UNIVERSITY OF NAIROBI

DEPARTMENT OF DIPLOMACY AND INTERNATIONAL STUDIES

GENETICALLY MODIFIED TECHNOLOGY AND THE ATTAINMENT OF SDG2 IN AFRICA: A COMPARATIVE STUDY OF SOUTH AFRICA AND KENYA

BY:

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DECLARATION

Declaration by the Student

I, **MARIAH FARIDAH MULI**, hereby declare that this research project is my original work and has not been presented for an award in any university.

Signed: …………………………………. Date: 14/11/2023

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This project has been submitted for examination with my approval as University Supervisor.

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DEDICATION

This project is dedicated to every South African and Kenyan actively engaged in the pursuit of Zero Hunger and those contributing to both states progress in achieving Sustainable Development Goal Two by 2023.

With the utmost appreciation, I want to express my deepest gratitude to all the people who have touched my life, leaving an enduring impression and adding to the richness of my academic journey with their presence.

I want to express my heartfelt thanks and deep appreciation to the following people. Their steadfast support and invaluable input have been instrument in shaping my journey and in the progress of this research project.

I am eternally grateful to my dear friends and colleagues, whose love and support have been a continual source of strength. To my extraordinary family, including my exceptional sisters, Riziki and Peninah, my brothers John, Brighton and Brando whose unwavering support has been a beacon guiding my way. I am indebted to my courageous and beautiful mother, Eunice Muli and in loving memory of my father, Henry Muli whose enduring light and love continue to illuminate our lives – continue resting in peace.

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ABSTRACT

Hunger is a global problem that is becoming more significant as a result of factors such as climate change, conflict and instability, poverty and inequality, population expansion and insufficient infrastructure in many parts of the world. More and more stable food supply is needed to feed the world population and accomplish the SDG2 objective of eliminating hunger by 2030. As a result, new agricultural technologies such as genetically modified technology are required to end global hunger. Agriculture's use of genetically modified (GM) crops has emerged as a potential option for solving food insecurity concerns and attaining SDG2-Zero Hunger in Africa. This research project examines South Africa and Kenya- two nations that are at various phases of embracing and applying genetically modifies technology in their agricultural systems. This study looks at the impact of genetically modified crops on the accomplishment of SDG2 in Africa. The study will do so by examining the progress made by African states in developing and adopting GM Technologies in the achievement of SDG2, to critique the policies and regulations governing the use of genetically modification technology in Kenya and South Africa and to analyze the challenges South Africa and Kenya face in adopting GM Technology for the achievement of SDG2. The study will adopt composite approach that incorporates secondary data gathered from literature studies and primary data obtained from interviews with relevant stakeholders. The study's findings reflect contrasting outcomes of GM Technology in the two countries, with South Africa adopting and reaping big from the technology while Kenya approaches the technology reluctantly and cautiously, stressing biosafety laws and public participation. This study contributes to existing knowledge regarding genetically modified technology and its relevance in achieving SDG2 in Africa.

Key words: GMT, GMO, Kenya, SDG, South Africa

ABBREVIATIONS AND ACRONYMS

ABNE	African Biosafety Network of Expertis
ABS	African Biofortified Sorghum
AFSA	Alliance for Food Sovereignty
Agbiotech	Agricultural Biotechnology
AGRA	Alliance for a Green Revolution in Africa
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AU	African Union
BCH	Biosafety Clearing House
BRICS	Biotech Regional Innovation Centers
BT	Bacteria Bacillus Thuringiensis
CIMMYT	International Maize and Wheat Improvement Centre
COMESA	Common Market for Eastern and Southern Africa
COVID-19	Corona Virus Diseases of 2019
CPA	Consolidated Plan of Action
CPB	Cartagena Protocol on Biosafety
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
DNA	Deoxyribonucleic Acid
DPH	Department of Public Health
DVS	Department of Veterinary Services
EAC	East African Community
EC	Executive Council

EIA	Environmental Impact Assessment
EU	European Union
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GE	Genetically Engineered
GHI	Global Hunger Index
GMO	Genetically Modified Organism
GMT	Genetically Modified Technology
HT	Herbicide Tolerant
ICRAF	World Agroforestry Centre
IFA	Institute of Food and Agriculture
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
IMAS	Improved Maize for African Soils
ISAAA	International Service for the Acquisition of Agri-biotech Applications
KALRO	Kenya Agriculture and Livestock Research Organization
KARI	Kenya Agriculture Research Institute
KEBS	Kenya Bureau of Standards
KEPHIS	Kenya Plaint Health Inspectorate Services
KIPI	Kenya Industrial Property Institute
KWS	Kenya Wildlife Service
MDG	Millennium Development Goals

