GENETICALLY MODIFIED FOODS AND IMPLICATIONS ON TRADITIONAL CROPS AND HEALTH SECURITY IN NIGERIA

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CERTIFICATION

I certify that the thesis titled: GENETICALLY MODIFIED FOODS AND IMPLICATIONS ON TRADITIONAL CROPS AND HEALTH SECURITY IN NIGERIA was a research carried out by **Olugbenga GBARADA** of the Department of Peace, Security and Humanitarian Studies, Faculty of Multidisciplinary Studies, University of Ibadan, Ibadan, Nigeria.

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DEDICATION

This thesis is dedicated to the Almighty **God** and the cherished memory of my late wife **Deaconess Mopelola Alice GBARADA** whose encouragement, dedication and commitment spurred me to embark on this academic sojourn but unfortunately, she passed away the very week I began this program. She will be fondly remembered for her invaluable contributions and sacrifice to my life and academic attainment, especially at this level.

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ABSTRACT

Genetically Modified Food (GMF) is an invention targeted at ensuring food security, but with significant environmental and health implications. There were controversies associated with its adoption in Nigeria. These included pesticide resistance, biodiversity and ownership of intellectual property rights. Studies have focused on these issues but with limited consideration for their implications on health and traditional crops in the local environment. The study therefore, examined the adoption of GMF and its implications for traditional crops and health security in Nigeria.

Burton's Human Needs Theory served as a framework while cross-sectional survey design was used. Data were derived from both primary and secondary sources using purposive sampling techniques. A questionnaire with themes that included reasons, perceptions of stakeholders, controversies, implications and concerns for GMF in Nigeria was used to collect data from 420 stratified respondents from the six geopolitical zones: academia (135), regulatory bodies (123), research institutes (80), farmers (19) and civil society organisations working on the health and environment (63). Twenty-two in-depth interviews (IDIs) were conducted with stakeholders in academia (5), regulatory bodies (2), research institutes (9), farmers (2) and civil society organisations working on the health and environment (4). Quantitative data were analysed using descriptive statistics and factor analysis at $p \leq 0.05$, while qualitative data were content analysed.

The regulatory bodies supported the adoption and cultivation of GMF in Nigeria while the members of civil society organisations working on the health and environment opposed it. Pesticide resistance and economic diversification were among the reasons for adopting GMF in Nigeria. The adoption of GMF in Nigeria improved resistance to pests and diseases (92.0%), led to a reduction in yield deficits (91.0%), improved nutritional quality (87.0%) and increased crop varieties (85.0). The controversies about GMF included genetic pollution of non-GMO plants (65.7%), health risk (61.4%), the risk to the environment (58.3%), the passage of a bio-safety bill to regulate GMF cultivation and sales (55.0%), suspicious scientific research and publications (54.3%). The high cost of GMF seeds and products can lead farmers into debt (52.4%) and food insecurity in Nigeria (50.0%). The individual factor loading indicated escape of modified crops from farms (0.78>0.5), gene flow (0.77>0.5) and horizontal gene transfer (0.74>0.5) as significant environmental issues capable of decimating traditional crops. It also indicated greenhouse gas emission (0.77>0.5), toxicity (0.74>0.5) and adverse nutritional changes (0.71>0.5) as potent risks to health security.

The adoption of GMF has checked the problems of pests and diseases, reduced yield deficits, increased crop varieties and improved nutritional quality. Nonetheless, to achieve an acceptable GMF regime in the country, stakeholders should provide measures to avoid genetic pollution. An indigenous intelligence framework of institutional collaboration should be put in place and stakeholders should be carried along in biosafety management to ensure the long-term protection of traditional crops and health security.

Keywords: Biodiversity, Food Security, Genetically modified foods, Health and indigenous crop extinction.

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ACRONYMS / ABBREVIATIONS

ABU	Ahmadu Bello University
AATF	African Agricultural Technology Foundation
AFJN	Africa Faith & Justice Network
CBD	Convention on Biological Diversity
CHIDICON	Catholic Doctors Association of Nigeria
CPC	Consumer Protection Council
DNA	Deoxyribonucleic Acid
ERA	Environmental Rights Action
ERAN	Environmental Rights Action of Nigeria
FDA	Food and Drug Administration
FoE	Friends of the Earth
GDP	Gross Domestic Product
GE	Genetically Engineered
GMF	Genetically Modified Foods
GMO	Genetically Modified Organisms
GOU	Godfrey Okoye University
HOMEF	Health of Mother Earth Foundation
IAR	Institute of Agriculture Research
IAR&T	Institute of Agriculture Research & Training
IITA	International Institute of Tropical Agriculture
NABDA	National Biotechnology Development Agency
NBMA	National Biosafety Management Agency
NABNET	National Biosafety Network
NABP	Nigeria Agriculture and Biotechnology Project

NACCGRAB	National Centre for Genetic Resources and Biotechnology
NAFDAC	National Administration for Food, Drug Administration & Control
NBC	National Biosafety Committee
NCRI	National Cereal Research Institute
NGO	Non-Governmental Organisation
NRCRI	National Root Crop Research Institute
OFAB	Open Forum for Agricultural Technology
PBS	Program for Biosafety System
SHESTCO	Sheda Science and Technology Complex
US	United States
USAID	United States Agency for International Development
UK	United Kingdom
WABNET	West Africa Biotechnology Network
WHO	World Health Organisation
WIN	Women in Agriculture

CHAPTER ONE
INTRODUCTION

1.1 Background to the study

Nigeria by necessity determined to expand its economy from crude petroleum reliance (Nwajiuba, 2013). Before she relied on oil and gas, Nigeria was essentially a food manufacturer and exporter, and the country was able to provide ninety-five per cent of the local food demand (Cerier, 2016). The nation became reliant on the importation of food to feed its growing populace she abandoned when she became a significant oil producer and exporter (Cerier, 2016). Due to poor governance, the successive government had not been able to transform the agricultural sector and identify elements that inform modern agriculture in her history of agricultural planning (Sanusi, 2010; Assessment of Nigeria Agricultural Policy, ANAP, 2005).

Agriculture that accounted for more than 75% of Nigeria's export earnings before 1970 became stagnated partly due to low investment, government neglect, and ecological issues like diseases, famine, and reduction in earth fertility. Consequently, the nation that was once an exporter of food to neighbouring countries needed to import food to meet its domestic demands. This trend was a twist of fate. Nigeria's major traditional crops include palms (used to produce oil), cocoa, rubber, and cotton, all of which were once exported to generate foreign exchange but are now locally marketed.

Over the years, the input of agriculture to the total Gross Domestic Product of Nigeria has declined significantly, from a leading position of 56.0 per cent of the Gross Domestic Product in between 1960 and 1970 to 28.0 per cent in 1971-1980, earlier growing to 32.0, 34.0, and 40.0 per cent during the years between 1981-1990, 1991- to the year 2000, years 2001 to 2009 and years 2010-2020 to 24.45% correspondingly (National Bureau of Statistics (NBS), 2020).

The federal government of Nigeria has formulated several good agricultural policies all through the years to encourage food production but such policies were never efficient and effective since the projected results were not accomplished. To achieve the Millennium Goals of hunger and poverty reduction, agricultural growth must be made a priority. There is an urgent need to develop a better approach to boost tomorrow's agriculture to influence agricultural production, competitiveness and diversification (Nchuchuwe and Adejuwon, 2012).

Agricultural practice in Nigeria is faced with a myriad of challenges which include; lack of funds, poor infrastructure, ignorance, lack of modern storage facilities, illiteracy, loss of land to Natural disaster, lack of mechanization and non-implementation of government policies, high production cost, poor distribution of inputs, low capitalisation, culminating in poor yields and decline harvests which results in low yield and diminishing outputs (Agbelekale, 2020 and Central Bank of Nigeria, (CBN), 2008).

These challenges have stalled agricultural productivity thereby adversely affecting the agricultural contribution to the national GDP in addition to increased food imports owing to population growth hence diminishing levels of food sufficiency. For illustration, between 2016 and 2019 (Oyaniran, 2020). Nigeria's collective agricultural imports stood at N3.35 trillion, four times higher than the agricultural export of N803 billion within the same period. With a population estimate of 200 million people, Nigeria's agricultural output is inadequate to meet the food demand of its rising population consequently increasing the demand and supply gap in Nigeria (Oyaniran, 2020).

The Government in her bid to address the growing decline in agriculture has employed several initiatives and programmes not limited to the followings; Agriculture Promotion Policy (APP), Nigeria–Africa Trade and Investment Promotion Programme, Presidential Economic Diversification Initiative, Economic and Export Promotion Incentives and the Zero Reject Initiative, Reducing Emission from Deforestation and Forest Degradation (REDD+); Nigeria Erosion and Watershed Management Project (NEWMAP); Action Against Desertification (AAD) Programme, amongst others. These initiatives were aimed to increase agricultural productivity to achieve adequate measures of food to meet local demand and exports (Tsokar, 2020).

To achieve food security goes beyond fulfilling yield deficits, which are more of having adequate physical, food security, nourishing, and traditionally tolerable diet (Sanchez and Witcombe, 2004) at the domestic level, without resorting to alternative provisions. This process requires sufficient food importation or dietary production to meet the anticipated shortfalls. However, agriculture, if well managed, is a veritable tool to achieve food security and economic prosperity (Alston and Pardey, 2014). One of the strategies to address the daunting food crisis in Nigeria is to accept genetically engineered foods (*Barrows et al., 2014*).

Genetically Improved Foods are obtained from genetically modified organisms (GMOs) (Halford and Shewry, 2000). They are made by introducing genes from external sources, which may include but are not limited to bacteria, viruses, plants, or animals, into usually isolated species of organisms. Biotechnology is capable of altering genetic materials amongst living organisms and overcoming intractable physiological barriers. The application of recombinant Deoxyribonucleic acid technology has the propensity to birth an organism that is preferred and invented by man (Halford and Shewry, 2000).

The genetic components of crops can be engineered genetically to improve the appearance, dietary quality, taste, and environmental adaptation (Sanchez and Witcombe, 2004) Recombinant technology is useful in addressing yield deficits and sufficient food production (UNEP, 2002). However, the potential and adoption of such technologies at the national level is not without controversies. There are concerns associated with the impact on human health and the ecosystem (UNEP, 2002). The implications of genetically modified (G.M.) technologies are challenging to enumerate (Berg, 2009).

The controversies associated with genetically modified foods are centred around the use of transgenic and engagement of biotechnology improved food production (Newswire, 2013). There are differences of opinion revolves among consumers, farmers, governmental regulators, non-governmental organisations, scientists, and biotechnology companies. (*Hollingworth et al., 2003*). The cogent issues of controversy connected to genetically modified food are its consequences on well-being and ecology, the implications on pesticide resistance and genetic effects on traditional crops (Newswire, 2013).

Countries in the global These nations own about 40 % of the overall cultivation land for genetically improved crops south are hurriedly accepting the technology with the hope that it will reduce malnutrition and lack. (Global Biotech, 2007) for example, the United States had the largest area of genetically modified crops worldwide in 2019, at 71.5 million hectares, followed by Brazil with a little over 52.8 million hectares. In terms of acreage, the most commonly genetically modified crops are soybeans, corn, cotton, and canola as of 2019.

Total health coverage and security are interrelated: improved access to health care and reinforcement of health systems provide a strong defence against probable natural or human-made threats. All countries have the onerous responsibility to protect their people (UN, 2005). According to the World Health Organisation Charter, which states that the well-being of mankind is central to the achievement of sustainable peace and safety and reliant upon the maximum collaboration of nations and individuals (WHO, 2006). Health emergencies constitute risks to lives, the global economy, and security (IHR, 2005).

In the context of this study, I adopted the WHO definition of universal community health safety as the method to reduce the risk and consequence of severe community well-being events which creates a danger to the overall welfare within the local and global geographical delimitations (HR, 2005). Environmental issues of genetically modified foods that pose a danger to the subsistence of traditional crops may arise because of; Escape of modified plants (Hannelore, 1999), Direct effects on unintended organisms, and outcrossing (*Richard et al., 2001*).

The environmentalists are of the view that technology could have devastating impacts on the health and environment (Africa Economic Analysis, 2005), which are capable of impairing the growth of traditional crops. However, in Africa, GM crops may benefit the environment because of their potentials to be resistant to pests and the need to spray with fewer or no pesticides. The technology also can develop varieties that can flourish in arid and semi-arid environments (Obadina, 2003).

What remains a controversy is that genetically modified food may not be safe for consumption, but there is an understanding that G.M. foods currently in the market are not risky to mankind than conventional diet (WHO, 2014). No known reports about the issues of

adversative effects of transgenic diets on the populace had been established, but scientists are worried about the tendency of genetically modified organisms to cause environmental harm (*Key et al.., 2008*). Therefore, the assessment of whether or not the G.M. food is considerably correspondent or not to native species considered fit for human consumption is a subject of food security by regulatory bodies (*Winter et al., 2006*).

1.2 Statement of the Problem

The pursuit of sustainable food production in Nigeria encouraged the government to adopt genetically modified foods for improved nutritional quality with enhanced harvests in the agronomic community. The government expected that the cultivation of genetically modified crops would improve the socio-economic status of Nigerian farmers, generate foreign investments and earnings, thereby enhancing national economic prosperity. The benefits accruable from G.M. crops include the sustainable environment, Jobs/wealth creation, and generating of crude materials for industrial production, mainly in the textile area. (Ebegba, 2017).

Despite the claims that the consumption of GMF is harmless (*Winter et al., 2006; Key et al., 2008*), It has been argued that the inherent danger to human health security and the ecosystem is a threat to humanity and the survival of traditional crops (Rinkesh, 2009). Though the issues of slavery, serfdom, war, and colonialism had remained the challenges to peace as well as sources of conflicts that threatened humanity, the discovered impact of environmental degradation by GMOs was not only a credible and severe threat to peace (*Keil et al., 1998*). Accordingly, it also represented a source of conflicts for humanity and, indeed, a potent global threat to all life on Earth.

Genetically modified foods (GMF) are part of economic activities as well as invention. There is a resultant relationship between these human economic endeavours and the destruction done to the biosphere. The ecosystem is at the mercy of development and modernity, and this explains why environmental degradation by GMOs would lead to disasters in the world with pronounced consequences if continued unchecked (Adams, 2009). There is a clear distinction between this human economic activity aimed at survival and the attendant benefit of technology with the resultant impact on the ecosystem upon which the survival of humanity depends (Boon and Eyong, 2005).

However, there are controversies and hesitations about the acceptance of genetically improved foods in Nigeria. The discussion on GMF shows the major divergence between two interests: (1) Government, Agri-biotech stakeholders, with their researchers who adopt agronomic bioengineering as a response to the dearth of food scarcity, scarcity of eco-friendly resources, wild and pests plagues; and (2) autonomous researchers, ecologists, agriculturalists and customers who forewarn that transgenic food presents novel dangers to mankind, such as environmental pollution, gene flow and the biodiversity loss (Kaplan, 2004). The environmental impacts associated with G.M. food can be either biological or genomic, which invariably might result in unplanned effects on the ecosystem from adversative effects on the unintended population. (FAO, 2013).

From the literature on genetically engineered foods, limited research attention has been directed towards the implications of GMF for traditional crops and health in Nigeria. Existing studies quarried genetically modified food as a recipe to hunger in Nigeria (*Subulade et al., 2007*), the commercial and ecological advantages to farmers (*Bennett et al., 2005*), the living standards of smallholder farmers, increased yields, and profits (*Kathage et al., 2012*). However, no too categorical studies had been done on the implications of GMF for traditional crops and health security in Nigeria.

1.3 Research Questions

The study examined the implications of genetically modified foods on traditional crops and health security in Nigeria. In light of this, this study ultimately addresses these questions:

1. What are the reasons (context) for the introduction of GMF in Nigeria?
2. What are the controversies surrounding the introduction of GMF in Nigeria?
3. What are the perceived effects of GMF on traditional crops and health in Nigeria?

1.4 Aim and Objectives of the Study

The study aims to examine the implications of GMF on traditional crops and health security in the country.

The specific objectives of this study are to:

1. Identify the reasons (context) for the introduction of GMF in Nigeria.
2. Examine the controversies surrounding the introduction of GMF in Nigeria.
3. Determine the perceived effects of GMF on traditional crops and health in Nigeria.

1.5 Significance of the Study

Since the commencement of field trials for genetically modified foods in Nigeria attention had been given to the importance of transgenic crops in the country. The nation has been experiencing a spate of challenges as a result of accepting genetically improved foods like some other countries of the world. Recently, discussions and opinions about genetically modified foods **h**ave been controversial (Scholderer and Verbeke, 2012). This study is quite significant because no too categorical study of this scope has been done to unveil the implications related to the adopting of transgenic foods (GMOs) on traditional crops and health security in Nigeria.

Therefore, this will be of immense value for future researches by discussing the implications that the introduction of GMF will have for traditional crops and health security in Nigeria and provide recommendations accordingly. It will fill the knowledge gap as well as serve as an early warning signal on how genetically modified foods (GMF) will impact the environment and health negatively.

This study will no doubt expand the frontiers of existing knowledge on the concerns associated with genetically modified foods in Nigeria. This study could be an addendum for fine-tuning of existing policies to de-escalate the controversies among the stakeholders by incorporating the recommendations of the study in the future proposal for the amendment of the National Biosafety Bill.

This study, among other things, will be a piece of credible and provable information to some stakeholders who have different perceptions on the introduction of genetically modified foods in Nigeria. Also, it will be a useful manual to guide national policy and decision-makers for formulating appropriate policies and processes on the safe use of GM-crop technologies in Nigeria by employing the suggested collaborating or joint-problem solving approach for managing the associated concerns.

1.6 Study Area

The study is limited to Nigeria. The study focused on the six geo-political zones in the country, namely; South West, South East, South-South, North West, North East, and North Central. Nigeria has 36 states and one federal capital, Abuja.

The Federal Republic of Nigeria is positioned in Western Africa. Cameroon, Chad and the Gulf of Guinea share boundaries with Nigeria in the south and the land border in the east, the Niger Republic in the north, and the Republic of Benin in the west delimiting the coastal boundary. The political capital of Nigeria is Abuja, and Lagos is the commercial capital and also its largest city. The total land area of Nigeria is approximately 924square kilometres, thus become the 32 largest nation in the universe. The coastline is 853 kilometres when equated to the land boundary of 4047 kilometres. The latitude and longitude of the country are 4° to 14°N and 2° to 15°E, respectively. The climate is equatorial in the south, arid in the north and tropical in the centre. The landscape of the country includes valleys, plateaus, and hills (Maps of World.com).

The economic activity of Nigeria which was predominantly commerce and agriculture and trade changed severely in the late nineteenth century. The population of Nigeria is about 2.5 per cent of the total population of the world. It ranks number seven on the globe. The population density is 205 per Km square. 48 per cent of the population is urban in the year 2016. 200 million is the population of Nigeria, as recorded by the 2015 world population data sheet (Worldmeters, 2015).

Figure 1: Nigeria: Showing the Six Geo-Political Zones (Study Area).

Source: Geography Department, University of Ibadan, Nigeria.

CHAPTER TWO
LITERATURE REVIEW

2.0 Literature Review

2.1 Conceptual Discourse

2.1.1 Concept of food

Food is any substance that essentially consists of protein, carbohydrate, fat, as well as other nutrients used in the body to support an organism to sustain growth and vital processes and also furnish energy. Food originates from plants, animals or fungal (*Rahman et al., 1999).* In the emergent world, mechanised system of food production are employed to produce energy- rich food that are didtributed through a supply chain to consumers. There are about nine food groups and they reflect foods with generally similar nutritional characteristics: (1) cereals, (2) legumes, (3) starchy roots, (4) vegetables and fruits, (5) sugars, preserves, and syrups, (6) meat, fish, and eggs, (7) milk and milk products, (8) fats and oils, and (9) beverages.

2.1.2 Concept of food security

Food Security: Food security is a condition that occurs when everybody, at every time, has physical, social and economic access to adequate, safe and healthful food that meets their nutritional needs and food preferences for an energetic and healthy life as well as to stabilise prices and production (FA0, 2002: IFPRI. 2019). Food security has also been described as an important aspect in any consideration of the sustainability of the wealth of a nation. This is because of its role as a critical factor in economic development, peace and stability (Adegboye, 2004).

Accordingly, food is said to be of high importance in matters of human wellbeing and economic productivity. The need for food in Nigeria, like other parts of the world, has, therefore, become a policy issue. Besides, the nutrients contained in food, it is considered a necessity for proper body functions (Olayide, 1982). To be food secure, sufficient resources are usually required to produce or purchase adequate food.

2.1.3 Determinants of Food Security: There are four pillars for food security: thus; accessibility, availability, utilisation and stability (Napoli *et al.*, 2011). These factors determining food security are directly and indirectly interrelated. Available food must be accessible to all members of the populace. What is available must also be adequate and the populace must be willing to eat, that is, what is available must be accepted as a preferred food.

1. **Availability**: It is mainly the supply or production of food materials. "The amount of food that is present in a country or area through all forms of domestic production, imports, food stocks and food aid" (WFP. 2009).

2. **Accessibility**: The concept of accessibility in terms of food security refers to "physical, social and economic access" (FAO. 1996). This term was first introduced by the Amartya Sen in the early 1980s after the Bengal famines (Sen, 1982). Accessibility means food is available to everyone in and out of seasom to nourish life.
3. **Utilization**: It means the proper consumption of food and nutrition. No access to clean drinking water, poor environment, lack of hygiene, poor health infrastructure, lead to reduced assimilation of the consumed food. To achieve nutritional security, environmental hygiene necessary, Primary health care and clean drinking water facility should be adequately available. Cooking habits also need cautious evaluation because some methods of cooking may lead to the loss of essential nutrients Swaminathan (M. S. 2006).
4. **Stability**: Stability defines the temporal dimension of food and nutrition security, individually the time frame in which food security is being considered. Stability is assumed when the supply of food, income and economic resources remain constant at a household level during the year and in the long term.

Besides, it is also essential to minimize external risks such as natural disasters, climate change, price volatility, conflicts or epidemics, etc. (Klennert, 2009).

2.1.4 Measures of food security:

Food security involves four pillars; availability, physical and economic access, utilization and stability (CFS, 2014). It has been difficult to find suitable parameters to measure food security.

Food security is a multi-faceted concept that involves an array of diverse factors which include social inequalities and environmentally sustainable food systems. Within the context of the definition of food security, access to food is the central constituent. Food security comprises of the four pillars such as availability, physical and economic access, utilization and stability (FAO, 2009).

Finding appropriate indicators to measure food security has been difficult. Acute malnutrition has been the key indicator including estimates built on the average availability of calories per person at the national level. Attribution is another task; the rate at which improvements in the food security condition can be ascribed to the result and outcomes of particular policies, programs and actions. There is a comprehensive agreement that the root of acute malnutrition globally today is poverty and that prolonged conflicts are contributing to more hunger (Haug. 2018).

2.1.5 Concept of food insecurity: Everybody at every time means the need for impartial and steady distribution of food, but it is more recognised that it also infers that the need for generational inputs to ensure sustainable production of safe and nutritious food for a healthy life' means that food insecurity can happen if the diet is not nutritious, or if food is not safe from harmful substances (FAO, 2001). In a nutshell, Food insecurity occurs when people do not have adequate physical, social or economic access to food. Those people whose food consumption cuts below their lowest calorie requirements fall under the food insecure grouping, in addition to the individual who is not physically fit, or are sick due to malnutrition, lack of food and hunger (FAO. 2000).

