level of education reached, the farmers ranged from those who had attained a university education to those with no education. Generally, most farmers had attained a secondary, college, or university education.

Concerning the second set of participants, the study used Key Informants from the crop scientists researching genetically modified food in Kenya. A representative sample of the scientists was obtained by using non-probability sampling. The scientists were selected through snowball sampling techniques. I used the snowball sampling technique because the scientists were relatively few and spread throughout the country; thus, locating and reaching them was difficult. So, I identified the first participant (scientist) through the National Biosafety Authority (NBA). After understanding the aim of the study and agreeing to participate in the interview, I requested the participant to refer me to another crop scientist researching GM food who also did the same, and it went on that way. I targeted 15 key informant scientists researching GM food in Kenya, but the actual sample of scientists used in this study was eight.

Regarding the sample size, I relied on Krejcie and Morgan’s sample size determination table (Bukhari, 2021) to determine the farmers’ sample size. In this study, 298 farmers from Uasin Gishu and Trans-Nzoia formed the study sample of this first set of participants. Of the 298 farmers respondents, 157 (52.7%) were from Cherangany (61), Kwanza (46), and Saboti (50) sub-counties in Trans-Nzoia county, whereas 141 (47.3%) were from Moiben (48), Soy (48), and Ziwa (45) sub-counties in Uasin Gishu county. On the other hand, the sample size for the crop scientists was determined by the saturation during the interviews; although I targeted 15 scientists, I attained saturation when interviewing the 8th scientist. Therefore, the study used a total of 306 respondents: 298 maize farmers from six sub-counties of Uasin Gishu and Trans-Nzoia in western Kenya and eight key informants from crop scientists researching GM food in Kenya.

3.6.3 Data Generation Techniques

Since this study employed a mixed methods design, the data were generated through qualitative and quantitative data collection techniques. The quantitative data were generated through a survey with maize farmers from Kenya's Uasin Gishu and Trans-Nzoia counties. On the other hand, the qualitative data were generated through Key Informant Interviews (KII) with the scientists researching GM food in Kenya. More about data generation and the application of these techniques are presented in the following section.

3.6.3.1 Survey with Maize Farmers in Uasin Gishu and Trans-Nzoia

As mentioned earlier, this study was a mixed methods study in design. The quantitative data were generated through a survey with maize farmers in Uasin Gishu and Trans-Nzoia counties. I administered a semi-structured questionnaire to the 298 farmer respondents sampled from the two counties. The questionnaire (see Appendix 1) included both open and close-ended and was divided into four sections. The first section had items about the demographic information of the participants. The second section contained items regarding the farmers’ awareness and knowledge of GM food and their need and access to GM food information. For example, respondents were asked whether they were aware of GMOs, whether they had heard or read about GM food, and their sources of GM food information. The third section was designed to test the farmers concerning how they made sense of and their perception of GM food information communicated to them. The last section of the questionnaire contained items related to the role of GM food information on the farmers' attitudes toward GM technology and food.

3.6.3.2 Interviews with Crop Scientists Researching GM Food Crops in Kenya

The qualitative data were generated through interviews with key informants from crop scientists researching GM food crops in Kenya. The research aimed to understand the scientists' conceptualization of the communication of GM food information to the farmers and the framing of the GM messages that went to the farmers. The study adopted the Key Informant Interview (KII) technique for this purpose. The Interviews (see Appendix 2) were centred on the following issues: the scientists' conceptualisation of the communication of the knowledge generated by their GM food research to the farmers, their framing of GM messages, the approaches to communicating to the farmers, and challenges encountered in communicating to the farmers. I prepared a short list of critical issues related to the above issues as an interview guide as advised by Stake (1995), cited in Jwan and Ong'ondo (2011). The interview questions in the guide were open-ended to afford me flexibility in discussing the scientists' communication of GM food to the farmers in western Kenya. Before the interview, I shared a brief introduction of the study and the objective of the interview. The interviews were kept to a maximum of 60 minutes, as Jwan and Ong'ondo (2011) suggested, and were audio-recorded using a digital voice recorder.

3.7 Field Work Procedures

The fieldwork for this study involved administering questionnaires to maize farmers and conducting interviews with the scientists. The questionnaire was administered to maize farmers selected from the two counties. Before administering questionnaires, I recruited and trained four research assistants from the two counties to assist in the process. One of the requirements in selecting the assistants was the ability to speak and understand English, Kiswahili, and Kalenjin, the dominant language for most farmers in the study. The ability to speak and understand the local language allowed the assistants to explain the questionnaire items to the respondents using the local language when required; indeed, most farmers needed this explanation during the data generation process. I explained the research objectives to the assistants and took them through the questionnaire to help them familiarize themselves with and understand the demands of each item. I also explained the sampling procedures to be applied during the fieldwork. For example, Moiben's questionnaire was to be administered to every other farmer on the list from the starting point (the starting point was the second farmer on the list). In contrast, in Cherangany, it was administered to every 4th farmer from the starting point on the list (the starting point was the first farmer on the list). If a farmer were unwilling to participate in the research (participation was voluntary) or unavailable, the next farmer on the list would be selected.

When administering the questionnaires, the farmers were required to first respond to the question, "Have you heard or read about GM food or GMOs?" to determine if they were eligible for participation in this study. This requirement emanated from the fact that most of the data required from the farmers related to the reception of GM food information. Therefore, if participants reported not having read or heard information about GM food, they were deemed unsuitable for this study; thus, the questionnaire was not administered to them. In this case, the next farmer on the list would be selected. Generally, it was explained clearly to the farmers that participation in this study was voluntary for every farmer. Farmers were free to agree or disagree to participate in responding to the questionnaire. They were also free to withdraw their participation from the study whenever they wanted. Farmers were asked to be free to respond to the question according to their understanding because their opinion was important and there were no wrong or correct answers.

Key Informant Interviews (KII) involved scientists researching GM foods to understand how they conceptualised and framed the communication of GM food information to the farmers and the challenges involved in the communication process. The scientist was first identified, and then I initiated communication to introduce myself and request their participation by explaining the study's purpose and the interview's objectives. After agreeing, the interview date was discussed, and the interview guide was shared. All the interviews were conducted via video conference using *google meet* at the request of scientists. The scientists' requests were mostly grounded on the new “normal” created by the Covid-19 pandemic, which prohibited unnecessary physical contact. Therefore, before the interview, the scientists provide verbal consent for their participation and for the interview to be audio-recorded. They, too, were free to withdraw their participation from the study whenever they felt like it.

3.8 Data Analysis

Regarding the analysis of quantitative data from the questionnaire, before processing the responses, data preparation was done on the completed questionnaires by cross-checking for their completeness. Then, the questionnaire responses, which were precoded before administration, were entered into Statistical Package for Social Scientists (SPSS) software version 20 to allow for the descriptive statistics analysis.

As for the qualitative data from the interviews, this study adopted the general steps in qualitative data analysis suggested by Creswell (2014). These are (1) organizing and preparing the data for analysis – involving transcribing interviews, (2) reading or looking at all the data to get a general sense of the information and an opportunity to reflect on its overall meaning, (3) coding all the data, organizing the data by bracketing chunks (or text or image segments) and writing a word representing a category in the margins, (4) using the coding process to generate a description of the setting or people as well as categories or themes for analysis, (5) advancing how the description and themes will be represented in the qualitative narrative, and (6) making an interpretation of the findings or results - asking, "What were the lessons learned?"

On the coding step, Cresswell (2014) highlights three scenarios: (a) where the researcher develops codes only based on the emerging information collected from participants, (b) where the researcher uses predetermined codes and then fits the data to them, and (c) where the researcher uses some combination of emerging and predetermined codes. Given the nature of the data needed to understand the crop scientists' conceptualisation and framing of the communication of GM food information to the farmers, a combination of emerging and predetermined codes was used. Therefore, the analysis in this study involved descriptive statistics analysis for the quantitative data and thematic analysis for the qualitative data. During the analysis and interpretation, the qualitative and quantitative data were integrated to help understand the crop scientists' communication of GM food information to the maize farmers in western Kenya and the impact of the accessible information on the farmers' attitudes toward GM food crops.

3.9 Ethical Considerations

Concerning ethical issues before, during, and after research, researchers should generally observe their trust and that of the participants, data protection, and avoid any misconduct that in one way or another would harm the participants. Thus, I adhered to all ethical requirements in this study, including protecting the participants. I first sought research clearance from the School of Information Science, Moi University, and then from Kenya's National Council of Science, Technology, and Innovation (NACOSTI). I also requested research clearance and authorization from the education directorates in Uasin Gishu and Trans-Nzoia counties, where the questionnaires were administered. In addition, I sought permission from the Cereal Growers Association (CGA) and Trans-Nzoia County's agricultural directorate to use their list of registered maize farmers from Uasin Gishu and Trans-Nzoia, respectively, as the sampling frame for maize farmers. Furthermore, participation in the research was entirely voluntary; every participant was free to participate and withdraw whenever needed.

Participant anonymity and confidentiality were also observed in that no participant was required to write their names anywhere in the questionnaire, so their responses did not bear names. On the other hand, the scientists required that their names and those of their institutions not be mentioned anywhere. I ensured this; therefore, although the scientists became known to me in some capacity, confidentiality was offered because neither the interview transcripts nor the research report disclosed their names or institutions. The scientists also required the interviews to be conducted via video conference to adhere to health protocols instituted because of the Covid-19 pandemic. Therefore, I ensured this requirement by conducting the interviews via google meet.

3.10 Summary

In this chapter, I have presented the methodology employed in the study. I first discussed the philosophical paradigm adopted and explained the justification for rooting the study in the pragmatism philosophy. I have also shown that the study adopted a mixed methods approach because it was thought to help me gain an in-depth understanding of the communication of GM food information to the farmers. As for the design, the study used a convergent mixed methods design, concurrently collecting qualitative and quantitative data and integrating them during analysis. In this chapter, I also discussed the techniques used in obtaining the sample of maize farmers in western Kenya and the crop scientists researching GM food in Kenya. I explained that I purposively selected Uasin Gishu and Trans-Nzoia because they are considered Kenya's food basket in maize production. The farmers in the two counties were then put in clusters of sub-counties, and then three sub-counties with the most farmers from each county were selected as sampling units. Systematic random sampling was then applied to select a total of 298 farmers. As for the scientists, the snowball sampling technique was used. The chapter then presented the data generation techniques: questionnaires for the maize farmers and interviews with the key informant scientists. I then explained the fieldwork procedures before concluding the chapter with ethical considerations.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION, AND DISCUSSION

4.0 Introduction

This study was about access to and utilization of scientific information on GM food crops among maize farmers in western Kenya. It aimed to explore the scientists' communication of GM food information to the maize farmers and its impact on their attitudes towards GM food crops. Specifically, the study sought to answer four research questions: How do the scientists conceptualise and frame the communication of GM food crop information to the farmers in Western Kenya? What information is available to farmers in Western Kenya regarding GM food crops? How do farmers in Western Kenya access and make sense of information on GM food crops? How does the accessible information influence the farmers' attitudes toward GM food crops? To answer these questions, I administered a semi-structured questionnaire to 298 maize farmers sampled from Uasin Gishu and Trans-Nzoia counties. I also interviewed key informants from crop scientists researching GM food crops in Kenya. The questionnaire responses were coded and entered into SPSS to allow for descriptive statistics analysis. On the other hand, interviews were transcribed and coded based on the combination of predetermined and emerging themes to allow for thematic analysis.

In this chapter, I analyse, present, and discuss the findings of this study. The chapter is divided into two sections: data analysis presentation and discussion of findings. First, I present the analysis of the data based on the research questions, which were:

i. How do the scientists conceptualise and frame the communication of GM food crop information to the farmers in Western Kenya?
ii. What information is available to farmers in Western Kenya regarding GM food crops?
iii. How do farmers in Western Kenya access and make sense of information on GM food crops? and
iv. How does the accessible information influence the farmers' attitudes toward GM food crops?

In addition, the analysis is enlightened by the four models of science communication – the deficit, contextual, lay expertise, and public participation which guided the study. In the second part, I discuss this study's findings based on their implication and relation to the previous studies' findings. I also discuss their implication to the models of science communication and communication of GM food information to farmers and the wider public.

4.1 Strategies Adopted by Scientists to Engage Farmers on GM Food

In this section, I present and analyse findings related to the study's first research question: *How do the scientists conceptualise and frame communication of GM food crop information to the farmers in western Kenya*? To understand how the scientists conceptualise and frame communication of GM food information, I interviewed crop scientists researching GM food crops in Kenya. The interview aimed at exploring the scientists' opinion about sharing the knowledge generated by their research with the farmers, the scientists' targeted audience for this knowledge, the scientists' framing of the GM food crops messages that went to the farmers, the approaches to communicating to the farmers, and the challenges encountered when communicating to the farmers and the public in general about GM food. Interview data were transcribed, coded into predetermined and emerging themes, and thematically analysed.

Generally, this study's results revealed that the scientists aim to communicate the knowledge generated by their research to various key stakeholders, including fellow scientists (scientific community), law and policymakers, seed companies, farmers, and the general public. They also consider the communication of GM food information important because it helps improve public awareness and knowledge of GM food and address their concerns about GM food crops and misinformation surrounding GM food.

4.1.1 Targeted Audiences for GM Food Information Generated by Scientists

During the interviews, I explored scientists' Conceptualisation and framing of the communication of the knowledge generated by their research to the farmers. I wanted to know what the researchers did with the knowledge they generated from their research, their opinion about communication of this knowledge, and ultimately, how they framed their messages for farmers. Regarding this, the results indicated that the scientists communicated this knowledge to various groups of audiences, including the general public, as seen in the words of one scientist who said:

> Partly, we communicate the knowledge we generate in what we call layman's reports in Newspapers. Only last year, we had training on how to communicate our research findings. So, we use media like Twitter and local channels like national print. So, we kind of present a layman's summary and try to educate the public. Also, we write articles and also collaborate with the National Biosafety Authority, who sometimes approaches us to forward articles for their newsletter. (Interview with crop scientists researching GM food in Kenya, July 2022)

Scientists also indicated that they shared the knowledge generated by their research on GM food crops with the scientific community through the publication of scientific research articles. They also shared the knowledge from their research with the non-scientific community through various means, such as media outlets like newspapers, Twitter, and other local channels. They also said they share their findings with regulatory authorities in Kenya. Scientists indicated that the ultimate goal when communicating GM food information from their research is to educate the public.

However, when responding to questionnaires (as discussed later), farmers lamented the lack of communication from the scientists, noting that they do not have reliable information from individuals or institutions concerned with GM food crops. Farmers said most of the information they have about GM food crops comes from hearsay, making it unreliable. Indeed, as elaborated later (see Figure 4.1), farmers ranked "*friends*" second in terms of their sources of GM food information. Regarding media use, the scientists indicated that they communicated through newspapers, which may be accessible only to some farmers, especially the elite. Similarly, they said they used social media, which could also be termed an ineffective means of reaching most farmers. Indeed, farmers ranked the internet very low in terms of sources of GM food information (as discussed later), implying that it is not a very appropriate means of reaching the farmers.

Since the scientists said they communicated the knowledge generated from their research to various audiences, including the scientific community members and the general public, including farmers, I asked them to identify the immediate targeted audience for the knowledge generated by their research. The findings of this study revealed that the primary audiences for this knowledge ranged from farmers to researchers to policymakers.

Farmers

The scientists researching GM food crops in Kenya reported that farmers were the primary target in their communication, and they consumed the knowledge generated from their research through various channels. According to them, most of their research was on food crops; therefore, they targeted farmers who would be GM food crops' immediate beneficiaries and consumers. In explaining the targeted audience, one scientist used the following words during the interview:

> "[…..] I would say the number one target audience is farmers because the genetic modification of food crops is known to have had a great impact on the development of the agricultural sector. So, farmers are the greatest beneficiary; they form part of the audience since there is a need to educate them on these emerging technologies in agriculture. (Interview with crop scientists researching GM food in Kenya, June 2022)

GM food crops researchers indicated that farmers could be both the producers and the consumers of the product of GM technology; thus, it was necessary to target them in communicating GM food crops research output. However, as I will discuss later, findings from questionnaire responses revealed that farmers complained about a lack of reliable information about GM food; they even mentioned that scientists had not reached out to them and educated them about GM food crops. The farmers' complaints could mean scientists did not communicate enough or used the wrong communication approaches to reach the farmers.

As assumed by the deficit model of science communication, the scientist pointed out that acceptance of GM food crops depended on farmers' involvement in ongoing research through clear communication, which will help them understand how the technology can enhance production. They clarified that this communication should give the farmer factual information and thus debunk myths and misconceptions surrounding GM food crops. The following is an extract from the responses of one scientist during the interview:

> [……] you actually have to work on debunking the myth that farmers have developed regarding genetic modification. Because I think there is a lot of miscommunication out there, especially in the media. So, you actually have to give them factual information so that they don't rely on their own knowledge to judge the product. (Interview with crop scientists researching GM food in Kenya, June 2022)

Scientists said that the myths and misconceptions are brought about by the circulating miscommunications about GM food crops, especially in the media. Numerous previous studies have reported miscommunication surrounding GM technology and food crops, similar to the scientists' observation (cf., Gheysen et al. 2019; Kosgey and Cyrus 2019). Farmers also exhibited elements of miscommunication about GM food when I asked them to explain what GM food means to them. They also demonstrated this by reporting that GM food information came from multiple sources with conflicting messages, as discussed later.

The study further revealed that scientists also targeted farmers indirectly by using various stakeholders, such as commercial seed growers, as middlepersons. When talking about the immediate target audience of the knowledge generated by their research, scientists indicated that they shared their findings with various stakeholders, who could then act as middle persons in sharing the information with the farmers, as seen in the following words of a scientist who said:

> The most immediate audience is farmers, but we are bringing in between the commercial seeds growers, who will be able to help us disseminate more information. Scientists may not even get enough time to go to the field and explain to farmers the importance of these crops and the benefits of genetically modified products, so we partner with these companies. (Interview with crop scientist researching GM food in Kenya, June 2022)

The use of middle persons could be said to create room for misinformation and miscommunication. It could also deny farmers first-hand information and interaction with crop scientists researching GM food crops. Notably, as explained later, the study findings revealed that these stakeholders (commercial seed growers) were not mentioned as the source of farmers' GM food information. Farmers maintained that they had not had responsible parties visit them and explain clearly what GM food entails.

Policymakers and Politicians

Crop scientists researching GM food in Kenya said their research findings were also meant to benefit politicians and the law/policymakers. The study's findings revealed that law and policymakers were among the primary target audiences of the knowledge generated by scientists' research. Scientists reiterated that the policymakers tended to make uninformed decisions that affected the public and the status of GM food in the country. One scientist said the following during the interview:

> In our case, we target mostly policymakers, and to some extent, we target farmers […..], but I would say policymakers are the immediate target audience in our case, and maybe investors. (Interview with a scientist researching GM food in Kenya, July 2022)

The scientists suggested that the politicians and policymakers had no facts regarding GM food crops, which led them to make decisions that affected the status of GM food crops in the country. Therefore, they targeted them with their communication about GM food crops to enhance their knowledge and influence their decisions about GM technology and food crops. Previous studies have also hinted at the uninformed decision by law and policymakers, attributing this to the scientists' inadequate communication of GM food information. For example, Kosgey and Cyrus (2019) blame scientists for their failure to engage the public on GM crops, leading to non-scientific public debate, hence misconceptions about GM crops. Oloo et al. (2020a), on the other hand, call on scientists to inform the political class about GM food to help them make informed decisions.

Researchers or the Scientific Community

The study results also revealed that other scientists' target audience for the knowledge generated by GM food crop research was researchers or the scientific community. During the interview, scientists pointed out that the knowledge generated by their research was intended to inform researchers who wish to conduct further research on GM food crops. According to the scientists, the field of genetic modification of food crops is relatively young and requires them to use research output to enrich the growing scientific knowledge base. Clarifying this, scientists said the knowledge they generate goes first to the scientific community as the immediate target audience before it is later broken down to be consumed by the non-scientific community, including the farmers. The following is an extract from an interview with one scientist:

> [….] the knowledge from the research we do is consumed by different researchers from different aspects of the value chain. Because you see, it is more findings that will be able to build upon research to lead to conclusive findings on GM food that I work with. (Interview with scientists researching GM food in Kenya, July 2022)

Generally, the study results revealed that farmers were among the primary target audiences for the knowledge generated by GM food research. In some cases, farmers were the secondary target audiences of this knowledge. It was realized that farmers were both directly and indirectly targeted by scientists' communication of GM food crop information. Scientists' aims of this communication were to increase the public understanding of GM food crops, debunk miscommunication surrounding GM food crops, and enhance acceptance of the food crops (more about the aims is discussed in the next section). However, findings from questionnaires revealed that farmers did not receive enough communication about GM food crops, especially from the scientists. It also revealed that they relied on unreliable information from various sources, some of which are prone to misinformation (more analysis of farmers' responses is presented later in this chapter).

4.1.2 Scientist's Framing of GM Food Information Shared with Farmers

After the scientists revealed that they shared the knowledge generated by their GM food crop research and discussed the audiences they target, I asked them to discuss how they conceptualised their communication with the farmers and, in turn, how they framed their messages for them. The results revealed that the scientists considered communicating scientific information on GM food to the farmers to be very important since it would help enhance their education, address their concerns, and address the misinformation, making farmers more receptive to GM food.