NACOSTI	National Commission for Science Technology and Innovation
NBA	Nationals Biosafety Authority
NEMA	National Environmental Management Authority
NEMBA	National Environmental Management Biodiversity Act
OAU	Organization of African Unity
ODA	Official Development Assistance
PBS	Program for Biosafety Systems
PCPB	Pest Control Products Board
QUT	Queensland University of Technology
RABESA	Regional Approach to Biotechnology and Biosafety Policy
RTFI	Route to Food Initiative
SADC	Southern African Development Community
SAGENE	South African Committee for Genetic Experimentation
SANBI	South African National Biodiversity Institute
SDG	Sustainable Development Goal
SP-NK	Supplementary Protocol on Liability and Redress
TIA	Technology Innovation Agency
UN	United Nations
UNICEF	United Nation International Children's Emergency Fund
US FDA	Food and Drug Administration
USAID	United States Agency for International Development
USD	United States Dollar
WAEMU	West African Economic and Monetary Union

WEMA	Water Efficient Maize for Africa
WFP	World food Program
WHO	World Health Organization

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CHAPTER ONE

INTRODUCTION AND BACKGROUND TO THE STUDY

1.0 Introduction

According to United Nations, hunger is characterized as a state in which individuals face severe food insecurity, resulting in prolonged periods without consuming any food. This condition arises from factors such as insufficient funds, limited access to food, or a shortage of other essential resources.[1] The global crisis of hunger and malnutrition has reached unprecedented levels, with over 345 million individuals facing severe food insecurity in 2023. This represents a doubling of the number since 2020, an increase of 200 million people. Additionally, more than 900,000 individuals are on the verge of famine, which is ten times higher than five years ago.[2]

The state of global hunger, as indicated in the 2022 Global Hunger Index (GHI), is extremely concerning. The several crises that the globe is presently experiencing have revealed the flaws within food systems, both on a global and local scale. These challenges have also shed light on the susceptibility of populations worldwide to hunger. Over the span of three years, from 2019 to 2022, the number of individuals suffering from undernourishment surged by approximately 150 million. The main causes of this crisis include conflicts, climate change, and the widespread impacts of the COVID-19 plague. The SDG2 objective of eradicating hunger, food insecurity, malnutrition, and advancing sustainable agriculture has just seven years remaining to be accomplished. Unfortunately, an FAO report has shown that the entire world is heading

[1]Action Against Hunger., *What is Hunger*., Accessed on https://www.actionagainsthunger.org/the-hunger-crisis/world-hunger-facts/what-is-hunger/
[2]WFP, *A Global Food Crisis*., https://www.wfp.org/global-hunger-crisis

in the wrong direction. Food insecurity has increased, and there hasn't been much progress made achieving the 2030 global nutrition targets.[3]

Africa has emerged as an area that is particularly susceptible, with around 21% of its population, equivalent to 282 million people, experiencing hunger in 2020. Following the COVID-19 epidemic which aggravated the state of affairs, leading to an additional 46 million individuals falling into hunger between 2019 and 2020.[4] According to Macrotrend data, the hunger statistics for South Africa in 2020 stood at 6.90%, representing a 0.6% rise from the previous year 2019. In 2021, approximately 2.1 million households in South Africa, reported facing hunger. Furthermore, in Kenya, the hunger statistics in 2020 indicated a rate of 26.90%, representing a 1.3% increase compared to 2019. According to a report by UNICEF in February 2023, the total of people facing acute food insecurity due to drought has risen to 4.4 million. These figures marked a rise from the 3.5 million and 884,000 figures recorded in July 2022, respectively.[5]

The United Nations (SDGs) serves as a universal initiative urging action to eliminate scarcity, safeguard the environment, and ensure universal well-being and peace. Commonly referred to as Agenda 2030, these goals were established in 2015 through UN General Assembly Resolution 70/1. With the intention of achieving the goals by the year 2030, they were unanimously endorsed by all UN members. The SDGs, which had a wider scope, superseded the MDGs. Unlike the MDGs, which were centered on poor nations, they are universal and

[3]Action against Hunger.,*Millions of people in Africa live in extreme poverty without access to safe drinking water and reliable sources of food.* Access on https://www.actionagainsthunger.org/location/africa/
[4]Nieva R. F., *Growing Hunger, High Food Prices in Africa Don't Have To Become Worse Tragedy*, Africa Renewal, May 2022 accessed 29 June 2023
[5]UNCEF, *Humanitarian Situation Report No. 3 Reporting Period 1 to 31 March 2023* Accessed https://www.unicef.org/media/138906/file/Kenya-Humanitarian-SitRep-March-2023.pdf

apply to all countries.[6] SDG2 targets to eliminate hunger, increase food security, increase nourishment, and push for the use of sustainable farming methods.[7]