Furthermore, food insecurity is grouped into three major classes by the FAO (Food and Agricultural Organization) as (i) **Acute**: Extreme hunger and malnutrition that poses a serious threat to lives instantly such as famine, (ii) **Occasional**: It is defined as the occurrence of food insecurity owing to a certain brief condition, (iii) **Chronic**: this is when the need for food needs is constantly or always under threat (FAO, IFAD. 2013).

2.1.6 Causes of Food Insecurity: some common causes are:

1. **Population growth-** Population growth intensified the pressure on environmental degradation, social causes and climate change and cause food insecurity problems to the locality.
2. **Conflict and Political Instability:** Food insecurity could be a direct cause and consequence of conflict and political instability. Conflict creates food scarcity that in turn lead to market collapse. Food security is a fallout of political stability. It is connected to increased risk of democratic failure which triggers protests and anarchy, public violence and civil war thereby creating food insecurity, malnourishment and in some cases starvation (Brinkman & Hendrix, 2011).
3. **Knowledge and Information Systems:** Appropriate and modern technologies are prerequisites for the transfer of technology for sustainable development, local food traditions and to encourage the modernization of local production systems. Education and skill acquisition are required to take advantage of these technologies (Rome Declaration, 1996: Reddy, 2017). Knowledge and Information Systems are required to understand agriculture-related knowledge, environment, administration, health and even political information. Knowledge improvement services, and information management systems are synergies to address food security (FAO, 2000).

4. **Malnutrition**

   Poor access to food and mainly healthy food equally contributes to malnourishment, undernutrition, overweight and obesity. Malnutrition increases anaemia in women of reproductive age. Food insecurity can affect micronutrient deficiencies by negatively affecting the sufficiency of food consumption. Inadequate intake of

vitamins, protein, calories, and minerals will also hinder foetal, infant and child growth and development (World Health Organization 2018).

5. **The 'financialisation' of food:** Financialisation of food is described as the increasingly substantial role played by financial markets in agribusinesses (Clapp, J. 2012). Speculators use food as a commodity in international markets for the sole purpose of profit maximisation. Speculators are in the agricultural business to generate income. They speculate to create price hikes that can generate severe and protracted food crises (Epstein, 2005).

2.1.7 Types of crops

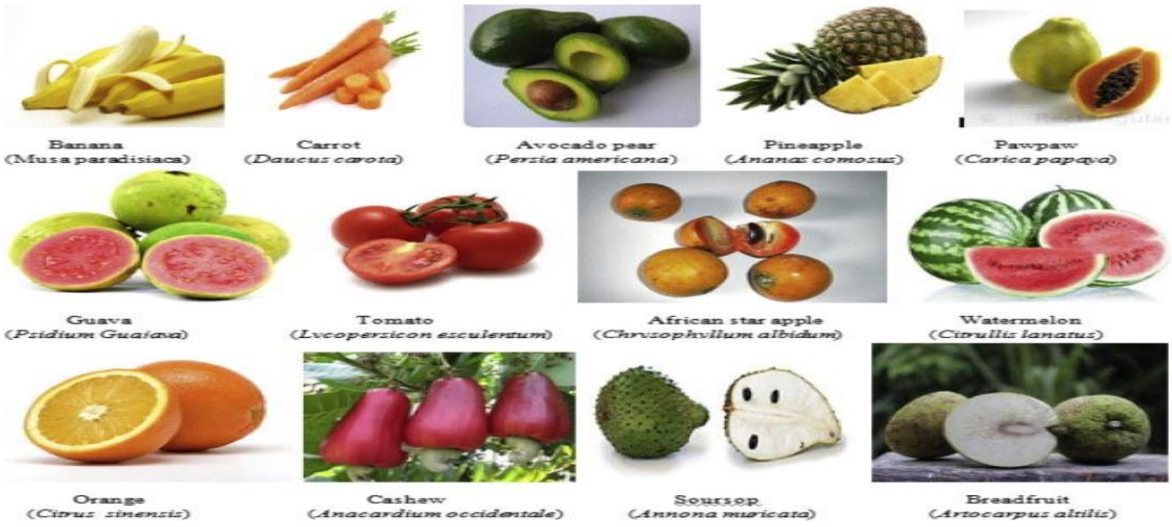
1. **Traditional crops:** Traditional crops also known as native crops refers to grown by local farmers which have their own land races of seeds and added to those that were introduced into the country. Native crops are produced and found growing in the country under various meteorological conditions but they do not give enough yield to feed to the entire population of the nation. they contribute to preserve the agricultural biodiversity of that geographical area where they are grown (*Johns et al., 2013*).

   . They are divided into three main classes; namely grains, vegetables and fruit.

   (i) **Grain crops;** are any crop yielding starch and protein-enriched seeds suitable for food. These crops are further subdivided into cereals (Millet) and pulses (Cowpea).

   (ii) **Vegetable crops;** are crops from which the tender leaves, stems and petioles are harvested and used in the preparation of vegetables. These crops are subdivided into roots/ tubers (Cassava and Potato) and leafy (Cowpea and Cleome).

   (iii) **Fruit crops;** are fruit types that are the seed-associated structures of certain plants that are sweet and edible in the raw state. Examples of fruit crops are marula, wild apricot, wild plum, raisin bush.



(Oboh et al., 2015)

2. **Improved Crop Varieties/ Hybrid:** They are crops cross-pollinated from two different varieties to produce a hybrid or off-spring that contains the best traits of each of the parents for example to achieve bigger size or better disease resistance. Hybridization takes a long time but has favourable traits such as dependability, early maturity, higher yield and improved flavor. The major shortcoming of hybrid crops is that they produce less yield, less vigour and have variable physical features in their second generation i.e. When the seed is saved for replanting (Kowalczyk, 2018).

(www. Hybrid variety plants.com)

3. **Genetically Modified Crops:** Genetically modified crops also known as transgenic crops are those crops whose genomes have been genetically altered through the introduction of DNA from similar or different species by the process called recombinant DNA technology. Examples of such traits produced in food crops include resistance to some pests and diseases, environmental conditions, reduction of spoilage and resistance to chemical treatments (for example, resistance to

a herbicide) or improving the nutrient quality of the crop. Examples in non-food crops include production of biofuels, pharmaceutical agents and other industrially raw materials (*Behrokh et al., 2011*).

2.2 The Push for Genetically Engineered Foods into Nigeria

2.2.1 Nutritional Benefits

Malnutrition is a recurrent decimal in Sub-Saharan Africa where the impoverished depend on a particular crop like rice for their primary food. Nevertheless, rice does possess the required nutritional ingredients for malnourishment. Therefore, one way to alleviate nutrient deficiencies is to engineer rice to contain additional minerals and vitamins genetically. For example, this could avert impaired vision as a result of vitamin A deficit, which has been a general challenge in underdeveloped countries. Agronomists from the Swedish Technological Institute developed a species of Bt. rice that contains an extraordinarily rich level of Vitamin A. The Institute expects to distribute the transgenic seed at no cost on request to any developing nation (Rice Biotechnology,1999). There are prospects that the golden rice that has increased iron content will be developed. Conversely, the grant that funded the production of these two rice strains was stalled, perhaps due to the vigorous anti-GM food protests in Europe, thus leading to the fading away of the hope that this transgenic rice might not get to the marketplace (Rice Biotechnology,1999).

A transgenic crop is a GMO. Transgenic indicates that a transfer of genes has occurred using recombinant DNA technology. A transgenic crop contains one or more genes that have been

inserted artificially either from an unrelated plant or different species. Transgenic crops have the essential benefits of being able to generate more nutritious varieties for under-developed countries presently experiencing the worst levels of malnutrition (*Ljungqvist et al., 2010*).

Transgenic maize has a beneficial value than indigenous crops because of its enhanced enrichment (*Perez-Massot et al., 2013*). For example, the varieties of transgenic crops like rice, maize, soybean, or potato tend to fight against many infections, such as *Helicobacter pylori bacteria* infestations and virulent hepatitis B, which is exemplified by the leading examples of cultivable edible vaccines (*Kramkowska et al., 2013*).

GMO technology is a response to starvation and malnutrition prevalent in Africa where more than two billion are under the scourge of micronutrient deficiencies, particularly iodine, vitamin A and iron (*Chakraborty et al, 2000*). Surreptitiously, most developed countries. received this genetic technology as an elixir. The genetic modification had produced several transgenic crops carrying novel traits that were cultivated for commercial purposes (Arthur, 2011). G.M. technology allowed preferred traits such as insertion of an iron-binding protein gene (lactoferrin) introduced into a maize crop having a comparative advantage over the conventional breeding methods to produce a novel variety (James, 2008; James, 2012; Chondie and Kebede, 2015; Wakeel and Maryke, 2021).

2.2.2 Economy

Genetically modified food gained prominence in world crop production with an accentuated increase in twenty-nine nations of the world (Conrow Joan, 2018). Data from the Intercontinental Provision for the Procurement of Biotechnology Implementation indicated an approximate number of 17.0 million growers cultivated genetically modified crops in the year 2011, while about ninety per cent happened to be local farmers in the under-developed nations such as India and China, where they planted collectively 14.5 million hectares of G.M. crops (ISAAA, 2012).

United States (U.S.) remained the principal producer of G.M. crops, having 69.0 million hectares of soybean, cotton, sugarbeet, pawpaw, maize, canola, and alfalfa). Brazil rated second (30 million hectarage, soya bean, Zea mays, fibre), Argentina (24 million hectarage,

soya bean, *Zea mays*, fibre), India (11 million hectarages of fibre), Canada (10 million hectarages of canola oil, sugarbeet, *Zea mays*, soya bean) and China (4 million hectarages of papaya, poplar tree, tomato plant, common pepper) (Environmental News Network, 2020). In Europe, about six E.U. republics (Poland, Spain, Portugal, Romania, Slovakia, and Czechia) cultivated about 115 hectares of Biotech maize, with Spain budding 85 % of the overall percentage in the European Union.

G.M. crops have manifold potentials targeted to guarantee adequate provisions for diets essential raw materials for enhanced production to sustain the teeming populace because of depletion of natural resources (Braun 2007). G.M. crops can boost the financial fortune of rural societies and reduce poverty in third world countries (*Fan et al. 2005*). Nutritionally enhanced crops exemplified by G.M. crops may help transform consumers' wellbeing (Bouis 2007; *Unnevehr et al., 2007*).

G.M. foods have economic value to farmers and developing nations as demonstrated in a 2010 study in five Midwestern states where Bt corn gave commercial profits worth $7 billion the highest over one and half a decade (*Hutchison et al., 2010*). Genetically modified crops improved farm revenues globally by $13.8 billion in 2010, with more than $7 billion going to farmers in developing nations (FAO, 2017). The socio-economic impact of G.M. cultivation is linked with the economic benefits because of the attendant favourable yields to alleviate poverty, food security, medication, and education (Gouse et al., 2005; Gouse, 2009). G.M. crops have commercial benefits for the agrarian sector in the industrialised nations, with noticeable substantial plausible effects in the emergent world where G.M. plants generate more wealth for subsistence farmers and women empowerment (Christou and Twyman, 2004).

In the developing nations, G.M. plants are pests and disease resistant, eliminate destructive agricultural methods, malnutrition, and reduce famine and produce inexpensive medicines to douse some of the global socio-economic fears (*Farre et al., 2011*). Generally, in both developed and developing countries, G.M. crops can increase the farmer's income (Brookes & Barfoot, 2017), thus having a direct impact on financial empowerment and a better standard of living, which are the critical component of sustainable development (Brookes & Barfoot, 2017).

In 2006, Bt cotton was reviewed and the results showed a mixed prospect with variable commercial profits over the years ranging from farm type and environmental location" (*Smale et al., 2006*). The anti GMOs maintained that without societal acceptance, G.M. products would not survive commercially (*Nap et al., 2003*). Production of G.M. foods is comparatively cheaper than their natural counterparts because genetic modification reduced price, particularly on pest management during planting and storing. Consumers remain the direct beneficiaries of this relief as they produce at cheaper rates leading to pocket-friendly medication (EASAC, 2013; Carpenter and Gianessi, 2001).

2.2.3 Higher Yields

GMF apologists usually argue better yields, affordable prices, and wider choices as assertions to support this innovation as indispensable to feeding the teeming global population (William, 2010). From literature statistics, the United States (U.S.) maize yields increased by ~.8 bushels/acre between 1937-1955 by conventional hybrid seeds. By the application of improved genetics, mechanisation, pesticides, and fertiliser, the rate increased to 2 bushels per acre annually. The development of G.M. maize increased the rate marginally to 2.0. On average, the U.S. maize yield in 2014 was 174.2 bushels per acre (Nielsen, 2012). Transgenic crops are capable of reducing yield loss occasioned by insect or weed infestations (Wesseler, 2005).

Genetically modified crops offer an immediate solution to chronic hunger (McGrath, 2014) as they offer improved quality food with better nutritional harvests, nutritionally cost-effective food, and crops of fewer chemical inputs, like herbicide-resistant maize (*Singh et al., 2014*)**.** The potential of G.M. crops to increase yield determines the number of harvests on farmland, thus providing a comparative advantage over conventional crops. G.M. crops are unaffected by microbial contaminations, herbicides, and pests as demonstrated by the potato mildew that caused the white Potato Scarcity experienced in the nineteenth century (McGrath, 2014).

Despite the potential of non-G.M. maize crop for high yields, the cultivation of genetically modified corn gained a competitive market advantage over non-G.M. maize product for the

premiums in Kentucky, U.S.A (Gurian-Sherman, 2009) contrary to the fears that farmers may experience yield loss without using genetically modified crops. GM plants have higher yields than native crops at ratios of 3.0 to 28.0 (Lee and Halich, 2008).

There is heated debate about the efficacy of this technology on the field to increase crop yield, but in a recent review of almost one hundred and fifty studies (*Mayo-Wilson et al, 2011*), it was discovered that in the past two decades Genetically Modified technology has contributed immensely to higher crop yields resulting to higher profits for farmers. Maize, Soybeans and cotton of GM varieties accounted for a 22% total increase in yield, a 37% reduction in pesticide use, and a 68% growth in farmer profits (*Klumper et al., 2014*). In Sub-Saharan Africa, farmers experienced a higher dimension of yields and turnover in the range 14% and 60% respectively, in comparison with their counterparts in the developed worlds (*Grassini et al., 2013*). The yield factor became a motivation because food shortages are a significant concern in underdeveloped countries. This claim is supported by the recent report from the Union of Concerned Scientists, which revealed that G.M. crops do not increase crop yields (Hans and Marcia, 2010).

Genetically modified maize is commercially cultivated in eleven countries of the world, including the U.S.A, Philippines, South Africa, Argentina, and Brazil (*Singh et al., 2014*). Africa countries that employed the G.M. technology includes South Africa, Zimbabwe, the Republic of Kenya, Mauritius, Burkina Faso, Uganda, through the commercial release of G.M. crops by only South Africa, Egypt, and Burkina Faso (Arthur, 2011).

Reports revealed that USAID did not record a success story for developing genetically modified crops over the past two decades despite the considerable investment of taxpayer's money. A recently publicised partnership between USAID and Monsanto to develop a virus-resistant sweet potato in Kenya was an abysmal failure. After fourteen years of trials and an enormous investment of $6 million on G.M. crops, local varieties enormously outpaced their genetically modified version in field trials (Hans and Marcia, 2010). A ten-year USAID project for G.M. eggplant in India recently met with stiff resistance from the scientists and farmers alike, which compelled the government to put its release on hold. Evidence of insect resistance to genetically modified corn and cotton is an indication that

the technology portends a failure over a long time and is capable of making the functioning of the ecosystems defective (Hans and Marcia, 2010).

2.2.4 Pest Resistance

Crop losses due to infestation by insect pests result in a devastating financial loss for farmers, thereby engendering starvation in developing countries (Soehardi, 2000). The loss implies that farmers will use excess tons of chemical pesticides per year. Consumers may dislike food treated with pesticides because of its attendant health hazards, and the environment could suffer untold harm from the disproportionate application of fertilisers as well as pesticides, which can be toxic to the water table— G.M. foods cultivation such as Bt. Corn can be cost-effective and help to eliminate the use of chemical pesticides (Nature Biotechnology, 2001).

The role of G.M. crops in intensive crop farming cannot be underrated. However, its characteristics of monoculture, the usage of pesticides and herbicides, automotive equipment and irrigation are environmentally unfriendly, hence, constitutes a threat to industrial agriculture (Ruchir, 2017). Insects such as European Corn Borer (ECB), which had constituted a menace to the North American maize farmers for over sixty years, had consistently defied pesticides but were controlled by the transgenic maize strains developed by plant breeders (Kaster and Gray, 2005). G.M. technology had curtailed the losses of maize occasioned by stem borers (*Wanyama et al., 2004*). The *B. thuringiensis* maize was of better grain quality with increased competitiveness among farmers and a healthier product (*Wanyama et al., 2004*).

A study by Ernst Berliner in Thuringia, Germany revealed enhanced yield attributable to the decline of pest damage with the introduction of *B. thuringiensis strain of* maize (Huesing and English, 2004). Findings established those commercial farmers profited economically from the cultivation of yellow maize that was engineered to be insect-resistant (*Singh et al., 2014*) Farmers who adopted *B. thuringiensis* yellow maize despite its cost implications enjoyed high returns from the revenue generated from pesticides, better yield and pest control management (Huesing and English, 2004).

Spain adopted G.M. maize production technology but with harrowing experience with the pest called European Corn Borer, which ultimately reduced yields (James, 2008). A bacterial chromosome generated toxin will develop resistance to harmful insects, causing crop yield deficits without attendant adverse effects on the well-being of animals and humans (Twardowski, 2010). MON810 a maize trait developed by Monsanto's was genetically modified to resist corn borer, several countries have planted MON810 and did not experience harmful effects. G.M. agriculture has direct health benefits through its ability to reduce contact with insect repellent (*Bertho et al., 2000*).

2.2.5 Herbicide tolerance

Farmers resort to spraying herbicides for weed control rather than the physical weeding that is very expensive as well as time, and energy-sapping. Consequently, farmers may be required to spray excess herbicide for effective weed control; this may entail a cautious approach to ensure herbicide does not damage the produce, human, and the ecosystem. One of the characteristics of G.M. crops is that they are herbicide-tolerant and insect-resistant because of the specific proteins inserted into them (USDA, 2001). Herbicide-tolerant transgenic plants can endure the prevalence of weedkillers *(Carman et al., 2013*).

Though crops genetically improved to be impervious to a strong weed killer could turn to safeguard the ecosystem, by preventing environmental damage and reducing the application rate of the estimated weedkiller, a good illustration was the Monsanto brand of soyabean genetically engineered to be resistant to Roundup, a weedkiller produced by Monsanto. These soybean require only one application of weed-killer as a substitute to the multiple applications thus limiting the risks of agricultural waste, run-off and reducing production cost (Pesticide Science, 1999)

The application of herbicide (glyphosate) tolerance and *B. thuringiensis* toxins ensure that crops are inedible by some pests (*Hammond et al., 2006; Seralini et al., 2009*). The report of the National academy of Sciences committee on genetically engineered crops indicated that no key biological changes ascribed to the eating of G.M. maize (National Academies of Sciences*, 2016: Hammond et al., 2006*).

Globally, the emergence of G.M. maize technology has led to the reduction of the utilisation of herbicides and pesticides required by farmers on their crops. Though in specific cases, there may be some varying responses from one species to another, thus positively contributing to the outputs of agriculture (Ball and Norton, 2002). The use of *B. thuringiensis* maize has become valuable to reducing mycotoxin pollution, thereby making the grain safer for consumption (Phipps and Park, 2002). The emergence of G.M. maize technology created a global reduction in the utilisation of pesticides and herbicides globally. Nonetheless, there may be some variations in response. The distribution of *B. thuringiensis* - maise seeds newly improved to give high yields are meant for consumers to tackle the challenges associated with food insecurity (*Oliva et al., 2006*).

2.2.6 Disease resistance

Genetic modifications are to resist plant diseases caused by fungi, bacteria, and viruses (Crop Science, 2001). Maise streak virus (MSV) associated with *Zea mays L* is one of the diseases that constituted a significant challenge in the cultivation of maize in some parts of Africa, thereby causing grave food insecurity (Bosque-Perez, 2000).

In 2001, Southern African countries rejected G.M. food aid from the U.S in the course of a severe drought because of environmental concerns. There is a consensus among scientists that pollen disbursal is a distant possibility of attendant environmental risk (Stephenson, 2010).

2.2.7 Cold Tolerance/Salinity Tolerance/Drought Tolerance

With the growing world population and increasing land demand for housing, farmers will be compelled to grow crops in locations formerly unsuitable for plant cultivation. Creating plants that can survive a saline environment will be considerably helpful to such challenges (Nature Biotechnology, 2001). The development of drought-resistant crops is a strategic approach to address droughts related challenges threatening harvest worldwide (Mahmoud and Maarten, 2014). Also, drought-driven food supply may result in escalated prices and, thus, further, limit the poor's access to the food supply. Farmers could forestall these impending shortages by planting G.M. crops capable of thriving amidst inclement

conditions. Indigenous farmers could take advantage of this unexploited agricultural opportunity to increase yields in famished nations.

G.M. crops engineered to be drought-resistant have no comparative advantage over the drought-resistant crops developed through selective breeding. Drought resistance is the function of varied genetic encryptions and ecological factors. These crops are yet to maximise their full potential as the contemporary investigation has not quite ascertained the genetic manipulations that will enable crops that allow crops to flourish in harsh environments.

The golden rice plant is a new strain of G.M. food, fortified with beta-carotene biosynthesis genes for growth transformation so that this rice should not cause unintended ecological problems. The paddy field is accountable for about seventeen per cent of global methane emissions adjudged to be a windfall for our stomachs and environment (*Su et al., 2015*). Nevertheless, political agitations and activism stalled this development, significantly impeding the release of novel first-set of G.M. crops that was saline and drought-resistant, and also the second set of G.M. crops with improved nutritious content (Bawa and Anilakumar, 2013).

Flood-resistant rice and maise adaptable to thrive nitrogen-deficient habitat, and potatoes that can be an antidote to hepatitis B infection are other auspicious G.M. crops of the nearest future (Wilcox, 2015). Some of these concepts remain science narrative, but convincing evidence has already revealed that molecular modification of the food can help to solve some of the world's leading challenges.

The reckless use of chemicals and mismanagement of natural resources, which grossly contributed to the depletion of the productive capacity of the ecosystem, is an issue to be addressed concerning food security. This development presents G.M. crops as an innovation in agriculture, capable of increasing productivity, and enables farmers to meet the food demands of the overwhelming population. G.M. crops are adaptive to biotic and abiotic stresses, can resist disease, insects, weeds, and climatic changes, and are also have better nutritional values. They can withstand unfavourable conditions such as droughts, floods, and varying environmental conditions (Arvind, 2013).

2.2.8 Developing Nations

Arguments are rife among the third-world nations on the requirement for the provision of better-quality foods as well as the technology to accomplish it. Hence, several researchers proposed a need for another agricultural turnaround scheme driven by the application of bio-tech crops to make available adequate nutriment (*Raney et al., 2007*). The Interglobal Valuation of Agronomic Scientific and Technical for Advancement approved the application of transgenic food to support emerging nations realised this objective, but no consensus was reached as of 2008 (*Diels et al., 2011*).

Antagonists of G.M. food claimed that the shortfall in food supplies was not about production but politics and channel of distribution (Behrokh and Ali, 2011). Other opponents expressed that the second green revolution created more of a challenge than the solution for the world population because of the unsustainable agricultural practices employed, thereby leaving the populace with hunger than the globe can withstand (Joel, 2009). It was presumed that if industrial agribusiness could meet the dietary need of the current, it is dependence on fuel energies, which he inadvertently projected in the year 2006, would generate optimum yield between 2006 and 2010, resulting in an untoward escalation in the prices of food kinds of stuff and energy (Pfeiffer, 2006).