According to the deficit model of science communication, the science communication process aims to improve the public's knowledge about science, believing that more information will induce a positive attitude toward science. Asked how they conceptualise the communication of their research findings on GM food to the farmers, the scientists pointed, in line with the deficit model's assumption, to the importance and the role this communication can play in the farmers' acceptance of genetic modification technology and GM food crops. They said that sharing GM food information with the public would help improve their understanding of GM food and make them more receptive. Scientists said the public believes GMOs are harmful, perhaps because they do not understand them. They believe they will become more positive once they receive enough information and understand fully. The following extract represents the response of one scientist during the discussion about the conceptualisation of the communication of GM food information to the farmers:

> [.....] I think it is really important because when you give them that information, they get a sense of what actually goes on behind the work. And you find that once they understand, they are more receptive to some of these things. [.......] because some of the concerns that I have actually witnessed over the years is that they kind of feel like genetically modified organisms are bad. They don't actually understand much, but we really try to change their mindset. (Interview with crop scientists researching GM food in Kenya, June 2022)

Scientists said farmers do not understand GM food, leading them to perceive it as bad. Similarly, the study's findings from questionnaires (as discussed later) revealed that farmers corroborated the scientists' feelings regarding the lack of a clear understanding of GM food. They indicated wanting more information from scientists and the government to help them completely understand what GM food entails and address their concerns regarding GM food.

Despite scientists admitting that communicating GM food information to the farmers and the public is important, they also said it had not received enough attention from the scientists involved. As explained later, the farmers' complaints about the lack of reliable information from parties involved in GM food also hinted at this lack of attention. According to the deficit model of science communication, failure in science communication can be blamed on inaccuracies in news coverage and irrational beliefs in the public. The study revealed that scientists believed the farmers had a wrong perception of GM food, which fueled their concerns about GM food. Scientists said these concerns could be addressed by communicating more information to the public to help improve their understanding of GM food.

Scientists further said that delegating this activity (of communicating GM information) to other individuals and groups (such as the media) alone might sometimes lead to loss of information, hence miscommunication. Regarding this, scientists explained that some communicators, for example, media personnel, may (knowingly or unknowingly) send the wrong information to the public. Therefore, they insisted scientists should take a central role in communicating their findings on GM food to the farmers to ensure that what is communicated represents their findings and implications. One scientist said the following regarding the importance of scientists taking a central role in the communication of GM food information:

> [……] I believe some of the information, the right information, might not reach the farmers. We should try as much as possible, even before we send out this information, for example, to the media, to check the words to make sure farmers can get the intended information without losing the intended message. (Interview with crop scientists researching GM food in Kenya, July 2022)

This scientist implies that scientists should become the voice in the information that goes to the farmers. They should, therefore, ensure the accuracy of information when using a middle person such as a journalist.

On the other hand, farmers underscored the importance of media (specifically radio) as a source of GM food information. As discussed later, radio was ranked first in terms of the farmers' sources of GM food. 78.2% of all the farmers indicated receiving the information from the radio. However, farmers still noted that the information accessible does not help them understand GM food more clearly. Scientists' observations on how media handles the communication of GM food information came out in one of the previous studies by Lore et al. (2013). They reported that media coverage of GMOs was not balanced because it was more biased toward negative than positive information about GM food, cementing the need for scientists to ensure farmers get the intended information.

Communication of scientific information in the deficit model of science communication assumes that the public has no scientific knowledge. Similarly, when discussing their conceptualisation of the communication of GM food information to the farmers, the scientists indicated that there is a clear gap between what the scientific community knows and what the public knows regarding GM food crops. Therefore, they said there was a need to increase the communication of information from GM food research to narrow the knowledge gap. One scientist emphasised this during the interview by using the following words:

> [….] I would say it [communication of GM food information] is much needed. Probably there is a need for more communication; there is a gap in scientific communication, and I acknowledge that as scientists, we might not be able to work on the bench and then go back to the farmers and tell them what we are doing. It's very challenging, and in my opinion, we try as much as possible [………] the information we generate is used more by scientists, and we might not have reached directly to farmers. The available platforms may be quite limiting. I would say, in my opinion, there is a need for more of us to engage in communicating with the public. (Interview with the crop scientist researching GM food in Kenya, July 2022)

They added that the scientists had not done enough in sharing their research findings with the farmers, indicating that the communication platforms available could be limited for this. The scientists also acknowledged that much of the knowledge generated by their research benefits the scientific community more than the farmers, thus calling for more scientists to communicate with the public. The lack of communication from crop scientists researching GM food may exacerbate misinformation regarding genetically modified organisms (as discussed in Chapter Two and later in this chapter). It may also leave the law and policymakers making un-informed decisions, affecting GM food status. Similar to the results of this study is the observation by Kosgey and Cyrus (2019) that the public engages in non-scientific debate about GM food because of a lack of scientific communication from scientists, leading to the misconception about GM food crops. Indeed, the farmers in this study said during the questionnaire that the information they received was unreliable because the scientists had not visited them to explain what GM food entails (results from the questionnaire are discussed later).

The scientists also indicated that sharing scientific findings with the farmers would help improve understanding and reduce the panic and misinformation surrounding GM food. In line with Kosgey and Cyrus (2019), scientists in this study said that politicians are the ones who come up with laws about GM food and that these laws are based on their perception rather than scientific facts about GM food crops. The following words were extracted from the interview with one of the scientists:

> [……] One of the biggest problems we have is that politicians or legislators in the parliament are the ones who come up with laws, and it's not based on facts but on their thinking and their own opinions. I think we have been lacking scientists at the frontline when it comes to advising the government and the ordinary people, like, say, farmers. They need to be told the risks and benefits of GM food. […….] I think scientists need to take the platform and explain these things to these people and open their minds. The panic and misinformation circulating out there are actually not true. (Interview with crop scientists researching GM food in Kenya, June 2022)

There seems to be a lack of interaction between crop scientists researching GM food crops in Kenya and the government, leading to a situation in which science does not inform policy decisions. Scientists also apportioned themselves a part of the blame for the misinformed decision by the politicians, citing that they have not been on the front line in communicating scientific information about GM food and in advising the government and the public about GM food. Similar to these results, Oloo et al. (2020a) observed that the political class needs to be convinced by scientists regarding GM food's potential benefits and risks to make informed decisions. The lack of scientists on the front line of the communication of GM food information may warrant misinformation and uninformed decisions based on individual perception. The call by scientists in this study for scientific information on GM food to inform public decisions aligns with the assumptions of the public participation model of science communication.

On the other hand, farmers corroborated the lack of public engagement on GM food affairs, pointing out that scientists do not go on the ground to talk to them about GM food. They said they rely on information from multiple sources with conflicting messages about GM food, some of which confuse them. They also demonstrated a lack of understanding of GM food, especially when they were asked to explain what GM food means to them (I will discuss more about this later in this chapter). Indeed, when defining GM food, farmers pointed out many issues that could be associated with misinformation and miscommunication surrounding GM food. For instance, farmers described GM food as one that causes cancer and abnormality and as research that is tried in Africa by Europeans. These descriptions could be linked with messages spread by anti-GM campaigns that stress the perceived negative aspects associated with GM food.

Generally, the scientists conceptualised the communication of their research findings to the farmers as a much-needed. However, they thought this communication had not received enough attention from the scientists themselves, creating room for misinformation and un-informed decisions. The scientists agreed that communicating scientific research findings regarding GM food to the public required more scientists at the frontline for it to be more effective in increasing the public understanding and addressing their concerns about GM food. According to Burns et al.'s (2003) AEIOU definition of science communication, adopted in Chapter Two, science communication is a process aimed at achieving one or more of the AEIOU responses. Similarly, this study's results revealed that scientists conceptualised their communication of scientific information on GM food as aimed at achieving three objectives: (i) to educate farmers and improve their knowledge about GM food crops, hence making them more receptive to GM food (ii) to respond to farmers' concerns and questions about GM food crops, and (iii) to debunk misinformation surrounding GM food crops. They indicated that this communication would help the public become more receptive to GM food. In line with this, the study revealed that the scientists framed their GM food messages for the farmers aiming to achieve these objectives. On the other hand, the farmers stated that they had not received enough [reliable] information from sources they could trust, such as scientists. Indeed, they indicated that they needed parties concerned with GM food to visit them and educate them about GM technology and food with the information they could rely on.

4.1.3 Scientists' Approaches to Communicating GM Food Crop Messages to Farmers

While discussing the communication of their GM food research findings to the farmers, I asked the scientists to describe the framework for engaging farmers with the knowledge generated by this research. The crop scientists explained several approaches employed in scientists-to-public (farmers) communication processes. Generally, the approaches discussed can be grouped into direct (those involving scientists communicating directly to the farmers) and indirect (involving scientists reaching the farmers through other partners/stakeholders).

Direct Approaches

The study revealed that scientists communicated the knowledge generated by GM food crop research directly to farmers using direct approaches. In these approaches, GM food crop information flows directly from the scientists to the farmers. The approaches also are meant to allow direct interaction between the crop scientists and the farmers, as summarised below.

Field visits. According to the scientists, one of the direct approaches to sharing GM food crop information with the farmers is *field visits* which were applied in two ways. First, scientists would follow farmers in the fields (their farms) to explain their research findings on GM food. During the sharing, farmers were afforded the opportunity to express their concerns and questions for the scientists to address. Secondly, the farmers would be invited to the scientists' research institution. Here, the scientists said they prepared seminars or workshops and allowed farmers to engage with the scientists and, like in the first case, raise their concerns and questions regarding GM food crops, which they wanted the scientists to clarify.

> [.......] We do it through what we call scientists-public participation, whereby we invite them to some conferences or even seminars. We try to break down all these things in a way that they are able to understand without using jargon they don't understand. That is one platform; the other way is, sometimes, we go to the field and engage them [.......]. (Interview with a crop scientist researching GM food in Kenya, July 2022)

Scientists also said they used other materials such as leaflets, recorded videos of the scientist explaining their findings, flowcharts, and sometimes drawings to aid the communication of GM food crop information to the farmers during the seminar/workshop. One scientist said the following during the interview:

> [......] actually, we only have like one-on-one with them, either at the field or we bring them over to the organization where we can have like a whole day's seminar or workshop. We explain what we are doing, have lunch with them, get their concerns, and respond to them. [......] actually, when we have them over, it is more of us hearing from them and responding to their concerns. (Interview with a crop scientist researching GM food in Kenya, July 2022)

According to the scientists, the direct approach allowed them to listen more to the farmers than disseminate information. It also helped them share information addressing specific farmers' concerns. This approach could align with the public participation/engagement model of science communication, which encourages audience participation in the science communication process. It also aligns with the contextual model of science communication's assumption that the audience in science communication is not passive but rather concerned and questioning.

According to the contextual model of science communication, scientific information should be communicated in a way that relates to the intended audience. Similarly, the scientists said when it came to following farmers to the field, they first identified the problem that farmers were facing, which their research would seek to address, then reached out to determine the target group to be engaged. The scientists said they also used this opportunity to find out what farmers already know regarding GM food crops before developing a communication approach that would suit the target group identified. The desire to understand what the farmers know aligns with the lay expertise model of science communication since scientists consider the farmers to have something to communicate to the scientists rather than just being a passive audience. Therefore, scientists said they listened to the farmers during field visits to learn their understanding of GM food crops before framing their messages. However, it is essential to note that, as discussed later, the farmers lamented the lack of direct contact with scientists researching GM food. Indeed, very few farmers indicated accessing GM food crop information from seminars/workshops (10.4%).

Use of agricultural shows and barazas. The study results further revealed that other direct approaches for communicating GM food crop information to farmers used by the scientists were agricultural shows and barazas. Scientists explained that such events were open to the public and allowed scientists to present their findings to the farmers in attendance. The scientists said that similar to seminars and workshops, barazas and agricultural shows allowed them to receive and address farmers' concerns and questions on GM food crops. One scientist used the following words to describe the use of barazas:

> [….] we try to organize public engagement, especially through barazas, to get to meet different stakeholders there from the government, that is, policymakers, students from universities, and also, farmers. So, through such programmes, we are able to communicate what we have from the labs by presenting progress reports regarding the project. So, while presenting, we give them our expectations, and we also try to get expectations from their side. [……] barazas are open to the public because we try to bring in community ownership according to the Kenyan constitution. (Interview with a crop scientist researching GM food in Kenya, July 2022)

This aligns with the contextual model of science communication's assumption that science is communicated to the public as it relates to them and that the public is a concerned participant in the communication process.

On the other hand, farmers indicated having concerns about GM food crops, as discussed later. Still, contrary to scientists' claims that they addressed farmers' concerns, the farmers said that the information they accessed did not address these concerns. As discussed later, the study also revealed that these two approaches were ineffective in communicating GM food crop information to farmers. Indeed, very few farmers (4%) indicated accessing information from barazas, whereas no farmer reported accessing GM food information from agricultural shows. These results suggest that the scientists' assumption that agricultural shows and barazas were open to the public and had farmers in attendance seems questionable. They imply that scientists need to rethink the operationalization of these approaches to ensure that they achieve the intended purpose of public engagement with GM food affairs.

Indirect Approaches

The study revealed that crop scientists' communication of GM food information to the farmers was also done using indirect approaches. The indirect approaches are the ones that do not involve a direct flow of information from scientists to the farmers. These approaches have slim chances for a direct interaction between scientists and farmers. I discuss the indirect approaches used by the scientists below:

Use of partners. In explaining how their research findings on GM food crops were communicated to the farmers, the crop scientists indicated that some communication activities included partnering with various stakeholders who could help disseminate the information intended for the farmers. One of the partners identified by the scientists is commercial seed growers. The scientists said they used this partner as their representative (go-between) in communicating GM food crop information to farmers. The scientists expressed their belief that commercial seed growers could be much closer to the farmers and could, therefore, play a positive role in disseminating the scientists' information about GM food crops to the farmers in different parts of the country. Consequently, the scientists said they shared GM food information with this partner, who was then expected to share it with the farmers they interact with.

However, as pointed out later, farmers' identification of the sources of GM food crop information available to them (see Figure 4.1) did not feature the stakeholders that scientists said they used (commercial seed growers). Farmers’ information sources were predominantly the media and friends.

The study further revealed that, unlike the direct approaches, where scientists intended to listen to the farmers and address their concerns and questions, the indirect approaches were primarily meant to disseminate GM food knowledge to farmers to improve their understanding. This aim of disseminating information reflects the deficit model of science communication's assumption that the focus in science communication should be passing scientific knowledge from experts to the public to improve their understanding and make them more receptive to science.

Peer-to-peer communication. The study also revealed that farmers were sometimes used as a link between scientists and other farmers when communicating GM food information in what the scientists termed a "peer-to-peer communication approach." According to scientists, the peer-to-peer approach involves three stages. First, scientists recruited a few farmers (preferably the leaders of farmers' groups) from various target locations. Secondly, they trained the selected farmers on disseminating information before sharing GM food information with them. Thirdly, the farmers disseminated the GM food crop information to fellow farmers in their respective locations. The scientists indicated that this approach worked well because the trained farmer communicated the information in informal farmers' gatherings called "Kamukunji." During the process, the "farmer communicators" were advised to refer farmers who required further clarification or had concerns and questions about GM food crops to the scientists. The farmers who received information from other farmers were also expected to disseminate it to other farmers, who were also expected to share it with other farmers, and so on. One scientist described the peer-to-peer communication approach by saying:

> "There is one framework that we used and one that is actually being used in another project too [……] it basically involves you [scientist] going out and training, say, like two farmers, and once you have trained them, it is now up to them to train two people who will also train two people. And it goes on that way; it is peer-to-peer training, and in the end, you have more people actually learning about your GM food crop findings. (Interview with a crop scientist researching GM food in Kenya, July 2022)

In line with this, 52% of the farmers reported in the questionnaire responses said that they received information from their friends, who could be assumed to include farmers from this peer-to-peer approach. As discussed later, the farmers also reported sharing the information they received with several other groups, including fellow farmers. It should be noted that this approach could also become a source of misinformation and miscommunication since the message could be watered down as it is passed from one farmer to the next. Indeed, I found from the farmers that only 49% reported understanding the GM food crop information received. Still, at the same time, 80.2% of the farmers reported sharing the same information they accessed, meaning farmers shared information they did not understand with other farmers who perhaps shared it with others, and so on.

It became clear that the scientists did not only focus on informing the farmers about GM food crops (as in the assumptions of the deficit model) but also prepared them for participation in GM food crop research. Public participation is the concern of the public participation model of science communication. This model assumes that the communication of scientific information should be aimed at increasing public participation/engagement in science. According to the scientists, the farmers shared GM food crop information with other community members in the peer-to-peer communication approach. At the same time, they also provided scientists with information about the community involved and helped mobilise the community members to participate in GM food crop research. Although this peer-to-peer communication could facilitate misinformation and miscommunication, it could perhaps eliminate the knowledge gap assumed by the deficit model of science communication.

Use of the media. The study's results indicated that media was another indirect approach to communicating GM food crop information to the farmers used by scientists. The scientists said they used mainstream media such as Newspapers and social media like Twitter to communicate their findings on GM food crops to the farmers, as explained by one scientist during the interview using the following words:

> […..] We normally do public participation and majorly involve, maybe publishing the information [….] I'm working with a government institution, so we normally publish the information in the Kenya gazette, even in mainstream media such as newspapers and television. (Interview with a crop scientist researching GM food in Kenya, July 2022)

As later discussed, the media dominated the farmers' GM food crop information sources, corroborating scientists' reports that they used media to communicate with farmers. However, although media can reach a more significant proportion of public members, it can also be ineffective because some media may still be inaccessible to some farmers. Anti-GM groups can also use the same media, making farmers not know which information about GM food crops is reliable.

Generally, it became clear from the findings of this study that whatever approach was used by scientists in communicating with the farmers, the scientists maintained that farmers ought to be involved from the beginning of GM food research to be able to accept the findings and the products of genetic modification. If farmers are not involved fully in the process, they could likely suspect that scientists were trying to keep something from them and, therefore, would probably reject the outcome. This belief aligns with the assumption of the public participation model of science communication, which encourages public democratisation of science.

4.1.4 Factors Influencing Scientists' Framing of GM Food Messages for the Farmers

During the interviews, I asked the scientists to describe the process of sharing information with farmers regarding how they framed the communication messages regarding GM food. The scientists explained that during the communication process, they made sure that they structured and packaged information so that farmers could access and get the intended message, which was reflected in the scientists' conceptualization of communication of GM food crop information to the farmers. As discussed earlier, scientists conceptualised their communication of GM food information to the farmers as aimed at achieving three main objectives. These include enhancing the farmers' awareness and knowledge of GM food, addressing farmers' concerns and questions about GM food, and debunking the misinformation surrounding GM food to make them more receptive to GM food crops. Therefore, the primary frames used to achieve these objectives were the educational frame, concerns/questions frame, and misinformation frame. It became clear from the findings of this study that several factors influenced these scientists' framing of GM food crop messages for the farmers. These factors are summarised below:

Language

The crop scientists said language is essential when packaging GM food crop information for farmers and the general public. They said that when framing GM food crop messages, they ensure that the language used is non-scientific and free of scientific jargon for the farmers to understand. Scientists explained that framing the messages using plain language helps ensure that farmers understand their messages. Still, at the same time, they have to ensure that dejargonizing the language does not water down the content of the message intended. The following words were extracted from the interview with one of the crop scientists researching GM food crops:

> […….] What we normally do is try to make sure that information that is going to the farmers is information that they can easily understand. […..] We make sure that scientific information remains with us, and we use easy-to-understand language without using common scientific terms. But we have to ensure we don't lose the message in the process. (Interview with a crop scientist researching GM food in Kenya, June 2022)

Similarly, as discussed later, the study findings revealed that most farmers did not identify language as challenging when making sense of the information they received about GM food crops. Indeed, 84.6% of the farmers said the information was in a language they could understand easily. Still, just over half of the farmers (51%) said they did not understand the information they accessed about GM food, which may imply that language is not the only factor in understanding GM food crop information.

The contextual model of science communication requires that scientific information be relatable to the public. Likewise, this study found that apart from easy-to-understand language, scientists sometimes translated the GM food crop message into the local languages of the targeted audience. They explained that translating GM food crop information into local languages helped them reach a broader audience since some farmers were conversant with neither of the two national languages: English and Kiswahili. Therefore, translation made the message intended for farmers more accessible and relatable to as many farmers as possible. However, it was revealed that one possible downside of translating GM food crop messages into the local language is "meaning lost in translation." The message could either lose its quality or be lost altogether due to the lack of equivalent terminologies in the local languages, thus leading to possible miscommunication.

Media availability and accessibility. The study results revealed that another factor that informed the scientists' framing of GM food crop messages to the farmers is the question of what media is available and accessible to the farmers targeted. Scientists said that knowing where and how farmers accessed information more easily before packaging the information was imperative. They also said it was equally important to know what media the farmers were conversant with, which also went hand in hand with the farmers' literacy level. To widen the coverage, the scientists observed that GM food crop messages should be packaged to suit multiple media, including mainstream and social media. They clarified that using numerous media platforms would ensure that farmers could access information from the media most accessible to them and when needed. The following words of one scientist were extracted from the interview:

> One of the key factors that we consider is the media through which these farmers access their information. Are they listeners to the radio, readers of newspapers or journals? [……] for instance, in this digital age where people are consumers of the internet, it is important to know if they can consume digitally produced content. (Interview with a crop scientist researching GM food in Kenya, July 2022)

As later discussed, when responding to questionnaires regarding the sources of GM food information, farmers indicated accessing the information from the media, with some media being more useful than others. For example, (see Figure 4.1) radio was used by 78.2%, Newspapers by 40.6%, television by 46%, and the internet by 33.2% of the farmers. It is important to note that disseminating information through the media aims to improve the audiences' knowledge, as assumed by the deficit model of science communication. Information can also be communicated because it relates to the audience, which conforms to the assumptions of the contextual model of science communication. However, the reliability of the information communicated through the media remains questionable because scientists and GMO opponents can use it.

Myths and misinformation surrounding GM food crops**.** Scientists explained that it is also essential to consider myths, misinformation, and miscommunication surrounding GM food crops when framing their messages to the farmers. It became evident during the interview that when communicating to the farmers, the scientists framed their messages to debunk the myths, misinformation, and miscommunication on which farmers have been made to rely. Equally important, scientists also said they framed the GM food crop messages in a way that helped the farmers understand the GM food crops benefits while at the same time responding to their many concerns, mainly about the costs involved and the feeling that GM would spoil the non-GM crops. The study found that the scientists' belief in the assumptions of the deficit and contextual models of science communication lingered in their framing of the communication messages about GM food crops. The scientists were clear that most of their framing strategies were geared toward helping farmers enhance their knowledge, debunk misinformation, and address their concerns about GM food. They seem to think of farmers as somewhat active audiences with concerns and questions that must be addressed.