1.1 Background to the Problem

A genetically modified organism (GMO) refers to any living organism, including plants, animals, bacteria, or viruses, whose genetic composition has been altered with a specific purpose. To illustrate, a plant can be modified by incorporating an additional gene obtained from another organism, such as a bacterium, to enhance its resistance against insect pests. The process usually entails extracting genetic material that carries a desirable trait from one species and introducing it into another. One instance is the integration of a Bacillus thuringiensis (Bt) gene into plants, making them toxic to certain insects and thus safeguarding the plants against these insects.[8]

Genetically modified (GM) produces have turn out to be more prevalent worldwide currently, especially among small-scale farmers in developing nations. There have been some sectors that have experienced remarkably high growth rates. The safety record of genetically modified (GM) crops over the past 15 years demonstrates that, despite initial concerns, there are no noteworthy risks to the environs or public well-being associated with this type of genetic modification. Africa has been reluctant to embrace agricultural biotechnology, despite the region's low agricultural productivity and the growing need to boost agricultural production. Only four countries currently commercially cultivate genetically modified (GM) crops: Sudan,

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[6]Rasul, G., Managing the food, water, and energy nexus for achieving the Sustainable Development Goals in South Asia. *Environmental Development*, 18, pp.14-25, 2016.
[7]FAO, *An Introduction to the Basic Concepts of Food Security*. (2008). Available at: http://www.fao.org/3/a-al936e.pdf
[8]Maina, J. *South Africa has Reaped Major Benefits from GM Maize*. Accessed (2023, June 9). https://allianceforscience.cornell. edu/blog/2021/06/south-africa-has-reaped-major-benefits-from-gm-maize-study-finds/

Burkina Faso, South Africa and Egypt. However, several other nations have conducted controlled field testing and may potentially adopt this technique, including Uganda, Zimbabwe, Ghana, Kenya, Malawi, Nigeria, and Tanzania.[9]

South Africa introduced genetically modified (GM) varieties of soybeans, cotton, and maize in the late 1990s. Adopting genetically modified crops has produced notable benefits despite a slow start, especially with GM maize. Small-scale farmers now make more money, the environmental impact has decreased, and food security has improved as a result. A recent study by researchers at Ghent University in Belgium, the Agricultural Research Council in South Africa, and the United States found that between 2001 and 2018, GM white maize produced welfare benefits totaling USD 694.7 million. Insect-resistant Bt white maize has been developed successfully in South Africa.[10]

With an approval rate of 85%, South Africa had planted over 1.1 million hectares to GM cultivars for uninterrupted public intake by 2017. The study established that the usage of genetically modified white maize added 4.6 million meals annually, reaching a high of 7.4 million in 2017. Between 2001 and 2018, the usage of genetically modified white maize lead to in an extra 83.5 million meals. South Africa created Biotech Regional Innovation Centres (BRICs) to show its commitment to biotechnology; these centres were eventually combined into the Technology Innovation Agency (TIA) in 2008. Research and development conducted locally is encouraged to be commercialised by the TIA in a number of industries, such as manufacturing, biotechnology, health, agriculture, and energy.[11]

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[9]Juma, C., *The New Harvest: Agricultural Innovation in Africa*. (New York: Oxford University Press, 2011).
[10]Gouse, M., 'South Africa: Revealing the Potential and Obstacles, the Private Sector Model and Reaching the Traditional Sector.' In S. Fukada-Parr (ed.), *The Gene Revolution: GM Crops and Unequal Development*. London: EarthScan, pp. 175-195(2007).
[11]Kimenju, S., H. De Groote, C. Bett, and J. Wanyama., Farmers, Consumers, and Gatekeepers and Their Attitudes towards Biotechnology. *African Journal of Biotechnology* 10 (23): 4767–4776. 2011

Over the past twenty years, the topic of GMOs has garnered a lot of attention in Kenya. The three primary topics of dispute are the viability and sustainability of GMOs economically, their security for human intake and the environs, and the need of GMOs as promoted by its proponents. Both parties have provided different impressions and ideas about Kenyan customers as the discussion continues. According to a survey carried out by the Route to Food Initiative (RTFI) in 2022, it was found that a majority of Kenyans, specifically 57%, are unwilling to consume GMOs. On the other hand, the survey revealed that 43% of Kenyans are open to consuming GMOs.[12]