The limitations facing emerging nations include the absence of easy accessibility, paraphernalia budgets, and trade secrets which constitute an albatross to developing countries. However, an aid and research organisation named Consultative Group on International Agricultural Research (CGIAR) earned a World Bank commendation. Therefore, the World Bank endorsed a change to genetics and capacity for enhanced research.

This study is not without difficulties, which include; intellectual property, commercial licenses, the right to use patents, and the struggle in accessing genetic resources in developing countries. International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), made efforts to address this challenge, unfortunately, the outcomes were unpredictable. Consequently, finger millet and groundnut, along with tef, yam, cassava, and others, are part of a class of crops that's often called “orphan crops”

because they tend to receive less attention and attracted paltry investment (Naylor, 2004). Genetically Modified crops are substantially equivalent to natural crops (Borlaug, 2000). Global food security will be enhanced by policymakers using this innovative technology, and disregarding this truth would render future solutions vague (*Kagale et al., 2010*).

2.2.9 Diversification of Nigerian Economy

Nigeria is making concerted efforts to diversify its economy from total dependence on crude petroleum. The country has been facing a looming food security crisis with a growing population that is increasingly dependent on imported foods. Also, the once-dominant subsistence-oriented farm economy is at risk due to gradual abandonment. Insecure land tenure, scarcity of funds and credit, labour scarcity despite overall high unemployment, and stagnant technology have crippled the development of subsistence agriculture. Moreover, a wide range of policies, programs, and projects have had not succeeded in ameliorating these problems (Nwajiuba, 2013). Agriculture provides a window of opportunity to transform rural poverty and stagnation into development (Alston and Pardey, 2014). To this end, the government is opting for the introduction of genetically engineered foods (*Barrows et al., 2014*).

An account of the UN Organisation for Food and Agriculture highlighted the benefits of bioengineering for communal farming in third world nations (FAO, 2004). It gauged the present situation of agricultural bioengineering, its possible use by smallholder farmers in developing nations, possible risks, and the status of biosafety regulation. The report stated that agriculture is facing many difficult challenges as the world population increases.

At present, 384 million people are chronically food insecure, most residing in the countryside in an under-developed nation-state (*Galhena et al., 2013*). Quite a lot are nutritionally deficient due to poor diet and nutriments. While the global need for food aid has decreased in the past 15 years, the need in the Africa continent continues, with thirty-eight of her forty-three nations found to require assistance in 2003 (*FAO et all, 2019*). Also, seven of the eight countries in the Catholic Relief Services in the East Africa areas were pronounced food disasters in the year 2004 (Sperling Louise, 2008).

Public agitations heightened about the relationship associated with sustainable agriculture and G.M. crops. The dearth of food supplies became an issue of concern in several parts of Africa due to some salient factors such as poor soils, drought, and insufficient water resources, in concert with socio-economic pressures, thereby necessitating G.M. crops as food aid. However, many nations have shown apprehension about the use of genetically improved crops as donations and welfare packages to Africa owing to the uncertainties about their prospective impacts (Mohamed- Katerere 2003).

Anti-GM food agitations worldwide have influenced public opinions toward G.M. foods in Nigeria. Consumers International (CI), in alliance with other thirty-eight member organisations in some African countries, played active roles in influencing the discussions around G.M. foods. It canvasses a legal platform mandating issues around G.M. foods be subject to extensive independent safety analysis, traceability requirements, and labelling making producers responsible for the attendant health or environmental harm ensued from their products (CI, 2005). Hence, this approach globally had received overwhelming acceptance.

As being practised in other places, globalisation, economic liberalisation, and public participation in Agronomic Research & Development are foundational to the emergence of G.M. food in Nigeria (*José et al., 2013*). Nigeria's receptiveness to G.M. technologies was heralded with apprehensions over increasing lack, nutritional deficiency, food insecurity, along with declining municipal agronomic investigation, finances, and expertise. African model of agrarian research replicated in Nigeria, coupled with the denationalisation of agronomic research, resulted in strong demand for hi-tech based solutions with a preference for transgenic crops in preference to traditional models (Scoones 2005). Universally-driven agronomic research and technical -know-how identifies yield as a driver for Nigeria's food security problems, thereby making G.M. crops particularly attractive as a "quick fix." (FAO, 2015)

A combination of factors responsible for the uncertainty in food security include markets uncertainty, hindered access to water, soil infertility, fluctuating climate, obsolete infrastructure, lack and tribal conflicts are undermined in developing solutions. The marketing strategies of the prominent Research & Development companies are targeted

towards environmental health, human development, and food security issues, such selfless concerns are not likely to drive their investment. Taking into cognisance that Europe is unreceptive to G.M. products and over seventy per cent of Africans are involved in peasant agricultural production, Africa, thus become a thriving market as well as consumers and producers of genetically modified food (IFAD, 2001).

2.2.10 Hunger and Hunger Reduction Strategies

The world population experienced an upsurge of more than half over have a decade ago and steadily increased by more than a hundred million yearly. The population may hit 11 billion by 2100 despite the downward trend of the growth rate (UN, 2019). Thomas Malthus warned of the fear ensued by the theatrical boom about our ever-increasing human population will exceed the carrying capacity of Earth for mankind,

Despite the ethical, geographical, religious, and political inclinations in Nigeria, the nation did not engage the use of modern infrastructures to ensure food sufficiency for the population, thereby saving about eight hundred million who are undernourished from starvation (Cohen and Fedoroff, 1999). Feeding the population is difficult despite the existing production output of more than 10.5 billion people with about 2,000 calories per day, approximately 800 million people remain malnourished (Biello, 2011),

The mortality rate increased yearly, being susceptible to protracted hunger than from severe ailments like HIV/AIDS, tuberculosis, and malaria (Gillespie, 2006). Developing countries host a large population of the world hungry. The most efficient approach to save lives and alleviate poverty is the availability of food supply to the poor regions of the world. Should we fail to improve our approach of farming, distributing, and harvesting crops, we stand the risk to be caught in the web of the vagaries of climate change that can increase the dearth of the food supply by the duration and intensity of crop-crippling droughts, which could be catastrophic (FAO, 2015).

Hunger is an excellent pointer to the multi-dimensional occurrence of poverty, and stamping out hunger from the population is, therefore, central to the eradication of other scopes of poverty (UNEP 2002). Chronic hunger impedes poverty alleviation and is a threat to sustainable economic growth. Hunger, in an economic sense, is a manifestation of market

failure since those who most require food are the least able to express their demand. Although the world food production is more than what is required to provide everyone with a sufficient diet; still over 800 million people representing a ratio of 1:7, do not have adequate food to eat. The majority of these reside in the South and South-South of the Asian Continent (FAO 2002). Globally, obesity has become a severe health challenge because farmers avail themselves of the ease of technology to produce excess food.

The Universal Declaration of Human Rights and the Food and Agricultural Organization of the 1940s (FAO) Constitution made explicit provisions for the right to food (FAO, 2002). However, there has been little progress towards its implementation. The United Nations (U.N.) Committee on Economic, Social and Cultural Rights has facilitated the task of implementing the fundamental right by adopting, in 1999, the General Comment on the Right to Food, which stipulates how states can meet their obligations to protect, respect, and fulfil this right. Given that the concerns for the integrity of natural habitats will limit the significant further areal expansion of agriculture, other strategies established to feed a world population that may exceed seven billion in 2010 (FAO, 1996) with several other scenarios suggested.

2.3 Genetically Modified Food Controversies

2.3.1 GMF Controversies

There is a lingering controversy about genetically modified food. Some researchers opposed to the consumption of G.M. maise; have additional evidence that demonstrates that G.M. maise affects biodiversity and destroy the ecosystem. Scientists' research on G.M. maise is inconclusive; hence, the need for further research (*Buiatti et al., 2013*). There is a connection between the productive genes and selective breeding of crops adaptable to diverse ecosystems, with G.M. maize crops (Phipps and Park, 2002). While scientists continue to debate on the effects and risks inherent in genetically engineered maise pollen on butterfly populations, there have been severe declines in the use of pesticides through the introduction of G.M. crops (Benbrook, 2012). The adverse effects of G.M. maise on the environment and human health security are yet to be ascertained in close to a decade.

Some countries which include Tanzania, Uganda, Malawi, and Ghana, are in the first field trials while Poland has allowed the commercial cultivation of G.M. *B. thuringiensis* maise crops since 2006. (Benbrook, 2012). The G.M. maise feed was under restriction in Tanzania, awaiting government approval (Benbrook, 2012). Poland only allowed the use of GMOs in feeds on an occasional basis until 2012 (Maciejczak and Was, 2008). There are heated discussions at different fora on G.M. crops in Poland, and the consensus showed that half of Polish society is opposed to G.M agricultures (Maciejczak and Wąs, 2008), even with the *Bt.* gene, isolated from *Bt.* bacteria are thought to be resistant to the transgenesis of maise (Rogério , 2014).

The GM cotton harvests situation in India as exemplified in Tamil Nadu, Karnataka, and Maharashtra occasioned an estimated forty-two per cent harvest growth in the year 2002, as the advent of the economic implanting. An intensive famine in Andhra Pradesh in the year 2002 decimated the yield increase because of the nature of the G.M. strain that was not drought-tolerant. This dearth revealed the implications of outputs (Schurman, 2013). Drought-tolerant species developed, which subsequently reduced substantial losses to insect predation before the modification of 88% of Indian cotton in 2011 (James, 2011*)*. There is a dispute about the documented commercial and ecological benefits of genetically improved cotton to agriculturalists (Bennett, 2005*;* Global Research, 2010).

Revelation from a 2002 study in India depicted that yield increase, amelioration of the living standards of small-scale farmers, and profit was the economic benefits of G.M. Cotton, but recently, cotton bollworm defied resistance to Bacillus G.M cotton (*Kathage et al., 2012)*. Consequently, genetically improved cotton was outlawed in Maharashtra in 2012 and instituted an autonomous socio-economic study of its usage (Environment News, 2012). Indian supervisory body eventually approved the commercial release of a genetically engineered eggplant called Bt brinjal, in the last quarter of 2009. However, the antagonistic stance of some researchers, agronomists and environmental activists led to the suspension release of the Bt. brinjal in February of the year 2010 with a precautionary measure to create communal faith and assurance (Rogério , 2014).

Genetically improved foods were mandated to be labelled by 1st January 2013. The Legal Metrology Act, 2009 stipulated that every package containing GM food should display the 'GM' letter on its panel. These guidelines were made applicable to nineteen foodstuffs, which include bread, breakfast, puffed rice, pulses and biscuits, e.t.c. The rules came under attack by Consumer rights activists including others from the agro-allied industry criticised the law on the ground that its enforcement and implementation were devoid of the legal framework (Daily Mail, 2013*)*. Notwithstanding the opposition, they certified ten genetically altered plants in India, also approved the experimental field of biotech crops, comprising maize, wheat berry, and *Oryza sativa* (Ahuja et al., 2012).

2.3.2 Public Awareness and Remonstrations

Environmentalists from notable organisations like Earth Actions, GM Watch, and the Institution of Knowledge in Civilisation regarded GM food as a significant concern, not only to the environment but also to politics (Mike, 2013).

In 1983, environmentalists influenced the decisions of authority in America and consequently stalled the farm trials of the transgenic traits of *Pseudomonas syringae* with lawful manoeuvrings. The first genetically modified organism (GMO) *Pseudomonas* syringae *(P. syringae)* was released into the environment in 1987. The environmental activists uprooted the plants in a strawberry field in California, where a seed potato was sprayed with the bacteria in the field trails but was replanted the second day (BBC, 2002). Differing perceptions were classifying genetic modification as interfering with organic processes with potentially adverse effects. Genetic engineering itself was also perceived from the opposing dimension as evolved from traditional selective breeding (Suzie, 2008). Surveys show the apprehension of the public on the associated harms with the consumption of genetically modified food (Shahla and Kelsey, 2015) that due to the hazards inherent in biotechnology, more information is required to enable consumers to decide on whether the risks are worth taking (Lazarus, 1991).

Organizations driving the media attacks on genetically modified food comprise the Biological Customers Union, Association of Disturbed Researchers, and Greenpeace, International which is critical about the Golden rice (Alberts et al.; Keith, 2014). Religious based groups have been concerned about the likelihood of genetically modified food

becoming kosher or halal. Up until 2001, GM food had not been any such foods that had been tagged as unacceptable by clerics (Marlene-Aviva, 2013). However, some Jewish based groups dispute this description (Abdallah, 2009).

Members of Greenpeace were reprimanded in 2011 with subsequent nine-month suspended sentences for breaking into the locations of CSIRO, based in Australian and devastated the G.M. wheat plantation. (Karl,2013). Gerald Miles led a group called "Take the Flour Back" remonstrated against the delegation from a United Kingdom-based firm, Rothamsted Experimental Station, to conduct a field trial of G.M wheat to resist aphids (Quick, 2013). The group worried about the ability of the crops to spread into the ecosystem and mentioned consequential instances in Canada and the U.S. (BBC News, 2013). The Rothamsted based Research Center carried out investigations about such a potential (Anon, 2012).

A broad-based protest was organised on the 25th of May, 2013, against an American agrochemical and agricultural biotechnology corporation, Monsanto with demonstrations in Argentina and other cities in Buenos Aires (Xia, 2013). Hundreds marched in Los Angeles with over 6,000 protesters estimated by Oregon police in Portland (Associated Press, 2013). CTV account showed that hundreds of activists and protesters demonstrated massively in Ontario, Canada. It was quoted that a huge number of protesters participated in the remonstration The organisers documented 436 cities made up of 52 countries where the protest was held (Quick, 2013).

Golden rice is an ingenious invention to avert vitamin A deficit, which causes infant blindness or leads to the mortality of several children annually in under-developing nations. Demonstrators devastated field trial of transgenic rice based in the Philippines on August 8, 2013. Mark Lynas, formerly famous as a GMO antagonist, indicated in the schedule that the devastation was done by an exuberant group, taking other protesters by surprise. (BBC News, 2013).

Another group named “The league of European Scientists on Social and Environment made a statement in October 2013 that claimed ignorant of any scientific endorsement of the safety of GM foods (Dave, 2013). Friend the Earth, Greenpeace International with other

activists have damaged Biotech study universally. About eighty studies owned by the government and private laboratories were wrecked with the United Kingdom field Within the UK and Europe in 2014 by demonstrators. (Specter. 2014)

2.3.3 GMO Controversies in Africa

In Africa, the move to introduce Genetically Modified Organisms into Africa was retarded, surprisingly in disappointment to the GM producers. Attempts made over the distribution of welfare packages and subsistence farmers produced little progress. Recent attempts are targeted at the perception that Africans are nutritionally deficient in essential vitamins and the kids are undernourished, impaired, and disposed to visual impairment. Sadly enough, several African countries hoodwinked to have embraced the notion and accepting the universal seed rules without knowing the negotiations (Kirtana and Nnimmo, 2013). It is pertinent that the government should respect people's freedom to choose their diet and agronomic practices. The failed prospects of GM crops abroad is enough testimony that the commercialisation of GM crops in our country may not be in the best interest of our people (Kirtana and Nnimmo, 2013).

African countries are in a state of a dilemma on whether to invest in biotechnology or subscribe to the importation of genetically modified food owing to fear of their traditional crops contaminated with GM seed and risk losing their foreign markets. The development of GM food is trailed with controversies in the western nations; hence, consumers are wary of GM products and apprehensive of the long term implications on human health and the ecosystem (Obadina, 2003).

The member countries of Africa are at different levels on the adoption of GM food. South Africa took the initiative like Egypt to release new transgenic maize into the market, countries like the Federal Republic of Nigeria, Mali, Republic of Zimbabwe, Kenya, and Uganda have also accepted transgenic maize in the continent of Africa. Other nations are engaged at the explorative stage in GM research, whereas others such as Morocco, Republic of Benin, Malawi, Republic of Cameroon, Ghana, Namibia and Zambia are in confined field trials (Moola and Munnik, 2007). In 2002, Zambia faced a severe famine, and GM food was

packaged aid to assist the nation, but they rejected it, based on the precautionary principle (Alexandria, 2007).

Kingsley Amoako who was the scribe of UNECA- an organ of United Nations in charge of Economic matters in Africa, at a conference in Addis Ababa in Ethiopia, admonished African countries to embrace transgenic food and frowned at the public's abhorrence of biotechnology. The investigation carried out in Uganda pointed out that transgenic bananas could alleviate communal lack while the middle-class with higher wages disdain the crop (*Kikulwe et al., 2011*).

Opponents of biotechnology opined that sending food aids to southern Africa from the United States was not a strategy to address hunger but for promoting GM food. The US applied the initiative in the 2000s to supply some countries in Africa with food and provision during a food emergency, but the moment some African realise the mixed up with GM food, they rejected the products and blackmail the United States of using the exploitation of Africa as an instrument of civic relations (Olga, 2003).

2.3.4 GMO Controversies in Nigeria

African countries believe that they are agriculturally rich in resources that can enhance sufficiency in food production through the conventional traditional farming approach (Eva-Marie and Matin, 2018). At best, this is an assumption and myth to be interrogated. African countries are no longer enjoying the naturally favourable climate and weather conditions to support the outputs of intensive agriculture. More so, most of the land is friable and experiencing diminishing returns of infertility (Lutz et al., 2019).

Take Nigeria, for example, large stretches of the land in the north and south are devastated by desertification and erosion. The 1996 edition of the World Bank report noted that further increases in agricultural production in Nigeria must come from the productive use of the land in the country, and this will serve as a factor for additional growth in agricultural production. The report revealed that sustaining and increasing the portion of land under cultivation will cause an extreme decline in soil fertility, erosion, and deforestation (Obadina, 2003).

If African countries must enhance labour and physical efforts, they need to invest in modern technology to rapidly improve their agricultural production to satisfy domestic needs and to participate competitively in the international market. To this end, appropriate technology is employed to stimulate increased output but appropriate for organic farming and nascent technology (Obadina, 2003).

Civil society groups in Nigeria and around the world have studied the global evaluation, pattern, and implications of GM crop releases around the world for more than two decades to help separate the hype from reality to provide a holistic assessment of the universal impacts and spread of GMOs (FoEN, 2014).

Some prominent non-governmental organisations petitioned the National Assembly over the efforts of the Nigerian government to introduce genetically modified (GM) rice, cotton, cowpeas, and maize into Nigeria's agricultural system. The groups include Environmental Rights Action/Friends of the Earth Nigeria (ERA/ FoEN), Health of Mother Foundation (HOMEF), All Nigerian Movement Union (ANCOMU), Rice Farmers Association of Nigeria (RIFAN), Women Environmental Programme (WEP), and Nigerian Women in Agriculture (NAWIA) (Nyiam, 2016).

This petition came just as the National Biosafety Management Agency (NABMA) has made pronouncements to address the apprehensions of Nigerians about genetically modified (GM) crops, saying every genetically modified organism (GMO) in the country will come under the scrutiny and approval of the agency to safeguard unforeseen circumstances. The groups, in their joint petition, alleged that "apart from the potential of contaminating local varieties, the health risk of the introduction of the GM maize into Nigeria is enormous, because maize is a staple depended on by the people." (Nyiam, 2016).

2.3.5 Health Risk

There is apprehension that GM food is capable of affecting the transfer of antibiotic-resistant genes to humans (Environmental news network, 2002). This will make people resistant to ordinarily used antibiotics, resulting in the inability to treat ailments with antibiotic drugs (Jarvis 1999). Toxicity and allergenicity are the possibilities reportedly associated with genetically modified foods (Nestle, 1996; Hiefle, 1999 and Margulis, 2006).

Genetic engineering is inaccurate and fickle. Insertion of genes from organisms is a novel invention that is capable of introducing new proteins to the food chain. The possibility exists that this could cause illness and is a concern that these could trigger hypersensitive reactions (ERA/FoE, 2004). Evidence abounds that G.M. maize is resistant to mycotoxins contamination such as aflatoxin and fumonisin, resulting from maize fungi infections, which are causes of severe ailments in mankind and faunas (DeVilliers and Hoisington, 2011).

2.3.6 Environmental Risk

The topical issues dominating the arguments of GM antagonists include the capability of biotech crops to undermine environmental sustainability as a result of a decrease in plant biodiversity. The possibility of insect-resistant plants killing other pests and undermine competition made some pests become a problem (Haliweli, 1999) is rife. Also, this could make the population of one pest shift to another plant population formerly unthreatened. The emergence of GM plants that are tolerant to herbicide requires growers to administer weed killers of a wider range on the farms, which invariably destroys crops of other species. There is anxiety over the tendency to decimate farmland wildlife because Genetically Modified crops will require weeds removed from all crops in the typical arable farming system (Whitman, 2000).

Arthurs (2011) was critical about Maise crops, on the ground that it affects the core values of crop diversity. There is a provision in Germany's law that allows a ban on GMO products that portends harm to humans and the environment. Other countries are encouraged to borrow a leaf from this by adopting Germany's law to safeguard the ecosystem (Stephenson, 2010). Another probable effect of GM foods on the environment is the potential harm to essential groups of organisms found in the ecosystem by residues from herbicides or pest-resistant crops (Snow, 1997).

2.4 The Perceived Effects of Genetically Engineered Foods on Native Crops and Health

According to Kuzma & Haase (2012), generally, GE food safety concerns are categorised as adverse nutritional changes, toxicity, horizontal gene transfer, and allergenicity. A notable concern associated with each of these categories is summarized below.

2.4.1 Toxicity

Naturally, Crop plants usually produce a range of chemicals that shield them from herbivores and pathogens. Some of these chemicals may be toxic to humans when consumed in large amounts. The Food and Agriculture Organization revealed that it is natural for some foods to contain toxins or antinutrients at natural concentrations common in diets that can be safely consumed by humans (OECD, 2000).

In most cases, chemicals from primary metabolism which are the ones involved in nucleic acids, fats, carbohydrates and proteins formation are generally shared between plants and animals are not likely to be toxic. Perceived risks occur when the natural products in plants technically called secondary metabolites are. There are over 150,000 secondary metabolites available in the plant kingdom (Springob and Kutchan, 2009).

When consumed in a large quantity secondary metabolites such as peptides and protein may be lethal. Some examples of secondary metabolites in this category are; Steroidal glycoalkaloids found in green potato skin may cause diarrhoea and discomfort in the gastrointestinal tracts. Cyanide poisoning can occur from the Cyanogenic glycosides found in cassava. Ultraviolet sunlight activates the phototoxic psoralens in celery to cause dermatitis and skin cancer (Friedman, 2006).

2.4.2 Horizontal gene transfer

A major fear about Genetically Modified Organisms is the danger of horizontal transference of genes. Horizontal gene transfer is described as the reception of extraneous genes through the process of transduction, transformation, and coupling by fauna in designated ecological conditions. This concern is a response to varying habitats that predispose organisms, particularly prokaryotes, to access to genes that are alien to the one that can be inherited (Martin, 1999; Ochman, 2000).

Although GE crop producers are phasing out these genes, they are still prevalent in GE crops on the market. No evidence has been documented for the uptake of digested DNA by gut bacteria after the consumption of food, although few studies have addressed this possibility. Contemporary studies recommend that genes from GE foods can survive in the

gut environment and enter the bloodstream, so uptake by gut microbes is a possibility. The rate and consequences of uptake remain uncertain (Gijs, 2005).

2.4.3 Inadvertent Ecological Destruction and Biodiversity

Genetically modified crops are a semblance of regular crops planted in fields. They derive their nourishment from the parent plants and interconnect with other creatures in the ecosystem. Pollination from the parent crops takes place in an environment similarly applicable to other plants. The process had generated anxieties about the implications of genetic crops on the habitat. Some of these probable outcomes comprise resistance to pesticides, genetic pollution and emissions of green gas. There is a tendency that the development of superior GM strains might reduce crop genetic diversity. Indirect effects are likely to affect other organisms. The extent to which agrochemicals affect biodiversity is a function of the alterations that generate demands for their application. Moreover, effective traits entail their use or the attendant strength in resistance will necessitate more requirements for chemicals to counterbalance improved resistance in desirable organisms.