However, (as explained later) findings from the questionnaire responses revealed that farmers had concerns about GM food, which they said were not addressed by GM food information they access. Most of them also reported not understanding the GM food information they received; indeed, most farmers could not define GM food precisely and expressed inadequate knowledge of GM food.

4.1.5 Challenges Encountered by Scientists in Communicating GM Food Information to Farmers

During the interview with the crop scientists researching GM food crops in Kenya, I asked them to discuss the challenges they encountered in communicating the knowledge generated by their research to farmers. The study revealed that communicating GM food crop information to farmers was setback by several issues, including a lack of science communication skills, language barriers, and "lobby group" campaigns against science. Other setbacks were the absence of GM products in the country and farmers' reluctance to accept GM food crop messages, exacerbated by myths and misinformation surrounding GM food crops.

Lack of Science Communication Skills

According to the scientists who participated in the study, one of the major challenges they encountered in communicating GM food information to farmers was a lack of science communication skills. The study revealed that scientists faced difficulties tailoring their messages to the levels accessible to the farmers. I also realized that another such skill was translating GM food information into the local languages of the targeted farmers. The scientists explained that most of them were from science backgrounds and did not have the skills that would enable them to communicate science to the non-scientific audience, such as farmers, without tampering with the intended meaning of the message. One scientist elaborated on this by using the following words:

> […] I think the other challenge is that GM food is not well understood, and trying to make that non-scientific audience understand without losing your science is difficult if you don't have experience. If you don't have a background in communication, you become more scientific; you use those big words, and the audience is left wondering, 'What is happening here?[…….] (Interview with a crop scientist researching GM food in Kenya, July 2022)

They said when communicating GM food crop information to the farmers, they are likely to sound more scientific in their use of language. At the same time, their audiences are not conversant with the scientific language, which may lead to miscommunication.

Scientists indicated that the lack of science communication skills was also coupled with a lack of experience communicating science to a non-scientific audience. They added that this problem might be a challenge faced by scientists and other actors in communicating GM food crop information. Scientists gave an example of the media by pointing out that sometimes the media, with good intentions, have tended to "simplify" scientific information from the scientist but ended up sending a different, wrong, and sometimes very negative message regarding GM food crops. It became more apparent from the study's results that the targeted audience for GM food crop information was heterogeneous. Therefore, for the communication to be impactful, it should be made as accessible and straightforward as possible while keeping the intended message intact.

Language Barriers

The findings revealed that scientists encountered language barriers when communicating GM food information to the farmers and the general public. It became apparent that the language barrier was closely related to the lack of science communication skills. The language barriers in communicating GM food crop information manifested in three ways: the difficulty of the language used compared to the level of understanding of the target audience, using a language foreign to the target audience, and losing the intended meaning because of translation. During the interviews, scientists explained that some of the communities they targeted during communication understand neither English nor Kiswahili. However, when they released their communication through the media, it tended to be mainly in these two languages, leaving out members of these communities. Worse still, in cases where they resorted to translating the GM food messages into the local languages of the targeted audience, there was a possibility of the messages losing the intended meaning because of a lack of equivalent terms in the local languages, as seen in the following words of one scientist:

> […..] Remember, when we are disseminating this information, we normally use the national languages, that is, Kiswahili or English. But sometimes, the farmers that we are intending to get the information to, may not understand the languages. So, trying now to maybe get the information into their local languages is a challenge that is really coming up […] (Interview with a crop scientist researching GM food in Kenya, July 2022)

Findings from farmers' responses to the questionnaire (which I discuss later) did not corroborate the scientists' issue of the language barrier. The farmers said the information they received was in a language they could understand easily. However, they reported the information not being communicated to them often enough. In addition, farmers lamented the lack of direct communication from scientists, which could result from the language barriers the scientists identified.

Farmers' Demand for Finished GM Products

The study revealed that scientists' communication of GM food crop information to farmers was rendered difficult because most of the GM food crop research was ongoing, and their products were not ready for farmers' consumption. Scientists indicated that after working to convince farmers to buy into their findings from GM food research, farmers begged a tricky question: "Where could they get the GM food crop seeds or see the GM product?" The scientists further revealed that farmers tended to become disappointed when told it was still an ongoing process that awaited approval from relevant authorities in the country. The scientists said this made farmers less receptive to the subsequent communication about GM food crops. One scientist used the following words to explain this challenge during the interview:

> Like I mentioned earlier, most of the communication is done without available products to give to farmers. So, I consider this a challenge because they actually want to see them, and some are eager. There are early adopters that want this product, but we don't have them, and that is one of the challenges. (Interview with a crop scientist researching GM food in Kenya, June 2022)

The availability of GM food crop products such as seeds was indeed one of the aspects that dominated farmers' concerns about GM food in the questionnaire responses, as discussed later. Most farmers were concerned about the availability of seeds and why the government had not allowed the adoption of GM food crops in the country if the benefits they were told were true.

Farmers' Reluctance and Resistance

During the study, it became apparent that myths, misinformation, and miscommunication surround GM food crops in Kenya, making farmers resistant to scientists' communication of scientific GM food crop research findings. Scientists discussed this in the interview and explained that the misinformation and miscommunication surrounding GM food crops are exacerbated by "lobby group campaigns," which they said are against the genetic modification of food crops. The scientists said these paid groups ran the campaigns against GM food crops and are organized well to ensure their message reaches the farmers and the general public. Consequently, their anti-GM communication fuels the hostile attitude among farmers toward GM food crops, making them reluctant to accept reliable GM food crop information from scientists. One scientist clarified using the following words:

> [……] I think there are lobby groups that actually believe in natural products and crops. They actually run campaigns somewhat parallel to what we are doing, and the farmers are no longer incentivized to take up GM food information [……]. These groups have funders just the same way science is funded. They have funders who are against science with so many resources, and they are actually able to reach the farmers more easily than we are. [….] that actually affects it, so you get to the farmer, and they have already been given all this misinformation, being told how terrible GM foods are and how they should rely on natural food. (Interview with crop scientists researching GM food in Kenya, July 2022)

According to Gheysen et al. (2019), various European NGOs conduct anti-GMO activities in African countries to spread wrong information about GMOs, making African countries hesitant and less receptive to it. The authors provide an example of the activities of spreading "misinformation" about GM food done by Greenpeace International, Action Aid-Uganda, and Friends of the Earth International, all headquartered in Europe. Kosgey and Cyrus (2019) also argued that negative campaigns by some NGOs and anti-GM groups increase the public's negative perception of GM crops. Similarly, farmers identified several issues that could be linked to misinformation and miscommunication from these groups when defining GM food, as discussed later. Notably, farmers said GM food could lead to diseases such as cancer, ulcers, mutations, and abnormal growth, which is heavily featured in the communication of anti-GM groups.

Another form of reluctance that became obvious from the study's results is the cultural beliefs of some targeted communities. Certain members of the society are not allowed to engage in community activities, including activities for communicating GM food crop information. According to crop scientists, some communities prohibited women and girls from participating in organized communication activities. Although in this study, women did not dominate in terms of the farmers who participated (i.e., those who engaged in farming), Kosgey and Cyrus (2019) observed that women in most African countries are farmers but are not involved in decision-making. Hence, the men taking up decision-making positions could become a barrier in deciding whether to adopt GM crops.

Some other communities tend to be reluctant because they believe they have different priorities regarding the problems they wish to be addressed by science. The scientists explained that to these communities, genetic modification might not be the most immediate problem that they are facing, hence their reluctance, as seen in the following words of one scientist:

> [……] Let me just put it this way, you know, if you go to a place, let's say Turkana county, and you want to carry out a study there or give information about GM foods. Then you realise they have bigger problems than what you are going to tell them; they are not going to listen to you. (Interview with crop scientists researching GM food in Kenya, July 2022)

The question of reluctance seems to align with the lay expertise model of science communication, which calls for scientific knowledge to be verified through other forms of knowledge, including local experts' knowledge. The audiences' cultural beliefs and social systems must be considered when planning science communication activities for the farmers. Also, scientists must be more aggressive and proactive in communicating with the farmers to help fill the demand for GM food crop information, which could otherwise be filled with misinformation from the anti-GM campaigns. These GM opponents are constantly looking to exploit communication gaps left by scientists (Oloo et al., 2020b).

Generally, this study's results revealed that scientists encountered several challenges when communicating GM food information to farmers. Some challenges emanated from the scientists, while others came from the farmers and the social structures they lived in. Altogether, these challenges slowed scientists' communication of GM food information to the farmers and the general public. On the other hand, farmers pointed out several factors that hindered the smooth reception of GM food messages, especially in making sense of information communicated to them. These are explained later in this chapter.

4.2 Farmers' Awareness and Knowledge of GM Food Crops

This section presents results from the questionnaire administered to the farmers from western Kenya who participated in this study. These results concern the study's second research question: *What information is available to farmers in Western Kenya regarding GM food crops*? To answer this question, I designed and administered the questionnaires to maize farmers in Uasin Gishu and Trans-Nzoia to determine what the farmers knew about GM food. I did this by probing their awareness of GM food and testing their knowledge about it. The study used open and close-ended questions to help determine farmers' awareness of GM food and allow them to demonstrate their understanding of GM foods. The study's results revealed that almost all the farmers (99.3%) reported being aware of GMOs. On the other hand, regarding the source of this awareness, all 298 farmers involved in the study said they had read or heard something about GM food crops. Table 4.1 summarises the results of farmers' reports on the awareness of GM food.

Table 4.1: Percentage of farmers' Awareness of GM Food Crops

	N	**Per cent**
Aware of GM technology/GMOs	296	99.3
Not aware of GM technology/GMO	2	.7
Read or heard about GM food	298	100

Source: Primary data from a questionnaire administered to farmers, April – July 2022

The findings of this study are consistent with several previous studies on the public’s self-reports of awareness and knowledge about GM food/crops (cf., Kimenju et al., 2005; Chengwena et al., 2019; Karau et al., 2020). However, a mismatch has been reported between these self-reports and the public’s ability to demonstrate an understanding of GM food. Notably, farmers have reported being aware of GM food but failed to confirm this awareness when asked to explain what GM food meant to them. For example, Karau et al. (2020) found that of 89.3% of respondents who said they were aware of GMOs, only a small portion could correctly explain what GMOs meant.

Therefore, after farmers reported being aware through reading or hearing about GM food crops, I probed on their knowledge of GM food by asking them to explain what GM food means to them. This study showed that farmers gave various definitions focusing on numerous aspects of GM food or the genetic modification process. The findings revealed that farmers' definitions were a mixture of correct and incorrect descriptions of the genetic modification process and GM foods. This could demonstrate, in line with Changwena et al. (2019), that farmers had a poor understanding of the genetic modification process and GM food crops despite reporting to be aware.

The study findings revealed that some definitions from farmers focused on increased or improved yields and resistance to pests and diseases. Farmers said that GM foods are genetically engineered for better yield because they resist diseases and pests, which could otherwise decrease the yields. On the other hand, other farmers said GM foods require fewer farm inputs but still have increased production (yields). Others focused on the growth of GM food crops and stated that GM food crops grow faster than conventional food crops, but this trait could also make the resulting foods damaging to human health. Generally, these descriptions show that farmers do not clearly understand GM food crops. These mixed descriptions of GM food by the farmers may mean that they access limited information that does not help them understand GM food completely.

The study also revealed that another theme that dominated farmers' definitions of GM food was the perceived adverse effects of GM food on human health. Regarding this, some examples of farmers' definitions of GM food are:

- *These are foods that make people grow abnormally after consuming them,*
- *foods that cause cancer and ulcers,*
- *GMOs are foods with some side effects when used on human beings and animals,*
- *These are crops that increase production up to double, but they can also affect the human body; they could cause mutations, reduce lifespan and productivity,*
- *GM food is food that is tasteless and not fit for human consumption*.

Source: Primary data from a questionnaire administered to farmers, April – July 2022

The farmers' focus on these perceived adverse effects of GM food on human health could reflect the fear created by misinformation and miscommunication surrounding GM food crops. As pointed out in the previous section, misinformation competes with scientists' communication of GM food crop information. Indeed, scientists pointed out during the interviews that the misinformation causes panic among the public because the perpetrators' agenda is to eclipse the benefits of GM food crops by spreading negative information to make the public believe that GM foods are bad.

The study further revealed that some farmers' definitions were centred on the genetic modification process. Farmers defined GM food based on their perception of the process involved or the composition of the resulting food. Most farmers' perceptions of the genetic modification process seemed negative and could be deemed incorrect. For example, farmers said:

- *GM foods are Seeds injected with chemicals for the purpose of increasing productivity,*
- *[….] I think it is food that is prepared from the lab by use of chemicals*
- *These are food crops artificially manipulated in the laboratory and which tempers with the ecosystem,*
- *GMOs are foods whose genes are artificial,*
- *GMOs are Plants modified from the lab and given to farmers to experiment.*

Source: Primary data from a questionnaire administered to farmers, April – July 2022

These definitions mean that farmers access information that could be more negative than positive and could be aimed at making the genetic modification process look dangerous. It is important to note that, as discussed earlier, scientists said that one of the challenges they encountered is farmers resisting scientific communication about GM food because of what they were already made to believe, supposedly by the misinformation from some anti-GM groups.

The study also revealed that some farmers referred to the ownership of genetic modification technology when asked to define GM food. These farmers said, for example, that *GM food refers to research being tried in Africa by Europeans*. The perceptions of these farmers depicted in their definitions align with the observation by Kosgey and Cyrus (2019) that the slow adoption of GM crops could be attributed to the fact that developed countries developed them. Therefore, African countries may think that developed countries are taking advantage of them (Ezezika et al., 2012; Kosgey and Cyrus, 2019). Connected to this is the observation that African governments are sometimes misinformed that Europe will reject food imports if they start cultivating GM crops (Karembu, 2017; Gheysen et al., 2019). More farmers' common definitions of GM food are presented in Table 4.2 below.

Table 4.2: Common Farmers' Definition/descriptions of GM Food

It is food performing so well, resistant to diseases, but may cause humans to suffer from cancer.
These are crops that are not in their natural state since they are modified in a manner that they adapt to the environment.
These are foods produced from organisms that have changes introduced into their DNA using the method of genetic engineering.
This is whereby crops and animals are made to either produce more milk, meat, eggs, or seeds to compete with the world's growing population.
It's an improved crop with a high level of aflatoxin.
Plants modified from the lab and given to farmers to experiment.
GMOs are crops that are not fit for human consumption; they are tasteless.
Food that is not good as it is artificial and made in the laboratory. This food is made to have certain traits to adapt to certain conditions hence producing highly.

Source: Primary data from a questionnaire administered to farmers, April – July 2022

Generally, when defining GM food, farmers based their definitions on several aspects of GM food and how they perceived such aspects. Some farmers' definitions of GM food based on these aspects were correct, while others were incorrect. A theme that dominated most definitions was the idea of increased yields. While this trait is positive regarding GM food crops, farmers associated it with the possibility of making the food prone to some negative characteristics, hence their association of GM food with adverse effects on human health. It became apparent that farmers' reports of awareness about GM food could not be fully demonstrated by their understanding of the GM process and GM food. Farmers seemed to exhibit signs of misinformation about GM food, especially regarding its perceived adverse effects on human health.

These effects seemed to overshadow the benefits of GM food in the farmers' definitions.

Overall, the findings have revealed that farmers' reports of being aware of GM food do not match their understanding of GM process and GM food, as expressed in their definitions. Indeed, farmers know some aspects of GM technology or food, but they seem to have incomplete information, or rather, they seem to have competing sets of information about it. On the one hand, they know GM food can increase yield, resist pests and crop diseases, and tolerate droughts. On the other hand, they seem to strongly believe that, ultimately, this food could destroy human health or the environment because of the traits it is given. This contradiction shows that farmers have inadequate knowledge of GM technology and food, perhaps owing to the nature of GM food information accessible to them, which seems to be limited.

4.3 Farmers' Reception of GM Food Crop Information

This section describes farmers' reception of information regarding GM food crops. The findings presented and analysed in this section were in response to the third research question: *How do farmers in Western Kenya access and make sense of information on GM food crops*? The results include farmers' responses when I asked them to identify the various sources of GM food information and provide their opinion on whether they understood the information they received. Generally, the study found that farmers reported accessing GM food information from several sources, some of which did not conform to the various approaches described by the scientists during the interview, as discussed earlier. Additionally, a little over half (51%) of the farmers said they do not understand the information they receive on GM food crops.

As stated earlier, farmers reported that their awareness of GM technology or GM food came from either reading or hearing about it. When I asked them to identify the sources of this information, farmers stated that they read or heard about GM food from various sources such as radio, television, Newspapers, schools, friends, extension officers, workshops/seminars/training, barazas, and the internet. Figure 4.1 below summarises the percentages of farmers who accessed GM food information from each source identified.

The study revealed that most farmers relied on radio and friends as their primary sources of GM food information since 78.2% and 52% of the farmers said they accessed the information through the radio from their friends, respectively.

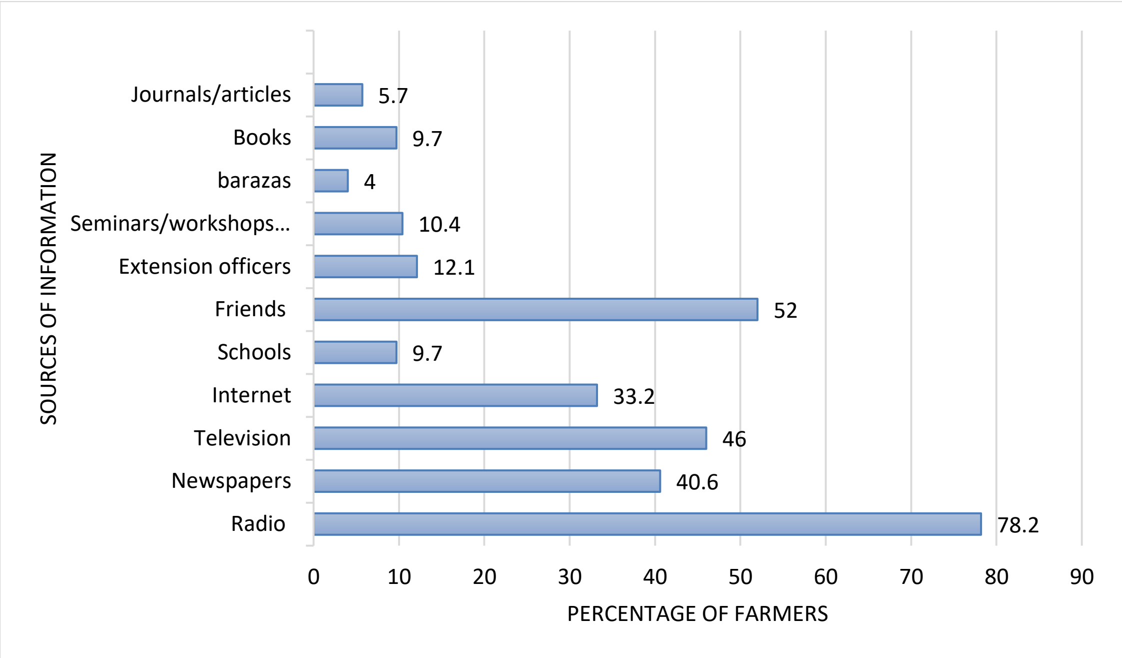

Figure 4.1: Farmers' Sources of GM Food Crop Information
Source: Primary data from a questionnaire administered to farmers, April – July 2022

Farmers also identified television and Newspapers, whereby 46% and 40.6% of the farmers said they received GM food information from TV and Newspapers, respectively. Generally, the mainstream media dominated the farmers' sources of information about GM food crops. On the other hand, as discussed earlier in this chapter, the scientists also identified media as one of the approaches to communicating information emanating from GM food crop research to the farmers. Similar to the farmers’ identification of the media, scientists said they communicated to farmers through radio, Newspapers, television, and social media.

Regarding the farmers’ access to GM food information from social media, the internet was used to access GM food information by 33.2% of the farmers, making it less favourable among all the media reported by farmers. Consistent with this study’s findings, previous studies have also reported the media as the primary public source of GM food information (Kimenju et al., 2005; Karau et al., 2020). Generally, as I have earlier noted, media could be ineffective in that some, like newspapers and social media, might be less favourable to some farmers, for example, those in rural areas. Media can also be biased in communicating GM food information (cf., Lore et al., 2013), leaving the public not knowing what information to rely on.

The study also revealed that few farmers accessed information from seminars/training/conferences/workshops (10.4%). This contradicts the scientists’ reports of communicating with farmers through this source, as discussed earlier. In their approaches to communicating GM food crop information, scientists said they visited farmers in the field and engaged with them by sharing their research findings on GM food. Scientists also noted that sometimes, they invited farmers for seminars or workshops where they presented the information they intended to share with farmers from their research. Scientists further said they used these interactions to respond to farmers' questions and concerns regarding GM food.

Contrary to the scientists' claim of using a direct approach to communicating with the farmers, farmers complained of the lack of such communication from the scientists when discussing their concerns about GM food (as will be elaborated on later in this chapter). Farmers lamented that scientists had not visited them and explained what GM food means, which left them relying on unverified claims about GM food. Also, farmers did not indicate having been invited by scientists for seminars or workshops on GM food crops.

The findings further revealed that barazas and journals/articles were reported as the least used means of accessing GM food crop information by farmers, with only 4% (12 out of 298) and 5.7% of the farmers reporting to have used these sources, respectively. On the other hand, Scientists said that farmers accessed GM food information from their research through barazas. As discussed earlier, scientists explained that one of their approaches is to organize barazas and agricultural shows to share their research findings about GM food crops with farmers and the general public. They also said that these barazas and agricultural shows were open to the public, bringing together various stakeholders ranging from policymakers to farmers. The study revealed, similar to the assumptions of the public participation model of science communication, that using barazas to communicate GM food crop information to the farmers enhanced public engagement in GM research. Scientists clarified that these barazas and agricultural shows brought various members of the public together, which gave their GM food research a sense of public engagement.