The Kenyan government made a big move in December 2019 when it approved the commercial use of Bt Cotton, a genetically modified crop that is owned by the Monsanto Company. This choice demonstrated the government's increasing commitment to encouraging the creation of genetically modified crops. Many crops that have undergone genetic modification (GM) are being developed for commercial production. These include Bt Maize, which has been changed to resist pests, and a variety of other crops including bananas, cowpea, pawpaw, sorghum, and cassava that have been designed to resist the cassava mosaic virus. Nevertheless, despite the demand for GM crops, Kenya has maintained a ban on GMO food imports since 2012. Nevertheless, there have been significant advancements in the legislative and legal frameworks for GM crop research and management. The lifting of the GMO restriction, coupled with a narrative emphasizing the potential of GMOs in addressing food and nutrition insufficiency, is presented as a means to enhance agricultural productivity and combat hunger.[13]

[12]Route to Food, *The Perception of Kenyans on Genetically Modified Foods*, 2022, access on July 4, 2023 https://ke.boell.org/sites/default/files/2022-12/final-gmo-perception-study-report-digital-3_1.pdf
[13]*ibid*

This comparative study investigates the variables influencing genetically modified (GM) technology research and adoption in Africa, with an emphasis on South Africa and Kenya. In both nations, the study looks at policy frameworks, laws, public perception, stakeholder participation, and socioeconomic implications and how other African states can learn from South Africa. The primary goal is to inform policymakers and stakeholders on the problems, possibilities, and best practices related with the deployment of GM technology in Africa, on top of its potential influence to SDG2 (Sustainable Development Goal 2) attainment. The research highlights the necessity of informed policy and decision-making, as well as addressing socioeconomic and environmental aspects, by assessing the obstacles, possibilities, and potential results of GM technology adoption. It highlights how genetically modified organisms (GMOs) can possibly rise food security and support regional agriculture's sustainable growth. It emphasizes the potential of genetically modified organisms (GMOs) to expand food security and promote sustainable agricultural development in the region.

1.2 Statement of the Problem

African countries grapple with significant challenges in policy formulation, characterized by poor politics, economic instability, and financial constraints. The long-term insecurities prevalent in nations like Somalia, South Sudan, and Congo have perpetuated conflicts, hindering agricultural development and hampering the establishment of robust institutional frameworks. Consequently, the adoption of crucial technologies, such as genetically modified (GM) technology, remains restricted due to these unfavorable conditions. Additionally, the prevalence of climate-related adversities, particularly droughts, exacerbates the agricultural struggles faced by African nations. The Horn of Africa and Sahel regions bear the blunt of these climate-related issues, making them more susceptible to food insecurity and hunger. As a result, these areas face considerable challenges in attaining sustainable development and agricultural growth.

South Africa is the African continent's leader in the use of genetically modified (GM) expertise in food production. The country has been cultivating GM maize, soybeans, and cotton with characters like insect resistance and herbicide tolerance since the late 1990s. The Genetically Modified Organisms Act of 1997 established a regulatory framework to ensure responsible use and assess the safety of GM crops for people, animal, and environmental well-being. South African farmers prefer genetically modified crops due to potential benefits such as higher yields and lower pesticide use. However, environmental concerns, cross-pollination, and seed firm control have sparked debate. Kenya, on the other hand, uses GM technology in agriculture less extensively than South Africa. The country is researching and testing genetically modified crops such as maize, cotton, and cassava, and debates over the benefits and drawbacks of these products are ongoing. The National Biosafety Authority (NBA) is in charge of Kenya's guiding structure for the management, importation, and release of genetically modified organisms.

African countries recognize the importance of adopting GM technology as a potential tool to attain SDG 2 of zero hunger. However, there is a need to assess African states' progress in developing and implementing GM technologies to contribute to SDG2. This study aims to examine the policies and regulations that administer the use of genetically modified technology in Kenya and South Africa. The study seeks to understand how the use of GMO technology can effectively contribute to the achievement of SDG2 in both the broader context of Africa and the specific cases of South Africa and Kenya through a comparative analysis. The research aims to provide valuable insights into the role of GM technology in advancing food security and sustainable development in the region, as well as recommendations for improving its successful implementation, by examining these aspects. The study's results will be beneficial to policymakers, stakeholders, and other entities interested in incorporating GM technology into agricultural development plans and assisting Africa in meeting its SDG2 goal of achieving zero hunger.

1.3 Research Questions

The research questions listed below will guide this section.

1. What progress has been made by African states in developing and adopting GM technologies in the achievement of SDG2?
2. What policies and guidelines manage the usage of genetically modified technology in Kenya and South Africa?
3. What challenges do South Africa and Kenya face in Adopting GM Technology for the achievement of SDG2?

1.4 Study Objectives

1.4.1 General Objectives

This project's main goal is to compare South Africa and Kenya in order to examine how genetically modified technology (GMT) has affected the continent's efforts to achieve SDG 2.