A comparative study on the genomic variety of cotton showed that variety has no appreciative yield in the US, while there was a shortfall in India. This variance resulted from the high quantity of genetic was ascribed to the higher figure of varieties in the United States in comparison to the republic of India (Carpenter, 2011). No reliable, substantial, and long-standing microbial effects on the environment in the assessment of the ecological impacts of transgenic crops (*Snow et al., 2005*). The range and quantity of wild plant populations revealed the reduction in field trials in Denmark and U.K when compared between herbicide-resistant plants and their organic counterparts (Beckie and Tardif, 2012).

The field trial carried out in the United Kingdom revealed that a variety of birds could be negatively affected by the reduction in wild plants that were available for scavenging (Gibbons, 2006). The publication from the farm-scale experiments revealed that herbivorous birds were in large numbers on organic maize after treatment with the herbicide showing no substantial changes in any other crop or before herbicide application (Chamberlain, 2007). Established by a 2012 study report is a relationship between the

reduction in the population of decline in fully-grown monarch butterflies and the decrease of silkweed in a glyphosate-resistant plantation in Mexico (Andrew, 2011; Pleasants, 2013).

The environmental groups had used a 2005 study to claim that the usage of agrochemicals led to unintended damage to the habitat and biodiversity (Robin, 2005). The study was a mock experiment created to "trigger the effects of a straight overspray on a marshland" using four diverse agrochemicals, namely: (malathion, dichlorophenoxyacetic glyphosate 2,4 acid, and carbaryl (Sevin), in controlled preparation) by making mock ecologies in cisterns and spread over "separate chemical at the manufacturer's recommendations the outcome recognised that the "species vitality declined by about fifteen per cent with Sevin, 22% - Roundup, and 30% - malathion, but 2,4-D did not give any outcome (Relyea, 2005).

2.4.4 Gene flow

GM crops differ with their predisposition to the crossed variety, the potential for fertilization is a function of their sexual compatibility or crops having different environments (*Miguel et al., 2015*). GM crops have some viable benefits over the native crops, hence, they may grow in a certain location and disrupt the environment (Pleasants, 2001and Ford, 2007).

Genes from a GMO may flow across species. The process of outcrossing enables genes to pass from a GMO to another organism as it happens for an endogenous gene and may happen in native diversity. The presented species can flow to correlated types notably in three forms of gene pass: from plants to wild, wild, and plants. plant-to-weedy flow means the transmission of the genome to a wild; plant-to-wild denotes transmission between a transgenic plant to a weedy, untamed species, and in crop-to-crop comprises the transfer of genome from a transgenic crop transported to an organic crop. (Gerhart, 2015).

There are anxieties over the spread of genes from modified organisms to unmodified relatives that may produce species of weeds resistant to herbicides (*Conner et al., 2003*) that could disturb the ecosystem or pollute the neighbouring non-genetically modified crops (Andrew, 2012). This situation is quite an issue of concern if the survival capacity of a transgenic organism is substantial to upsurge and thrive in natural habitat. In a development where the genes from transgenic plants flow across to wild species, a contrast to the course of "superweeds" or "super germs" that are pesticides resistant in a natural environment.

Environmental assessment and studies are essential requirements for the endorsement of a GMO for profit-making in some countries. Also, a monitoring procedure is required as a matter of necessity to recognize unanticipated impacts of gene flow. An indication that gene flow occurred in 2004 when Bt protein was discovered by Chilcutt and Tabashnik in an organic crop planted to host herbicide-resistant pests (GM Compass, 2006).

Researchers at the Ecology and Hydrology centre based in the United Kingdom disclosed in 2005 the initial proof of horizontal gene transfer of pesticide-resistant weeds. The gene transfer occurred in a collection of crops from a single point; they lack substantial proof showing the survival of the crosses in subsequent periods. In 2007, Scotts Miracle-Gro was penalised 2007 with an amount of about $500,000 by the authorities of the United States. Department of Agricultural Department when genetically manipulated DNA from G.M crawling bentgrass linked with him was uncovered within the species families of the same traits (Agrostis) (Chilcutt, 2006) with natural grasslands up to about 21 km distance to the experimental field (BBC, 2005).

Mexico made a monitoring framework for genetically modified maize in 2009 (Watrud, 2004), but even Mexico being a maize's hub of variety, there were apprehensions about the effects of GM maize on local traits (*Mayra et al., 2018*). There was a documented report in 2001 of the cross-breeding of Bt maize with native *Zea mays* in the city of Mexico (Mike, 2004). The findings elected emanated from an artefact and periodical publication as an addendum that "the available evidence is inadequate to substantiate the publication of the original paper." At the same time, it did not retract the paper (Katie, 2001). Later in 2005, an extensive study established there was no indication of gene flow in Oaxaca (Quist, 2001). Nevertheless, other researchers reported having established signs of gene pass (Kaplinsky, 2001).

Findings documented in 2010 from the research conducted by the government of Canada disclosed that about eighty-three per cent of native canola tested positive to transgenic genes coded for herbicide resistance (*Ortiz et al., 2005*). The researchers said that the absence of documented information in the United States of America was evidence of inadequate monitoring and oversight (Black, 2010). It was indicated in the year 2010 account that the

introduction of glufosinate-resistant weeds was likely to make GM crops lose their usefulness, except growers apply glufosinate alongside other weed-control procedures (Eisberg, 2011).

There are environmental concerns concerning the genetic pollution of traditional crops, capable of disrupting genetic constitution and reduce productivity. There is a need for more investigation to establish the practicality of GM *Zea mays* to prevent danger to mankind including faunas (*Park et al., 2011*). In the season after the field trial, a report indicated that the waste grains from GM maize that was genetically engineered to express biopharmaceutical compounds were found to have germinated with soybeans grown on the same ground. This development caused contamination that consequently .affected the seed markets.

2.4.5 The Escape of Modified Crops

Most farmers sell to markets that discriminate against GM foods. This situation essentially makes the pollution of native crops with GM seed that escaped from the neighbouring field a significant concern to farmers as their harvested products will be genetically contaminated thereby impeding access to nations that are opposed to GMO products (Pollack, 2009). In the year 1999, researchers in Thailand reportedly uncovered GM wheat that was resistant to glycoside which did not get official recognition in a shipment of grain, though it was only grown in field trial plots. However, the farmers did not discover the channel for the escape (Hannelore, 1999).

When they discovered that Golden corn was available within the United States of America cafeterias and markets in 2000, they instituted a recall procedure immediately when they discovered Taco Bell shells retailed in the superstores contained it. This discovery necessitated the termination of StarLink (King, 2000). Aventis willingly withdrew the registration for Starlink selections by October 2000 (Kaufman. 2000). Consequently, the exports of American rice to European countries were interjected in 2006 when the modified version of LibertyLink was detected in commercial crops without approval (Marc, 2007).

A study instituted at the instance of the United States Department of Agriculture to establish the reasons and context for the genetic pollution failed (Aphis, 2013).

Uncertified glyphosate-resistant GM wheat yet to be approved for human feeding (Andy, 2013) was in May 2013 found in an Oregon's field cultivated with wintertime wheat. Monsanto's brand was tested on the field from the year 1998 to the year 2005. The detection undermined US wheat exportations, which amounted to an approximate amount of $8.1 billion in 2012 (Alan, 2013), making the company recall it. Taiwan, the Republic of South Korea, and Japan deferred the purchases of wintertime wheat due to the associated concerns raised by organic food promoters (Reuters, 2013). Even though the origin of the Bt. wheat continued unidentified, Taiwan, the Republic of South Korea, and Japan continued to place orders from August 30, 2013 (Melissa, 2013).

2.4.6 Outcrossing

When a native crop is accidentally bred with related species, outcrossing is said to take place. The introduced genes can outcross weedy families and equally have the potential to create weedy varieties. Outcrossing remains a significant concern associated with genetically modified food production

An extensive study instituted in 1990 spanning over a decade established no noticeable risk of the higher magnitude of invasion or persistent wild habitats for GM crops such as sugar beet, corn, potatoes, and oilseed rape; weedkiller acceptance and insect safety species established when equated to their usual crops (*Allister et al., 2006*). However, the researchers invariably indicated that these results "might not imply that genomic alterations might not escalate weedy or invasive species, but stated that biotech crops might not be durable." Notably, however, by the dictates of regulations required, to appraise different GM crops on a case-by-case basis, before and after commercial release.

2.4.7 Direct Effects on Unintended Organisms

There was a report by Cornell University in May 1999 that pollen from Bacillus thuringiensis (Bt) insect-resistant corn impacted negatively on milkweed (Blaine**,** 1999**)**. This account generated apprehensions and queries than responses around potential dangers to Milkweed and possibly other unintended species. Some researchers, though, prescribed a precautionary approach over the clarification of the study because it indicates a different situation from what takes place in the environment. The author stated that the laboratory

study raises an important issue; it would not be suitable to draw any assumptions about the risk to Monarch populations in the field solely on these initial results." A 2001 study published in PNAS revealed that the impact of Bt corn pollen on Monarch butterfly populations is insignificant (*Sear et al., 2001*).

The content of the investigation report of the United States Environmental Protection Agency (EPA) had no credible evidence to show a measurable negative impact of Bt proteins expressed in plants on non-target wildlife. Also, a joint study by North American scientists indicated a low level of Bt protein expression in native crops. No significant findings from the laboratory results show any acute toxic impacts of Bt proteins at any pollen density in the field (*Lang et al., 2019*). A collaborative finding from journals; laboratory findings (Hilbeck et al., 1998; Hilbeck et al., 1999) and detailed fieldwork indicated no severe effect on Monarch Butterfly habitat (Fitt and Wilson, 2003).

2.4.8 The Development of Insect Resistance Species

Bt crop is prone to insect resistance. The joint effort by the scientists, industry, and government to manage this concern resulting in the emergence of insect resistance management procedures. These procedures include a provisional requirement of native crops associated with insect-resistant crops in every population. The native crops will be a refuge for insects to develop natural tendencies. The researchers are considering supplementary resistance management plans that will align with post-approval monitoring necessitating the continuous assessment of GM crops and the located environment to identify changes notwithstanding the period of release (Ammann, 2004).

2.5 Ethical Issues

Ethical issues associated with GM foods are of serious concern as they are fundamental to ecological sustainability. Arguments bothering on ethics associated with genetically modified food revolve around cloning, patenting, and bio-piracy, the management of the ethical issues will determine the effects they have on environmental conservation (Marion. 2010).

2.5.1 The Conflicts of Interest

Biotech scientists require funding for their researches, and more often than not, their immediate constituencies to receive attention may be regulatory bodies and development partners. In most cases, some of these researchers are on consultancy retainership with the government and biotech corporations. This development creates avenues for a bias of decisions emanating from their findings as they may not be critical of their funders. At the same time, establishments and institutions that sponsor their work may expect compromise. These summed up to undermine the objectivity of their findings. Nowadays, scientists serve as consultants to companies and advisers to the government, while universities collaborate actively with partners in commerce and industry. All collaborations of this nature challenge the credibility of researchers thereby questioning the fairness of their outcomes (De-angelis, 2000). In recent times, questions have emerged about the field trials for herbicide-tolerant strains conducted by UK based farms (Gura, 2001).

A question frequently asked is whether researchers on GM foods are biased towards the interests of industries and governments. The assessment of the conduct and outcome of the field trials that were to ascertain the effects of herbicide-tolerant plants on the ecosystem is an exclusive reference as a case study on conflicts of interest. They compared the impact from the field trials with the native crops using an environmental evaluative model designed with selected species as indicator entities (DETR, 1999).

The government was the sole funder of the field experiment and gave the project design for publication and peer review journal. The environmental groups and independent advisory body to the British Government (AEBC) presented the study design with grave comments (Gura, 2001). They associated the flak with the criticism emanated from the framing of questions that bother on the parameters used for the assessment of the effects of transgenic crops on the ecosystem.

The opponents distrust scientific adequacy and the extent of the field experiments; they cited those interim experiences are employed to measure long-standing impacts. Therefore, scientists are vulnerable to a type-II error. Understandably, the biotech corporations conduct research centring on the beneficial effects of their crops without regard to the possibility of adversative effects. However, with collective capital like the environment, development

partners, industry, and regulators should not influence the scope of studies and the importance of scientific ambiguity.

Henceforth, to achieve credible and verifiable research outcomes that will promote fundamental knowledge with innate characteristics of GM plants and their dealings with the receiver ecologies, the aprons of most biotech genetic engineering research laboratories around the globe should not be tied to the grants and funds sourced from the protagonist of biotechnology applications. Public sponsorship of autonomous study will ensure transparency of research funding (Gurney and Sass, 2001).

Public interest should be the focus of research and development. Nature and Medical journals should safeguard industrial freedom, and protect the integrity of study projects beforehand (Gibbons, 1999. To implement the reality of science, the guidelines for the conflict of interest should become obligatory for scientists to ensure the application of basic science and technology know-how is responsively applied to safeguard the apprehensions and desires of the public (Gibbons, 1999).

2.5.2 Patenting Life: Intellectual Property Rights

Biotechnology issues related to intellectual property rights are concerned with the moral and ethical implications of patenting living organisms. There are concerns linked to fears that biotechnology, via the enforcement of intellectual property rights, will transfer resources from the public sphere to private ownership. Therefore, firms that have invested in the development of genetically modified varieties want to protect their proprietary knowledge, but many farmer groups have protested that enforcing intellectual property rights will make them depend perpetually on the company for seedlings. Farmers are not inclined to buying seeds, having been accustomed to harvesting and replanting their seeds conventionally. The controversial TRIPs Article 27.3(b) is gaining attention to this debate. (Grain, 2000), which exempts certain life forms from patentability but requires countries to establish some form of protection for plant varieties.

The cost implication of biotechnological research has hindered contribution to agricultural development in Africa, thereby limiting research to needs-based projects of developed countries. Transgenic research is quite expensive than conventional biotechnology methods. On a comparative basis, the estimated funding for both marker technology and tissue culture

was three hundred thousand US dollars while it cost six million and two million US dollars to fund IRMA for five years and GM sweet potato projects, respectively (*Odame et al., 2003*).

It is pertinent to know that the corporations that engage in the production of genetically modified plants have a monopoly over the products (Carpenter and Gianessi, 2001). Many new plant genetic engineering technologies and GM plants are patented, and infringement on the patent is considered a big concern of agri-business (Whitman, 2000). However, consumer advocates are worried that patenting these new plant varieties may increase the price of seeds and make them unaffordable for farmers, thus widening the gap between the wealthy and the poor (McGloughlin, 1999).

Monsanto being an agrochemical company whose registration as a traditional breeder, uncertainly seized the opportunity of the advent of genetic engineering for going into the seed production business. It made patents and penetrated the market with strategies to maximise profit (*Vandana et al., 2011*). This patent denied the farmers the opportunity to replant their seeds for harvest as Monsanto has taken the intellectual property right. This patent invariably will increase seed prices that may send farmers out of business (*Jacobsen et al., 2013*).

The absence of a legal framework and supportive policy is a hindrance to the growth and advancement of biotechnology. Without legal backing, development partners may not be encouraged to fund research that is capitally intensive to recoup their investments (Seshia 2002). For intellectual property rights (IPR) to have sound footings to drive the GM initiatives, it must have a sound legal framework to support research and not limited to be guided by including only clear procedures for risk assessment and trade (Yamin 2003). Even though the World Trade Organization's (WTO) overseeing the trade-related aspects of IPR (TRIPS) had formulated the IPR standards, local intellectual property rights in Africa is not healthy. There is a conflict between the intellectual property rights of farmers and the interests of the Aboriginals. The apprehension is that the IP protection will encourage monopolies for the global production of food by not many corporations thus encouraging reliance on developed countries. Intellectual Property protection might limit the rights of farmers to store and replant seed. (Glover 2003).

The perception in Africa is that GMOs is likened to taking the 'place of God', thereby unethical to tamper with natural plants scientifically. This has implications on the values and beliefs of the religious inclination of Africans. Gene patenting could create a social imbalance if not well managed (ERA, 2005 and Portfolio 21 2005). Patenting Genetic resources are ecological endowments naturally obtainable by the community, patenting genetic material will deny the public access to it and amount to a deprivation of their rights to sustainable development (ERA, 2005).

Access to intellectual protection connected to the technologies for gene termination is a way to make African nations rely on developed countries whose multinational corporations may monopolise world food production. There is anxiety on Biopiracy because many African countries are yet to put in place a legislative and enforcement framework to address the unlawful exploration of genomic materials. Furthermore, the dividends accrued from the extraction of these resources and capacity building were not adequately addressed.

The exclusive rights associated with GM technology has implicated safety and ethical issues. The contention is the conflict between the rights of development partners and consumers of GM food. The rally is based on ecological or ethical reasons, doubt, and public access to information, inclusive of labelling (Mohamed-Katerere 2003).

Development partners and marketers are taking advantage of the opened doors created by the revolutionary development in technology to access the global industry previously dominated by a few large organisations. The speedy market consolidation produced an inclusive industry principally controlled by a few large establishments. Accordingly, the seedling business at the moment is a cartel of universal fifteen billion dollars trade net-worth (Jeremy, 1998).

Development partners have made enormous commercial profits because of the robust Intellectual Property (IP) securities on their products. Subsequently, the public also gained commercially from creativity, improvement, and product development engendered by these protections (Spectar, 2002). Intellectual property rights remain a topical issue on the trade agenda of both development partners and the United States (USTR, 2005). Globally, the

United States has the best securities for intellectual property rights, whereby agricultural businesses influence IP biotechnology procedures (Susan, 2002).

Intellectual property protection had gained prominence due to the higher rate of investment and special dividends from GM technology. Agronomic bioengineering is a practice by researchers to make, transform, or alter crops. Genomic alteration is a bioengineering method employed by scientists to produce, increase, or transform plants. The advantage of genetic engineering over selective breeding lies in the ease and precise movement of genes for the consistent improvement of seed production (USDA, 2005).

Agricultural biotechnology has enormous economic and humanitarian potential: "the excellent expectation for genetically modified crops is that they will feed the world (Lara, 2000). There are vast benefits: more productive harvests, improved food quality (such as vitamin-enriched products), with minimal dependence on environmentally dangerous chemicals and pesticides (Henrique, 2000).

Nevertheless, there are many unknowns regarding genetically modified foods. There is no scientific confirmation that these foods are safe, and many countries are adamantly opposed to the marketing of genetically altered foods. There are also reservations on increased resistance to pesticides, the adaptation of insects, unknown environmental impacts, and harmful effects on the plants' gene pool (Samantha, 2002).

2.5.3 Human Health Concerns

Given the hesitation about the attendant threats of GM food, opinions divided on how it affects human health and food security, environmentalists and consumers have advocated a precautionary approach to GM products. The concerns include the process of animal production by domestic and industrial use of genetically modified ingredients in livestock feed e,g. GM- fortified cereals and oilseeds. Industrialised nations have stopped the use of GM derivatives in food production as a proactive measure to forestall unintended hazards (Soil Association, 2003).

2.5.4 Labelling of GM foods

A controversial issue concerning the use, sale and marketing of GM foods is the labelling of the products. Labelling is essential for consumers as it provides them with first-hand information about the products on the market shelves and leaves them with the option to exercise their discretion. The European Union approved labelling and traceability guidelines to allow consumers to know what they are buying for the use and consumption of GM food (EC, 2005).

The number of countries not limited to France and Luxembourg placed proscription on some GM products. For instance, while labelling was not addressed in the United States, Hungary was the first central European country to legislate against the cultivation of Monsanto's transgenic seeds in the year 2005, followed by Poland that banned GM maize (Reuters 2005).

2.6 Policy Frameworks for Genetically Engineered Foods

2.6.1 The Cartagena Protocol on Biosafety

The Biosafety Protocol is a legal provision to safeguard biological diversity from the potential risks associated with living modified organisms resulting from modern biotechnology. The Biosafety Protocol indicates that products from new technologies are subject to the cautionary approach to permit emerging countries to stabilise communal well-being concerning commercial profits. It empowers countries to prohibit the importations of transgenic materials if there is no sufficient scientific proof that it is safe.

There was the requirement of fifty instruments of certification by countries reached in May 2003. Following the provisions of Article 37, the Protocol entered into force on 11 September 2003. The precautionary approach, contained in Principle 15 of the Rio Declaration on Environment and Development, is to contribute to ensuring an adequate level of protection in the field of the safe transfer, handling, and use of 'living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, also taking into account risks to human health, and specifically focusing on transboundary movements (SCBD, 2000).

The Biosafety Protocol, which is a Multinational Environmental Agreement (MEA), is to devise entrusted a complete universal monitoring method to the safety of the ecosystem.
The Cartagena Protocol, concluded in negotiations in Montreal on January 29, 2000, establishes rules to manage the environmental risks of transboundary movements of genetically modified living organisms. Although the BSP has an environmental orientation, it also has provisions that have significant potential implications for trade in GMOs. The preamble did not interpret this as modifying the civic privileges and responsibilities of nations under global treaties, like World Trade Organisation. The Cartagena Protocol on Biosafety finally came into force, after years of negotiation, on 11th September 2003. This protocol regulates trade in GMOs based on the precautionary principle. This internationally binding environmental agreement is explicitly to protect human health, the environment, and biodiversity from the risk posed by GMOs. (Cartagena Protocol, 2000).

The main features of the Protocol

An Overview of the features

The rules and procedures for the handling and use of Living Modified Organisms (LMOs) with emphasis on transboundary movements are established by the protocol to promote biosafety. It comprises of a conventional guideline that must be adhered to when introducing genetic materials into the biosphere called the procedure for accelerated information contract for Living Modifies Organisms proposed as a feed or food processing.

The transboundary movement must have required documentation that specifies how to identify the genetic materials and the locations to garner more information. These regulations were put in place to assist parties importing the genetic products with relevant information required to make provisional decisions on the acceptance or non-acceptance of modified organism's importations and for management, wrapping, and conveying them safely (Wikipedia, 2000).

Importation is made following scientific procedures for sound risk assessments. The Protocol contains standard operation procedures for conducting a risk assessment. In a situation where there is inadequate appropriate technical knowledge also information, the Party making the importation might be of import may be directed by guidelines to decide

on importation. Parties might consider the social and economic effect in taking decisions on the importation of modified organisms.

2.6.2 Coexistence with conventional crops

The US has no legislation governing the relationship among mixtures of farms that grow organic, conventional, and GM crops. The country relies on a "complex but relaxed" combination of three federal agencies (FDA, EPA, and USDA/APHIS) to manage coexistence and states' standard law tort systems (Michael, 2011). The Team on Biotech was convened by the Secretary of Agriculture to learn about co-occurrence and counsel accordingly.

The membership of the team comprises; farming communities, the seed company, representatives of the biotechnology company, food producers, State administrators, consumer and community associations, the organic food industry, the health profession, and scholars. The committee suggested research to evaluate the capacity for commercial losses to US native farmers, a crop insurance program as a buffer for losses, a training to safeguard that native farmer puts proper agreements in place, ensure neighbouring GMO agriculturalists take precautionary actions. The findings suggested robust agricultural schemes with varied agricultural schemes (FAO. 2017).