However, as explained above, barazas did not seem adequate because only 4% of the farmers reported receiving the information from barazas. On the other hand, there was no mention of agricultural shows on the farmers' sources of GM food information.

The assumption that barazas and agricultural shows were open to the public and had farmers in attendance seems questionable. These findings could imply that scientists need to re-conceptualise the operationalization of barazas and agricultural shows to ensure that they achieve the intended purpose.

The study also revealed that Farmers received GM food information from their friends (52%). This use of friends as a source of information could be interpreted to align with scientists' reports of using farmers to communicate with other farmers, discussed earlier. The scientists said they partnered with other people or groups who helped them communicate their research findings to the farmers. Scientists said they sometimes chose farmer representatives who, after training, shared GM food information with them and sent them out to disseminate the same to other farmers. According to the scientists, these farmers acted as advocates of scientists to other farmers. Whenever needed, they were advised to refer farmers to the scientists for more clarification on any questions or concerns they had. Similarly, as discussed below, farmers also indicated that they shared the information they received from various sources with several other groups, such as family members and fellow farmers. It should be reiterated that the use of farmers to communicate with other farmers and the sharing of information received by farmers could warrant misinformation about GM food crops.

The results further revealed that 12.1% of the farmers reported accessing information from extension officers. Notably, this source of farmers' information did not feature in the scientists' approaches to communicating GM food information to the farmers discussed earlier.

Generally, farmers accessed information mostly from indirect sources, which did not seem to afford direct interaction with crop scientists. The study revealed mismatches between the scientists' approaches to communicating with farmers and the farmers' sources of GM food information. As discussed later, farmers lamented the lack of reliable communication from the scientists and other authorities involved in GM food. They longed for direct communication from crop scientists to help them understand the GM process and GM food.

GM Food Crop Information Sharing among Farmers

The analysis of the questionnaire results further revealed that farmers acted as a source of information regarding GM food. Both scientists and farmers hinted at the possibility of farmers becoming the source of GM food crop information other farmers accessed. Whereas, during the interview, the scientists said they trained farmers to assist in disseminating the information, during the questionnaire, 52% of the farmers identified "*Friends as the source of this information."* Friends was outranked only by radio, which was identified by 78.2% of the farmers out of all the sources reported by farmers.

I asked farmers whether they shared the information received with others, and 80.2% reported sharing the same information received and (therefore) acting as sources of information about GM food to other farmers. Table 4.3 below presents the findings on farmers' sharing of GM food information.

Table 4.3: Percentages of Farmers' Sharing of GM Food Crop Information

Groups they shared information with	Shared	Didn't share
Family members	61.7	37.3
Neighbours	42.3	57.7
Fellow farmers	54.7	45.3
Church/religious members	9.4	90.6
Friends	53.0	47.0

Source: Primary data from a questionnaire administered to farmers, April – July 2022

Of the 298 farmers to whom the questionnaire was administered, 61.7% said they shared the GM food information they received with their family members, whereas 54.7% and 53% reported sharing it with their fellow farmers and friends. 42.3% of the farmers indicated sharing the information received with their neighbours, while 9.4% said they shared it with their church/religious members. Notably, during the interviews, scientists noted that in the peer-to-peer communication approach, farmers were expected to share GM food information with a few other farmers (say two), who were also expected to share with a few others (say two), and so on it went, in that order.

Generally, the study findings revealed some similarities and differences between the scientists' approaches to communicating GM food crop information to the farmers and the sources through which farmers said they accessed information about the same. Essential to reiterate is the absence of agricultural shows and scientists' field visits on the farmers' identified sources. On the other hand, extension offices did not feature in the scientists' approach, although only 12.1% reported it as one of the sources of information. Similarly, barazas and seminars/workshops, which scientists highlighted in their approaches, were ranked very low by the farmers as sources of information (4%) and (10.4%), respectively. These findings seem to imply that scientists must re-think their communication strategies to ensure they can reach farmers with complete information, especially during this era of infodemic. There is a serious need to rethink the operationalisation of the direct approaches to communicating GM food information with the farmers

4.3.1 Farmers' Perception of GM Food Crop Information Received

The study also examined farmers' perceptions of the information received about GM food crops. I supplied farmers with positive and negative statements describing the information they received about GM food crops. I asked the farmers to indicate '*agree*' if they agreed with the statement (i.e., the statement was correct about the information they received) and '*disagree*' if they thought the statement was incorrect about the information received. There was also the third option, *'I don't know,'* if they knew nothing about the statement concerning GM food crop information. Farmers' perception of the information received is summarised in Figure 4.2 below.

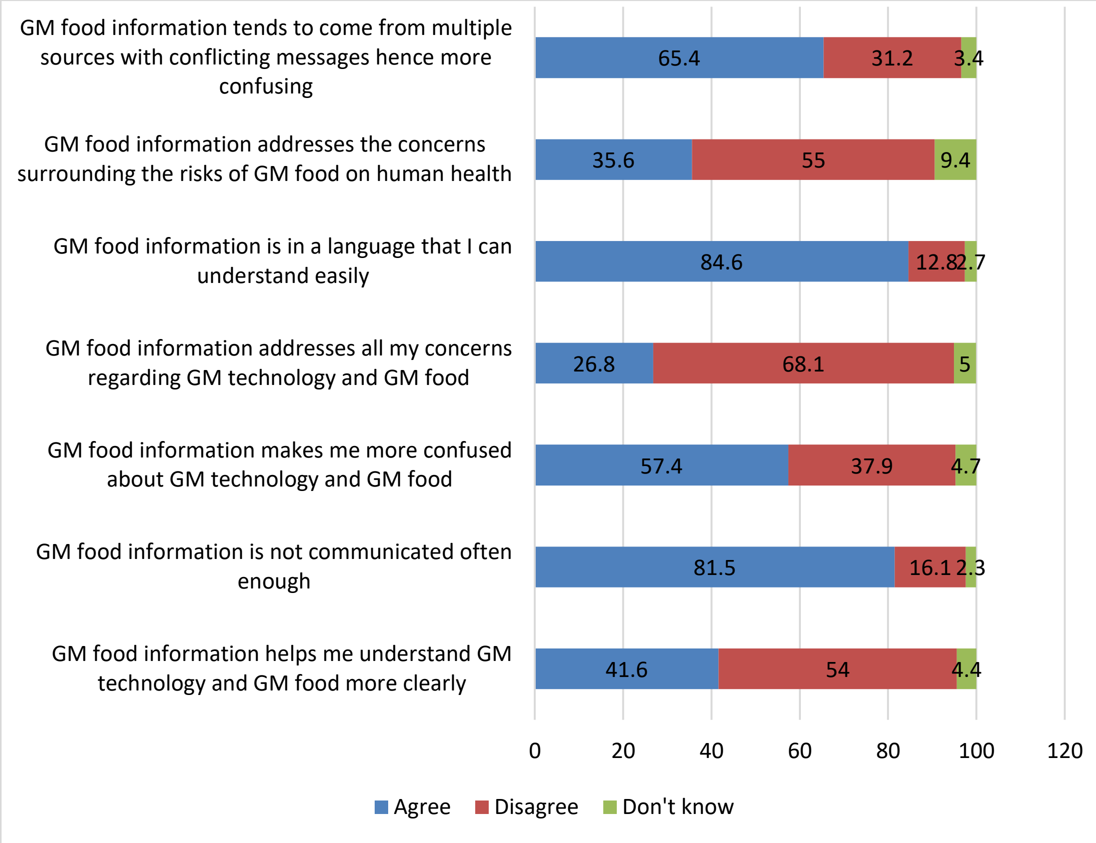

Figure 4.2: Percentages of the Farmers' Perception of GM Food Information
Source: Primary data from a questionnaire administered to farmers, April – July 2022

The study revealed that slightly over half of the farmers (54%) agreed that the information they received about GM food crops did not help them understand GM technology and food more clearly. On the other hand, less than half of the farmers (46.6%) agreed with the statement that *GM food information received explains impartially what genetic modification technology and GM food mean*, whereas 48.7% of the farmers disagreed with the statement, and 4.7% said they didn't know. Additionally, 54.7% of the farmers said the information they received confused them more about genetic modification and GM food, whereas 65.4% of the farmers in the study agreed that the information they received came from multiple sources with conflicting messages; hence, it was more confusing.

The study further revealed that most farmers (81.5%) said GM food crop information was not communicated often enough. However, most farmers said the information was in a language they could easily understand (81.5%) when it was communicated. Most farmers felt that the information explained GM food's benefits to the farmers (81.9%), but it did not address all their concerns about GM food crops (68.1%).

The results from farmers' perception of GM food crop information they received corroborated the findings of this study on the farmers' knowledge of GM food presented in the previous sections of this chapter. Similar to their agreement that the information did not help them understand what GM food means, most farmers could not clearly define GM food. Their perception of information also confirmed the existence of multiple sources with confusing messages about GM food and a lack of enough communication from reliable sources. Equally important, although the scientists said they focused on receiving and addressing farmers' concerns (during their communication of GM messages), farmers indicated that the information they received did not address all their concerns about GM food. Also, scientists said they aimed to improve farmers' awareness and knowledge of GM food. Still, farmers felt that the information they received confused them more about GM technology and GM food. These findings continue to consolidate my argument that the nature and quality of information the farmers received may have a role in their inadequate knowledge of GM food.

4.3.2 GM Food Crop Information Need among Farmers

Apart from the report on farmers' access and sharing of GM food information presented above, I also wanted to determine the farmers' information needs. Before doing this, I wanted to determine whether farmers were satisfied with the amount of

GM food crop information accessible to them. I asked them to give their opinion on their access to GM food information and whether they were satisfied with the amount of information they received. Regarding this, the study revealed (see Table 4.4) that only 25.8% (77 out of 298) of the farmers said they were satisfied with the amount of information they received regarding GM food, whereas 74.2% (221 out of 298 farmers) said they were not.

Table 4.4: Percentages of Farmers Satisfied with the Amount of GM Food Information Received

		N	Per cent
Are you satisfied with the amount of information received about GM food?	Yes	77	25.8
	No	221	74.2
	Total	**298**	**100.0**

Source: Primary data from a questionnaire administered to farmers, April – July 2022

The questionnaire was also designed to follow up on this by allowing farmers to indicate how often they received GM food crop information. I asked them to choose between *daily*, *weekly*, *monthly*, and *occasionally* to reflect on how often each farmer received the information. They could also select '*never*' to indicate that they did not receive any information about GM food if that was the case (it is important to note that, as already established, all the farmers indicated receiving GM food crop information from various sources) the study's findings for this are summarized in Figure 4.3 below.

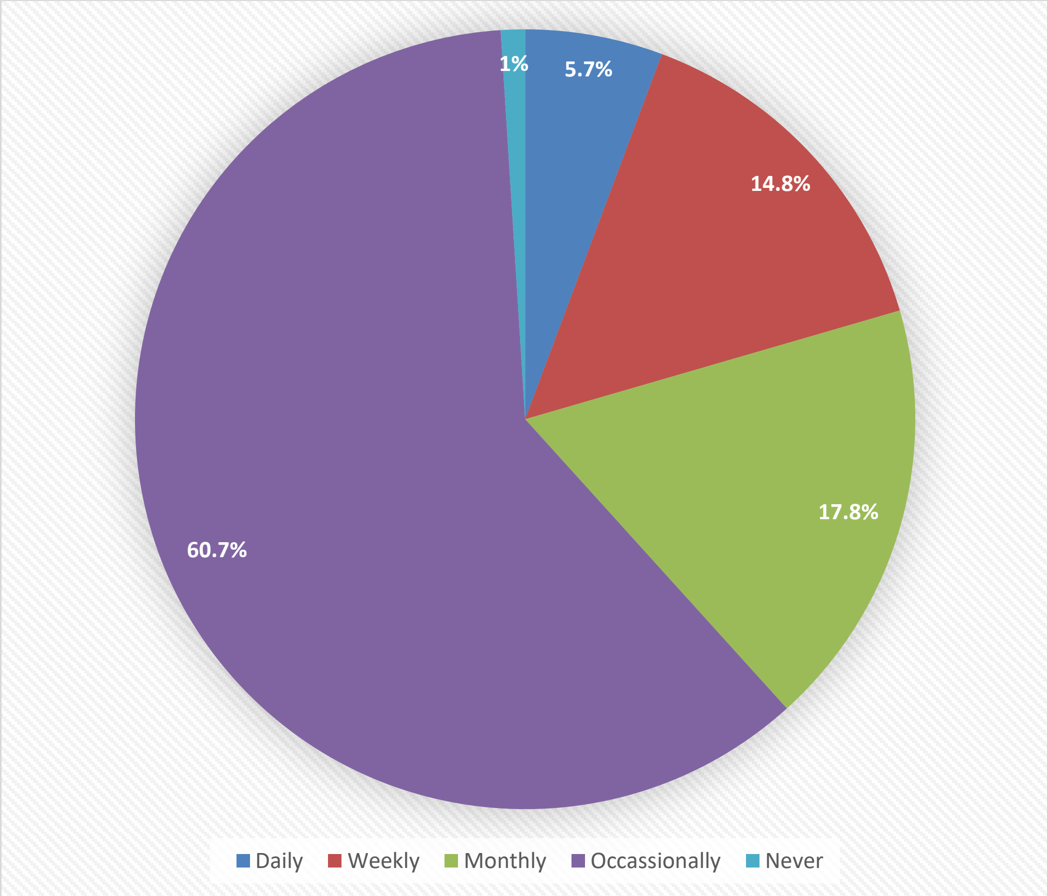

Figure 4.3: Percentages of how often Farmers Received GM Food Information
Source: Primary data from a questionnaire administered to farmers, April – July 2022

The study revealed that more than half of the farmers who participated in the study (60.7%) indicated that they received GM food information only occasionally. 17.8% of the farmers said they receive information monthly, while 14.8% reported receiving it weekly. Only (17 out of 298) 5.7% of the farmers said they received GM food information daily, whereas 1% (3 out of 298) of the farmers indicated that they never received GM food information.

Previous studies have reported similar findings; for example, Karau et al. (2020) reported that 58.1% of the participants in their study received GM information monthly. These findings speak to the farmers' need for enough information about GM food. They imply that the scientists have not done enough to reach farmers with complete GM food information. The farmers seem to demand information more than the scientists are communicating this information. This situation could have contributed to the farmers' limited understanding of GM technology and GM food, expressed when defining GM food. It could also render the farmers helpless when required to decide on GM food or lead them to make an uninformed decision.

The questionnaire was designed to further follow up on farmers' access to information by asking what other information they would like to receive regarding GM food. The result revealed that farmers demanded to know several issues regarding GM food, some of which reflected their concerns as presented in the sections ahead. The study showed that common issues in farmers' responses to farmers' GM food crop information demands were connected to the effects of GM food on the human body/health, environment, and ecosystem. Other issues were connected to procedures used in genetic modification, the composition of GM food, and the purpose or benefits of GM food.

Farmers also indicated that they want to know if GM foods have been tested by the responsible authorities to ensure their safety. They needed to know where to get GM seeds, how to use them, and the potential of GM food to cause diseases such as cancer and ulcers or reduce the life span. In addition, farmers said they would like to get simplified information on the science behind GM technology as well as the negative and positive effects of GM food. Again, all these speak to a lack of complete, precise, and reliable information about GM technology and GM food, especially on the potential benefits and risks associated with adopting the technology. Table 4.5 below summarises some common issues farmers want to know concerning GM food.

Table 4.5: Issues Farmers Demand to Know Concerning GM Food Crops

Does it really have negative effects on the human body? I want to know more about the demerits and merits of GMOs.
Can it be dangerous to other insects and humans due to the use of chemicals?
The origin of GMOs and places that have practised them well.
Does GMO have long-term effects or short-term effects, or chemicals?
The real and factual side effects on human health. What generally contributes to the fast growth of GMOs.
I wish the extension officer could teach me so that I understand and make a better decision.
Where do GMO products get tested and proven to be safe for human consumption.
Chemicals used to make plants and animals mature faster.
Seed companies to involve farmers in the process they take to manufacture GM seeds.

Source: Primary data from a questionnaire administered to farmers, April – July 2022

4.3.3 Farmers' Understanding of GM Food Information

The questionnaire was designed to allow farmers to explain whether they understood the GM food information they received and to give their opinions on why they did not understand (whenever they didn't). The study's findings revealed that although the farmers and scientists indicated that there were several means of accessing GM food information available to farmers (the mismatches identified, notwithstanding), some of the farmers reported they did not understand the information received. As shown in Table 4.6 below, slightly over half (51%, 152 out of 298) of the farmers said they did not understand the information they received regarding GM food crops, whereas 49% (146 out of 298) of the farmers indicated understanding the information.

Table 4.6: Percentages of Farmers on Understanding Information about GM Food

	N	Per cent
Understood GM food information received	146	49.0
I didn't understand the GM food information received	152	51.0
Total	**298**	**100.0**

Source: Primary data from a questionnaire administered to farmers, April – July 2022

These results continue to cast doubts on the quality and nature of GM information the farmers received from the earlier identified sources. The results also may help enlighten the lack of complete understanding of GM process and GM food, demonstrated by farmers in the awareness and knowledge section above.

When asked to provide their opinion on why they did not understand the GM food information they received, farmers gave several responses grouped into the following common themes. Some farmers based their reasons for not understanding the information on the quality and clarity of the information. For example, most farmers said the information received was not clear on GM foods, or the information they received was complicated.

Regarding the clarity of the information, during the interviews, scientists indicated a lack of science communication skills as one of the setbacks in communicating GM food information to the farmers. They specifically mentioned that translating the information into farmers' local languages could sometimes tamper with the quality of the information. Farmers also indicated relying more on radio and friends as their sources of information and less on barazas, agricultural shows, and seminars/workshops, which could also speak to their claim on the unreliability of the information. Farmers felt the information did not come directly from people they could trust, including the scientists researching GM food crops in Kenya and the government.

Another common theme in farmers' responses is the reliability (credibility) of the information received. Farmers said they did not understand the GM food information received because it was unreliable. They said the information they received came from (gossip) hearsay; they did not have the facts about GMOs. Previous studies have also featured the unreliability of public information sources about GM food. Karau et al. (2020) reported that the respondents in their study received information from the public grapevine. The implication here could be that the sources that could be trusted, such as the scientists, have not communicated enough. Indeed, other farmers based their opinions on why they did not understand GM food information on the lack of trusted sources of information and the availability of information with conflicting messages. These farmers said they did not understand the information received because it came from multiple sources and, therefore, was confusing. They also said there was not enough and proper communication from the government regarding GM food crops, and the GM food experts had not visited to enlighten them to explain critical GM food issues. Some farmers also indicated that public sensitization on GM food was very limited and that this contributed to their failure to understand the GM food information they received.

These opinions from farmers contradict the scientists' report that they visited farmers in the fields and shared GM food information with them. Farmers demonstrated that scientists had not visited them to share GM food crop information with them, neither had they invited them to seminars and workshops, as reported earlier by scientists. On the other hand, farmers' mention of confusion courtesy of information from multiple sources is in line with scientists' observation that misinformation and miscommunication competed with scientists' communication of scientific information about GM food. Table 4.7 below summarises some of the common challenges identified by farmers in making sense of GM food information.

Table 4.7: Farmers' Reasons for not Understanding GM Food Information

Because the information comes from multiple sources, so it is confusing; we don't have the real facts about GMO
Information about GMOs is very shallow, and nobody has come out and given us more information
I have not seen any of the crops/food
We are not well informed; the information is 'hearsay'; no one has come out and educated us clearly
We are told GMO foods can cause cancer in our bodies, but no one has come out to tell us their comment about that
I just copy my neighbours, and they don't know a lot when I ask them

Source: Primary data from a questionnaire administered to farmers, April – July 2022

It is important to note that despite the farmers' report of not understanding the information received about GM food, they reported that they received information from their friends (52%). Farmers also reported sharing the information received with several groups, including their friends, family members, and fellow farmers. This situation could create possibilities for misinformation and miscommunication about GM food. It seems reasonable to argue that farmers struggled with incomplete information about GM food from many sources they could not trust. This situation confused farmers, fueling their concerns about GM food, as discussed below.

4.3.4 Farmers' Concerns about GM Food Crops

The study further revealed that farmers were sceptical and concerned about several issues related to GM technology and GM food crops. Farmers' reports of not understanding the information about GM food crops seem connected to their concerns about GM food. As summarised in Figure 4.4 below, when asked if they have concerns about GM foods, 61.7% of the farmers indicated concerns about GM food, whereas 34.9% said they had no concerns, and 3.4% did not respond.