1.4.2 Specific Objectives

1 To examine the development made by African states in developing and adopting GM technologies in the achievement of SDG2

2 To critique the policies and guidelines governing the use of genetically modification technology in Kenya and South Africa

3 To analyze the challenges South Africa and Kenya face in Adopting GM Technology for the achievement of SDG2.

1.5 Literature review

Within the literature review, this part thoroughly investigates both theoretical and empirical literature on genetically modified technology (GMT) and its impact on achieving SDG2 in Africa, notably in South Africa and Kenya. The empirical literature evaluates past studies, academic papers, and pertinent publications on the issue to identify gaps in research and highlight noteworthy findings from earlier studies. A theoretical framework also comprises the identification and study of relevant ideas that serve as the foundation of the research, providing a theoretical perspective through which the research subject is approached and explored.

1.5. Empirical Literature Review

This section extensively reviews and discusses a wide range of authors' and academic writers' works. It will be led by the objectives of the investigation, which will serve as a firm basis for understanding the researcher's dilemma. The goal of this literature review is to give a complete overview of existing research on Genetically Modified Technologies (GMT) and their potential to aid in the achievement of SDG2, with a particular emphasis on Kenya and South Africa.

1.5.1 The Concept of Genetically Modified Technology and Sustainable Development Goals

The interplay of Genetically Modified (GM) technology and the underlying philosophy of SDG 2, aiming to achieve "Zero Hunger," has sparked significant interest and debate globally. This review aims to consolidate key ideas regarding GM technology and the philosophical foundations of SDG2, exploring their interconnection and implications for addressing global food security challenges.

1.5.1.1Genetically Modified Technology

Genetically Modified Technology involves modifying the genetic composition of organisms, particularly crops and livestock, using genetic engineering methods. GM crops come in various types, including those resistant to herbicides, insects, and enriched with nutrients. GM technology offers potential advantages such as higher crop yields, reduced pesticide usage, and improved nutritional value. These benefits can enhance food security by boosting agricultural productivity and resilience. Concerns related to GM technology include environmental risks, potential health effects, and socio-economic issues. Ethical and regulatory debates have focused on topics like intellectual property rights, corporate dominance, and unintended consequences of genetic alterations. GM technology regulation varies worldwide, with some countries imposing stringent rules and others opting for more lenient approaches. International accords, like the Cartagena Protocol, offer a structure for the harmless movement, management, and application of genetically modified organisms.[14]

1.5.1.2 SDG 2 -Zero Hunger

SDG 2 seeks to eliminate hunger, ensure food safety, increase nutrition, and encourage workable agriculture. It recognizes that addressing hunger entails multifaceted challenges that are influenced by factors other than food production, such as poverty, inequality, and environmental sustainability. SDG2 emphasizes the importance of varied and nutrient-dense diets through a holistic approach that considers both the quantity and quality of food. It promotes sustainable farming practices and equitable resource access. SDG2 is related to

[14] Rissler, J. and Mellon, M., *The Ecological Risks of Engineered Crops*, (MIT Press, Cambridge, 1996)

several other SDGs, including SDG12 (Responsible Consumption and Production), SDG 1 (No Poverty), and SDG 3 (Good Well-being and Health). These connections highlight the importance of a multifaceted approach to achieving food security.[15]

1.5.1.3 Interplay and Conflict between GM Technology and SDG2

The technology developed by GM could potentially help SDG2 by increasing crop yields, minimizing food wastage, and enriching crop nutrition. Biotechnological advancements can support sustainable agricultural practices, such as reduced pesticide usage and improved crop resilience. However, conflicts arise due to concerns about GM technology, including environmental and health risks, corporate dominance, and ethical quandaries. The philosophy underpinning SDG2 advocates for sustainable, fair, and all-encompassing solutions, which might not align with the profit-driven motives of certain GM technology stakeholders.[16]

1.5.2 The adoption of Genetically Modified Technology to achieve SDG2 by 2030

According to Klümper and Qaim's analysis of a hundred-plus researchs, the use of chemical pesticides decreased by 37% as a consequence of the adoption of genetically modified (GM) technology, particularly in developing countries. The growth of genetically modified crops that are irrepressible to pesticides and herbicides has been a major factor in encouraging farmers to use conservation tillage techniques.[17]

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[15] Hails, R.S., Genetically Modified Plants: The Debate Continues. *Trends in Ecology and Evolution*, 15 (1), 14-18. 2000.
[16] i*bid*
[17] Klümper, W., and Qaim, M., *A Meta-Analysis of the Impacts of Genetically Modified Crops*. PLoS ONE 9(11): e111629. (2014) doi.org/10.1371/journal.pone.011162

According to Fullman et al,[18]despite great success in decreasing micronutrient malnutrition and meeting SDG2 nutrition goals, over 2 billion people continue to be malnourished in one or more deficiencies. According to Wesseler et al[19], this circumstance necessitates supplementary treatments to existing successful micronutrient therapy such as vitamin A or iron supplementation. As a result, significant advances in conventional bio fortification have been accomplished since the beginning of the twenty-first century, with the introduction of various crops supplemented with micronutrients in over 50 priority nations, as claimed by Harvest Plus in 2015. According to Haas et al,[20] there is extensive and developing data suggesting that such crops are a very cost-effective technique for improving micronutrient status among targeted populations.