The European Union effected protocols on traceability and co-concurrence. Traceability is a common occurrence in the nutrition and feeds chain of most countries, though GMO traceability is laden with legal complications for unsolicited mixing. Orthodox and traditional food and feedstuffs authorized since 2001 to comprise up to 0.9 per cent of approved genetic material without displaying a genetic inscription (Czarnak, 2010). Any iota of unauthorised alteration is the reason for a cargo rejection). A non-profit group called Co-Extra was established by many countries to develop the ability to discover, find, and categorise GM foods (Jeremy, 2007).

2.6.3 The Precautionary Principle

The emergence of increasingly unpredictable, uncertain, and unquantifiable but possibly catastrophic risks such as those associated with Genetically Modified Organisms, climate change, e.t.c., has confronted societies with the need to develop a third, anticipatory model

to protect humans and the environment against uncertain risks of human action: the Precautionary Principle (PP). The emergence of the Precautionary Principle has marked a shift from post damage control (civil liability as a curative tool) to the level of a pre-damage control (anticipatory measures) of risks.

The Polluter Pays Principle is complimented by a preventive policy aimed at reducing the damage that requires repairs and compensation. The practicability of this principle based on prevention is better than the cure model. This principle makes polluters liable for the cost of pollution for fairness and practicability. This principle is borne out of the idea that science can evaluate and quantify risks; therefore, this principle could be applied to reduce or eliminate severe damage.

For more than ten years, the Precautionary Principle has remained the justification for quite several international treaties and declarations for food safety, environmental protection, trade, health, and sustainable development. The Precautionary Principle is an approach to cope with scientific hesitations in the evaluation and control of risks. It is about a "stitch in time saves nine." The understanding is: 'better safe than sorry and 'look before you leap,' what precaution implies is taking remedial action to safeguard human health and protection of the environment against untold damage.

Nevertheless, in the international fora, precaution and Precautionary Principle has a different meaning in different contexts. The Precautionary Principle is a vital tool for sustainable development, meaning a development that addresses the necessities of the moment without mortgaging the potentials of future generations to meet their needs. By protection against severe and, principally, irrevocable harm to the natural resource base that might endanger the capacity of future generations to provide for their own needs based on ethical concepts of intra- and inter-generational equity.

Some people fear that a more precautionary approach to forestalling the potential hazards of a morally unacceptable nature may stifle innovation or hamper scientific progress. They point to the fact that new technologies typically introduce new risks. However, there are immense challenges to, and opportunities in, understanding complex and emergent systems while meeting human needs with lower health costs and lower ecological damages. Wider

use of the Precautionary Principle can help stimulate both innovation and science by replacing 19th-century technologies and simple science of the 1st industrial revolution with the "eco-efficient technologies" and systems science of the third." (Poul, 2002)

It is useful to elaborate on what the Precautionary Principle is not, to avoid misunderstandings and confusion, The Precautionary Principle is not based on 'zero risks' but aims to achieve lower or more acceptable risks or hazards. It is not based on anxiety or emotion but is a rational decision rule, based on ethics, that aims to use the best of the 'systems sciences' of complex processes to make wiser decisions. Finally, like any other principle, the Precautionary Principle in itself is not a decision algorithm and thus cannot guarantee consistency between cases. Just as in legal court cases, each case will be somewhat different, having its facts, uncertainties, circumstances, and decision-makers, without eliminating the element of judgment.

The Precautionary Principle (PP) remains an approach to scientific hesitation (Freestone and Hey, 1996). At the moment, the threats associated with the ecological impact of GMO utilization constitute a drawback to the consent on the significance of genetically modified food (Clark and Lehman, 2001).

Risks and safety evaluations based on the framework of scientific and science-based evidence is a function of the choice of variables/indicators, implementation of methods, design of the study. The existing outlines employed in regulating GMOs are limited in application and inefficient to address the apparent technical doubt and communal apprehension. To adequately address the scientific apprehension, framing of hypothesis, and the significance of evidence, a robust application of the Precautionary Principle is necessary (O'Riordan and Jordan, 1995; Buhl-Mortensen and Welin, 1998).

2.6.4 Substantial Equivalence

Substantial equivalence was a concept introduced in 1993 by the Organisation for Economic Co-operation (OECD) and acknowledged after that by Food and Agriculture Organization (FAO) in 1996 to assess and evaluate the safety of GM foods (OECD, 1993; FAO, 1996). The idea of substantial equivalence is to assess the risk associated with the safety of transgenic food and determine if it is safe in comparison with traditional crops. If a

genetically modified food is said to be substantially equivalent it implies it has no risk effect and will then be qualified for certification and used commercially.

Deductions from a substantially equivalent crop are centred on the analysis of the chemical composition of the crop. There are debates on whether the application of this idea is strong enough to assess the risk significant risk factors or limits the scope of the study (*Millstone et al., 1999*; Trewavas and Leaver, 1999; Gasson and Burke, 2001). Advocates of GM food claimed there was no reason to anticipate different impacts from GM food than the traditional crops without taking into consideration that the genetic engineering process is imprecise.

However, the argument associated with the use of substantial equivalence in safety assessment is that it is inadequate neither to notice changes in the forms of how genes ate expressed endogenously nor to establish whether the inserted genes move along the horizon of the receiving genome. Variations in the components like allergens, anti-nutrients and toxins may result in Pleiotropic plant effects (Novak and Haslberger, 2000).

For better clarification, it will be essential to research to notice variations in how genetic products are expressed in transgenic foods and to confirm if such variations have adversative effects on the users. Accordingly, a holistic food security assessment would involve holistic research based on toxicologic and biochemical tests (Millstone et al., 1999). Dependence on how substantially equivalent a biotech product may be has resulted in abandoning the important study on subordinate metabolite reporting, feeding experiments and immunology studies.

In 2001, The Royal Society of Canada inaugurated an authoritative expert committee intending to consider the implication of genetic alteration at six important levels: transcript, metabolite, protein, health impacts, genome, and environmental effects (Kuiper et al., 2002). Also, to evaluate health safety, it is crucial to use feeding studies to assess the changes in metabolic roles of tissues and organ's structure. (Domingo, 2000).

The practice of the idea of substantial equivalence might be a method to handle the complication of the problem associated with GM food to a reasonable dimension through the instrumentality of conventional science (Clark and Lehman, 2001).

For example, the assessments of GM products are analogous to the products from chemically conventional farming. Products from organic agriculture will have higher standard baselines for the comparison of GM products. The standard benchmarks used for safety extrapolation to determine that adversative effects do not surpass those of the native plants will be relatively different conditional on whether it remains organic farming as against chemically intensive agriculture.

Likewise, the range of variance allowable amongst a transgenic and the non-transgenic equivalent required a precise definition before non-substantial equivalence is confirmed. The engagement of the Precautionary Principle is associated with a high level of consciousness of the value of risk-correlated technical information. The risk involves the location of places where ignorance prevails over technical consideration. (Raffensperger and Barret, 1999).

The precautionary Principle recommends how to effect the procedures that are required to safeguard the health and the environment. (Pouteau, 2000) advocates for ethical assurance in food chains, alluding that social and involve ethical issues should also, along with health and environmental issues in the assessment of safety. To ascertain the achievement and application of factors that ensure wellbeing should determine the food safety assessments. Subsequently, to ensure food security and processes used for the application of the process of quality assurance, it is important to incorporate different scientific disciplines and other stakeholders.

2.6.5 Nigerian National Biosafety Management Agency Act, 2015

The Convention on Biological Diversity (CBD) highlighted the significance of regulating modern biotechnology. It identified the prospects of modern biotechnology in the advancement of human well-being, particularly in bridging the food gap, boosting agriculture and health care (SCBD, 1992).

Also, the CBD is a legal framework that underscores the need for developing relevant measures to ensure the safety of biotechnology by stemming down potential threats to biological diversity bearing in mind risks to human health. The provisions in Articles 8(g) and 19(3) of the Convention on Biological Diversity (SCBD, 1992) require contracting

parties to design local biosafety processes and equally ensure that appropriate procedures are put in place in the field for handling, safe transfer and use of living modified organisms emanating from biotechnology that may cause deleterious consequences on the ecosystem and ecological use of biological diversity".

Nigeria is a signatory to the Cartagena Protocol on Biosafety and consequently bound by its provisions. The main thrust of the protocol is to provide a regulatory framework and direction for the sustainable development and management of genetic engineering as well as its application and safe use of its products without constituting a risk to national sovereignty, environmental health, public health, human dignity and fundamental human rights (Nang'ayo, 2006).

In this connection, Nigeria has a comprehensive National Biosafety Guidelines and a National Biosafety Committee in 2001. The guidelines seek to facilitate and affect the establishment and development of national capacities to evaluate and manage probable risks linked with biotechnology under the Environmental Impact Assessment Decree 1992. Subsequently, the Government established the National Biotechnology Development Agency (NABDA) to prospect the full benefits of biotechnology for Nigeria's economic development.

This Act establishes the National Biosafety Management Agency charged with the responsibility for providing a regulatory framework, an institutional and administrative mechanism for safety measures in the application of modern biotechnology in Nigeria with the view to preventing any adverse effect on human health, animals, plants, and environment (NBMA Act, 2015).

The National Biosafety Management Agency Act, 2015, was signed into law in the last week of the administration of President Goodluck Jonathan in May 2015. Despite the far-reaching importance of biosafety matters to citizens of Nigeria, there were controversies about the process that led to the passage of the Biosafety Bill and its eventual signing into law and complaints from key stakeholders, including farmers, consumers, and civil society groups.

United States Agency for International Development (USDA) and GM crop proponents are encouraging Nigeria to develop its biosafety laws to allow the adoption of GM products in the country (Bassey-Orovwuje, 2016). The formulation of the Biosafety laws was to regulate GMOs and to allow a comprehensive assessment of economic, environmental, health, and socio-cultural effects of the introduction of GMOs before accepting or releasing an imported GM product. This law implies the right to say no, to ban and restrict GMOs to the country.

What Nigeria requires is the African version of the Biosafety law strictly formulated to prevent Nigeria from becoming a laboratory for the testing of unconfirmed technologies and a dumping ground without resort to the precautionary principle. The bottom line is that the interest of Nigerians must be uppermost in issues of biosafety, and development partners should not be allowed to dictate industrial food and agricultural policies that will truncate sustainable agriculture and our food prospects.

2.7 Theoretical Framework

In using science to explain the phenomenon, a 'theory' is an idea or belief about something arrived at through assumptions, and in some cases, a set of facts, propositions, or principles analyzed in their relation to one another (Berberoglu, 2005).

Conflict is a natural part of our daily lives, and it is a development that is imperative in the lives of mankind (Isard, 1992). Conflicts that take place within a society may be attributed to the resultant effects of several factors. Due to this reason, explanations for social conflict, whether on a small or large scale, whether resulting from interactions between social groups or caused by external factors have been an issue of common concern.

This study anchored on the Human Needs Theory of social conflict and discussed thus;

2.7.1 Human Needs Theory

The Human Needs Theory was propounded by a group of twelve sociologists but expounded by John Burton. Human needs theories propose that all humans have specific basic universal needs, which, if not met, leads to the occurrence of conflict (Danesh, 2006). The concepts of human needs, conflict, and peace are interrelated and affect all aspects of human life.

This theory is based on the deprivation of individuals' or communities' access to the satisfaction of their basic needs, which exacerbates conflict. These basic human needs include food, security, water and employment. Terrel (1989) argued that the drive to meet unmet needs at the societal, group, and individual levels are the primary cause of protracted or intractable conflict.

Applying the human needs theory, this study analyses how the development of genetically modified organisms (GMO) has opened up whole new possibilities for improving the nutrition of humanity. For the first time, humans can genetically engineer species or organisms by transferring DNA between totally different organisms, potentially allowing for food to be grown in harsher climates, for example, or for existing crops to yield more food. However, under capitalism, GMOs are being abused by large agro-corporations, such as Monsanto, to maximize shareholders' profits at the expense of ordinary people around the world. Instead, GMOs have reduced the safety and security of the food system for billions of people.

The first assumption of this theory is that all humans have basic human needs that they seek to fulfil and that the denial and frustration of these needs by other groups or individuals could affect them immediately or later, thereby leading to conflicts (Rosati *et al.*, 1990). Basic human needs, in this sense, comprise, physiological (food), physical, psychological, social, and spiritual needs, without which existence is not possible.

The second assumption was that human needs theory would be relevant for working towards fundamental structural social change within the context of the environmental conflicts of GMOs in Nigeria. The intervention is based on the notion that satisfying basic human needs, such as food security, is a legitimate and dynamic organizing principle for reforming and creating social structures and institutions. The analysis was that the existing social structures were dysfunctional to satisfy needs and thereby create tensions and the potential for overt or violent environmental conflict in Nigeria.

The 'problem to be solved' then becomes: what would satisfy these needs in the Nigerian context, and how could Nigerians create sustainable social structures and institutions that purposively facilitate needs satisfaction? It is important to state that, while the study takes

note of critiques of needs theory, particularly by the opponents of GMO introduction to Nigeria, the study is not primarily concerned with a critical examination of needs theory concerning conflict resolution.

A third assumption is that the most efficient and effective way to examine the themes and questions in the context of this study and provide the opportunity for creating new information is through the deliberate integration of human needs theory frameworks. For example, the environmental concerns associated with GM food undermine security. Countless Farmers were of the same views as environmentalists that GM food is an infringement on the environment and health security. Farmers have apprehensions over the uncertainties surrounding GMOs. The controversy is growing worldwide. Food security unmet needs for farmers and environmentalists are the offshoots of the implications of GM food.

A new window was opened to the theory of conflicts by the human needs theorists who provided a vital conceptual tool not limited to addressing human needs at all levels but identifies the existence of negotiable and non-negotiable issues contextually applicable to environmental issues associated with GMOs (*Roger at al, 1988*). Needs theorists understand that needs are non-negotiable and are superior to interests. Thus human needs defy the traditional negotiation approaches that do not take into consideration non-negotiable issues. Therefore, conventional power negotiation models, interest-based negotiation models, and consensus-building models that construe conflict management as actual or zero-sum inclined are inapplicable (*David et al., 1988*).

The theorists take into consideration that human life is complicated. The human needs approach, on the other hand, supports collaborative and multifaceted problem-solving models and related techniques, such as problem-solving workshops or an analytical problem-solving process. These models take into account the complexity of human life, and human needs demand expression to be met, thus necessitating the application of GMOs. These problem-solving methods address the concerns associated with GMOs, particularly on traditional crops and health security, while taking into account the necessity to satisfy unmet needs that are capable of generating untoward implications.

Furthermore, they involve stakeholders in prospecting suitable means of meeting everyone's needs. Even though the human needs theory maintained that needs could not be compromised but handled with a win-win or positive-sum approach (Burton, 1990). This assertion provides the premise on which the management of the concerns associated with genetically modified foods can stand.

2.8 Concluding Thoughts

The literature was reviewed with references to the international, continental and national narratives on genetically modified foods. Due attention was given to the factors responsible for the adoption of GMF in Nigeria. Biodiversity in agricultural systems is under pressure worldwide. The damage to animal and plant genetic resources by its lessening use in contemporary agriculture has generated much concern about the impending vulnerability of agricultural production and related pest and disease risks, food security, and environmental stability.

Applying human needs theory, this study analysed how genetically modified organisms (GMO) has created the prospects for improving the nutrition of humanity. It is a novel development that humans can genetically modify species or organisms by transferring genes between totally different organisms, possibly allowing for crops to be grown in unfavourable environments and for existing crops to yield more food. However, development partners, such as Monsanto, are exploiting the hapless to maximize shareholders' profits all over the world. Somewhat, GMOs have undermined the safety and security of the food system for billions of people.

CHAPTER THREE
RESEARCH METHODOLOGY

3.0 Methodology

This methodology section is divided into the research design, study population, study area, sample and sampling technique, research instruments and methods of data analysis.

3.1 Research Design

The study adopted the survey research designs. The technique that was used to elicit information was cross-sectional where information was obtained from selected respondents at a point in time. From the populations of the study, key officials who were involved in and informed about the genetically modified foods (GMOs) were interviewed or questioned to elicit the required information.

3.2 Study Population

For this study, five groups of stakeholders constituted the study population. They are; the research institutes, regulatory bodies, Civil Society, Farmers and the academic community. The population of the study was based on occupation, profession, education, economy and activities. The target population was selected from these four populations as follow;

The first group of the population comprises the research institutes working on genetically modified food. These include the International Institute of Tropical Agriculture, Ibadan- IITA. National Centre for Genetic Resources and Biotechnology- NACGRAB, Ibadan. Institute of Agriculture and Research, Zaria- IAR, Sheda Science and Technology Complex, Abuja- SHETCO, National Cereals Research Institute, Badegi, Niger State- NCRI and National Root Crop Research Institute, Umudike, Abia State- NRCRI.

The second population comprises the regulatory bodies on GMF, namely; National Biosafety Development Agency, Abuja - NABDA, National Biosafety Management Agency, Abuja- NBMA. Consumer's Protection Council, Abuja- CPC. Monsanto Nigeria, Dupont Pioneer Nigeria.

The third population comprises the Civil Society on GMF notably; Environmental Rights Action/Friends of the Earth Nigeria, Benin-City- ERA / FoEN, Health of Mother Earth Foundation, Benin-City- HOMEF, Catholic Doctors Association of Nigeria, Owerri - CHIDICON, African faith and Justice Network, Abuja- AFJN. Justice, Development, and Peace Commission, Abuja. Nigeria Farmers Association, Abuja- JDPC.

The fourth population comprises the academic community central engaged in activities on genetically modified food GMF, namely; Department of Biochemistry, Ahmadu Bello University, Zaria. Department of Botany and Microbiology, Ahmadu Bello University, Zaria. Department of Biological Sciences, Ahmadu Bello University, Zaria. Department of Crop Protection, Department of Botany, Genetics and Molecular Biotechnology Unit, University of Ibadan., University of Ibadan. Department of Crop Protection and Environmental Biology, Department of Chemical Engineering, Obafemi Awolowo University, Ile-Ife. Federal University of Agriculture, Abeokuta. Biotech Centre, University of Maiduguri. Maiduguri and Godfrey Okoye University, Enugu.

The fifth population comprises; Farmer's association, Abuja. Women in Agriculture, Enugu- WIA. Farmer's Association, Ibadan. Farmer's Association, Kaduna, Farmer's Association. Maiduguri, Farmer's Association, Sokoto. Catholic Women group, Calabar.

3.3 Sample and Sampling Techniques

The study used purposive sampling for both quantitative and qualitative research. The purposive sampling helped in selecting those members of the community who could provide the best information and were willing to be studied (Susan, 1993 and Creswell, 2012). In purposive sampling, the researcher intentionally selected individuals and sites to learn or understand the central phenomenon (Patton, 1990).

3.4 Sample size determination

The population size of the relevant departments within the selected organizations and agencies was six hundred and ninety. The information on staff strength was obtained through the institutions' website and during visitation. The sample size of the population for the study was determined using Slovin's sample size determination formula (Guilford & Frucher, 1973). A sample size of 453 respondents was selected. The sample size for this study was determined with an error of 5% and with a confidence coefficient of 99% using the sample size formula below:

$$n = \frac{N}{(1 + N€2)}$$

n = required sample size

N = estimate population (690)

e = degree of error tolerance (0.01) (99%) confidence interval)

(For higher confidence levels, the confidence interval was increased to 99%. The study seeks more confidence in catching the population value with a wider interval)

However, the study was conducted by involving 420 participants out of the sample size of 453 initially determined and selected across the selected agencies. The sample size determination for each of the selected centres and the sample size used for the study are indicated in Table 3.1

3.5 Sources of Data

Primary and secondary sources were used to collect data for the study.

Primary Sources: Primary sources were the In-depth interviews and surveys conducted with respondents from regulatory bodies, research institutes, civil society organisations working on the health and environment and the academic community.

Secondary Sources: Secondary data were collected from existing and relevant literature, newspaper, conferences and internet materials on GMF.

3.6 Methods of Data Collection and Research Instruments

The combination of quantitative and qualitative research methodologies via the primary and secondary sources of data collection to enable triangulation of findings were used for this study. These involved the use of In-depth interviews and a structured survey questionnaire, for collecting primary data.

Table 3.1: Sample Size Determination and Sample Size of the Selected Centres

S/N	Centres	Estimated Population of Personnel (N)	Sample size determination of each entre (n)	Actual Sample Size
1	International Institute of Tropical Agriculture (IITA), Ibadan	31	20	19
2	National Centre for Genetic Resources and Biotechnology, (NACGRAB). Ibadan.	23	15	14
3	Institute of Agriculture and Research (IAR), Zaria.	15	10	9
4	Sheda Science and Technology Complex (SHETCO, Abuja)	23	15	14
5	National Cereal Research Institute (NCRI), Badegi,	23	15	14
6	National Root Crop Research Institute (NRCRI), Umudike .	23	16	14
7	National Bio.safety Development Agency (NABDA), Abuja.	61	40	37
8	National Biosafety Management Agency (NBMA), Abuja.	46	30	28
9	Consumer's Protection Council (CPC), Abuja.	31	20	19
10	Environment Right Action / Friend of the Earth Nigeria (ERA/FoEN), Benin-City	46	30	28
11	The Health of Mother Earth Foundation, (HOMEF), Benin-City.	31	20	19
12	Women in Agriculture, Enugu (WIA).	15	10	9
13	Catholic Doctor Association of Nigeria (CHIDICON), Owerri.	31	20	19
14	African Faith and Justice Network (AFJN), Abuja.	15	10	9
15	Justice, Development and Peace Commission (JDPC), Abuja	31	20	19
16	Farmers.	31	20	19
17	Department of Biochemistry, Ahmadu Bello University, Zaria.	31	20	19
18	Department of Botany and Microbiology, Ahmadu Bello University, Zaria.	23	16	14
19	Department of Biological Science, Ahmadu Bello University, Zaria.	31	20	19
20	Biotech Centre, University of Maiduguri.	15	10	9
21	Department of Crop Protection and Environmental Biology, University of Ibadan.	31	20	19

22	Department of Botany, Genetics and Molecular Biotechnology Unit, University of Ibadan.	15	**10**	9
23	Department of Crop Science, Federal University of Agriculture, Abeokuta.	31	**20**	19
24	Department of Biotechnology, Godfrey Okoye University, Enugu.	23	**16**	14
25	Department of Chemical Engineering, Obafemi Awolowo University, Ile-Ife.	15	**10**	9
	TOTAL	690	**453**	**420**

3.6.1 Questionnaire

The quantitative data for this study was based on a survey approach with a structured questionnaire. This approach was adopted for ease of broader participation in the study. The structured questionnaire covered the objectives of the study and was designed in the open and closed-ended format with options for a simple response from respondents.

Four hundred and fifty (453) copies of the questionnaire were distributed with four hundred and twenty (420) retrieved for analysis.

The questionnaire comprises nine (9) sections in alphabetical order with seventy-five (75) questions as presented in appendix II. The first section which is signified with 'A' is made up of three questions that address necessary information on organizations' biodata, such as the name and category of the organization, as well as the status of the interviewee. Section 'B' is based on the reasons for the introduction of GMF in Nigeria. It is made up of twelve (12) questions. Section 'C' assesses the actors/stakeholder's disposition to GMF in Nigeria. The section is made up of ten (10) questions.

Section "D is structured on the causes of GMF concerns. The section is made up of ten (10) questions. Section 'E' examines the implications of GMF in Nigeria. The section is made up of twelve (12) questions. Section 'F' examines the factors affecting the controversies of GMF to their increasing, stable or decreasing effect in Nigeria. The section is made up of ten (10) questions.

Section 'G' is structured on the consequences of GMF in Nigeria. The section is made up of twelve (12) questions. Section 'H' is structured on the regulations governing GMOs. The section is made up of eleven (11) questions. The last section, which is section 'I', seeks the

respondents' opinions on proposed interventions for the operation of GMF in Nigeria. This section is made up of five questions.