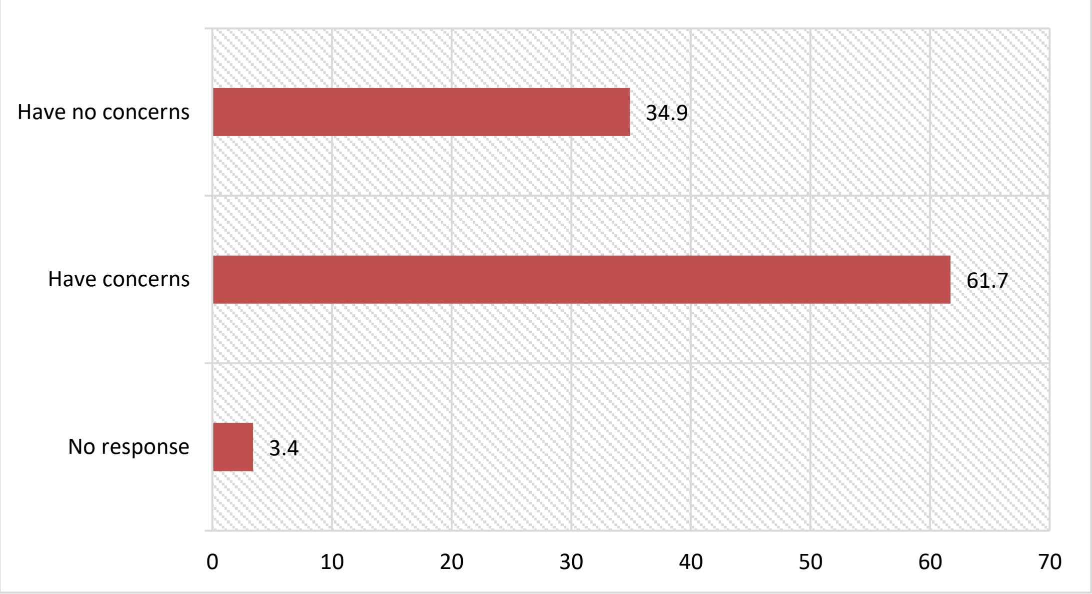

Figure 4.4: Percentages of Farmers with Concerns about GM Food
Source: Primary data from a questionnaire administered to farmers, April – July 2022

It became apparent from the study findings that farmers identified several concerns about GM food, which could be grouped under various common themes. Farmers said their concerns were on the real meaning of GM food, the availability of GM products, benefits of the technology to farmers, perceived health and environmental risks, the food quality compared with the conventional ones, and whether chemicals are used in genetic modification. Table 4.8 summarises some of the farmers' shared concerns about GM food.

Table 4.8: Examples of Common Farmers' Concerns about GM Food

The risks on human health –which we have heard but not proven. No information about the risks and the chemicals used
From hearsay, it grows faster, and it can harm people. This is our reasoning, but no one knows if it is true or not
They have rumours that it is the main cause of cancer in our societies
We want to see it practically. We want to know partners. They should open branches so that we can visit them
I want to have knowledge of how to grow these crops and their productivity compared with other crops
Why is it not implemented in our countries? Do its disadvantages outweigh the advantages?

Source: Primary data from a questionnaire administered to farmers, April – July 2022

Farmers clarified that most of their concerns came from issues they picked from information communicated to them, primarily through *hearsay* or *rumours*. Farmers said they could not ascertain the reliability of these issues and had not received help from people they believe have complete and reliable information, such as scientists. Similar to this study, several previous studies reported on public concerns about GM food (for example, Kimenju et al., 2005; Kagai, 2011; Mbugua, 2016; Oladipo et al., 2020), most of which were based on perceived health risks and environmental risks of GM technology and GM food. These findings show that farmers not only want the information to be disseminated to them; they want the communication process to be done in a way that acknowledges some issues related to their lives and what they already know.

Generally, farmers’ concerns about GM food were also hinted at in this chapter's previous sections, especially in the farmers' reasons for not understanding GM food information and the challenges encountered by scientists when communicating GM information to the farmers. In line with the farmers' concerns, the scientists identified the lack of finished GM products as one of the challenges when sharing information with farmers. Clearly, the lack of precise and reliable information about GM food crops, primarily on the potential benefits and risks, seems to be at the root of most farmers' concerns. It also seems evident that the conflicting messages from the multiple sources of information, as reported by the farmers in the reasons for not understanding the information, fuel these concerns. For example, farmers questioned whether the disadvantages outweigh the advantages of GM food. This concern speaks to the nature and quality of information farmers receive and the confusion it causes.

According to the contextual model of science communication, the audience in the communication process is not passive spectators as in the deficit model. Farmers' concerns about GM food show that the audiences in the communication process are concerned and questioning. The contextual model also assumes that audiences will understand scientific information differently in different contexts, which is also reflected in farmers' reasons for not understanding the information and their concerns about GM food crops. Also, in line with the assumption that the audience is questioning participants, farmers in the study said they wanted to get more information (as earlier discussed) about several aspects of GM technology and food, which could help clarify their questions and concerns.

4.4 Role of Accessible Information in Shaping Farmers' Attitude toward GM Food Crops

This section presents and analyses findings from farmers who participated in the study concerning the fourth research question: *How does the accessible information influence the farmers' attitudes toward GM food crops?* The questionnaire was designed to allow farmers to describe how GM food crop information they received made them feel about GM technology and food. Specifically, I asked farmers to choose '*positive*' if the information accessible to them makes them feel positive about GM technology and food and '*negative*' if it makes them feel negative about GM technology and food. I also included a third choice: '*I have not received any information'* and asked farmers to choose it if they wanted to indicate that they had not received any information regarding GM food. As summarised in Figure 4.5 below, the study findings revealed that farmers said the information they received made them feel more positive than negative about GM technology and food.

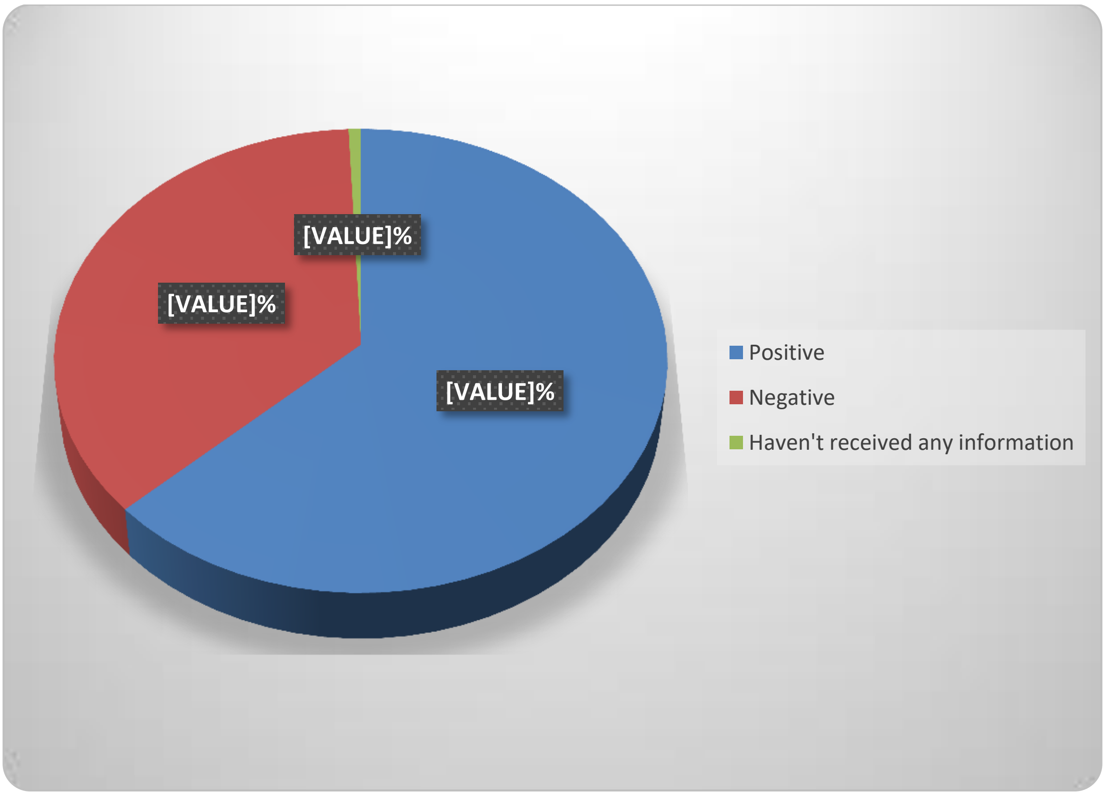

Figure 4.5: Impact of GM Food Information on Farmers' Attitudes toward GM Food

Source: Primary data from a questionnaire administered to farmers, April – July 2022

Specifically, 63.1% (188 out of 298) of the farmers said the GM food crop information they received made them feel positive about GM food. When asked why the information made them feel optimistic about GM food crops, the farmers gave various common responses, some of which are summarised in Table 4.9 below.

Table 4.9: Farmers' Responses on why GM Food Information Made them Positive about GM Food

The information makes me want to indulge in the farming of GM foods due to the high probability of profits
This technology can help control droughts, alleviate food shortages and hunger in developing countries
Because from the information I have, the advantages outweigh the disadvantages
Because expenses are so minimal compared to conventional ones hence saves time and money
Because of global warming and high population, I think it will assist people in improving lives standards, and food security will be secured
Genetic modification technology increases the availability and quality of food and medical care. It can also contribute to a cleaner environment

Source: Primary data from a questionnaire administered to farmers, April – July 2022

Generally, most of the farmers' reasons for feeling positive about GM food seemed connected to the perceived benefits of GM technology and food. Farmers said the information made them feel positive because of the prospect of improved production, in terms of high yields, offered by GM technology. They also said the information made them feel positive because it made them realise that GM food crops grow faster and are resistant to pests, which would help improve their lives by increasing production. Other farmers said they felt optimistic about GM food because, according to the information they had received, GM food crops could help solve the world's food problem. These findings show that despite the issues related to the nature and quality of information discussed earlier, farmers are positive about the prospects of GM technology in improving their food production. It seems reasonable to argue that if the quality of information is improved by making it more complete in terms of explaining what GM technology clearly entails, its benefits, and risks, farmers will be more positive about it.

On the other hand, 36.2% (108 out of 298) of the farmers indicated that the information received made them feel negative about GM food crops. Most of the farmers in this category said their negative attitude came from the fact that the information they had received made them believe that GM foods are made up of many chemicals and, therefore, may be dangerous to human health and the environment. They believed GM food might cause cancer, allergies, obesity, abnormal growth, and heart diseases. It is important to note that farmers pointed out that they did not have enough information about GM food and don't understand why the government has not allowed it in the country. Farmers felt that if GM food had all the benefits they had heard of, then the government would not have a problem with it; therefore, they felt that there could be something wrong with GM food crops. Some common reasons why the information made farmers feel negative about GM food are given in Table 4.10 below.

Table 4.10: Farmers' Responses on why GM Food Information Made Negative about GM Food

Because GM food has negative effects on the human body, i.e., it can bring cancer.
The growth is faster, which is abnormal
Because it can lead to alteration in the human body because it uses many chemicals.
We hear that it causes cancer because of many chemicals that are being used
Because it is risky for human health as it grows faster compared to normal ones
It can damage the environment because of using very many chemicals
Due to the process of production, it is assumed that it uses a lot of chemicals that might lead to diseases like cancer. From the information received, it has more health effects in the long term
The information isn't enough, and it is contradicting
Based on the information I got, it is not understandable whether GM food is good or bad
Because GM food is a killing machine, slowly by slowly
Because the government has not allowed the practice of GMOs in this country

Source: Primary data from a questionnaire administered to farmers, April – July 2022

It seems evident from the findings that farmers' reasons why the information made them feel negative highly reflected evidence for two issues. One is the possibility I have earlier explained regarding the lack of enough scientific communication regarding GM food crops or poor quality of the information in terms of completeness and clarity. Farmers seem to have bits of information that are insufficient to make an informed decision. The second issue I have also advanced on earlier is the existence of misinformation and miscommunication about GM food. Evidently, the misinformation and miscommunication seem to be constantly competing with scientific communication about GM food crops, rendering farmers more confused about GM food crops. The government's position on GM technology and food also seems essential in determining farmers' attitudes toward GM crops. Farmers seemed to believe the government's position and were doubtful about GM food because of its stance. For example, farmers said the information they received made them feel pessimistic about GM food crops because the government had not allowed GMOs in the country. These findings imply that scientists should convince the government with scientific facts about GM food crops so that they both read from the same script when relaying information to the farmers and the general public.

I also designed the questionnaires to further probe farmers' attitudes toward GM food by testing their judgments of various statements regarding GM food. These statements described GM technology or food based on several issues, including the potential benefits, perceived adverse effects on human health and the environment, ethical/moral issues, and equity issues. I asked farmers to indicate how they felt about such statements by saying whether they agreed, disagreed, or didn't know about each issue in the statements. Study findings for this are summarised in Table 4.11 below.

The analysis of the findings reaffirmed that farmers were more optimistic about GM food crops than negative, but they also expressed mixed feelings on some aspects that were tested. It became clear that most farmers agreed with positive statements about GM technology and food. They felt that genetic modification of food crops could reduce pesticides in food (69.5%) and the environment (69.1%). They also believed that it could increase productivity, solve food problems (90.3%), and create food with increased nutritional value (69.1%).

Table 4.11: Farmers' Attitude toward Genetically Modified Technology and Foods

	Statement	**Agree**	**Disagree**	**Don't know**
Benefits	GM can reduce pesticides in food	69.5	17.1	13.4
	GM technology increases productivity and offers a solution to the world's food problem	90.3	6	3.7
	GM can create foods with enhanced nutritional value	69.1	18.1	12.8
	GM has the potential to reduce pesticide residues in the environment	69.1	16.4	14.1
Risks	People could suffer allergic reactions after consuming GM foods	42.6	37.6	19.8
	Consuming GM foods can damage one's health	45.3	40.6	14.1
	Consuming GM foods might lead to an increase in antibiotic-resistant diseases	36.9	37.9	25.2
	GM foods contain many dangerous chemicals	33.2	54.4	18.1
Ethical issues	GM can lead to a loss of original plant varieties	42.3	48.3	9.4
	GM is tampering with nature	39.3	50.3	10.4
	GM technology makers are playing God	17.4	71.8	10.7
	GM food is artificial	62.4	32.9	4.7
Equity issues	GM products are being forced on developing countries by developed countries	25.2	69.5	5
	GM products only benefit multinationals, making them	20.5	70.8	8.7
	GM products don't benefit small-scale farmers	19.1	76.8	4

Source: Primary data from a questionnaire administered to farmers, April – July 2022

On the contrary, farmers had mixed feelings about the potential adverse effects of GM technology and food. While 45.3% of the farmers felt that consuming GM food could damage their health, 40.6% felt that might not be the case, and 14.1% said they didn't know. They also did not think that consuming GM food may result in immediate negative effects (69.1%) or could destroy human genes (47.3%). However, they were divided on whether consuming the food could lead to an increase in antibiotic-resistant diseases; 36.9% felt it could, 37.9% felt it could not, and 25.2% said they didn't know.

Regarding the ethical/moral issues, farmers expressed concerns but were more positive than negative toward GM technology and food. For example, more than half (55% and 50.3%) of the farmers did not feel that GM food is either threatening the environment or tampering with nature, respectively. The majority of the farmers (71.8%) did not think GM technology makers were playing God. In contrast, they were almost divided on the potential of insect-resistant GM crops causing the death of untargeted insects, in that 47.7% and 34.6% agreed and disagreed, respectively. 48.3% of the farmers felt that GM crops could not lead to the death of original plant varieties, whereas 42.3% felt they could. 62.4% of the farmers felt that GM foods are artificial, whereas 32.9% felt they are not, and 4.7% said they did not know.

Concerning equity issues, 69.5% and 70.8% of the farmers, respectively, did not feel that genetically modified products were being forced on developing countries by developed countries or would benefit only the multinationals making them. Indeed, 76.8% of farmers felt that the technology could help small-scale farmers. These findings contradict observations made by previous studies (cf. Kosgey and Cyrus, 2019; Gheysen et al., 2019) that developing countries might be hesitant to embrace GM technology because it was developed in developed countries. Farmers in this study demonstrated a belief that GM technology and food could benefit small-scale and large-scale farmers and did not raise any concerns about the ownership of the technology.

Generally, GM food information made farmers in Western Kenya more positive than negative toward GM technology and food. Farmers seemed to focus on the benefits rather than the perceived adverse effects of GM technology and food. However, the reason for the negative attitude showed that more precise communication from reliable sources, which farmers could trust, would make them more positive. Similarly, these reasons for negative attitudes were reflected in the farmers' concerns about GM food and their GM food crop information needs, both discussed earlier. Altogether, these findings cement the need for more communication, especially from the scientists, on the potential benefits and risks of adopting GM technology and food crops. Farmers need thorough and clear communication about what the GM process entails for them to make informed decisions.

Previous studies have reported similar findings on the public attitude toward GM food. For example, Lewis et al. (2020) reported that participants in their study were more receptive to the potential use of GM crops, whereas Deffor (2014) reported the participants' negative attitudes and low intentions to consume GM food. Of interest to note is the fact that contrary to this study, where I associate the attitude of the farmers with the information they received, other studies associate public attitudes with socio-economic factors. Therefore, despite the farmers' concerns in this study, they were more optimistic about GM food because of the potential benefits they had heard about GM technology and food.

4.5 Discussion of Findings

This section is about the discussion of the findings of this study presented and analysed above. I discuss the implication of the findings, how they relate to the findings of previous studies and the assumptions of the four models of science communication which informed this study. This study sought to explore the crop scientists' communication of GM food information to maize farmers in western Kenya. I explored this communication from the senders' (scientists') point of view and the receivers' (farmers'). From scientists, I wanted to find out how they conceptualised their communication to farmers and, consequently, how they farmed the GM food messages that went to the public (farmers, in particular). Additionally, I examined the scientists' approaches to communicating GM food information to the farmers and assessed the challenges they encountered during the communication process. From the maize farmers, the study sought to assess (i) the information available to them and the information they need regarding GM food crops, (ii) farmers' reception and perception of the information they access, and (iii) farmers' use of the information in terms of how it shapes their knowledge and attitudes towards GM technology and food crops.

Generally, the study's results, analysed and presented above, have revealed several lessons about the communication of GM food information worth discussing: (i) scientists' conceptualization of the communication of GM food crop information inform their framing of GM messages for the farmers; (ii) the communication of GM food crop information is set back by several factors, including misinformation and a lack of science communication skills; (iii) farmers are aware but have inadequate knowledge of GM food owing to the limited information accessible; (iv) scientist' direct approaches to communicating GM food information are ineffective; (v) farmers do not often understand the accessible GM food crop information but the information makes them more optimistic than negative about GM food crops; (vi) farmers have concerns about GM, and they demand information from reliable sources to address these concerns; (vii) farmers expressed mixed meanings of GM food owing to the nature and quality of information accessible to them.

In this section, I will discuss the findings of this study in light of these lessons, findings from previous studies, and the four models of science communication. Then, I will conclude by providing these findings' implications for communicating GM food crop information to farmers and the public in general.

4.5.1 GM Messages Framing is Influenced by Scientists' Conceptualisation of Communication about GM Food

The study findings revealed that the crop scientists researching GM food in Kenya had different conceptualisations of GM food information communication to the farmers. Similarly, the scientists had different ways of framing GM messages to the farmers. The analysis of the findings revealed a link between the scientists' conceptualisations and the framing of GM messages to the farmers in that the GM messages were framed to reflect the conceptualisation.

In line with the deficit model of science communication's assumption that the public has a deficiency of scientific knowledge and, therefore, needs information to feel this deficiency, the scientists conceptualised communication of GM food information as a means for education provision to the farmers. They seemed to believe that this communication would improve farmers' knowledge and, thus, their acceptance of GM food. In the same vein, I found that the scientists in the study framed GM messages to inform/educate the farmers about GM food. It seems clear that scientists used the education frame because the main focus here was to disseminate information that would inform or educate the farmers about GM food. These findings are consistent with several previous studies that reported that the public lacks knowledge about GM technology and food and recommended improving public awareness and education about GM food. For example, Mbugua-Gitonga et al. (2016) pointed out a need to increase public awareness because the public lacks scientific knowledge about GM food. Kagai (2011) calls for improvement in information sharing and delivery to increase public awareness because the public will adopt and accept GM crops when they understand them. In the same vein, Deffor (2014) argued for the need to promote effective education about the benefits of GM to increase the potential for acceptance. Similar to the scientists in this study, the deficit model associates the public's opposition to science (in this study, GM food) with the lack (deficit) of scientific knowledge. The scientists in this study said that if the public (farmers) understood their research findings about GM food, they would be more receptive and vice versa. Therefore, they focused on disseminating GM food information to the farmers to improve their awareness and knowledge and increase the likelihood of GM food acceptance.

It could be observed, similar to Suldovsky (2016), that the aim of communication here was to decrease the gap between the scientists (who know about GM) and the public (farmers) who were assumed to lack GM food knowledge. This communication would improve the scientists-public relationship thought in the deficit model as fractured. It should, however, be noted that although some knowledge about science is essential (Sturgis and Allum 2004), it is also important to consider other factors, such as cultural differences, which may affect how farmers understand GM food. As shown in the literature review chapter, this is one of the weaknesses of the deficit model of science communication. Indeed, farmers demonstrated this in their perception of the information they receive and their report of concerns about GM food.

The scientists also conceptualised communication about GM food as a means to address farmers' concerns about GM technology and food and debunk the myths and misinformation about GM food. Consequently, they framed their communication to address farmers' questions and concerns. This frame could be referred to as the question/concerns frame since the aim of the scientists here was to address farmers' questions and concerns regarding GM food. However, it should be noted here that the findings of this study have revealed that farmers did not feel that the information they received addressed all of their concerns. Indeed, they reported receiving information from multiple sources with conflicting messages, which might have increased their concerns because they said it confused them more.

The reception of information from multiple sources and conflicting messages can imply possibilities of misinformation and miscommunication about GM food, as reported by the scientists in this study. The findings of this study revealed that the scientists also used what I term a misinformation/miscommunication frame in framing their GM food messages. This framing aimed to debunk misinformation and miscommunication surrounding GM food. Several previous studies have reported misinformation on GM food and have indicated that to be done by anti-GM groups (Gheysen et al., 2019; Kosgey and Cyrus, 2019) and opinion leaders such as religious leaders, NGOs, and politicians (Nisbet and Mooney, 2007; Bubela et al., 2009). Regarding the opinion leaders, Kosgey and Cyrus (2019) observed that leaders and policymakers, without clear information about GM crops, pass on the wrong perception to the public GM (p. 13951). The impact of this misinformation may be said to slow down the adoption of GM technology and fuel the public’s negative attitude towards GM food. However, it is important to note that the lack of proper communication about GM food from reliable sources, such as scientists, legitimizes misinformation spread by these anti-GM groups. As Kosgey and Cyrus (2019) put it, the public's misconception about GM crops may result from the non-scientific debate about GM crops warranted by the fact that most scientists do not engage the public on issues concerning GM crops. This study found that the farmers did not receive enough communication (note that most farmers received information only occasionally), and the information they received was either incomplete or not from reliable sources; therefore, there was room for misinformation and miscommunication. The general argument of this study on scientists' conceptualization of GM communication to the farmers is that scientists framed their GM food messages to reflect their conceptualization, which was that the farmers needed their GM food knowledge to be improved so that they could be more receptive to GM food; farmers had questions and concerns about GM food which needed be addressed by sharing research findings on GM, and there existed misinformation and miscommunication about GM food; thus the communication was meant to debunk these.