De Moura and Stein et al, have reached similar conclusions regarding the potential of genetically modified (GM) biofortified crops to achieve SDG2's nutrition objectives. The implementation of GM biofortified crops, such as Golden Rice, has been shown to have successful applications in biofortification and the ability to significantly increase intake levels of micronutrients, including vitamin A, iron, and zinc. Ex-ante assessments conducted by De Steur, Wesana et al.[21] have further emphasized that investing in GM biofortified crops, particularly multibiofortified crop varieties, would be highly cost-effective in alleviating lack of nutrients. This is affirmed by Fiedler et al's findings, which show that policy actions targeting

[18]Fullman, N., Barber, et al. Measuring Progress and Projecting Attainment on the Basis of Past Trends of the Health Related Sustainable Development Goals in 188 Countries: An Analysis from the Global Burden of Disease Study 2016. *The Lancet* 390(10100), 1423–1459(2017).
[19]Wesseler, J., Smart, R. D., Thomson, J., and Zilberman, D., Foregone benefits of important food crop improvements in Sub-Saharan Africa. *PLoS ONE* 12(7): e0181353. (2017).
[20]Haas, J. D, Finkelstein, J. et al., Iron Biofortified Pearl Millet Improves Iron Status in Indian School Children: Results of a Feeding Trial. *The FASEB Journal*, 27 (1 Supplement), 355.2. (2013).
[21]De Steur, H., Mehta, S., Gellynck, X., and, Finkelstein J. L., GM biofortified crops: potential effects on targeting the micronutrient intake gap in human populations. *Current Opinion in Biotechnology* 44, 181–188. (2017).

such crops can yield economies of scale, resulting in significant benefits at a relatively modest cost.[22]

Talsma et al. envisage the relevance of GMO technology in the context of SDG2 as lying in its potential to address malnutrition and contribute to achieving nutrition targets. In their opinion, GM biofortified crops, enriched with essential nutrients, can be effective in reducing deficiencies in vitamin A, iron, and zinc. Thy further opine that while regulatory and anti-GMO lobbying[23] efforts pose challenges to the approval of GM crops addressing nutritional deficiencies, evidence suggests that consumers are receptive to biofortified crops, both conventional and genetically modified.

1.5.2.1 SDG 2 –Zero Hunger

The SDG is an international initiative that aims to eliminate hunger, ensure food safety, increase nutrition, and promote maintainable agriculture by 2030. This literature review synthesizes the perspectives of various scholars, shedding light on the key concepts, challenges, and strategies involved in achieving zero hunger.[24]

Scholar Smith emphasizes the multifaceted nature of hunger, covering aspects like food availability, accessibility, utilization, and stability. Addressing hunger comprehensively requires a deep understanding of its complex root causes, which vary significantly across regions and communities. Research by Johnson et al. underscores the vital role of sustainable

[22]Fiedler, J. L., Kikulwe, E. M., and Birol, E., An ex-ante analysis of the impact and cost effectiveness of biofortified high-provitamin A and high-iron banana in Uganda. *IFPRI Discussion Paper 1277*, International Food Policy Research Institute, Washington, DC. (2013).
[23]Talsma, E. F., Brouwer, I. D., Verhoef, H., Mbera, G. N. K., & Mwangi, A. M. (2013). Biofortified crops for preventing zinc deficiency: Progress and prospects. *In Food and Nutrition Bulletin*, 34(1), 21-28.
[24]United Nations. *Zero hunger challenge 2015*. Available https://www.un.org/zerohunger/content/pathways-zero-hunger(cited 28 February 2021)

agricultural practices. Innovations such as precision farming and agroecology not only boost food production but also promote environmental preservation, ensuring the well-being of future generations.[25]

To lessen the harmful impacts of climate change on food systems, Wang et al, emphasizes the critical need for resilient crop varieties, adaptive strategies, and climate-smart agricultural policies.[26] Patel's studies illuminate the socio-economic dimensions of hunger, emphasizing the role of inclusive economic policies, women's empowerment, and education initiatives in eliminating food insecurity. Advancements in technology, like block chain and large data analytics, propose promising ways to optimize food supply chains. Technology-driven innovations enhance transparency, traceability, and efficiency in food distribution, minimizing wastage and ensuring equitable access to food resources.[27]

Achieving zero hunger requires significant course of action at the local, nationwide, and global levels. Martinez examined the efficacy of global initiatives like the UN's Zero Hunger Challenge, food assistance programmes, and subsidies for small-scale farmers. They stress the significance of global coordination of efforts.[28] The research on SDG 2 reveals the complexity of the issue and the need for diverse approaches to ensure sustainable food security. Scholars agree on the importance of interdisciplinary efforts, technological innovations, inclusive policies, and global collaboration to address the root causes of hunger comprehensively.