3.6.2. In-depth Interview

Twenty-two (22) In-depth interviews (IDI) were conducted with the categories of people in the selected population to elicit information to achieve a holistic understanding of the interviewee's point of view. The interviewees were: Researchers (9), Academicians (5), Regulators (2), Environmental Activists (4) and Farmers (2). Interviewees were asked open-ended questions and probed wherever necessary to obtain data deemed useful. The study used the purposive sampling method for selecting participants for in-depth interviews. The primary criteria for selecting the groups that were interviewed were occupational, professional, educational, economic and activities relating to GMF to get accurate information because these represent the population in the study.

3.7 Validity and Reliability of the Instrument

To ascertain the face, content and construct validity of this study the researcher relied on experts in this area who assessed the questions while the necessary corrections were thereafter carried out by the researcher. Further to the final success and validity of the instrument, the researcher subjected the construction of the questionnaire to the pre-testing stage, which is adjudged as exploratory and systematic. To ascertain and ensure the instrument reliability, on the other hand, the researcher used the test-retest approach within a certain period, specifically three weeks.

To achieve this successfully, the researcher administered the prototype of the questionnaire among at least twenty members, that is, four members selected from each of the agencies, who were not necessarily among the overall sample selected for the study. The technique of Pearson product-moment correlation coefficient was adopted by the researcher and subjected to testing at 0.05 level of significance. The result showed a coefficient of 0.75, which was observed by the researcher as adequately moderate and reliably sufficient for the conduct of this study.

3.8 Method of Data Analysis

The analysis was done in the following order;

a. ***Questionnaire***: Descriptive, inferential statistics and dimension reduction (Common Factor Analysis) were adopted to analyze the questionnaire. These methods are appropriate to seek reasons to explain the joint modification of a usual variable quantity (Polit, 2012). Descriptive statistics were employed to identify the fundamental reasons for the introduction of GMOs in Nigeria and attendant controversies. At the same time, factor analysis was used to determine the factors associated with the implications of genetically modified foods (GMF) for traditional crops and health security in Nigeria. The computer software used in analyzing the questionnaire is the Statistical Package for the Social Sciences (SPSS).

The number of factors- This was done using the latent roots and screen test method. (Latent roots criteria holds that the amount of variation explained by each factor or latent root must be greater than 1). The screen test employed a plot of the size of the latent root against the number of factors in their order of extraction.

The factor- the axis rotation simply amounts to forming a linear combination of the factors. Varimax rotation was used in this study.

75th percentile score was used to classify the weighted percentage score. Also, the mean score was used to represent the total average point. Bartlett test and Measure of sampling adequacy (MSA) were used to support that scale can be factorized. Lastly, we have the labelling and interpretation of the factors. This was done by identifying what variables to go with each factor.

b. ***In-depth Interview:*** Data from the interviews were transcribed and content-analysed using descriptive and narrative techniques.

CHAPTER FOUR
DATA ANALYSIS AND DISCUSSION OF FINDINGS

This section presents the results of the analysis of the responses from the In-depth interviews and survey conducted with respondents.

4.1 Objective 1: The Context for the Introduction of GMF in Nigeria

Table 4.1 highlighted the different reasons given by the stakeholders for the introduction of GMF in Nigeria. The result showed that research institutions indicated that they need to improve crop adaptation to pests and diseases and to reduce the yield deficit was the most important 94.5% to improve nutritional quality 86.9% and increase crop varieties 89.0% were reasons for the introduction of GMF. The academia also stated that the need for pest and disease-resistant crops and reducing yield deficit were the most important 93.3% reasons for the introduction of GMF. Furthermore, the regulatory bodies highlighted the improvement of the nutritional quality of food as the most important 92.8% reason for the introduction of GMF with the need for increased resistance for pests and diseases in crops and reduction of yield deficit 90.8% as significant factors as well. The results also show that members of civil society organizations indicated that crop resistance to pests and diseases was the most significant 91.1% with improving nutritional quality and hunger and poverty alleviation 88.9 as reasons for the introduction of GMF. The farmers highlighted that improving pest and diseases resistance 85.9%, achieving pesticide resistance 85.9% were the most important as well as response to food insecurity 84.2% and a response to economic diversification as most important reasons for the introduction of genetically modified food.

The findings showed that improving resistance to insect and disease, improving nutritional quality, reducing yield deficits, improving crop varieties, hunger and poverty alleviation were the most potent reasons for the introduction of GMF. This finding agreed with Wanyama et al., 2004, who asserted that GM technology had checked the loss from maize

as a result of the activities of stem borers. *Gouse et al. (2005)* corroborated this finding by claiming that industrial maize farmers gained commercially using insect-resistant yellow maize. Also confirmed the finding was McGrath (2014) who said that Geneticists had equally grown plants that were pest-resistant and toxic to starving insects, significantly bringing a reduction to the rate at which farmers depend on biochemical insect repellent. Since its inception, it has been discovered that genetic engineering had brought a reduction in the losses of maize occasioned by insect larvas (*Wanyama et al., 2004*) and curtail the rate at which herbicides are being applied by initiating Bt. maize via transgenesis. Bt. corn in use have a higher grade, and motivate competition amongst farmers; an improved product, that did not meet the set standard like mycotoxin (*Wanyama et al., 2004*). Comparatively, the rate of damage by pests dropped with Bt, Corn. The decrease of pest destruction after the release of Bt. Zea mays rather than orthodox corn which led to yield increase (Huesing and English, 2004).

Some of the respondents from the In-Depth Interviews further supported the findings that GMOs were a practical response to overcome some diseases in plants. In his response, a respondent affirmed that;

> Maruka was a disease that feeds on Cowpea. No chemical had been able to destroy it. Bt Cowpea was developed to resist Maruka. The Bt cotton grown in India and Burkina Faso was resistant to many pests and diseases. This protected farmers from loss due to crop damage by Maruka. With this, farmers would only need to spray their cowpea twice with pesticides instead of five times. This would save costs. (IDI at ABU, IAR, Zaria, 31st May 2016).

This view was equally supported by another respondent in the International Institute for Tropical Agriculture who said;

> Nigeria was going to adopt Bt Cotton. Ordinarily, farmers sprayed conventional cotton about eight times; most of the chemicals were adulterated. With GMO, Farmers would spray fewer chemicals about two times. There would be less pollution, including early maturation and higher yields. Factors such as increased yields, less time, fewer chemicals, less contamination of the soil and the farmers, were economic benefits and therefore translated to the economic motivation for GMOs in Nigeria. (IDI at IITA, Ibadan, 12th May 2016).

For another interviewee, many issues called for the introduction of GMOs in Nigeria;

> In the first place, certain destructive pests or diseases could not be overcome using the traditional breeding method, so you had to introduce biotech to reduce such resistance. By doing this through spraying, you were saving yourself lots of money. Injuries to one from the use of these chemicals would also be minimized. Also, higher yields and more money for the farmers translated to economic benefits or importance of GMOs (IDI at NBMA, Abuja, 27th May 2016).

Huesing and English (2004) justified that GMO pest resistance crops reduce the cost of production for farmers from the money saved as a result of pest and pesticides management and yield increase (Singh et al., 2014) argued on how pest resistance was done by the coding gene for Bt. toxin. Genetically engineered plants have the potentials to resist bacteriological infestations. (McGrath, 2014)

However, Hans and Marcia (2010) disagreed with this finding. They posited that growing genetically modified cotton and corn was already failing farmers and would continue to fail over the long term by devastating the functioning of the ecosystems on which we depend.

This study showed that the introduction of GMOs was also believed to be capable of improving the nutritional quality of foods amongst Nigerians. This finding was supported by Jerome (2012) that the dietary needs of the community or human beings should be given the highest priority. Jerome (2012) posits that the underlying theme of the food security concept underscores the accessibility of the community's or individual's dietary needs at all times, which places a moral obligation on all human beings to ensure that this topmost priority amongst the necessary requisites of man was met for his survival. Golden rice was designed to prevent vitamin A deficiency which, blinded or killed hundreds of thousands of children annually in developing countries (BBC News, 2013).

An interviewee indicated that the motivation for GMOs was to improve the nutritional quality of foods for Nigerians. This was to protect the interest of the Nigerians who were looking for other ways to ensure nutritional quality. According to the interviewee;

> We also have in Zaria, Africa Bio-fortified Sorghum modified in a way that it could now produce iron, zinc, and protein and also could produce vitamin A. The essence was to increase the nutritional content. (IDI at UNIMAID, Maiduguri, 5th July 2016).

In a similar view another interviewee responded;

> In Nigeria, Consumers needed answers to malnutrition, and it was through the GMOs that this could be easily realized. They wanted benefits from the crops they consume. Our interest was to find a way to make our food more nutritious. For instance, GMO cassava was genetically engineered with Vitamin A to enrich our Garri and other food products derivable from cassava (IDI at Biotech Dept. GOU, Enugu. 16th July 2016).

The interviewees expressed some opinions on the issue of improving the nutritional qualities of our food as strategies for the introduction of GMOs in Nigeria. For instance, an interviewee explained that;

> If there was the determination of the government to feed its citizens nutritionally, GMOs could be seen as a credible option especially at this period that everybody seems to be grumbling about nutritional deficiency in our staple foods necessitated by the parlous state of the economy in the country (IDI at Biological Sciences Department, ABU, Zaria, 1st June 2016).

These findings agreed with James, 2013; *Perez-Massot et al., 2013*; Chondie and Kebede, 2015) who said that the improvement of Bt. maize in certain nutritious crops made such maize diets to have better nutritional quality over native foodstuffs frequently and that some genetically engineered crops having carrying innovative qualities had been produced and released into the market (Arthur, 2011). The inference from this finding was that the prevalence of diet-related diseases in Nigeria emanated from a nutritional deficiency that GMOs could address positively.

However, another interviewee dismissed this claim as spurious and said that the percentage of Vitamin A in carrots far outweighed the claim in GMO cassava.

> The bio-engineering of GMOs cassava with Vitamin A was spurious. The Vitamin A contained in two sticks of carrot was far more than what was claimed to be in a bag of GMOs cassava. In essence, before you could get the equivalent of the value of Vitamin A in two sticks of carrot from GMOs cassava, you would need to consume up to one bag of GMO cassava. (IDI at HOMEF, Abuja, 26th May 2016).

The respondents stated that GMOs would be a solution to yield deficit, (William, 2010) pointed out that the yield increase, affordable costs, and variety of biotech products will

meet the food needs of the teaming populace while (McGrath, 2014) said that GM crops had been engineered to improve yields as a strategy for hunger management (Singh et al., 2014) supported these findings. He said that genetically modified crops might provide yield increase, cheap and healthy food. (Hans and Marcia, 2010) disagreed with this finding. He said that local varieties vastly outperformed their genetically modified versions in field trials. (Fedoroff and Cohen, 1999).

In contrast, (Lee and Halich, 2008) argued that farmers were concerned that they might be losing yield without using GMO hybrids because their findings showed that GMO hybrid yield was higher than the non-GMO crops at a ratio of 2.5 to 25.5 ratios. (*Klumper et al., 2014*) maintained that transgenic crops have contributed immensely to yield growth and profitability for farmers for almost two years even though the seeds are costly.

In terms of higher yields, a respondent confirmed that GMOs were a response to improving crop varieties and yield deficits. In the interview, he said;

> Conventional crops take years to mature but GM crops will mature in few years with giving higher yields. For example, The Newest Rice currently on a field trial in National Cereal Research, Institute, Badegi, Niger State, is Nitrogen Efficient (Low Input, i.e. it could grow on a land that was low in Nitrogen, Water Efficient (drought resistance), Salt Tolerant (It could withstand Salinity). It could mature between 3-4 months and be ready for harvest (IDI at NCRI, Badugi, 2nd June 2016).

The literature confirmed this finding that GM crops that had been developed generate more yield (McGrath, 2014). Protagonists of orthodox farming agreed that its potential for yield increase, cheap costs and variety are claimed that transgenic technology will respond adequately to world hunger (William, 2010).

In line with this, an interviewee explained that;

> Nigeria was one of the signatories to an agreement to end hunger by 2030 or 2050 that no African would go to sleep in hunger. How did we intend to achieve this? The GMO could play a critical role in addressing yield deficit through the improvement of seeds to farmers hence improved yields. On the part of agriculture, many farmers would abandon agriculture if things continued as they were. This could be tackled by the GMOs, especially if there could be adequate inputs where the farmers

> would not need to work exhaustively. Our agricultural products were technologically friendly (IDI at OAU, Ife, 26th April 2016).

(Nature Biotechnology, 2001) confirmed these findings by saying that producing crops that are adaptable to drought or saline environments will help to cultivate places previously unsuitable for cultivation. Other promising examples include the transgenic flood-resistant rice, Bt. maize adaptable to the nitrogen-deficient environment, and potatoes capable of giving consumers immunity against hepatitis B infestation (Wilcox, 2015). Extraordinary proofs indicated that molecular manipulation of food can be a solution to the challenges of the world.

A respondent maintained in an interview that GMO is a product of technological breakthroughs adapted to resist climate change;

> Nigeria is a tropical country, and rainfall is sporadic and unpredictable. We have a lot of biotic and abiotic stresses against our agricultural activities. Much environmental stress, drought and desertification affect our agricultural productivity. The developed countries have developed crops that can withstand these problems. So we need drought-tolerant plants that can withstand the effect of climate change on our crops so that the deserts can be converted to fruitful agricultural lands. (IDI at GOU, Enugu. 16th July 2016).

Supporting this finding is (*Barrows et al., 2014*), who stated that the Nigerian government is opting for the introduction of genetically engineered foods to diversify her economy from crude petroleum dependency. Hence, according to (Alston and Pardey, 2014) agriculture provides an opportunity to turn rural poverty and stagnation into development. (Christou and Twyman 2004) affirmed that more development is obvious in the emergent world where transgenic crops ameliorated the quality of life of local farmers who are now generating more yields that are fetching them additional incomes to meet their educational, medical and domestic responsibilities as well as women empowerment

Hutchison et al., (2010) confirmed the findings by saying that genetically modified crops offered financial benefits to farmers in third world countries. *FAO* (2017) concluded that GM crops contributed significantly to farm fortunes universally in the year 2010, including developing countries. Furthermore, according to (Fan et al. 2005), GM technologies have

been playing crucial roles in financial empowerment and transformation in the rural communities in developing nations (Bouis 2007).

One of the interviewees described GMOs as an economic fortune for the country;

> GMOs will be a source of economic fortune for the country. It has the potential to generate higher yields. This will create wealth and open the doors for opportunities for rural populations. (IDI at NRCRI, Umudike, 15th August 2016).

In a similar view, an interviewee explained that;

> There is hope for the economic benefits of GMOs. Farmers can now smile at banks. The high yields will bring profits. Farmers will spend less on chemicals. They can increase the size of their farmland, thereby employing more hands. GMOs are a source of generating foreign currency (IDI at IITA, Ibadan, 12th May 2016).

In a contrary position, an interviewee reported that biotech industries are merely looking for new markets;

> The available markets are saturated and therefore looking for new frontiers, and Africa is the last territory to be conquered while Nigeria is seen as a critical entry point. Once they get to Nigeria, they have got Africa. The only economic motivation for GMF in Nigeria is profit-making simply because GMOs companies are not in this country because they are interested in food production for the country but profit-making. GMF is just profit-making propaganda. It is a way of enslaving the people, giving an instance, if you give Nigerians GMF this year, there is no probability that it will be available the following year (IDI at HOMEF, Abuja, 26th May 2016).

Also in disagreement with the findings, an interviewee opined that;

> The economic motive is very obvious. The advanced western countries are interested in subjugating African countries to the level of slavery, suffering, let them lose their sovereignty. Anybody supporting GMF introduction is subjecting Nigeria to the biological slave trade rather than economic and employment opportunities for Nigerians. GMO companies are criminals, and proponents are traitors. Nigerians should treat them with disdain. (IDI at CHIDICON, Abuja, 25th May 2016).

An interviewee explained that definitely, there are issues of economic dominance and control;

> The GMO products coming in are controlled by corporations that have a profound influence in their countries. For instance, presidents of rich countries like the US calling on other presidents asking them to accept GMF seeds. You can be forced to legalise it based on their wealth, power, and leverage. The political and economic aspects of GMF are interwoven. I believe there was an agenda of re-colonizing Africa. Nigeria has domesticated the law allowing GM Technologies to be used in the country because without the laws, GMF will be impossible in the country (IDI at ERA/FoEN, Abuja, 26th May 2016).

Table 4.1: Context (Reasons) for the Introduction of GMOs (Note: I > Important; N/I > Not Important)

	Research Institutes (180)		**Academia (135)**		**Regulatory Bodies (123)**		**Civil Society Organisations (63)**		**Farmers (19)**		**Average weighed Percentage**
Reasons	**I**	**N/I**	**I**	**N/I**	**I**	**N/I**	**I**	**N/I**	**I**	**N/I**	
To provide an alternative method for Farmers.	63 (79.3%)	17 (20.7%)	94 (69.2%)	41 (30.8%)	91 (73.8%)	32 (26.2%)	45 (71.4%)	18 (28.6%)	15 (78.9%)	4 (21.1%)	74.0%
Practicable response to food insecurity in Nigeria	63 (79.3%)	21 (20.7%)	114 (84.2%)	21 (15.8%)	111 (90.8%)	12 (9.2%)	52 (82.5%)	11 (17.5%)	16 (84.2%)	3 (15.8%)	85.0%
To improve nutritional quality	69 (86.9%)	11 (13.1%)	106 (78.3%)	29 (21.7%)	114 (92.3%)	9 (7.7%)	55 (87.3%)	8 (12.7%)	10 (52.6%)	9 (47.4%)	87.0%
To improve insect and disease resistance	75 (94.5%)	5 (5.5%)	126 (93.3%}	9 (6.7%)	111 (90.8%)	12 (9.2%)	53 (84.1%	10 (15.9%)	17 (89.5%)	2 (10.5%)	92.0%
To increase crop yield	75 (94.5%)	5 (5.5%)	126 (93.3%)	9 (6.7%)	111 (90.8%)	12 (9.2%)	56 (88.9%)	7 (11.1%)	12 (63.2%)	7 (36.8%)	91.0%

To alleviate hunger and poverty	69 (86.2%)	11 (13.8%)	111 (82.5%)	24 (17.5%)	111 (90.8%)	12 (9.2%)	58 (92.1%)	5 (7.9%)	15 (78.9%)	4 (21.1%)	87.0%
For increasing crop varieties	72 (89.0%)	8 (11.0%)	113 (83.3%)	22 (16.7%)	106 (86.2%)	17 (13.8%)	51 (81.0%)	12 (19.0%)	14 (73.7%)	5 (26.3%)	85.0%
A response to economic diversification	63 (79.3%)	21 (20.7%)	95 (70.8%)	40 (29.2%)	94 (76.9%)	29 (23.1%)	50 (79.4%)	13 (20.6%)	16 (84.2%)	3 (15.8%)	76.0%
Boosting of raw material production	62 (77.9%)	18 (22.1%)	91 (67.5%)	44 (32.5%)	103 (83.1%)	20 (16.9%)	48 (76.2%)	15 (23.8%)	15 (78.9%)	4 (21.1%)	76.0%
To achieve pesticide resistance	67 (83.4%)	13 (16.6%)	0%	0%	111 (90.8%)	12 (9.2%	54 (85.7%)	9 (14.3%)	17 (89.5%)	2 (10.5%)	65.0%
To benefit from a technological breakthrough	72 (89.0%)	8 (11.0%)	95 (70.8%)	40 (29.2%)	111 (90.8%)	12 (9.2%)	53 (84.1%	10 (15.9%)	14 (73.7%)	5 (26.3%)	85.0%
A solution to generating employment and wealth creation	75 (94.5%)	5 (5.5%)	106 (78.3%)	29 (21.7%)	114 (92.3%)	9 (7.7%)	55 (87.3%)	8 (12.7%)	10 (52.6%)	9 (47.4%)	87.0%

Source: Author's Computation Underlying Data from Survey, 2016.

$$75^{th} \text{ percentile weighed Percentage Score} = \frac{\text{percentage positive agreement across the agencies}}{\text{No of agencies}}$$

The 75th percentile score was used to classify the weighted percentage scores into good and poor. The 75th percentile score was 87 percentage score. Any item whose weighed averaged score is 87%, and above was regarded as adequate, and those below 87% were regarded as inadequate. The 75th percentile in a standard curve also represents that which the best performing 25% of the distribution falls. This was set to remove arbitrariness or random performance scores due to chance. Table 4.1 shows the distribution of the scores, and the 75^{th} percentile scores fall within 87% and above.

4.2 Objective Two: The GMF controversies in Nigeria

Table 4.3 presented the data which explained the necessary factors influencing the GMF controversies in Nigeria. Figures above 50.0% point were considered highly satisfactory. Therefore, items No 9, 4, 5, 8, 6, 1 and 7 were perceived as the most critical factors in order of ranking while items No: 3 and 2 were the least important factors in the controversies around GMF in Nigeria.

Table 4.3 showed the degree of GMF debates in Nigeria. For instance, the introduction of genetically modified foods in Nigeria is characterized by controversies, disagreement, including scientific and political uncertainties all of which have constituted causes of the debates on the adoption of GMF (Pusztai, 2001; *Prakash et al., 2011*).

A higher percentage (65.7%) of the respondents reported the genetic pollution of GM plants at an increasing rate, 20.0% reported that this effect on farmers could have a stable rate while 14.0% stated that it has a decreasing rate. Health risk to the consumers, in the view of 61.4% of the respondents, has been increasing, but 22.4% opined that it is stable and 16.2% believed that it is decreasing. Precisely 58.3% of the respondents reported that risk to the environment has remained at an increasing level; while 19.3% explained that it is stable, 22.4% showed that it is decreasing.

The passage of the biosafety bill in 2015 to regulate GMF cultivation and sales was reported by 55.0% of the respondents to be increasing, 31.5% reported that the risk was stable, while

18.5% indicated that it was decreasing. The literature indicated that the risks and benefits associated with GM technologies were difficult to quantify, and as such there had been no overwhelming scientific indication that transgenic food was found dangerous with long-term consequences on health and survival of native crops (Kaplan, 2004; Berg, 2009).

Nevertheless, 54.3% of the respondents reported that suspicious scientific research and publications had been increasing, 24.0% reported that it had been stable while 21.7% opined that it had been decreasing. In another development, 52.4% of the respondents indicated that the high cost of GM seeds and products had been increasing, 32.1% reported that this phenomenon was stable, while 15.5% reported that it was decreasing. The argument that food insecurity in Nigeria triggered the introduction of GMF in the country was believed by 50.0% of the respondents to be increasing, 22.4% reported that the degree of such argument was stable while 27.1% opined that it was decreasing.

The ownership of intellectual property rights that may limit the spread of GMO technology to most impoverished communities was explained by 49.5% of the respondents at an increasing rate, 28.1% stated that it was stable while 22.4% reported that it had been decreasing. The non-labelling of GM food and products was reported by 44.0% of the respondents to be increasing, 39.0% reported that this situation was stable while 16.9% stated that it had been decreasing.

Conflicting views were generated from interviewees based on their comments on the position of the government on GMF in the country. For example, an interviewee was of the view that the government meant well for Nigerians with the passage of the Biosafety bill;

> The position of the government is evident based on its establishment of the National Bio-safety Management Agency (NBMA) to regulate and ensure that the country is on the safe side of Biotechnology. This will benefit the country immensely. (IDI at OAU, Ife, 24th April 2016).