Consequently, scientists used the educational/awareness, question/concerns, and misinformation/miscommunication frames. Scientists, however, need to re-think their communication strategies to balance their focus between increasing awareness and involving the farmers. When miscommunication [and misinformation] has dominated, science communication must start with what the audience knows or has been convinced to believe (Oloo et al., 2020b). Oloo et al. observed that in communicating about GM food, scientists must not just let the science speak for itself; they must also share with the public who they are, their interests, and why they are involved in GM research. They also noted that scientists should present their results with the view that they are simply part of "alternate farming and not necessarily the panacea" of all the public's problems (p. 690)

4.5.2 There were Similarities and Differences between Farmers' Information Sources and Scientists' Communication Approaches

Numerous previous studies have featured the issue regarding the public's source of GM food information. The sources of GM food information have been used to explain farmers' awareness of GM technology and food. Most studies report that the public access information mostly through the media, specifically radio, newspapers, and television (e.g., Kimenju et al., 2005; Kagai, 2011; Karau et al., 2020). Similar to the findings of these studies, I found that media, especially radio, dominated the farmers' sources of GM food information, with 78.2% (233 out of 298) of the farmers reporting accessing information through this source. Interestingly, the findings of this study have shown that more than half of the farmers (52%, 155 out of 298) received GM food information from friends, which puts a question mark on the quality of information farmers got. Furthermore, the farmers reported sharing information they received with other people, including their family members and fellow farmers. Indeed, 53% of the farmers said they shared this information with friends.

The fact that farmers received information from friends and shared the same information warranted a possibility for misinformation and miscommunication. This is especially so because just over half of the farmers (152 out of 298, 51%) reported not understanding the information they received. This implies the possibility of farmers receiving information from 'friends' who did not understand the information they shared. After receiving it, they also shared the same information they might not have understood. This kind of sharing could prove very likely to become a source of misinformation, making farmers more sceptical. Indeed, the study findings have shown that farmers perceived the information they received as confusing due to conflicting messages from multiple sources.

Regarding the farmers' sources and scientists' approaches to communicating GM food information, the findings of this study have shown that similarities and differences exist. The study found that both farmers and scientists reported radio, Newspapers, television, seminars/workshops, and barazas as sources of GM food information and channels used to communicate the information. However, the difference in using these sources/approaches is interesting. Whereas scientists reported reaching and disseminating/sharing information to/with farmers through seminars, workshops, and barazas, farmers reported these three sources as least used in receiving GM food information, as shown in the table below. Scientists use farmers as middle people for sharing information with other farmers, which could be similar to farmers' reports of receiving information from friends and sharing information they received with others. Indeed, in using farmers as communicators, scientists encouraged farmers to share information with other farmers who would also share with a few others. Of interest in the findings is the absence of scientists' visits to farmers or farmers' invitations to research institutions in the farmers' list of sources. This may serve as evidence for the ineffectiveness of scientists' direct communication approaches (cf. the next section). There was also an absence of extension officers in the scientists' approaches. The scientist said they partnered with commercial seed growers, which did not feature in the farmers' sources. These mismatches imply that scientists must re-strategise their approaches. Since the extension officers are much closer to the farmers, they could provide a more worthy partner in helping the scientists engage farmers with GM food issues.

Table 4.12: Farmers' Sources of GM Food Information vs. Scientists' Communication Channels

Farmers' sources of information		Channels used by scientists
Radio	233(78.2)	Radio
Newspapers	121(40.6)	Newspapers
Television	137(46)	Television
Internet	99(33.2)	Social media
Friends	155(52)	Partners (e.g., farmers; commercial seed growers)
Seminars/workshops/ training	31(10.4)	Workshops and seminars
-		Agricultural shows
Barazas	12(4)	Barazas
Schools	29(9.7)	-
Books	29(9.7)	-
Extension officers	36(12.1)	-
-		Field visits
Journals/articles	17(5.7)	

Source: Primary data from a questionnaire administered to farmers, April – July 2022

It seems obvious from the analysis of the findings that the communication of GM food information to the farmers involved a more linear one-way information transfer, especially through the media. This is in tandem with the scientists' conceptualisation and the deficit model's assumption that public awareness and knowledge need to be improved. The communication approaches and sources that could allow participation or a dialogical approach between scientists and farmers were either less used by farmers or did not exist in the farmers' list. Clearly, farmers need interaction with scientists to help address their scepticism and help them make informed decisions about GM food. Overreliance on the media could also be a challenge since the media also circulates miscommunication on GM technology and food (Oloo et al., 2020b). Still, since media dominated farmers' sources of information, scientists could capitalize on this and use it to reach more farmers. Overall, scientists need to re-think their communication strategies to ensure increased farmers' participation in the process and simultaneously achieve their aim of enhancing farmers' awareness and knowledge of GM food.

4.5.3 Scientists Used Direct and Indirect Communication Approaches, but Direct Approaches were Ineffective

Apart from the findings of this study showing that scientists' comceptualisation of communication of GM food information influenced the framing of the GM messages for the farmers, the findings further demonstrated evidence for scientists' use of both direct and indirect approaches in their communication. The direct approaches included scientists visiting farmers in the fields or scientists inviting farmers to the research institutions as well as seminars, workshops, and barazas. Indirect approaches, on the other hand, included media use and stakeholders such as commercial seed growers and selected farmers. Figure 4.6 below summarises these approaches in the framework used by scientists to communicate GM food information to the farmers.

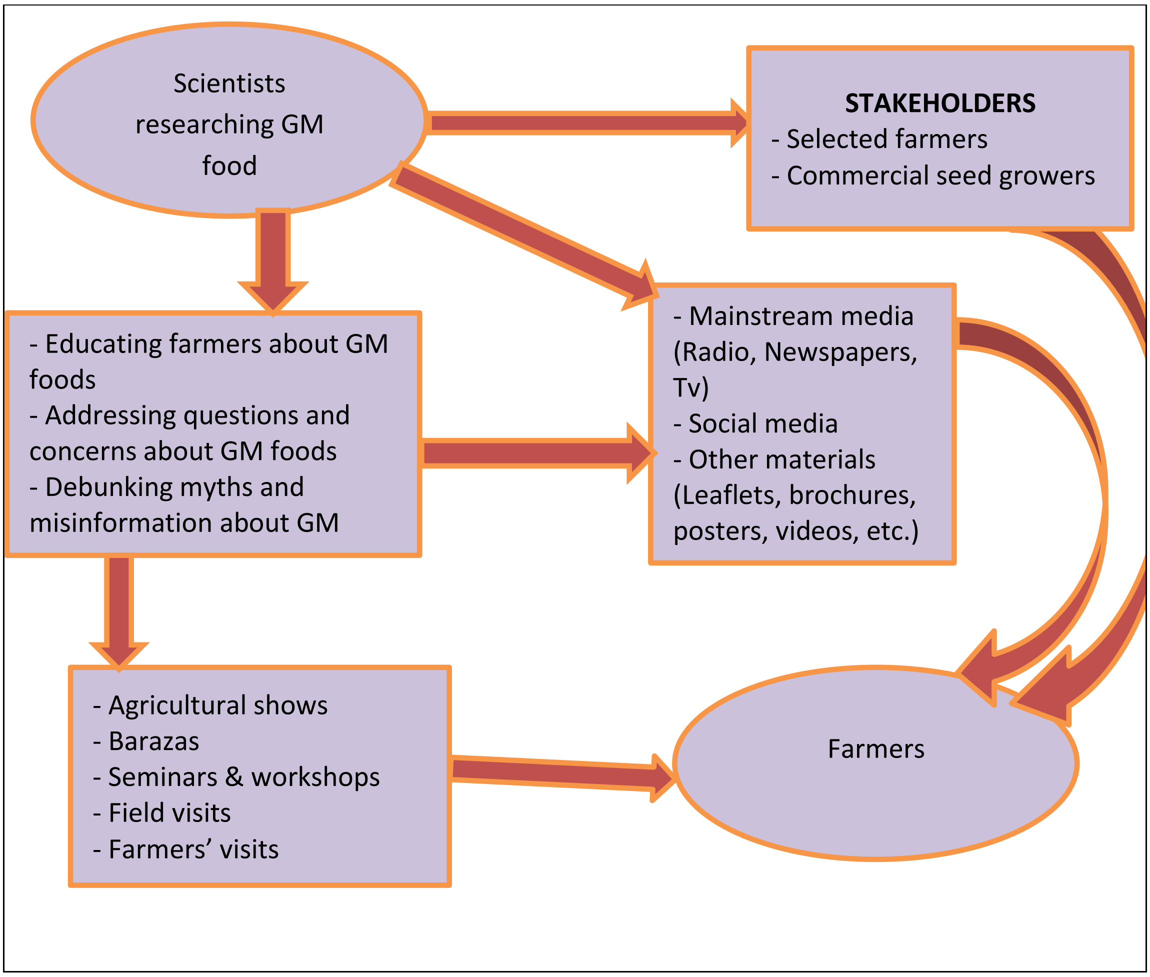

Figure 4.6: Scientists' Framework for Engaging Farmers with GM Food Affairs
Source: Primary data from the interview with Crop Scientists Researching GM food crops in Kenya, April - July 2022

Of interest in this study, as I have noted earlier, is the finding that very few farmers received information through direct approaches. Specifically, only 10.4% (31 out of 298) and 4% (12 out of 298) of the farmers received information from seminars/workshops and barazas, respectively, whereas none of the 298 farmers reported being visited by scientists or visiting the GM food research institution. These findings imply that farmers get little information about GM food directly from the scientists researching GM food in Kenya. Furthermore, the farmers depended on information from the media and fellow farmers/friends, which, as I have argued earlier, may warrant misinformation and miscommunication about GM food. It also seems evident that most of the communication the farmers received was linear, involving the scientists disseminating the information generated from GM food research to the farmers indirectly. This indirect dissemination of information was primarily through the mainstream media: radio, Newspapers, and television, as discussed earlier.

It is important to note that the use of social media (as reported by scientists) could prove unreliable since not many farmers could access information from this source; notably, the internet was identified by 33.2% of farmers as one of the sources of GM food information. Even more importantly, the unreliability of social media (and the internet in general, as identified by the farmers) could be because anyone can post/share information and their perceptions through the internet. Therefore, social media could stand a high chance of misinformation and miscommunication.

These findings have further demonstrated the evidence for the dominance of the deficit model of science communication in the scientists’ communication of GM food information to the farmers. The relationship between the scientists and the farmers seemed to be more linear, with the one-directional transfer of information from scientists to the farmers through indirect approaches, especially the media. On the other hand, there was limited bi-directional interaction between the farmers and scientists through seminars/workshops and barazas. The findings of this study have also shown that scientists perceive the farmers as lacking knowledge of GM food, thus their use of a linear, indirect communication approach. Although the findings have corroborated this lack of knowledge, they have also demonstrated that the farmers preferred a more multi-directional approach to communicating GM food information. The farmers wanted more direct interaction with the scientists, other parties like the government, and discussion/interaction with fellow farmers and other groups of people on GM food-related matters. The implication is that the communication of GM food information activities needs to balance dissemination and public engagement by encouraging activities that could improve the latter.

4.5.4 Farmers Have Inadequate Knowledge of GM Food Crops Courtesy of Information Accessible

The question regarding public knowledge and awareness of science has been the concern of much research in science communication. The deficit model of science communication views the public as suffering from scientific knowledge deficiency and, therefore, requires scientific information to be disseminated to them to cure this deficit. The findings of this study have demonstrated that farmers had inadequate knowledge of GM food. These findings align with this assumption and the scientists' conceptualization discussed earlier in this section. The findings are also consistent with those reported in previous studies (e.g., Kimenju et al., 2005; Lweis et al., 2010; Changwena et al., 2019; Karau et al., 2020; Oladipo et al., 2020).

Almost all the farmers in this study (295 out of 298) reported being aware of GM food but could not back this awareness when asked to define GM food. Farmers' definitions of GM food were a mixture of correct and incorrect definitions with a focus on some aspects of GM food. This signalled that farmers had incomplete information or were misinformed about GM food. These findings have clearly shown that the information farmers received about GM food did not help them understand GM food clearly. Indeed, all the farmers reported receiving GM food information from various sources, but 77% were not satisfied with the amount of information, whereas 81.5% indicated it was not communicated often enough (note most farmers received information only occasionally). 51% of the farmers did not understand the information.

Furthermore, the findings have shown that farmers (65.4%) felt that the information they received confused them because it came from multiple sources with conflicting messages. The implication here could be that the reliable sources of GM food information, such as the scientists involved in GM food research, have not adequately involved the public in GM issues, especially through communication, similar to the arguments by Kosgey and Cyrus (2019) and Changwena et al. (2019). Indeed, this study found that most farmers did not receive enough GM food information through some of the channels used by scientists, such as seminars, workshops, barazas, and field visits. This may have denied farmers first-hand information, something the farmers appeared to lament about.

Previous studies associate the public's poor level of GM food knowledge with a lack of clear communication or absence of it. However, I argue that the inadequate level of farmers' knowledge about GM food demonstrated by the findings of this study could be the function of the nature, amount, and quality of information they received. Farmers seemed to access incomplete information from various sources, some of which could warrant misinformation and miscommunication. As Kosgey and Cyrus (2019) put it, this situation may have led to non-scientific public debate about GM, hence, misconception. For example, 52% of the farmers in this study received information from friends, which may stand a great chance of being unreliable.

4.5.4 Meanings Expressed by Farmers about GM Technology and Food

As discussed in chapter one, GM food crops result from genetic engineering or genetic modification of food crops. GM foods have been used for human and animal feed in several countries for over 20 years. Furthermore, there has been numerous research on GM food, findings of which have shown that the food has not brought any new risks to either human health or the environment (Snell et al., 2012; De Francesco, 2013; Nicolia et al., 2013; Klumper and Qaim, 2014; Gheysen et al., 2019). Despite GM food being around for this long, the findings of this study have demonstrated that the farmers have inadequate knowledge of GM food (as discussed above) and that they had a mixture of correct and incorrect definitions of GM food. This is despite the fact that they all reported hearing or reading about it. The findings also showed that the farmers expressed mixed meanings when defining GM food. Most of the farmers' definitions focused on certain aspects of GM food. They may be said to reflect the public's (farmers') perception of it, which could be the function of the nature, quality, and amount of information they receive.

Some of the correct meanings expressed by the farmers focused on the characteristics/benefits of GM food, such as increased production, resistance to pests and diseases, tolerance to droughts, and improvement of farmers' earnings. Most definitions under this category portray GM food as one that results from crops modified to produce more yield. However, while this part of their definition was positive and correct, the study found that farmers tended to associate these positive properties with some perceived negative effects, especially on human health. For example, they associated GM food with abnormal growth and cancer-related diseases. Again, these meanings demonstrated that farmers received incomplete information and that such was coupled with misinformation and miscommunication about GM food.

Some other definitions could be deemed incorrect and focused on or associated with some of the perceived negative aspects of applying GM technology or consuming GM food. The meanings expressed under this category associate consumption of GM food with adverse effects on human health or the environment. For example, some meanings expressed associated GM food with causing cancer, ulcers, obesity, mutations, and abnormal growth. The common description used by farmers here was that GM food is developed in the laboratory, uses a lot of dangerous chemicals, is artificial, grows faster, and, therefore, is not fit for human consumption. However, as I already pointed out, evidence from the literature shows GM food has not been found to cause these adverse effects.

It seems evident that the meanings of GM food expressed by farmers are a function of the information they receive. It also seems obvious that the communication of scientific information about GM food competes heavily with misinformation and miscommunication about it. These meanings could also be said to be the result of what France and Gilbert (2019) call the failure of the biotechnology industry to introduce educational and awareness creation programmes to address public perceptions early on. As discussed earlier, the findings of this study have demonstrated, similar to the findings in previous studies, that the misinformation and miscommunication about GM are perpetrated by some NGOs and anti-GM groups whose campaigns seem fairly strategic. It could be plausible to argue that the meanings expressed by farmers show that the anti-GM groups are superior to scientists and pro-GM groups in terms of engaging the public with GM food issues. This argument is supported by the fact that the meanings expressed by farmers featured some of the messages spread by the anti-GM groups more than they featured the aspects of correct messages about GM food. For example, regarding the consumption of GM food causing cancer, the anti-GMO campaign tends to carry this message, as in the communication through a local radio in Uganda by ActionAid-Uganda that GM foods cause cancer and infertility (Karembu 2017, cited in Gheysen et al., 2019). According to Gheysen et al. (2019), this communication was later declared incorrect by the same UK-based organization but had already caused the damage. It fueled a lot of anti-GMO activism and delayed the biosafety bill needed for GM crop cultivation. It is also important to note that because the findings have shown that farmers received information from other farmers and shared it with others and that direct communication from scientists was limited, there could have been numerous chances for misinformation.

Generally, the meanings expressed by farmers about GM food cement this study's findings that farmers received information from multiple sources, which warranted misinformation; farmers had concerns about GM food (61.7%), and they accessed information that did not address all of these concerns (68.1%). Obviously, when the public does not receive accurate, complete, and credible information about a scientific phenomenon (like GM food, which is relatively new), they will rely on speculations and unreliable (including ill-intended) information from anti-GMO groups. It is important to stress, in line with Oloo et al. (2020a), that these groups focus on less critical issues about GM technology and food while ignoring the positive aspects of GM. They also quickly exploit communication gaps left by scientists (Oloo et al., 2020b) to share their negative agenda, leading to public confusion and uncertainty about GM food crops.

4.5.5 Farmers are concerned but Positive towards GM Food Crops

The contextual model of science communication considers the audience (public) as questioning and concerned rather than passive. The findings of this study have demonstrated that farmers had concerns about GM food, especially about the perceived risks of GM food on human health and the environment, as well as the availability of GM products such as seeds. These findings are consistent with those of previous studies (for example, Kimenju et al., 2005; Kagai, 2011; Oladipo et al., 2020), which reported that the public is concerned about GM, especially concerning the potential health and environmental risks.

The interesting finding regarding farmers' concerns is the country's hesitation to adopt GM technology and food. Farmers questioned if GM food was as good as they had heard; why, then, was the government against its adoption? They thought there was something that the government knew that they did not. Key to this study is the finding that the information farmers received about GM food did not address all their concerns. Indeed, I argue that the information exacerbated their concerns because, as these findings have demonstrated, it confused the farmers more. This confusion was perhaps because the information from scientists constantly competed with miscommunication and misinformation from some anti-GMO groups, which, according to the scientists in this study, had clear strategies for reaching the farmers. It should also be noted that farmers' confusion and scepticism are fueled by the fact that the government and scientists speak different languages about GM technology and food.

Despite the farmers' concerns, the findings further revealed that farmers were more positive (63.1%, 188 out of 298 farmers) than negative (36.2%) about GM food, courtesy of GM food information they received. It is important to note that farmers said the information they received made them feel positive because, among other things, it described GM food as having more benefits to farmers. Similar findings were reported by Lewis et al. (2010), who observed, on the farmers' attitude, that there was a tendency of farmers in their study to focus on the benefits rather than the long-term health effects. These findings imply that proper communication of GM food information from credible sources would help the public make more informed decisions about GM technology and food. Although previous studies associated the public attitude toward GM food/crops with socio-demographic factors (Anunda et al., 2010; Nyindosi et al., 2017; Deffor, 2014; Changwena et al., 2019), this study found that farmers’ attitudes toward GM food can be associated with the nature and quality of GM food information they received. This means, in line with the assumption of the deficit model of science communication, if the quality of the information the farmers receive is improved, farmers can be more receptive to GM food.

4.5.6 Farmers Demand Complete Information about GM Food Crops from Credible Sources

Although farmers reported receiving GM food information, this information (as discussed earlier) seemed incomplete and insufficient and did not help them understand GM food more clearly. The findings have shown that farmers needed more information about GM food, and they needed this information from sources they could trust. They needed information that could help them clearly understand several issues concerning the GM process and GM food, in terms of what it is, what the benefits are, and the potential risks to human health and the environment. The findings of this study have further shown that credible information regarding these aspects is either not properly communicated or is lacking, which may confuse farmers and increase their scepticism. It also seems likely that credible information about GM food was diluted by misinformation and miscommunication surrounding GM food.

These findings imply, similar to the findings of several previous studies, that there is a need to provide the public with complete GM food information to improve their understanding of it (e.g., Anunda et al., 2010; Kagai, 2011; Deffor, 2014; Changwena et al., 2019; Oladipo et al., 2020). It is important to reiterate that this study found that farmers demonstrated inadequate knowledge of GM food despite reporting receiving information about it from various sources. It also found that farmers were not satisfied with the amount of information they received (74.2%) because it was not communicated often enough (81.5%). Besides, they perceived the information as containing conflicting messages (65.4%). The persistent implication here is that miscommunication about GM food seemed to be amplified more than the scientific communication about it. Therefore, scientists need to engage the farmers more with their GM food research; indeed, farmers demonstrated this need by claiming that they had never had those concerned with GM food visit them to provide education. Certainly, the information the public receives seems to influence the public's attitude and actions toward GM food; thus, it is important for the parties involved to ensure that the public gets the appropriate information. Anunda et al. (2010) also insisted on the need to communicate with the public with complete information about GM in a proactive way.