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[25]Agarwal, B., *Gender equality, food security and the sustainable development goals*. Current Opinion in Environmental Sustainability 34, 26-32. (2018)

[26]Caiado RGG, Leal Filho W, Quelhas OLG, de Mattos Nasci-mento DL, Ávila LV. *A literature-based review on potentials and constraints in the implementation of the sustainable development goals*. (J Clean Prod 2018; 198: 1276–88)

[27]*ibid*

[28]Sachs JD. *From Millennium Development Goals to Sustainable Development Goals*. Lancet 2012; 379:220611. doi:10.1016/S0140-6736(12)60685-0

Collaboration between policymakers, researchers, and communities is crucial, involving the integration of knowledge and evidence-based strategies to attain a hunger-free world by 2030.

1.5.3 Policies and Regulations Governing the usage of genetically modified technology in Agriculture in Kenya and South Africa

In Kenya and South Africa, different policies and laws govern the usage of genetically modified organism (GMO) technology in agriculture. According to Hall, Kenya's use of GMOs is governed by the Biosafety Act, which was passed in 2012. He emphasizes that the legislation establishes a legal framework for GMO evaluation and approval, including genetically modified crop cultivation, importation, and release. The act's goal, according to him, is to guarantee the harmless usage of GMOs while also guarding human well-being, biodiversity, and the environment.[29]

Kenya's approach to GMOs has been cautious. This affirms Tasma et al. argument that a 10-year ban on genetically modified crops had to be imposed before lifting the ban in 2023. The extent of cautiousness informed the decision to lift the ban which was accompanied by the approval of only specific genetically modified crops like Bt cotton, Bt maize, and genetically modified cassava. However Tasma et al. further point out that concerns have been raised about the lack of public participation and the potential threats connected with GMOs in Kenya, highlighting the importance of post-market surveillance and monitoring for unintended effects.[30]

[29]Hall, D. R., & Ruane, J., *Agricultural biotechnologies in developing countries: Options and opportunities in crops, forestry, livestock, fisheries*. Food and Agriculture Organization of the United Nations (FAO) (2013).
[30]Talsma, E. F., Brouwer, I. D., Verhoef, H., Mbera, G. N. K., & Mwangi, A. M. (2018). *Biofortified Cassava With Pro-Vitamin a is Sensory and Culturally acceptable for Consumption by Primary School Children in Kenya*. PLOS ONE, 13(2), e0192173. https://doi.org/10.1371/journal.pone.0192173

Conversely, South Africa presents an entirely distinct narrative. Tasma and other scholars argue that since 1996, South Africa has been a leader in the acceptance of genetically modified crops in Africa, with commercial cultivation having begun there. That being said, this does not mean that South Africa does not have regulatory frameworks. Tasma states that the National Environmental Management: Biodiversity Act of 2004 and the Genetically Modified Organisms Act of 1997 make up the legal framework for GMOs in South Africa. He claims that these laws guarantee the safe and controlled release and usage of genetically modified organisms, with the appropriate risk assessments and monitoring conventions in place.[31]

According to the United Nations, the use of GMOs in South Africa has improved agricultural output and sustainability. Cotton, soybeans, and maize are among the genetically modified crops that have been successfully gone commercial in the country.[32] This is affirmed by studies conducted by scholars such as Smith et al. which have shown that genetically modified crops have contributed to increased crop yields and reduced pesticide consumption, helping both large- and small-scale farmers.[33] South Africa's adoption of GMOs has been driven by the possible financial paybacks and the need to address the country's food security challenges.[34]

1.5.4 Challenges South Africa and Kenya face in Adopting GM Technology for the achievement of SDG2

Wambugu and Kamanga's points emphasize several important factors that contribute to the widespread hostility to genetically modified organisms (GMOs). They contend that Kenya