Other interviewees also corroborated this statement by saying that;

> The government had put in place appropriate biosafety law, and regulatory agencies such as National Biotechnological Development Agency (NABDA), National Centre for Genetic Resources and Biotechnology (NACGRAB) and Biosafety Management Agency (NBMA) to promote and regulate Biotechnology in Nigeria thus creating

> level playing ground for cultivation and management of GMF in Nigeria. (IDI at NBMA, Abuja, 27th May 2016).

Nevertheless, another interviewee submitted that the position of the government was to the detriment of the nation. The interviewee opined thus;

> The past administration assisted the GMO companies to come into Nigeria bypassing the Biosafety bill to the detriment of Nigerians. Besides, the present administration is yet to formulate a clear stance on GMF, and this stance can only be rejected and ban GMF in Nigeria. However, GMF has been accepted under the present administration (IDI at ERA/FoEN, Abuja, 26th May 2016).

An interviewee believed that the position of the government by signing the Biosafety bill into law would have negative impacts on the local farmers;

> However, there is a policy on the ground in respect of GMF in the country. The government has taken a stand that GMF can be cultivated and used in the country, especially by domesticating the law. By this law, it shows that these products from GMOs are free and that we can use them. This will affect our farmlands. (IDI at WOMEN IN AGRICULTURE, Abuja, 25th May 2016).

From the findings, low awareness of GMF in Nigeria is a significant issue of controversy. Hence, the move to adopt GMF in Nigeria could not be resisted early enough before the legislation on GMOs was put in place in the country. This finding was supported in the literature by (Lazarus, 1991) that awareness and information management is required to empower consumers to alleviate the fears of accepting GMF. The level of ignorance of GMF in Nigeria necessitated the civil society organizations in providing public awareness in the media against the harmful effects of GM foods (*Alberts et al., 2013*; Keith, 2014).

An interviewee accepted that the disagreements on GMF in Nigeria were based on ignorance by the opposition as he explained;

> Some NGOs are against the introduction of GMF into the country because of their inability to get updated on the current global trends of GMF. The level of awareness about GMF in Nigeria is very low because the sensitization awareness level is still low. The oppositions are the environmentalists from the friends of the Earth and other movements that are unfavourably disposed to the technology, claiming that GMF can pollute the environment or become dangerous to the survival of

> traditional crops (IDI at DuPont PIONEER, Enugu, 26th November 2015)

Another Interviewee was of the view thus;

> It is impossible to mount opposition against an invisible enemy. There is total ignorance. This is because GMF comes like a criminal whose arrival and motive may not be clear. They are claiming that there is no GMF in Nigeria; while it is gradually taking over everywhere. (IDI at IBT Farms, Gonigora, Kaduna, 30th May 2016).

It was also reported that in Nigeria, many people did not know about GMF, and that awareness was generally low as an interviewee comprehensively said;

> The level of opposition is certainly not from the government. The GMF protagonists have vested in influencing journalists and peddling their position through books and pamphlets. The level of opposition to GMF in Nigeria is deficient perhaps because of ignorance and lack of education on the harmful effects of GMF on health and the environment (IDI at HOMEF, Abuja, 26th May 2016).

Another interviewee cited examples of other countries to explain his points by saying this;

> Countries like the USA, Switzerland, Britain, and Germany who have adequate knowledge of GMF and knew its implications are always opposed to it through protests, marches, rallies, and going to lawmakers telling them that they cannot do it. There must be an understanding of its economic consequences, ecosystem, and displacement of the farmers before the opposition could be sufficient. (IDI at AFJN, Abuja, 24th May 2016).

Two other Interviewees corroborated this explanation saying;

> GMF came into Nigeria by conspiracy. The level of sensitization and opposition was not high enough. Also, the level of awareness was low; hence meaningful contributions could not be made to the debate for its adoption. There was a need for pubic sensitization. There was total ignorance, explaining that people lack the knowledge of what GMOs was all about and what it meant for the country. The farmers, the masses, the people needed to be educated. If Nigerians had an adequate orientation about GMF, they would have rejected it. (IDI at WOMEN IN AGRICULTURE, Abuja, 25th May 2016 &IDI at IBT Farms, Gonigora, Kaduna, 30th May 2016).

Respondents generated similar views in respect of the state of public debate on GMOs. An Interviewee opined that;

> There is a polarization of debates among various groups in the country. The public debate has been positing that the introduction of GMOs will increase yields, increase the economy. Public debate is very minimal. There is no real opposition. International organisations are sponsoring the few people portraying GMF as bad. Probably, the awareness exists mostly within the academic community (IDI at OAU, Ife, 24th April 2016).

This finding showed that ignorance made some African countries signed up for GMF in their country. The literature justified this finding. According to Nnimmo Bassey, various African nations have accepted the idea and embraced, even, seed regulations without being parties to the negotiations (Kirtana and Nnimmo, 2013). This means that many African nations joined the race for GMF as a bandwagon effect. The findings showed that the conflict of GMF progressed with its protagonists claiming that it is a panacea to food insecurity in Nigeria. This finding agreed with the literature that GMF can ensure food security and the availability of essential raw materials for a teeming populace (von Braun 2007). (Arvind, 2013) posited that GMF is a new wave in agriculture and that it could increase productivity and help farmers meet the food needs of ever-increasing populations such as Nigeria.

In confirming this finding, (Thirtle et al., 2003) said that Africans had weak infrastructure and technology that made it difficult to embrace G.M technology. However, with the application of biotechnology, GMF would provide a potential contribution to sustainable agriculture productivity and new inputs for resource-poor and small-scale farmers. According to (World Bank, 2007), GM crops could impact food security in three possible pathways; First, GM crops could contribute to an increase in food production and, thus, improve the availability of food at global and local levels. Second, GM crops could affect food safety and food quality. Third, GM crops could influence the economic and social situation of farmers, thus improving or worsening their economic access to food.

From the findings, it was confirmed that the genetic pollution of non-GMF plants is one of the controversies surrounding the adoption of GMOs in Nigeria. This was confirmed by the literature that the gene flow to traditional crops could produce herbicide-resistant weeds (Conner, 2003) that could pollute adjoining native crops or cause ecological disruptions (Gerhart, 2015 and Andrew, 2012).

Responses from interviewees agreed and disagreed with this finding as shown below; the position of an interviewee is that GMOs should be rejected because of their potential to pollute other non-toxic plants. He advised that;

> GMF should be rejected because it cannot help us. It will pollute other non-toxic plants. It is being forced on us to destroy our ecology and set our indigenous agricultural system back. It is biological colonization. Colonization kills in thousands, but GMF kills millions. GMF is an invisible weapon, and you cannot defend the ecosystem against a weapon you do not have radar to see. Once it is released, it is like a spirit, and it comes against the biodiversity from different angles. You do not even know which crop is GMF or natural crop. Once it is released, you cannot recall it (IDI at CHIDICON, Abuja, 25th May 2016).

In a different submission, an interviewee explained,

> We can have biodiversity pollution anytime, not only on GM products. So there must be a way of eliminating these conflicts as soon as they come. If there is any concern, you eliminate the crops. Even what we are growing naturally can cause a problem at any time, not only GM crops. (IDI at NRCRI, Umudike, 15th August 2016).

The findings revealed that the high cost of GM seeds and products could lead farmers into debt. The literature confirmed this according to (Schurman, 2013) that campaigners and researchers have given contradictory explanations on why farmers committed homicide due to indebtedness as a result of genetically modified crops, Benneth, 2005 narrated that high debt burdens of GMF were responsible for an estimated 17,000 suicides committed by farmers annually in India.

Table 4.3: The GMF Controversies in Nigeria

	Factors	Increasing	Stable	Decreasing	Ranking
1.	High cost of GMO seeds and products can lead farmers into debt	220(52.4%)	135(32.1%)	65(15.5%)	6th
2.	Non-labeling of GM food and products, with consumers unable to differentiate between GM non-GM products	185(44.0%)	164(39.0%)	71(16.9%)	9th
3.	Ownership of intellectual property rights that may limit the spread of GM technology to most impoverished communities	208(49.5%)	118(28.1%)	94(22.4%)	8th
4.	Health risk to the consumer	258(61.4%)	94(22.4%)	68(16.2%)	2nd
5.	Risk to the environment	245(58.3%)	81(19.3%)	94(22.4%)	3rd
6.	Suspicious scientific research and publications	228(54.3%)	101(24.0%)	91(21.7%)	5th
7.	Food insecurity in Nigeria triggered the introduction of GMO in the country	212(50.0%)	94(22.4%)	114(27.1%)	7th
8.	The passage of the Biosafety Bill to regulate GMO cultivation and sales	220(55.0%)	126(31.5%)	74(18.5%)	4th
9.	Genetic pollution of non-GMO plants	276(65.7%)	85(20.0%)	59(14.0%)	1st

Source: Author's Computation Underlying Data from Survey, 2016.

Figure 4.1 presented key variables describing the trend of GMF controversies concerning Nigeria. The extracted factors explained variation in trends of GMF controversies in the country. The individual factor loading is depicted in the graphical representation and ranked from highest to lowest. It shows that ‘genetic pollution of non-GMO plants’ loading is highest while ‘non-labelling of GM food and products with consumers unable to differentiate between GM and non-GM products’ is the least.

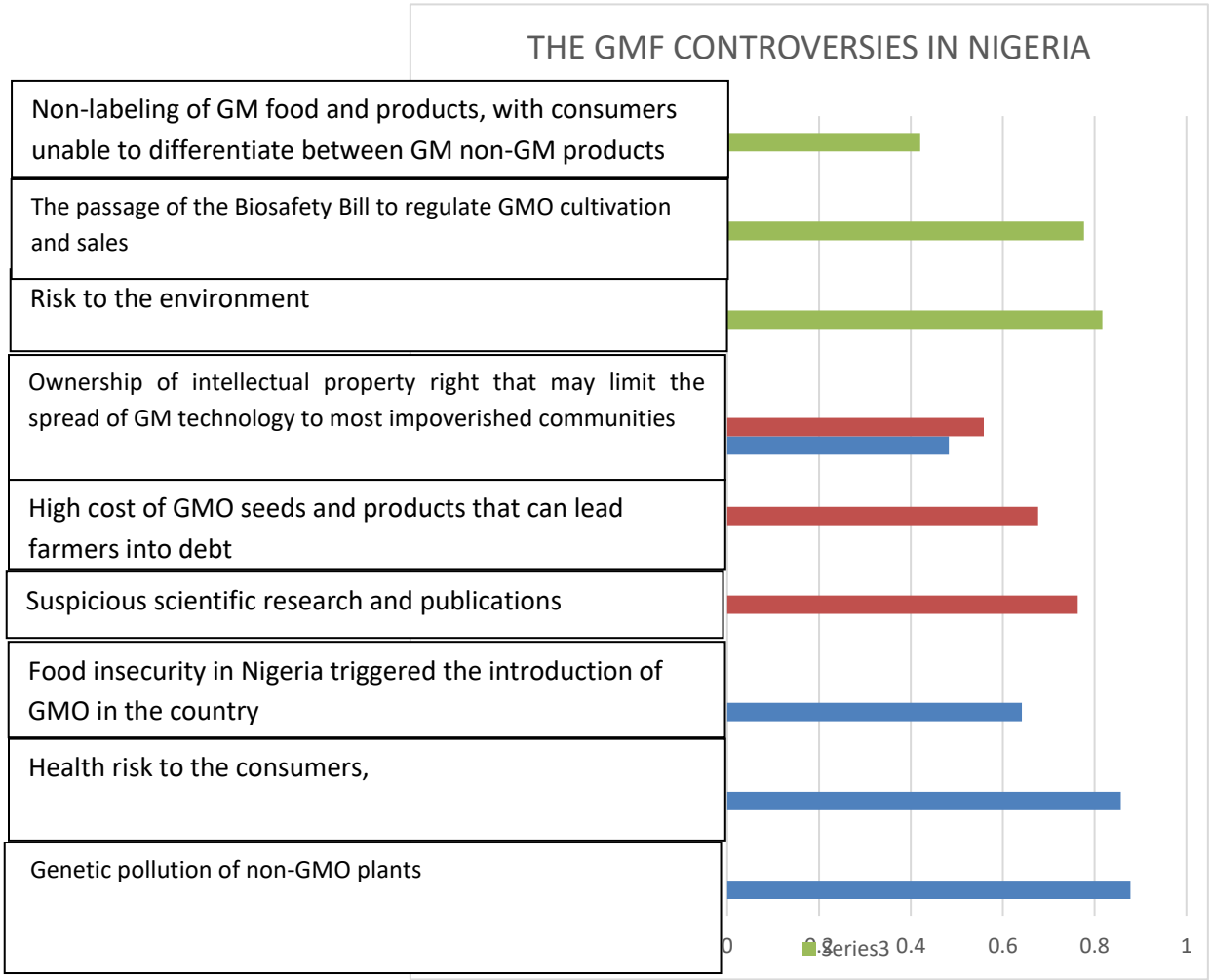


Figure 4.1 the GMF Controversies in Nigeria

Source: Author's Computation Underlying Data from Survey, 2016.

From the findings, it was confirmed that there were controversies about the passage of the Biosafety bill in Nigeria. The protagonists of GMF saw it as the legal framework to formally adopt and legitimize GMF in the country, whereas the anti-GMF group described it as a tool of conspiracy to foist GMF on the citizenry without passing through due process. This was confirmed by (*Fan et al., 2005*; FAO, 2017) that there had been a debate about the security and monitoring endorsement process of transgenic crops and diets.

The civil society groups were clamouring for a revisit of the National Biosafety Bill, which they considered unfavourable to environmental sustainability and survival of traditional crops in Nigeria. This remained a point of divide among the stakeholders as the pro-GMF groups insisted that the bill was a safeguard for the cultivation and regulations of GMF in Nigeria. This being a conflicting issue could serve as conundrums to the adoption, cultivation, and commercialisation of GMF in the country and might derail the overall objectives of the GMF initiatives in Nigeria as the process of legislation review would not be a quick fix. Therefore, it is expected that this controversy will linger for a long.

4.3 Objective Three: The Perceived Effects of GMF for Traditional Crops and Health Security in Nigeria.

Table 4.4 showed variables or factors explaining the environmental implications of GMF in Nigeria. The extracted factors explained 43.32% variation in major environmental implications in respect of GMF in the country. The individual factor loading was depicted in table 4.4 below and the factors ranked from highest to the lowest. It showed that 'escape of modified crops' loading was highest while 'genetic pollution' was the least for environmental implications. In table 4.4 greenhouse gas emissions were ranked highest and adverse nutritional changes lowest for health implications.

The finding was confirmed by Kuzma & Haase (2012), who listed horizontal gene transfer, genetic pollution and toxicity as part of the significant implications of GMF for native crops and health security.

This finding was supported by (Obadina, 2003) who explained that consumers are wary of GM products, fearing the deleterious effects on human health and the environment with devastating consequences on the conventional crops. The view of (GMO Compass, 2006)

confirmed that an orthodox crop grown to harbour pests might, in turn, be resistant to a GMF pesticide due to genetic pollution. (Martin, 1999 and Ochman, 2000) identified horizontal gene transfer as a major danger connecting to GMF which occurs mainly concerning climatic changes and offers procaryotes potentials to acquire genetic factors foreign to them.

The views of (Pleasants, 2001; Ford C.S, 2007) confirmed this finding in table 4.4 expressing that a resulting transgenic/wild hybrid with a competitive advantage over the wild population may persist in the environment and potentially disrupt the ecosystem thereby adversely affecting the survival of native crops. (Andy, 2013) also confirmed this finding stating how the transgenic crops that escaped from confinements were responsible for the discovery of unapproved glyphosate-resistant GM wheat was discovered in May 2013, in a farmstead located in Oregon, United States in a plot where wintertime wheat was cultivated. This discovery, according to (Alan, 2013), jeopardized approximately $8 billion US wheat exportations in 2012, compelling the corporation to recall it thus further confirmed this finding.

This finding was supported by (Environmental news network, 2002) with the view that GMF was capable of transferring antibiotic-resistant genes to consumers resulting in the loss of ability to treat ailments with antibiotic drugs. Also, supporting this finding was (Nestle, 1996) and (Margulis, 2006) and (Hiefle, 1999) who reported the possibility of genetically modified foods being toxic and allergenic. ERA confirmed this finding that GMF could cause allergic reactions and other health effects (ERA/FoE, 2004).

An interviewee categorically reported that GMF was not safe, and stressed that GMF contained chemical and biological substances harmful to the environment and human health. The interviewee explained that;

> GMF was not safe for Nigerians, because it would damage our agriculture, erode our biodiversity, create poverty, create dependence on the biotech industry and mortgage our future. The impact on future generations could not be predicted. It was intrinsically wrong for us to look for short term measures that would not even do anything better than conventional crops only to have a damaging impact on the posterities. (IDI at ERA/FoEN, Abuja, 25th May 2016 and (IDI at HOMEF, Abuja, 26th May 2016).

(Pollack, 2009) confirmed that the escape of biotech seed into neighbouring farms, and the contamination of the produce, was apprehension to growers. (*Miguel et al., 2015*) stated that since genetic pollution had occurred for ages between domesticated species and native plants, it was rational to assume that it might as well occur with genetically improved plants. (Pleasants, 2001; Ford C.S, 2007) confirmed this finding by saying that if a resultant Bt. weed had some viable benefits on the native species, it might later constitute a threat to the environment

Similarly, another interviewee opined that,

> There were so many health concerns. Some of the concerns were that it would contaminate the soil and pollute organic agriculture. It could have adverse effects on the health of farmers and consumers. Some felt it might be cancerous, and some also felt that some GM foods might affect the respiratory system, (IDI at Women in Agriculture, Abuja, 25th May 2016).

The further finding indicated that there was perceived environmental implications impacting conventional crops adversely, and this was on the issue of whether there was a likelihood of gene flu, superweed, and toxicity;

> An interviewee opined that the concern about the environment had to do with whether GMF could be ameliorated and whether the damage could become permanent. There was a severe environmental concern because the environment was highly being tampered with; the ecosystem was being disturbed, and the carbon dioxide being released would have to be inhaled again. Gene flow to traditional crops is a concern that will emanate from the cultivation of genetically modified foods in Nigeria. (IDI at Genetics and Biotechnology Unit, Dept. of Botany the University of Ibadan, 6th October 2016).

Another interviewee indicated that;

> The intention of introducing GMF was to destroy the environment so that farmers would not plant conventional crops. GMF are crops you cannot replicate. They would pollute the soil, the groundwater and cross-pollinate with all other natural crops turning them into GM crops. Ecological destruction, horizontal gene transfer, and pollination, among others, constituted environmental implications for native crops in the country (IDI at AFJN, Abuja, 24th May 2016).

An interviewee explained that, once you genetically modify any living organism, and then released it to the environment at that level of modification, it would have a massive impact on biodiversity;

> Accordingly, GMF has the dominant trait, and this posed a particular risk to the community and the environment. The risk was that all the plants that gained from it could be susceptible to a particular pest or another impact, and once you lose biodiversity, you would be losing resilience and would lose the capacity to withstand changes in the environment. Also, GMF had not reduced the dependency on chemicals, either pesticide or herbicide. Above all, GMF could not solve the hunger problem; they instead compounded it by sending the native crops into extinction. One of the concerns of GMF is the escape of modified crops. The extent of the damaging impact of this on the native crops was not predictable (IDI at HOMEF, Abuja, 26th May 2016).

In a more elaborate discussion, another interviewee recounted that;

> The laws were available, whatever you were bringing into the country has to be subjected to screening about its impact on the environment especially on the plants, humans, and animals; Factors such as toxicology, allergenicity, and others would be tested. So there would be nothing to be worried about or afraid of. Based on the provisions of the biosafety law, all the products would go through the procedures and evaluations to ensure that nothing harmful would be released to the environment to affect the crops negatively. There was no product free from concern, as such; concerns from the escape of modified crops, horizontal gene transfer and some others have implications on the traditional crops. We would ensure that GMF passed through the processes, procedures, and evaluations, if there was any concern to the environment, it could be rejected. There would not be any need for giving them to the farmers. Sometimes, the test or trial could take two years and above (IDI at NABDA, Abuja, 14th June 2016)

This was corroborated by an interviewee thus;

> Just like any other natural product, GMF could have implications for the environment and our crops. Gene flow and genetic pollution, are issues that can be managed. However, if they go through all the procedures and any crop was discovered to have a concern, it would be eliminated. So there was no need for us to be afraid. What of those of us working on the crops too, are we ready to die? We also want to live long (IDI at ABU, IAR, Zaria, 31st May 2016).

One of the Interviewee conceived GMF as a safe technology, explaining further that the GMF could be likened to antibiotics. For instance;

> When an antibiotic was being used against a particular microbe, the microbe would go round and develops its resistance. The scientist must, therefore, continue to do their work. There used to be stiff opposition to the use of chemicals, especially during the advent of GMF in the 1970s. Officially, a position could not be made now as regards GMF safety, and implications on health, what mattered would be cautious. Although, GM products were very safe without any doubt about it irrespective of the associated environmental implications like the escape of modified crops, gene flow and health implications, especially from adverse nutritional changes. These can be contained. (IDI at OAU, Ife, 24th April 2016).

An interviewee was of the view that there should be no adverse concern amongst public interest groups and consumers simply because;

> Before GM foods could be released, the concerns of gene flow, escape of modified crops, genetic pollution, horizontal gene transfer and its harmfulness to the human, animal system, environment, and even conventional plants would have been considered proactively. Besides, they were deeply studied, and that was why it took long for its production in Nigeria, Above all, the WHO and FAO had said there was no concern as regards GMOs for our native crops and health security. (IDI at MONSANTO, Enugu, 25th November 2015)

In a similar view, an interviewee explained that;

> There was just external sponsorship against GM foods in Nigeria. Nobody within the public interest groups or amongst consumers had proven that GMF had constituted a threat to conventional crops and health, all that existed was mere speculation. (IDI at IITA, Ibadan, 12th May 2016)

Table 4.4: Implications of GMF for the Traditional Crops and Health Security in Nigeria

Factors	Component	
	Health Implications	Environmental Implications
Greenhouse gas emissions	.769	
Toxicity	.735	
Allergenicity	.710	
Adverse nutritional changes	.547	
Escape of modified crops		.780
Gene flow		.773
Horizontal gene transfer		.743
Pesticide Resistance		.650
Environmental Degradation		.627
Unintended harm to biodiversity		.620
Intellectual property		.418
Genetic Pollution		.402

Source: Author's Computation Underlying Data from Survey, 2016.

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Rotation converged in 3 iterations.

$p \leq 0.05$

Opponents of GMF in Nigeria have pointed to the damage that GM plants and agricultural practices have caused biodiversity and native crops elsewhere as reasons why Nigeria should not support genetic engineering of food. Those in support of GMF technology in Nigeria also noted that considering the challenges facing global food production such as climate change and population growth, foods have to be produced with reduced environmental impact and with less input from non-renewable resources if the increasing demands for food and medicine worldwide are to be met. These dividers are the fuel for the implications of GMF for traditional crops and health security in Nigeria. Until these are addressed, the controversy will continue.

There are multiple stakes in the GMF controversy in Nigeria questioning the prospects of modern biotechnology. The diversity of stakes is an essential factor of intense and persistent public mobilization against the introduction of genetically modified foods in Nigeria. Environmentalists and farmer associations have played a vital role in the mobilisation of GMF canvassing support for the rejection of GMF owing to its harmful effects to destroy traditional crops and impair human health security. Public mobilisation in this regard has been able to influence and stalled the governmental pace for the cultivation and commercialisation of GMF in the country. This impasse will persist due to the implications of genetically modified foods on native crops and health security.

CHAPTER FIVE
SUMMARY, RECOMMENDATIONS, AND CONCLUSIONS

5.1 Summary

The general objective of this study was to discuss the implications of genetically modified food on traditional crops and health security in Nigeria. Specifically, the study examined the reasons (context) for the introduction of GMF in Nigeria, the controversies surrounding the introduction of GMF in Nigeria and discussed the implications of GMF on traditional crops and health security in Nigeria.