The farmers' demand for more reliable information echoes the assumption of the contextual model of science communication that the audience is not passive spectators but rather concerned and questioning. It also echoes the public participation model of science communication's assumption that advocates for more public engagement with science. Similarly, Chengwena et al. (2019) call for a need to engage the public in GM issues by consulting consumers during policy formulation about GM food. Clearly, farmers and the public, in general, need clear and complete information regarding what is involved in the GM process. As Anunda et al. put it, there is a need for well-designed and effective programmes to educate the public about GE in agriculture and food production. These programmes should be coupled with increased public engagement in GM food issues. It seems obvious that if the parties involved do not communicate effectively, it leaves room for misinformation and miscommunication, especially from the opinion leaders. These opinion leaders (who are not scientists), such as religious leaders, NGOs, and politicians, are said to be successful in formulating their messages about science in a manner that connects with key stakeholders and the public but, at times, contradict scientific consensus (Nisbet and Mooney, 2007, cited in Bubela et al., 2009).

4.5.7 Several Challenges Thwart Communication of GM Food Crop Information

GM food, a relatively new phenomenon, requires proper communication by the parties involved for the public to clearly understand it, engage in meaningful debate, and make informed decisions when called upon. The findings of this study have demonstrated that the scientists communicated the knowledge generated by their GM food research to the farmers. Still, this communication was insufficient because farmers needed more direct communication from scientists. Indeed, very few farmers reported receiving information through some of the channels in scientists' communication approaches, implying that scientists' communication approaches require re-thinking. The obvious implication here is that scientists must plan for more public engagement in GM food issues.

The findings of this study revealed that scientists' communication of GM food information to the farmers was setback by several challenges. These challenges ranged from negative campaigns by anti-GMO groups that spread misinformation and miscommunication to farmers' reluctance and demand for GM products to language barriers and lack of science communication skills. The findings have shown that one of the main challenges was the language barrier and lack of science communication skills. Finding equivalence of GM messages in local languages seemed to be a big huddle in communicating with the farmers. Due to the lack of equivalence, it seemed probable to lose the intended meaning during translation by scientists or other communicators such as the media.

Connected to the language challenge is the lack of science communication skills for scientists. Indeed, the study found that the scientists reported lacking such skills, which may have slowed down their communication with the farmers. The lack of science communication skills reported by the scientists could be a problem for other parties involved in the communication of GM food information to the public. Due to this, these parties could sometimes send misleading information regarding GM technology and food. For example, it is not uncommon to see, on the internet, a picture of a syringe piercing through, say, an apple, describing what GMOs are. Information like this speaks to the lack of science communication skills among some communicators of GM food information. It could also be why the farmers in this study referred to GM foods as foods injected with chemicals that could have adverse effects on human health. This example adds to the unreliability of the information farmers receive, especially from the media and friends, which they also share with others.

Another main setback was misinformation and miscommunication from the negative anti-GMO groups' campaigns. This study is consistent with other studies (Gheysen et al., 2019; Kosgey and Cyrus, 2019; Oloo et al., 2020a) that anti-GM campaigns spread very negative and incorrect messages about GM food and consequently led to farmers' misconceptions about GM food, making them less receptive of information from scientists. As Bubela et al. (2009) put it, individuals are drawn to news sources that confirm and reinforce their pre-existing ideas; therefore, farmers could be drawn more to information that conforms to the messages of the anti-GM group. These groups seem more organized and more strategic in reaching the public with their messages than the scientists and pro-GMO groups because scientists said the farmers already embraced the idea that GM food is bad, and thus, they were reluctant to change. Clearly, scientists and other parties involved in GM technology and food need to take a step back and re-group and develop improved strategies for engaging farmers with GM issues. A plausible solution to all these is a clear communication strategy that recognizes the demands of the contextual model of science communication that science be communicated to the public as it relates to them. This can better be done if there are communication initiatives that encourage more public (farmers) participation and deliberation (as in the public participation model), acknowledging that they, too (farmers), may have their ways of interpreting matters related to food. Improved public engagement will ensure that scientists understand what the farmers (public) know and then communicate from this perspective.

4.5.8 Implication for the Models of Science Communication – Information Sharing (dialogue) or Information Transfer (dissemination)

The debate surrounding science communication and the models of science communication has been centred on whether science communication initiatives should include transferring or sharing scientific information with the public. The difference between the two is defined by the involvement of the public in the process, whereby in information transfer, the public is seen as the receiver of the information about science and is not expected to contribute to the process of science communication. The main focus is improving the public knowledge of science. On the other hand, in information sharing, the emphasis is on the dialogue between the scientific information communicator and the receiver (the public) and between the members of the public. As discussed in the literature review section, the debate is summarised by the two paradigms of the models of science communication. At the heart of the discussion is an argument for the need to move from information transfer to information sharing to encourage more public engagement. In this study, I found that the scientists both transferred and shared GM food information with the farmers, courtesy of how they conceptualized the communication of this information to the farmers. At one point, Scientists expressed the need to educate the farmers about GM food (because they perceive them as lacking knowledge about GM), thereby transferring information to them, whereas, at another point, scientists needed to understand the farmers' questions and concerns about GM food in order to address them in their communication. Here, the scientists seemed to share GM food information with the farmers because they engaged them in discussions during seminars, workshops, and barazas. In these sessions, the scientists received and addressed farmers' questions and concerns about GM food. It is, however, important to note here that the findings demonstrated that very few farmers reported receiving GM food information from these channels (for sharing information) used by scientists. As observed earlier, the scientists transferred more than they shared information with the farmers, consistent with the argument by Bubela et al. (2009)

that many scientists and policymakers associate ignorance with controversies over science and, therefore, consider giving the public scientific facts as the solution.

The findings of this study have demonstrated that different models of science communication can co-exist in science communication activities and that the deficit model is still relevant in science communication. Indeed, the scientists' communication of GM food information to the farmers in this study was dominated by the assumptions of this model. The findings have further shown that scientists and communicators still need to balance information transfer with information sharing; farmers lamented the lack of direct interaction with the scientists and other parties involved in GM technology and food. The decision on which model to use rests on the communicators' conceptualization of science communication and, therefore, the objectives they aim to achieve. In this study, the communication of GM food information seemed to be aimed at educating the public, addressing the farmers' questions and concerns about GM food, and debunking myths and misinformation/miscommunication surrounding GM food. The ultimate goal was to make farmers more receptive to GM food. Indeed, these findings align with Burns et al.'s (2003) AEIOU definition of science communication, which I adopted earlier in this study (see Chapter Two). The communication of GM food information in this study was meant to increase farmers' awareness and interest, understanding (i.e., knowledge) of GM food, and form, reform, or confirm farmers' attitudes toward GM technology and food.

4.6 Summary

This chapter has covered data analysis, presentation, and discussion of the findings of this study. The analysis of data and presentation of findings was done according to the study’s research question as well as informed by the four models of science communication. The findings' interpretation revealed several lessons highlighted in this chapter's discussion section. Generally, the discussion of the findings of this study revealed the following.

Scientists communicated the knowledge generated from their GM food research to the farmers using both direct and indirect approaches, courtesy of how they conceptualized the communication of GM food information. However, the findings further revealed that some of the channels used in these approaches were ineffective since only a few farmers indicated them as their sources of information. The scientists’ communication was more indirect and linear than direct and interactive, focusing more on disseminating information to improve farmers' knowledge of GM food crops. On the other hand, farmers wanted more direct communication from scientists and to be more involved in GM food issues.

The findings revealed that farmers had inadequate knowledge of GM food despite self-reporting to be aware of it. This inadequacy resulted from the nature and the quality of information farmers received; farmers did not receive enough scientific information on GM food, and more than half did not understand the information received. Besides, the information they received did not help them understand GM food more clearly; it confused them because it carried conflicting messages from multiple sources. There seemed to be constant competition between scientific and non-scientific information, probably from opinion leaders and anti-GM groups’ campaigns. The misinformation and disinformation flourish because of the scarcity of scientific information about GM food. Farmers also shared the information they received with others, perhaps contributing to misinformation and further confusion about GM food.

The findings also revealed that the information accessible to farmers made them more optimistic than negative about GM food crops, implying that if the quality of information farmers receive is improved, they will become more receptive to GM food. The findings have further demonstrated that the assumptions of the deficit model of science communication dominated the communication of GM food information to the farmers compared to the other three models, signifying that it is still useful and that models of science communication can co-exist in science communication study.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

This chapter is about the summary of the study, the conclusion of the study, and recommendations. I begin by summarising this study, including what it set out to do and how I achieved it regarding how the data were generated, analysed, and interpreted. I then summarise the study's key findings for every research question and end the chapter with what this study recommends in order to improve the communication of GM food to the farmers and the general public and for future research.

5.2 General Summary

This study aimed to explore the scientists' communication of GM food crop information to the farmers. To achieve this aim, I explored issues regarding how the crop scientists researching GM food in Kenya conceptualised and framed the communication of GM food information to the farmers on the one hand and examined what GM food information is available to the farmers in Kenya (specifically from Uasin Gishu and Trans-Nzoia counties), how they access and make sense of this information, and the impact of the accessible information on the farmers' attitude towards GM food, on the other hand.

The study was rooted in the pragmatism philosophical paradigm and thus adopted a mixed methods approach and the convergent mixed methods design. I concurrently generated quantitative data from maize farmers in the two counties and qualitative data from crop scientists researching GM food in Kenya. I administered questionnaires to 298 maize farmers and interviewed eight Key Informants from the scientists. I analysed the data using descriptive statistics analysis for the quantitative data and thematic analysis for the qualitative data. I then integrated the data from the two methods during the analysis and interpretation of the findings in Chapter Four above, revealing the following key findings of the study:

i. Scientists conceptualised the communication of the GM food research findings to the farmers as a means of informing/educating farmers about GM food, addressing farmers' questions/concerns about GM food, and consequently, scientists used an educational frame, concerns frame, and misinformation/miscommunication frame when framing GM messages for farmers. The ultimate goal of the communication was to increase farmers' receptivity to GM food crops.

ii. Despite farmers' reported awareness, they had inadequate knowledge about GM food, which may be associated with the nature and quality of information they access regarding GM food because they received information from multiple sources with conflicting messages. This information did not help them understand GM technology or food more clearly; it made them more confused and sceptical.

iii. There were some similarities and differences between what the farmers identified as sources of GM food information and scientists' approaches to communicating GM food information to the farmers. Most of the direct approaches identified by the scientists did not feature in the farmers' sources or were identified by very few farmers. Most farmers received information from the radio and friends, but more than half of the farmers did not understand the information, and many more complained that the information was insufficient. Farmers wanted more direct communication from the scientists and other parties involved in GM, including the government. Furthermore, farmers shared the information they received with others, which might have contributed to further misinformation and miscommunication.

iv. Farmers had concerns, especially about GM food's effect on human health and the environment. In addition, they were also concerned about the entire GM process and the availability of GM seeds. These concerns are partly due to the nature and quality of the information they access (they received information from multiple sources with conflicting messages). Farmers demand complete, precise, and reliable information from credible sources, including scientists, to address these concerns.

v. Despite the farmers' concerns, most had a more positive than negative attitude towards GM food owing to the information they received about GM food. Farmers tended to focus on the benefits of GM technology and food rather than the perceived adverse effects on human health and the environment.

vi. Crop scientists' communication of GM food information to the farmers constantly competed with miscommunication and misinformation about GM food, among other setbacks such as the language barrier, lack of science communication skills, farmers' reluctance, and lack of finished GM products such as seeds.

5.3 Conclusions

In this study, I explored the scientists' communication of GM food crop information to the farmers, seeking answers to four research questions. Below, I will present each question, briefly explain the study findings for the question, and then state what the study concludes.

The first research question was *how do the scientists conceptualise and frame communication of GM food crop information to the farmers in western Kenya?* The study found that the scientists considered farmers their immediate audiences, and farmers have poor knowledge of GM technology and food. They also thought miscommunication and misinformation about GM food contributed to farmers' reluctance to receive their research findings. Scientists believed that their communication of GM food information was meant to achieve three objectives: improve farmers' knowledge and awareness of GM food, address farmers' questions and concerns about GM food, and debunk the miscommunication surrounding GM food to make farmers more receptive to GM food. These objectives informed scientists' framing of GM messages, which went to the farmers. Scientists used educational/awareness, concerns/questions, and misinformation/miscommunication frames.

The study concludes that scientists' conceptualization of the communication of GM food information to the farmers influenced how they framed their GM messages. Their conceptualization of the public as lacking knowledge about GM technology and food affirms the assumptions of the deficit model of science communication. Indeed, scientists' communication with the farmers was dominated by this model, proving that the deficit model persists and its assumptions can still be relevant to communicating scientific information. On the other hand, Scientists' conceptualization of the public as having concerns about GM technology and food aligns with the contextual model of science communication. This corroborates the idea that different models of science communication can be used simultaneously in science communication. The study further concludes that scientists' communication of GM food information to the farmers seemed to compete with misinformation/miscommunication from some anti-GM groups, which appeared to have good strategies for reaching the farmers. This situation caused confusion and reluctance among farmers. In addition, the communication was setback by language barriers, a lack of science communication skills, and the lack of finished GM products.

Concerning the second research question: *what information is available to farmers in western Kenya regarding GM food crops*? This study found that although farmers reported being aware of GM food, they lack a proper understanding of GM processes and GM food. Farmers gave a mixture of incorrect and correct meanings when defining GM food. The meanings expressed when describing GM food seemed to echo the messages of some anti-GM campaigns by stressing the perceived adverse effects of GM food on human health and the environment.

The study concludes that farmers had inadequate knowledge of GM technology and food, which could have resulted from the nature and quality of information they received about GM food. Thus, scientists must up their game to reach farmers with enough scientific information about GM food and help improve farmers' awareness and knowledge. Farmers need complete and reliable information (from sources they can trust) to understand the GM process and the resulting GM food to make the right decisions when required.

As for the third research question: *how do farmers in western Kenya access and make sense of information on GM food crops?* The study found that farmers received information from the media (mainly from the radio, television, and Newspapers) and from friends. On the other hand, scientists used indirect approaches such as the media and direct approaches such as agricultural shows, barazas, seminars, workshops, and field visits to communicate with the farmers. The study further found that very few farmers received information through the scientists' direct approaches; indeed, farmers lamented the lack of direct communication from scientists and the need for them to conduct field visits and talk to farmers about GM food. Farmers were utterly silent about receiving information from agricultural shows and field visits.

In addition, this study found that scientists used farmers as middle persons to communicate with other farmers. Similarly, farmers reported receiving information from friends and sharing information they received. Using farmers as communicators might have fueled misinformation and miscommunication since the same farmers were found to have inadequate knowledge of GM food. The study further found that farmers were dissatisfied with the amount of information they received because it was not communicated often enough (most farmers reported receiving information only occasionally). These findings align with the assumptions of the deficit model of science communication in that farmers demonstrated inadequate knowledge (in line with the scientists' conceptualization), and a lot of communication seemed to improve the farmers' knowledge and awareness of GM food.

Regarding farmers' understanding of the accessible information, the study found that just over half of the farmers (51%) did not understand the information they received and that farmers perceived the information as coming from multiple sources with conflicting messages, hence confusing. I also found that farmers felt that the information they received did not help them understand GM technology and food more clearly and did not address all of their questions/concerns about GM food (contrary to scientists' claims).

Farmers attributed their inability to understand the information to a lack of complete and enough communication about GM food and the clarity of the information communicated to them. They also alluded to the lack of interaction with "those concerned" with GM technology and food, including scientists and the government. Farmers wanted these parties to visit them and talk to them about GM technology and food. They longed for complete information about the GM process and the resulting GM food to make informed decisions.

This study concludes that scientists did not seem to do well communicating their scientific research findings on GM food to the farmers. Farmers received information from unreliable sources (e.g., friends), which could have contributed to their inadequate knowledge of GM food. The sources and communication approaches seemed to contribute to miscommunication about GM food since the same farmer who had inadequate knowledge about GM food could still share what they knew with other farmers.

Therefore, scientists need to re-think their communication strategies by engaging the public more through direct approaches such as field visits, barazas, agricultural shows, workshops, and seminars. Improved farmers' engagement could go hand in hand with improving farmers' knowledge and awareness about GM technology and food, which dominated scientists' communication objectives in this study. To make this more effective, scientists should consider communicating their research findings beginning with/from what the farmers already know. According to the mountain climbing analogy discussed in chapter two, scientific knowledge sharing should be done in a way that scientists (experts) also learn from their audiences. These audience groups have their social systems that determine how they understand scientific phenomena.

As for the last research question: *how does the accessible information influence farmers' attitudes toward GM food crops?* The study found that the farmers were optimistic about GM food because of the information they received. Farmers expressed doubts and concerns but were more optimistic (63.1%) than negative (36.2%) towards GM food. Their positive attitude was because they had heard more positive than negative things about GM food and felt that GM technology and food could help improve their lives.

The study concludes that information is necessary to inform the farmers' attitudes and actions toward GM food. The farmers and the broader public need information they can rely on from people they can trust, including scientists and the government, to make informed decisions about GM food. This information should explain the science behind GM technology and the resulting GM food; it should also transparently explain the benefits and potential risks of adopting GM technology and food.

Generally, this study confirmed that the models of science communication could co-exist in a single study and that the deficit model is still relevant in explaining science communication activities, although not self-sufficient. The choice of the model of science communication depends on the communicators' (scientists') conceptualization of what science communication ought to achieve. In this study, scientists mainly wanted to improve farmers' awareness and knowledge of GM food crops, address their concerns and questions about GM food crops, and ultimately debunk myths and misinformation surrounding GM food and make farmers more receptive to GM food. Thus, the deficit and the contextual models dominated the scientists' communication of GM food information compared to lay expertise and public participation. However, it is essential to note that the farmers demanded issues that align more with the two less-used models (in this study), such as more involvement in GM food crop issues through more direct interaction with the crop scientists researching GM food crops. Scientists and the concerned parties need to re-think their communication strategies to ensure they reach farmers with complete, precise, and reliable information about GM technology and food, which will address their questions and concerns and help them make informed decisions. Notably, rethinking communication strategies should go beyond how scientists will reach farmers to consider involving communication experts in the communication process. As France and Gilbert (2019) put it, scientists should not necessarily be the ones to share their findings with the public because being a researcher (scientist) does not automatically make them effective communicators (indeed, scientists reported a lack of science communication skills as one of the setbacks). Communication experts could be involved in GM food research to help design public engagement strategies to ensure accurate knowledge is shared with the public understandably and effectively. The scientists should also consider engaging the government and other opinion leaders in the scientific debate about GM technology and food to ensure that when relaying information to the farmers and the wider public, the scientists, the government, and the opinion leaders are reading from the same script. This could lessen public confusion and scepticism caused by conflicting messages about GM food.

5.4 Recommendations

This study looked at the communication of GM food crop information to the farmers in western Kenya to understand matters concerning farmers' access and interpretation of scientific information on GM food crops. The study has revealed that scientists conceptualised the communication of GM food to the farmers as a means for educating and improving farmers’ knowledge and awareness of GM food, addressing farmers’ questions and concerns about GM technology and food, and debunking the misinformation and miscommunication surrounding GM food. As such, these conceptualizations informed the scientists’ framing of GM food messages for the farmers. The study also revealed that there was a mismatch between farmers’ sources of information and the scientists’ channels of communication and that scientists relied more on indirect means of communication, contrary to the liking of the farmers, who preferred a more direct approach to communication to ensure interaction with the scientists. Despite the farmers’ self-reports of awareness, they demonstrated inadequate knowledge of GM food coupled with concerns and scepticism, which were associated with the nature and quality of information they received. Still, the information they received made them more positive than negative about GM technology and food. This is because farmers seem to focus on the benefits of GM food and ignore the perceived negative impacts on human health and the environment. Therefore, this study demonstrated that scientists’ communication of GM food to the farmers was ineffective and that this ineffectiveness, coupled with communication from unreliable sources, increased farmers' concerns and scepticism. So, to improve the communication of GM food information to the farmers (and the wider public), the study recommends the following:

i. Scientists' conceptualization of the communication of GM food information to the farmers was dominated more by the assumptions of the deficit model of science communication. This study recommends that future GM food communication activities consider approaches that will enhance public (farmers) participation to allow them to have a meaningful dialogue between farmers, scientists, and other farmers. Indeed, the study revealed that farmers lamented the lack of these approaches. These encounters will help the public learn the scientific facts about GM technology and food and help address most of their concerns, especially about the GM process. Scientists will also understand what the public already knows about GM food and how different groups perceive food to help them appropriately frame their communication.

ii. Farmers' inadequate knowledge and concerns about GM food cast doubt over the reliability of the sources of GM information. This study recommends that scientists involved in GM technology and food should improve their approaches to communicating their research findings to the farmers and the public. Farmers demanded more direct communication to allow engagement and participation; therefore, scientists should improve direct communication approaches, including seminars, agricultural shows, barazas, workshops, and field visits to enhance farmers' involvement. This will increase their knowledge and boost their confidence in science because they can communicate their concerns and worries directly to the GM experts. Scientists could also use other stakeholders closer to the farmers, such as the extension officer, to reach the farmers.

iii. Farmers expressed mixed meanings of GM food and technology. This study recommends that scientists and parties involved with GM should find out what the farmers know about GM technology and food before communicating scientific information. This knowledge would help the scientists communicate starting from what the farmers already know. In this way, the scientists will know what questions and concerns to address and which misinformation to correct. Public education programmes about the technology could also help enhance public awareness and knowledge of GM technology and food.

iv. The scientists should also engage the political class and other opinion leaders, such as religious leaders and government leaders, with scientific facts regarding GM technology and food. These groups have been revealed to influence public opinion and perception about GM technology and food. Farmers, for example, questioned why GM technology was yet to be adopted by the government if it was as good as they had heard, which may mean that they are likely to believe the government (sometimes even more than the scientists). Scientists should, therefore, provide scientific evidence and testimonies to these groups to ensure that they speak the same language when talking to the public and farmers about GM technology and food.

v. Scientists should not communicate GM technology and food as the only solution to the farmers' problems regarding farming. GM should be communicated as one of the options available and let the farmers and the public, in general, make decisions on which solution to adopt. The public and farmers should not feel as if they are pressured to adopt GM technology and food lest make them suspicious about the motives of those involved in it. They should be given all the facts in terms of the potential benefits and risks to allow them to make an informed decision.

vi. Scientists (and other parties involved in GM food crops) should attend training on science communication skills to improve their communication skills. Such training should also be offered to other stakeholders in GM food communication, such as the journalists, so they can know how to frame GM messages for specific groups of the public and the impact of their framing. Improving their communication skills should include understanding the audience for which their communication is intended.

vii. Scientists should consider bringing communication experts on board in GM food research; such would be charged with designing communication and public engagement strategies, understanding public concerns, and executing the communication of scientific findings about GM food.

5.5 Recommendations for Future Research

This study explored the communication of GM food crop information from crop scientists researching GM food crops in Kenya to maize farmers in western Kenya. Future research may look at the communication of GM food crop information to other stakeholders, such as opinion leaders like politicians and religious leaders, to understand what shapes their perception and attitudes toward GM food crops reflected in their communication to the public.

Also, another research could involve other groups of the public, for example, farmers of different crops, consumers, and business persons, to understand how GM is communicated to them and how it affects their attitudes toward GM technology and food.

Another study could also focus on the communication by other stakeholders in GM technology and food, such as NBA, KALRO, and KEPHIS, to understand their public engagement strategies.

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APPENDICES

Appendix I: Data Collection Tools

A: Questionnaire for Maize Farmers

My name is Joseph Olomy, a Ph.D. in Communication Studies student at Moi University, Department of Publishing, Journalism, and Communication Studies. As a part of the Ph.D. programme, I'm researching the scientists' communication of information on Genetically Modified foods to the general public. I'm requesting your participation in the study by responding to the questionnaire below.
The information you provide will be kept strictly confidential and will be used for the purpose of this research only.

<u>Research Topic</u>
Communicating Scientific Findings to the Public: A Case of Genetically Modified Foods in Kenya

A. Location of respondent

A1	**COUNTY**	Uasin-Gishu 1	Trans-Nzoia 2

A2	**LOCATION (Sub-county)**	1	Moiben
		2	Ziwa
		3	Soy
		4	Cherangany/Suwerwa
		5	Kwanza
		6	Saboti

1. **Demographic data**

1.1	**Sex of respondent**	Male 1	Female 2

1.2	**What is your age?**	1	18 – 23 years
		2	24 – 29 years
		3	30 - 35 years
		4	36 – 41 years
		5	42 – 47 years
		6	47 – 52 years
		7	53 years and above

1.3	**What is your level of education?** [ONLY ONE response possible]	1	Primary education
		2	Secondary education
		3	College
		4	University
		5	No education

1.4	**What is the size of the land you farm?** [Indicate acreage including the rented land]

1.5	**What is the size of the land you own?**	1	Small scale (smaller than 0.8 ha)
		2	Medium scale (0.8 - 2 ha)
		3	Large scale (larger than 2 ha)

1.6	**Are you aware of genetic modification technology or genetically modified organisms?**	Yes 1	No 2

2. Access and sharing of information on Genetically Modified foods

2.1	**Have you ever HEARD or read about GM foods?**	Yes 1	No 2

2.2	**Where do you get information about GM foods?** [MULTIPLE RESPONSES POSSIBLE]	
a.	Radio	1
b.	Newspapers	1
c.	Television	1
d.	School	1
e.	Extension officers	1
f.	Internet	1
g.	Friends	1
h.	Books	1
i.	Journals/articles	1
j.	Seminars/workshops/training/conferences	1
k.	Barazas	1
l.	Others (specify)	1

2.3	**What does Genetically Modified food/crop mean to you?**

2.4	**In your opinion, are you satisfied with the amount of information you receive on GM foods?**	Yes 1	No 2

2.4	**How often do you get/receive information about GM foods?**	1	daily
		2	weekly
		3	monthly
		4	occasionally
		5	never [RESPOND TO 2.4c]

2.4c	**If your answer is NEVER, what do you think is the reason?**

2.5	**When you get information regarding GM foods, do you share it with others?**	Yes 1	No 2 [SKIP to 3.1]

2.6	**Whom do you share information on GM foods with?** [MULTIPLE RESPONSES POSSIBLE]	
a.	Family members	1
b.	Neighbours	1
c.	Fellow farmers	1
d.	Church/religious members	1
e.	Friends	1
f.	Others (specify)	1

3. Making sense of information on Genetically Modified foods

3.1a	**In your opinion, do you understand the information you receive about GM foods?**	Yes 1 [SKIP to 3.2]	No 2

3.1	**If your answer is NO, please explain what you think is the reason**

3.3	**What other information would you like to get regarding GM foods?**

3.4a	**Do you have concerns about GM foods?**	Yes 1	No 2 [SKIP TO 4.1]

3.4	**If your answer is YES, explain your concerns**

3.4c	**Do you think the information you receive about GM foods addresses these concerns?**	Yes 1	No 2

4. Perception of information received regarding GM technology or foods

4.1	**To what extent do you agree with the following statements regarding the information you receive regarding GM technology or GM foods?**	agre	disagre	don't know
a.	GM food information helps me understand GM technology and foods more clearly	1	2	3
b.	GM food information explains the benefits of GM technology to farmers	1	2	3
c.	GM food information is in a language that I can understand easily	1	2	3
d.	GM food information addresses all my concerns regarding GM technology and foods	1	2	3
e.	GM food information makes me more confused about GM technology and foods	1	2	3
f.	GM food information is balanced as it explains the potential benefits and risks of GM technology and foods to the environment	1	2	3
g.	GM food information is not communicated often enough	1	2	3
h.	GM food information is focused only on the role of GM technology and foods in attaining food security	1	2	3
i.	GM food information explains impartially what GM technology and foods entail	1	2	3
j.	GM food information explains only the potential risks of GM technology and foods to the environment	1	2	3
k.	GM food information addresses the concern surrounding the risks of GM food on human health	1	2	3
l.	GM food information highlights only the benefits of GM	1	2	3

	technology and foods to the environment			
m.	GM food information uses a language that is too difficult for me to understand	1	2	3
n.	GM food information addresses only some of my concerns about GM technology and foods	1	2	3
o.	GM food information tends to come from multiple sources with conflicting messages hence more confusing	1	2	3

5. Attitude and actions toward Genetic modification technology and genetically modified foods

5.1	**How does the information you receive regarding GM foods make you feel about GM technology and GM foods?** [ONLY ONE RESPONSE POSSIBLE]
1	I have not received any information
	Positive [explain why]
3	Negative [explain why]

5.2	**To what extent do you agree with the following statements regarding GM technology or GM foods?**	agree	disagree	don't know
a.	GM can reduce pesticides in food	1	2	3
b.	GM technology increases productivity and offers a solution to the world's food problem	1	2	3
c.	GM can create foods with enhanced nutritional value	1	2	3
d.	GM has the potential to reduce pesticide residues in the environment	1	2	3
e	GM can lead to a loss of original plant varieties	1	2	3
f.	Insect-resistant GM crops may cause death of untargeted insects	1	2	3
g.	GM threatens the environment	1	2	3
h.	People could suffer allergic reactions after consuming GM foods	1	2	3
i.	Consuming GM foods can damage one's health	1	2	3
j.	Consuming GM foods might lead to an increase in antibiotic-resistant diseases	1	2	3
k.	GM food is artificial	1	2	3
l.	GM is tampering with nature	1	2	3
m.	GM technology makers are playing God	1	2	3
n.	GM products are being forced on developing countries by developed countries	1	2	3
o.	GM products only benefit multinationals making them	1	2	3
p.	GM products don't benefit small-scale farmers	1	2	3
q.	Eating GM foods has immediate negative effects	1	2	3
s.	Gm foods contain many dangerous chemicals	1	2	3
t.	Consumption of GM foods destroys human genes	1	2	3
u.	GM can create foods with reduced nutritional value	1	2	3

6	**Do you have any additional information that you would like to share regarding GM foods?**

B: Interview Guide for Crop Scientists Researching GM food in Kenya

The interview was guided by the following question, which were meant to allow scientists to provide their perspectives regarding the communication of the knowledge generated by their research to the farmers. Specifically, they were meant to guide them in discussing their conceptualization of the communication of GM food information to the public (farmers), their framing of GM food messages for the farmers, and the challenges involved.

i. For how long have you been researching genetic modification technology or genetically modified food?

ii. What do you do with the knowledge you have generated on GM technology or food?

iii. Tell us about the target audiences of the knowledge you have generated

iv. How do ordinary farmers access the knowledge you generate on GM technology or food?

v. Tell us about the framework for engaging farmers with the knowledge you generate

vi. What challenges do you encounter in communicating your findings to the public (specifically, farmers)?

vii. Do you have any additional information that you would like to share on communicating research findings to the public?

Appendix II: Sample Interview Transcript

SAMPLE INTERVIEW TRANSCRIPT – CROP SCIENTIST RESEARCHING GM FOOD CROPS IN KENYA

[Introduction by interviewer and a brief on the research and the objective of the interview. The researcher requests the interviewee's consent to participate in the interview and to audio record the conversation. The scientist consents and grants permission for conversation to be recorded]

INTERVIEWER: Okay, thank you very much. So shall we now begin our conversation?

SCIENTIST: Yes, absolutely.

INTERVIEWER: Okay you've said that you work with XXXX and you are now researching genetically modified food?

SCIENTIST: I am working with the XXXXX which collaborates with National Biosafety Authority of Kenya. I work as researcher.

INTERVIEWER: okay, so as a researcher how long have you been researching genetically modified food?

SCIENTIST: Okay, this is my third year since I started working as a researcher in this organization

INTERVIEWER: okay, thank you very much, now researching for three years you must have generated knowledge about genetically modified food….

SCIENTIST: yes we have generated substantial amount of knowledge in the area.

INTERVIEWER: …so what do you do with the knowledge that you generate from your research?

SCIENTIST: okay, so the knowledge that we generate from our research, we communicate it to the farmers especially on the safety of the GMOs. We also communicate to the commercial players about the risk of this GMO crops and then also we also communicate about the food safety, risk assessment, and then we also certify the institutions that are using the GMO crops so that they can proceed with the implementation and use of the genetically modified products and also food crops

INTERVIEWER: okay, thank you. You have said that you communicate the knowledge generated to the farmers and to the commercial players. So, generally who would you say are the immediate target audience of the knowledge that generate by your research?

SCIENTIST: okay, mostly our target is on the farmers on the field; that is farmers on the on the that we normally call national performance trials and then also for certified companies

INTERVIEWER: okay do you mean your most immediate audience is the farmers?

SCIENTIST: yes the most immediate are the farmers, but we are bringing in between now the commercial seed growers who will be able now to help us even disseminate more information. Because as scientists we may not even get more time going to the field explaining to the farmers the importance of this crops and also the potential benefits of this GM products and also the risk that may accompany them.

INTERVIEWER: okay, does it mean in the process of communication you collaborate with some other partners, like you mentioned the seed company companies?

SCIENTIST: yes yes the seed companies

INTERVIEWER: okay, thank you. As you have said farmers as your target audience, please tell us how do farmers access the knowledge that you generate from your research

SCIENTIST: okay, so even before we release the variety of any kind of the food maybe food or even the crop themselves for the farmers, we normally do public participation majorly involving maybe publishing the information. And because I am working with a XXXX we normally publish the information on the kenya gazette, even the mainstream media eeh such as the newspapers, and even the television and maybe when we get a chance we normally have eeh open public participation. Yes we have open public participation and also we have eeh… like shows that is agricultural. Because I'm dealing with crops we normally have agricultural shows across the country. We normally send our representatives so that they can get a chance of talking with the farmers one on one

INTERVIEWER: okay, this are good number of ways in which the farmers can access this information. You have mentioned public participation, publication in the media, and agricultural shows where you can also have one-on-one with farmers. Now again in your opinion what do you think about this sharing of knowledge to the farmers?

SCIENTIST: You know we normally try to talk with the farmers most of the time but there still exists perceptions. So the information that we normally disseminate may not really be received easily. The farmers may not accept especially for example we trying to gather the information about the current crop that cassava which is almost being introduced to the farmers in our country; the GM product of cassava. But there's still that perception of the farmers although we pass through all the regulatory institutions until we are almost at the tail end. But some farmers are still having some kind of perception about this kind of crop that we are yet to be included as part of the sustainability of our food in our country

INTERVIEWER: you mentioned perceptions, in your opinion, what do think causes these perceptions

SCIENTIST err… you know there are even some which are not scientifically true like these narratives that farmers do say that these crops may end up affecting eeh the general health of a person. So they say they can cause cancer, they can even maybe affect the genetic makeup of a person and such as a person may not be able to get children or they get deformed children. Those are some of the information that we get from farmers.

INTERVIEWER: thank you. In your case you're communicating what the science tells you about GM crops from the findings. Now, where do think farmers get this information which informs their perception?

SCIENTIST: okay, remember they getting as you have said we normally do public participation through the mainstream media, the moment they are being announced and then all the process has been explained to them. They now create a narrative that this information may not be true. So they are still likely that they still maybe some will be able to proceed now with the crops they are having, withstanding the challenges that we are still facing. But we have quite a number of farmers who are able now to understand what we normally communicate when we say that these crops may be able to help us in terms of securing our food situation in our country

INTERVIEWER: thank you. Now let's go back to the communication to the farmers. What framework do you use for this communication?

SCIENTIST: okay, so I think the main framework that we normally do is that eeh we are trying to make sure that the information that is going to the farmers are the information that they can easily understand. So we try to depict and make sure that scientific information remain to us and then we use the language which the farmers are able to understand without now using the common scientific terms to them. So the farmers to access the information, we nornally use maybe the language that they can be able to understand themselves

INTERVIEWER: Do you mean your focus is on the framing this communication and making sure that it is accessible in terms of the language used?

SCIENTIST: Yes!

INTERVIEWER: now apart from language what other factors do you consider when you are framing the communication that goes to the farmers?

SCIENTIST: okay apart from language maybe we normally try to also try to access farmer group; there're those farmer representatives which we normally try to locate them and then try to use them, give them the right information and then they can be able to explain to those farmers

INTERVIEWER: okay, you have said that when framing the communication that goes to the farmers you make sure that the language of the science is not used because it might not be at the level of the public, right?

SCIENTIST: yes

INTERVIEWER: now which other factor do you consider when you are framing this communication?

SCIENTIST: aah other factor is maybe the regions like now there are those regions which we normally target, like now if it for maybe a crop like aah cassava we normally target western and then also the Kwale region, and then for even, if it's for BT cotton, we target the eastern part of our country. Yeah, I think that is my response to that.

INTERVIEWER: Okay so, generally what I have gathered is that in communicating to the farmers, sometimes you might not go as a scientist directly, you can use someone in between, like the media?

SCIENTIST: Yes

INTERVIEWER: now, what is your opinion about this in terms of the effectiveness of the process?

SCIENTIST: okay, I believe some of the information, the right information actually may not reach the farmers but we are trying as much possible before even we disseminate information to the media we normally check the words we have used to make sure that even when we send the information to the farmers, they are able now to pick up from there, without losing the information we frame. So, otherwise when we introduce some scientific term, and then we sent the media to go and report it, there are some kind of the loss of information. So we try to make sure that the language that we use is the same language that the media or any other dissemination centre can be able to understand and then take up the message very well.

INTERVIEWER: Okay. So, what you are saying is the packaging of the information is done by the scientists not by the media

SCIENTIST: Yes

INTERVIEWER: Okay, thank you very much. Now could you tell us about the challenges that you may have encountered in communicating to the farmers? I know you mentioned the perception, but are there other challenges that you have faced when you are communicating to the farmers?

SCIENTIST: Okay. Some of the challenges that we got when we are trying to communicate this is communication barrier from the farmers, err so remember when we are disseminating this information, we normally use the national language, that is Kiswahili or English. But sometimes some of the farmers that we are intending to get the information right, err they may not understand this language. So trying now to maybe get the information to their rightful language, that's the local dialect, is a challenge. Err that is really coming up especially when we are doing some information dissemination to the farmers.

INTERVIEWER: Okay. So one we have their perception, then we have the language.

SCIENTIST: Yes, the language itself.

INTERVIEWER: is there any other challenge that you may have encountered?

SCIENTIST: then another one is maybe like a possible trade disruption. This is now at the regional level, I'm not talking only about our farmers, this is regional wise. Remember these crops that we are doing research on, …is for maybe partly for benefit to our country, the region on which we are, and so we were anticipating a possible trade disruption err regionally and even the internationally. Because when we introduce this and try to get this information reach the farmers growing these crops we may disrupt the trade that was existing before; because some may lose their trade because of this perception that we were talking about.

INTERVIEWER: So, if I got you clearly you are saying there could be some trade disruption in the region because of the perception?

SCIENTIST: Yes

INTERVIEWER: Okay, so, in other words you saying for example if Kenya was to approve maybe BT cassava, or maize, it could disrupt the trade in the region because of the perception?

SCIENTIST: Yes yes

INTERVIEWER: Okay, thank you very much. Are there any other challenges that you have faced?

SCIENTIST: err maybe this one is now on the part of scientific, I don't know if it will be able to help people? Okay. So as you know there is an emerging technology called gene editing, which is not really about the…about genetically modified organism, But this depends upon now the introduction of this emerging technology, eeee…..so this gene editing do not involve inserting a foreign gene. So for us now to communicate this kind of information, we need a clear framework to distinguish now the gene editing and the GMO. And that's the information that I wanted to really pass to you. We need to have a clear framework when we are communicating between the two.

INTERVIEWER: Okay. thank you very much. Now, what do you think ought to be done to improve communication of genetically modified food information to the farmers?

SCIENTIST: Okay. Err maybe now that this is a technology thing, and it is now currently stepping into Kenya, Because we are trying to make sure that we have a food secure country, we need to have a proactive communication plan to avoid these perception problems that I talked about. And then also, another thing is now the open communication on the potential benefits and also the risk that are involved in this kind of the crops that we are introducing.

INTERVIEWER: Okay. Thank you. Aaam…is there anything you want to add or a question maybe you would like to ask?

SCIENTIST: Okay, maybe one question which I would like to ask. That now you seem you are coming from Tanzania but you are studying here in Kenya. I know your country, in Tanzania you are far much ahead in terms of some of these technologies especially on cassava. Taking now this information that we have, so are you hoping the information will be able to reach to your country? I wanted to ask whether this err this genetic modified crops also exist in your country.

INTERVIEWER: Thank you for your questions. it does exist, but I think the regulations are much tighter compared to the regulations in Kenya, and it has not been very stable as it is here in terms of research. I think research wise, Kenya is doing much more in GM than Tanzania is at the moment. And yes, I also hope the output of this project will help improve scientist-public communication here and in my country as well.

SCIENTIST: okay thank.

INTERVIEWER: thank you very much. Thank you for your time.

Appendix III: Research License- NACOSTI

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NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 630995

Date of Issue: 25/March/2022

RESEARCH LICENSE

This is to Certify that Mr.. Joseph Joachim Olomy of Moi University, has been licensed to conduct research in Transnzoia, Uasin-Gishu on the topic: Communicating Scientific Findings to the Public: A Case of Genetically Modified Foods in Kenya for the period ending : 25/March/2023.

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630995

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Appenx IV: Letters of Research Authority from Ministry of Education

REPUBLIC OF KENYA
MINISTRY OF EDUCATION
State Department for Early Learning and Basic Education

Email: cdeuasingishucounty@gmail.com
: cdeuasingishucounty@yahoo.com
When replying please quote:

County Director of Education,
Uasin Gishu County,
P.O. Box 9843-30100,
ELDORET.

Ref: No. MOE/UGC/ACT/9/VOLL. IV/23

22nd April, 2022

Mr. Joseph Joachim Olomy
Moi University
P.O Box 3900-30100
ELDORET

RE: RESEARCH AUTHORIZATION.

In reference to your Licence Ref no. **NACOSTI/P/22/16402** dated 25TH March, 2022 from National Commission for Science, Technology and Innovation (NACOSTI), and your request letter dated 22nd April, 2022 you are hereby granted the authority to carry out research on ***"Communicating Scientific Findings to the Public: A case of Genetically Modified Foods, Period Ending 25th March, 2023,"*** Within Uasin Gishu County.

We take this opportunity to wish you well during this data collection.

FOR: COUNTY DIRECTOR OF EDUCATION
UASIN GISHU COUNTY
P O Box 9843 - 30100 ELD...
Date.................... Sign:....................

Indimuli Harrison
For: County Director of Education
UASIN GISHU.

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State Department of Early Learning and Basic Education

Telegrams: ....
Telephone: Kitale 054-31653 – 30200
Fax: 054-31109
Email: transnzoiacde@gmail.com
When replying please quote:

County Director of Education
Trans Nzoia
P.O. Box 2024 – 30200
KITALE.

Ref. No. TNZ/CNT/CDE/R.GEN/1/VOL.II/150

Date: 7th June, 2022

TO WHOM IT MAY CONCERN

RE: RESEARCH AUTHORIZATION – MR. JOSEPH JOACHIM OLOMY

This office acknowledges receipt of a letter on the above subject Ref. No. **630995** dated 25th March, 2022.

Mr. Joseph Joachim Olomy, is authorized to carry out research on **"Communicating Scientific Findings to the Public: A Case of Genetically Modified Foods in Kenya"** in Trans-Nzoia County for a period ending **25th June, 2023.**

The purpose of the letter is to request you to accord him the necessary assistance.

COUNTY DIRECTOR OF EDUCATION
TRANS - NZOIA COUNTY
P. O. Box 2024 - 30200,
KITALE.

LUKA C. KANGOGO
COUNTY DIRECTOR OF EDUCATION
TRANS-NZOIA COUNTY

PLAGIARISM REPORT

SR172

THESIS WRITING COURSE

PLAGIARISM AWARENESS CERTIFICATE

This certificate is awarded to

JOSEPH JOACHIM OLOMY

PHD/CS/5406/21

In recognition for passing the University's plagiarism

Awareness test with a similarity index of 01% and

Striving to maintain academic integrity.

Awarded by:

Prof. Anne Syomwene Kisilu , CERM-ESA Project Leader

24th /04/2023