Burton's Human Needs Theories constituted the framework while a cross-sectional survey research design was used. Data were derived from both primary and secondary sources by using purposive sampling techniques. A self-developed questionnaire with themes that included reasons, perceptions of stakeholders, controversies, implications and concerns for GMF in Nigeria was used to collect data from four hundred and twenty respondents from the six geopolitical zones: academia (135), regulatory bodies (123), research institutes (80), farmers (19) and civil society organisations working on the health and environment (63). Twenty-two in-depth interviews (IDIs) were conducted with stakeholders in academia (5), regulatory bodies (2), research institutes (9), farmers (2) and civil society organisations working on the health and environment (4). Quantitative data were analysed using descriptive statistics and factor analysis at $p \leq 0.05$, while qualitative data were content analysed.

Essentially, this chapter presents a summary of the major findings and the conclusion drawn from the findings. It also presents the recommendations of the research. The summary of the key findings is presented in line with the study objectives.

5.2 Summary of major findings

Genetically modified food and the attendant controversies and its implications for traditional crops and health security in Nigeria were problematised despite being an invention targeted to boost food. The regulatory bodies supported the adoption and cultivation of GMF in Nigeria while the members of civil society organisations whose thematic areas focussed on health and environment opposed the adoption. The adoption of GMF in Nigeria was centred on improved resistance to pests and diseases, reduction in yield deficits, pesticide resistance and improved nutritional quality,

Furthermore, debates heralded the adoption of GMF in Nigeria. These controversies were linked to broad issues associated with pesticide resistance, biodiversity and ownership of intellectual property rights. The topical issues which emanated from the debates included genetic pollution of non-GMO plants, health risk, the risk to the environment, passage of the bio-safety bill to regulate GMF cultivation and sales, suspicious scientific research and publications. Others include the high cost of GMF seeds and products that can lead farmers into debt and food insecurity.

Environmental issues constituted major implications of GMF on the traditional crops and health security in Nigeria. These issues were presented in the form of escape of modified crops from the farms, gene flow and horizontal gene transfer and, are capable of decimating traditional crops. In the same vein, issues such as greenhouse gas emission, toxicity and adverse nutritional changes were potent risks to health security in Nigeria.

5.3 Recommendation

The production of genetically modified foods should be encouraged in Nigeria to check the problems of pests and disease, improve yield deficits, increase crop varieties, and nutritional quality. This will enhance food production and subsequently reduce food insecurity in Nigeria it could also reduce dependence on foreign importation, thus, enhancing the Nigerians GDP and over-dependent on foreign countries, thereby boosting the nation-wide financial fortune and catalyse the inflow of investments from external countries and incomes from GM technology. However, stakeholders should provide measures to control the planted seeds and prevent unwanted seeds from sprouting to prevent genetic pollution.

To have an acceptable genetically modified foods regime in the country, stakeholders should put in place an indigenous intelligence framework of institutional collaboration to ensure the long-term conservation of traditional crops. Researchers are to ensure that scientific research and publications are credible, objective and reliable to guide stakeholders to make informed decisions. The cost of GMF seeds and products should be reviewed to encourage farmers' patronage.

Genetically modified foods have significant benefits and concerns to the populace. Therefore, being alien to Nigeria, regulatory authorities and research institutes should be guided by the implications of GMF on the environment and health and put appropriate biosafety measures in place to ensure health security. This will help to harness the benefits of this technology without being detrimental to traditional crops and human health in Nigeria.

5.4 Conclusion

Genetically modified foods are significant to food production and security in Nigeria. Its adoption is germane to improving crop resistance to pests and diseases, the nutritional quality of food, increasing crop varieties and enhancing crop yield. Genetically modified crops might threaten indigenous crops through gene flow and horizontal gene transfer. G.M crops could also influence greenhouse gas emissions, toxicity and have adverse nutritional effects which could be dangerous to human health.

5.5 Contributions to Knowledge

This study made two significant contributions to knowledge. Firstly, against the dominant narrative that Genetically modified food did not have environmental and health benefits to Nigeria and was a sponsored program to protect the economic interests of the biotech companies, this study scientifically ascertained that the adoption of GMF in Nigeria was premised on improved resistance to pests and diseases, reduction in yield deficits, improved nutritional quality, increased crop varieties, pesticide resistance and economic diversification.

Secondly, studies about GMF in Nigeria were not specific about the implications on traditional crops. This study advanced knowledge by looking beyond the general discussion on GMF to using the research tools of survey and in-depth interviews to identify the specific implications of genetically modified foods on traditional crops and health security

5.6 Suggestions for Further Study

Further research in these areas may consider the implications of genetically modified foods on traditional crops in Nigeria by using case study research methodology.

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APPENDIX 1: Interview Guide

NO	MAIN QUESTIONS	FOLLOW UP QUESTIONS
1	What are the reasons (context) for the introduction of GMF in Nigeria?	a. Do you think there is a need to introduce GMF in Nigeria, and why? b. Is there food security in Nigeria, and to what extent? c. Is GMF a solution to unemployment, and how? d. What impact will GMF make on Nigerian Agriculture?
2	What are the issues driving GMF controversies in Nigeria?	a. Will the introduction of GMF in Nigeria generate environmental concerns? b. What are the implications of the genetic pollution of GMF? c. What is the level of opposition to GMF in Nigeria? d. Will, the Intellectual Property Rights, help Nigerian farmers, and how?
3	What are the environmental implications associated with the introduction of GMF for traditional crops in Nigeria?	a. Are there environmental implications associated with GM foods? b. What are the implications of the genetic pollution of GMO? c. What are the proactive measures to address environmental concerns likely

		to be generated by GMF introduction Nigeria?
4	What are the health implications associated with the introduction of GMF in Nigeria?	a. Do you think that there are health implications of GMF in Nigeria? b. Do you think that Nigeria has Biosafety capacity for GMF? And to what extent? c. Is Nigeria equipped for the testing of GE foods, and how reliable? d. How will the Principles of Substantial Equivalent be a safeguard for GMF in Nigeria? e. What measures had been put in place by the Government to address the likelihood of challenges of GMF in Nigeria?

APPENDIX 2:

QUESTIONNAIRE
DEPARTMENT OF PEACE AND CONFLICT STUDIES
INSTITUTE OF AFRICAN STUDIES
UNIVERSITY OF IBADAN

Dear respondent,

I am a PhD student in the Department of Peace and conflict studies, University of Ibadan and I am researching 'Genetically Modified Foods and its Implications on Traditional Crops and Health Security in Nigeria'. I kindly seek your participation and promise that your responses will be treated with the utmost confidentiality. Please, your cooperation will help in the success of this research.

Thank you.

QUESTIONNAIRE ON THE ASSESSMENT OF ENVIRONMENTAL CONFLICTS ASSOCIATED WITH GENETICALLY MODIFIED FOODS IN NIGERIA

SECTION A: BASIC FEATURES OF THE ORGANIZATION

1. Name of Organization:
2. Position in the organization:
3. Type of Organization:
   (a) University
   (b) Research Institute
   (c) Regulatory Body
   (d) Civil Society
   (e) International Organization
   (f) Development Partners
   (g) Farmers

SECTION B: CONTEXT (REASONS) FOR THE INTRODUCTION OF GMF IN NIGERIA

Kindly indicate the extent to which you consider the following reasons for the introduction of GMF in Nigeria

S/N	REASONS	Very important	Important	Not important	Not a Factor
1.	To provide an alternative method for Farmers.				
2.	Practicable response to food insecurity in Nigeria				
3.	To improve the nutritional quality				
4.	To improve insect and disease resistance				
5.	To increase crop deficit				
6.	To alleviate hunger and poverty				
7.	For increasing crop varieties				
8.	Response to economic diversification				
9.	Boosting of raw material production				
10.	To achieve pesticide resistance				
11.	To benefit from a technological breakthrough				
12.	A solution to generating employment and wealth creation				

SECTION C: ACTORS/STAKEHOLDERS DISPOSITION TO GMF

Kindly assess the stakeholders involved in GMO products via the following statements. Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D), Strongly Disagree (SD)

S/N	Statements	SA	A	U	D	SD
1.	Stakeholders of GMF are pro-industry bias					

2.	Stakeholders of GMF treat public health issues as the number one priority					
3.	Hidden regulations from public scrutiny do not make stakeholders of GMF operate in a transparent way					
4.	Stakeholders are not susceptible to influence from organisations with connections to the biotechnology industry					
5.	There is usually a conflict of interests (vested interests) among the various stakeholders of GMF					
6.	Stakeholders operate proper guidelines or procedures for assessing GMF to prevent adverse health issues					
7.	Stakeholders attempt to exert greater control of food supply					
8.	Stakeholders have the technical capacity to regulate GMF in Nigeria.					
9.	Stakeholders have agreed that GMF should be introduced in Nigeria.					
10.	The public is carried along by stakeholders in the process of introducing GMF in the country.					

SECTION D: CAUSES OF GMO CONCERNS

Kindly indicate the extent to which you consider the following factors as causes of GMO concerns

S/N	**Factors**	**Very large extent**	**Large extent**	**Limited extent**	**Not a factor**

1.	The high cost of GMF seeds and products that can lead farmers into debt				
2.	Non-labeling of GM food and products, with consumers unable to differentiate between GM and non-GM products				
3.	Ownership of intellectual property right that may limit the spread of GM technology to most impoverished communities				
4.	Health risk to the consumers				
5.	The risk to the environment				
6.	The suspicious scientific research and publications				
7.	Biosafety bills do not address the risk associated with GMF				
8.	The concept of substantial equivalence is not a safeguard for GMF				
9.	The precautionary principle will prevent concerns associated with GMF				

SECTION E: PERCEIVED EFFECTS OF GMF ON THE ENVIRONMENT

Indicate the extent to which you consider the following as environmental conflicts of GMF in Nigeria

S/N	**Environmental Conflicts**	**Very important**	**Important**	**Not important**	**Not a Factor**
1.	Environmental degradation				
2.	Genetic Pollution				
3.	Gene Flow				
4.	Escape of Modified Crops				
5.	Toxicity				

6.	Adverse Nutritional Changes				
7.	Horizontal Gene Transfer				
8.	Allergenicity				
9.	Greenhouse Gas Emissions				
10.	Pesticide Resistance				
11.	Unintended Harm to Biodiversity				
12.	Intellectual Property				

SECTION F: GMF CONTROVERSIES IN NIGERIA

Indicate whether the factors causing the controversies of GMF in Nigeria are having an increasing, stable or decreasing effect on the debate

S/N	Factors	Increasing	Stable	Decreasing
1.	The high cost of GMF seeds and products that can lead farmers into debt			
2.	Non-labeling of GM food and products, with consumers unable to differentiate between GM and non-GM products			
3.	Ownership of intellectual property right that may limit the spread of GM technology to most impoverished communities			
4.	Health risk to the consumers of GMF			
5.	The risk to the environment			
6.	The suspicious scientific research and publications			
7.	Food insecurity in Nigeria triggered the introduction of GMF in the country			
8.	The passage of the Biosafety Bill to regulate GMF cultivation and sales.			
9.	Genetic pollution of non-GMF plants			

SECTION G: PERCEIVED EFFECTS OF GMO ON HEALTH

Indicate the extent to which you consider the following as consequences of GMF

S/N	Consequences	Very large extent	Large extent	Limited extent	Not a factor
1.	Death resulting from the consumption of GM foods				
2.	Degenerate diseases like cancer, arthritis, inflammation, lymphoma resulting from chemicals in GM food				
3.	Increases food allergies such as shock, itching, rashes, etc.				
4.	Congenital disabilities in the newborn, e.g. smaller size babies				
5.	Shorter life spans of users of GM products				
6.	Lowered nutrition, as GM foods have lower levels of vital nutrients				
7.	Bioengineered seeds and plants increase soil toxicity, thereby harmful to the environment.				
8.	GM bacteria that are supposed to decompose plant remains render the soil sterile				
9.	Loss of biodiversity that can consign agriculture with a bleak future				
10.	A monopoly of food production which leads to loss of competition, as few companies control food production				

11.	Violation of consumers' right due to non-labelling of GM foods				
12.	GMF cultivation will cause genetic erosion				

SECTION H: CONTROVERSIES ON REGULATION OF GMO

Kindly indicate the extent to which you agree with the following statements on GMO regulation. Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D), Strongly Disagree (SD)

S/N	Statements	SA	A	U	D	SD
1.	Regulation on GMF ensures the protection of consumers' health					
2.	Regulation on GMOs cannot guarantee the protection of the environmental					
3.	Benefits of GMO technologies can be harnessed through proper regulation					
4.	There is still no general agreement about the need for GMO regulatory framework/pattern					
5.	There are no differences in opinions on how strict regulation should be maintained					
6.	Nigeria currently lacks the resources to regulate GMOs adequately					
7.	Methodology for risk assessment under GMO regulation is well described					
8.	The GMO regulatory process does not encourage the involvement of the public, e.g. absence of labelling					
9.	The cost of regulation of GMOs is a severe constraint					

10.	Infringement of GMO regulation leads to economic damage, and someone should be liable					
11.	GM crops should be strictly regulated than non-GM crops					

SECTION I: PROPOSED INTERVENTION(S)

Kindly suggest interventions for transforming the conflicts associated with GMF introduction to ensure that the initiative for GMF benefit Nigerians

i.

ii.

iii.

iv.

v.

APPENDIX 3

Identity of Respondents to the In-depth Interview

Plate 1: Researcher with Professor Bamidele Ogbe, Department of Chemical Engineering, Obafemi Awolowo University, Ile-Ife. (IDI at OAU, Ife, 24th April 2016).

Plate 2: Researcher with Dr Christian Fatokun, Cowpea Breeder International Institute of Tropical Agriculture (IITA), Ibadan. (IDI at IITA, Ibadan, 12th May, 2016).

Plate 3: Researcher with Dr Robert Asiedu, Director, West Africa Research-for Development Directorate International Institute of Tropical Agriculture (IITA), Ibadan. (IDI at IITA, Ibadan, 12th May 2016).

Plate 4: Researcher with Mrs Ejim Loveln, Chairperson Women in Agriculture, Enugu. (IDI at WIN, Abuja, 25th May 2016).

Plate 5: Researcher with Dr Philip C. Njemanze, President - Catholic Doctors Association of Nigeria (CHIDICON). Owerri. (IDI at CHIDICON, Abuja, 25th May 2016)

.Plate 6: Researcher with Rev. Aniedi Okure, Executive Director, Africa Faith &Justice Network (AFJN), Washington. D.C. (IDI at AFJN, Abuja, 24th May 2016).

Plate 7: Researcher With Nnimmo Bassey, Director, Health of Mother Earth Foundation (HOMEF). Benin-City. (IDI at HOMEF, Abuja, 26th May 2016).

Plate 8: Researcher with Barrister Mariann Bassey-Orovwuje Friends of Earth Nigeria (ERA / FoEN). (IDI at ERA / FoEN, Abuja, 26th May 2016).

Plate 9: Researcher with Mr Rufus Ebegba, Director, National Biosafety Management Agency (NBMA), Abuja. (IDI at NBMA, Abuja, 27th May 2016).

Plate 10: Researcher with Ibrahim Tanuma, CEO-IBT Farm. Gonigora, Kaduna. (IDI at IBT Farms, Gonigora, Kaduna, 30th May 2016)

Plate 11: Researcher with Professor Daniel Aba (Project Director GM Sorghum). Institute for Agricultural Research, Samaru. Ahmadu Bello University, Zaria. (IDI at ABU, IAR, Zaria, 31st May 2016).

Plate 12: Researcher with Field Supervisor (GMOs Sorghum Confined Field Trial). Institute For Agricultural Research, Samaru. Ahmadu Bello University, Zaria. (IDI at ABU, IAR, Zaria, 31st May 2016).

Plate 13: Researcher at the GMOs Cowpea Confined Trial. Institute for Agricultural Research, Samaru. Ahmadu Bello University, Zaria. (IDI at ABU, IAR, Zaria, 31st May, 2016).

Plate 14: Researcher with Mr Ehirim Bernard, Rice Breeder / Technologist (GM Nerica Rice Confined Field Trial), National Cereals Research Institute (NCRI), Badeggi, Niger State. (IDI at NCRI, Badeggi, 2nd June 2016).

Plate 15: Researcher with Mr Nwaogu Ahamefule Stephen, Principal Agric. Supervisor (with Research Students), National Root Crop Research Institute (NRCRI), Umudike, Abia State. (IDI at NRCRI, Umudike, 15th August 2016)

Plate 16: Researcher with Dr Onyia Oby, Head of Department, Department of Biotechnology & Applied Biology, Godfrey Okoye University, Enugu. (IDI at GOU, Enugu, 16th August 2016)

Plate 17: Researcher with Dr A. I. Adesoye, Senior Lecturer, Genetics and Biotechnology Unit. Department of Botany. The University of Ibadan. (IDI at Genetics Dept, The University of Ibadan, 6th October 2016)

Plate 18: Researcher with Professor I. H. Nock, Head of Department, Department of Biological Sciences, Ahmadu Bello University, Zaria. (IDI at ABU, IAR, Zaria, 1st June, 2016).

Plate 19: Researcher with Olumide Ibikunle, Business Leader (Nigeria & Ghana), Dupont Pioneer. (IDI at Dupont Pioneer, Enugu, 26th November 2015)

Plate 20: Researcher with Esther Adebayo, Regulatory Affairs Associate, Monsanto. (IDI at MONSANTO, Enugu, 27th November 2015)

Plate 21: Researcher with Hajia Sadiq Yusuf, Biosafety Officer, National Biotechnology Development Agency (NABDA), Abuja. (IDI at NABDA, Abuja, 14th June 2016) Plate 22: Researcher in a GMOs National Biosafety Conference at Godfrey Okoye University,

Enugu. 27th November 2015.

Plate 23: Researcher in a National Conference on Biosafety Act in Abuja. 25th May 2016.

Plate (24): Researcher with Henry Mbaya, Biotech Centre, University of Maiduguri.

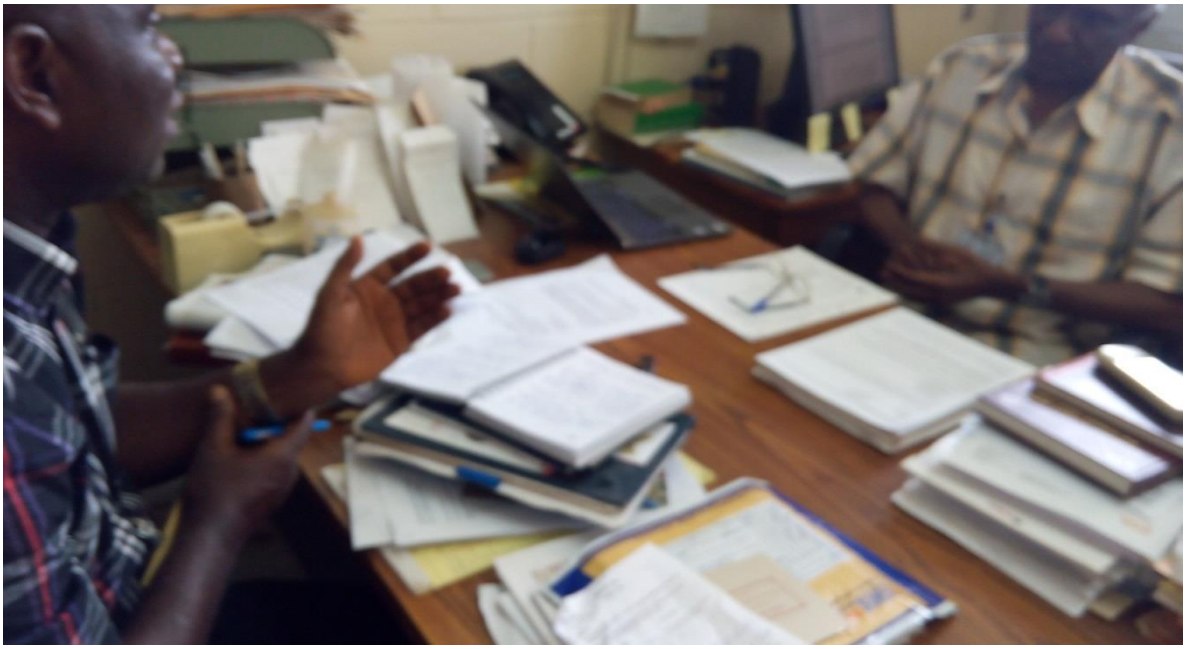
Maiduguri. Nigeria. (IDI at UNIMAID, Maiduguri, 5th July 2016)

APPENDIX 4

Digital Photographs of the Participants' Interactive Sessions with the Researcher

PLATE

Plate 1: Researcher with Professor Bamidele Ogbe, Former Director General National Biotechnology Development Agency (NABDA), Abuja. Lecturer at the Department of Chemical Engineering, Obafemi Awolowo University, Ile-Ife. (IDI at OAU, Ife, 24th April 2016).



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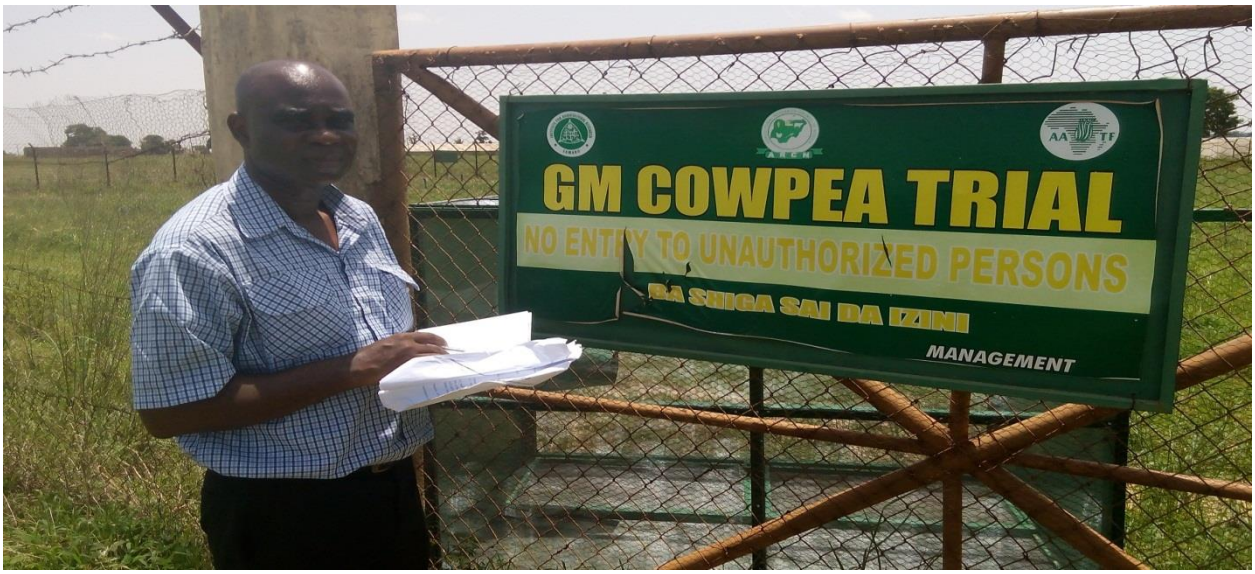

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Plate 22: Researcher with the DG. NBMA - Mr Egbegba Rufus (Centre) in a GMOs National Biosafety Conference at Godfrey Okoye University, Enugu. 27th November 2015.

Plate 23: Researcher (Extreme Left) in a group photograph at the National Conference on Biosafety Act in Abuja. 26th May 2016.