[31]*ibid*
[32]United Nations., *Sustainable Development Goals: 2 Zero Hunger*. Retrieved from https://www.un.org/sustainabledevelopment/hunger/
[33]Smith, J. R., & MacGregor, J. T., Genetically modified organisms and the environment: Current status and challenges. *In Environmental Science & Technology*, 36(4), 94A-101A (2002).
[34]United Nations. (n.d.). Sustainable Development Goals: 2 Zero Hunger. Retrieved from https://www.un.org/sustainabledevelopment/hunger/

faces numerous challenges that prevent widespread use of GM technology. The regulatory framework's delays and inconsistencies create uncertainty, which in turn lessens interest in funding and research in biotechnology.[35] Diverse public opinions on GM crops in Kenya are influenced by advocacy groups and safety concerns, making it more difficult to win over the public and convince them to adopt GM crops. Inadequate infrastructure for the distribution of genetically modified crops and unequal access to resources, particularly for small-scale farmers, are additional barriers. Concerns over intellectual property rights are also present, particularly in light of multinational businesses' sway over GM seeds.[36]

According to Paarlberg R, South Africa's problems are primarily caused by cumbersome yet potentially slow-moving regulatory barriers. Additionally, due to strict rules controlling GM products, entering overseas markets—particularly in Europe—poses a tremendous obstacle. Additional levels of complexity are added by public discontent and resistance, which are motivated by worries about safety, potential environmental effects, and the monopoly of corporate seed management. Additionally, benefits are not distributed equally, with small-scale farmers having trouble getting GM resources. South Africa has a strong biotechnology industry, but it needs to expand into rural regions if this technology is to be adopted fairly and widely.[37]

According to both scholars, there are common problems that need to be solved. These include a lack of access to international markets because of limitations on GM crops, which emphasizes the necessity of aligning laws and regulations with SDG2 goals. Implementing capacity-

[35]Wambugu F, Kamanga D., *Biotechnology in Africa. Emergence, Initiatives and Future.* (Nairobi, Kenya: Springer International Publisher Switzerland, 2014).
[36]Wangari D., *GMO position in Kenya* (Personal Communications, 2019)
[37]Paarlberg R., *Starved for science: how biotechnology is being kept out of Africa*. (Cambridge: Massachusetts Harvard University Press; 2009).

building initiatives geared at teaching farmers and academics about GM technology is essential. Concerns about environmental sustainability, such as potential effects on non-target creatures and biodiversity, must also be addressed. Setting up logical policies that seamlessly incorporate GM technology into larger agricultural development objectives and guarantee that the advantages be spread equally among all facets of the population are essential if SDG2 is to be achieved. Governments, public society, and the commercial sector must work together to overcome these complex problems.

1.5.3 Gap in the Literature

This research aims to fill a critical knowledge gap by conducting a comprehensive comparative analysis of South Africa and Kenya concerning genetically modified organisms (GMOs). Its primary goal is to provide a more in-depth understanding of the current state of GMO research, development, and regulatory frameworks in these countries, as well as their impact on SDG 2, which focuses on food security. The findings of this study have significant potential value, not only for South Africa and Kenya, but also for stakeholders, policymakers, and researchers across Africa and globally. The insights acquired from this research have the potential to shape the creation of effective strategies that can optimize the advantages of GM technology while addressing concerns linked to its acceptance and implementation.

1.6 Hypotheses

H1: African countries can learn from South Africa's GM Technology adoption for SDG2 by 2030.

H2: Policies and regulations in Kenya and South Africa affect GMO adoption in agriculture.

H3: African nations encounter challenges in GM Technology for SDG2.

1.7 Study Justification and significance

The importance of doing a research study that contrasts GM technology and the attainment of SDG2 in South Africa and Kenya is highlighted by this policy and academic justification. The study's goal is to learn important things about how genetically modified crops affect sustainable farming practices, nutrition, and food security. By examining the experiences of these two nations, the study seeks to generate evidence-based policy suggestions that might direct the appropriate application of GM technology in Africa and aid in the achievement of SDG2.

1.7.1 Policy Justification

Since development is a fundamental aim for any nation, all governments expect to have accomplished their sustainable development targets by 2030. The study's conclusions will help to educate decision-makers in the development and planning processes. The Ministries of Agriculture, Education, Science, and Technology, as well as other relevant government bodies, will be particularly important. They will use this research as a starting point for determining how genetically modified technology fits within Goal 2 of the Sustainable Development Agenda in general. Furthermore, this study will present policy suggestions to help Kenyan and South African decision-makers understand the significance of genetically modified technology in achieving SDG2.

1.7.2 Academic Justification

Despite Africa's growing acceptance of GM technology, there is a notable lack of policy direction and comprehensive research that investigates the experiences of different nations. This research intends to fill that knowledge gap by performing a comparative examination of South Africa and Kenya. This will reveal significant insights into the challenges, successes, and key lessons learned from their diverse approaches to GM technology.

1.7.3 Public Justification

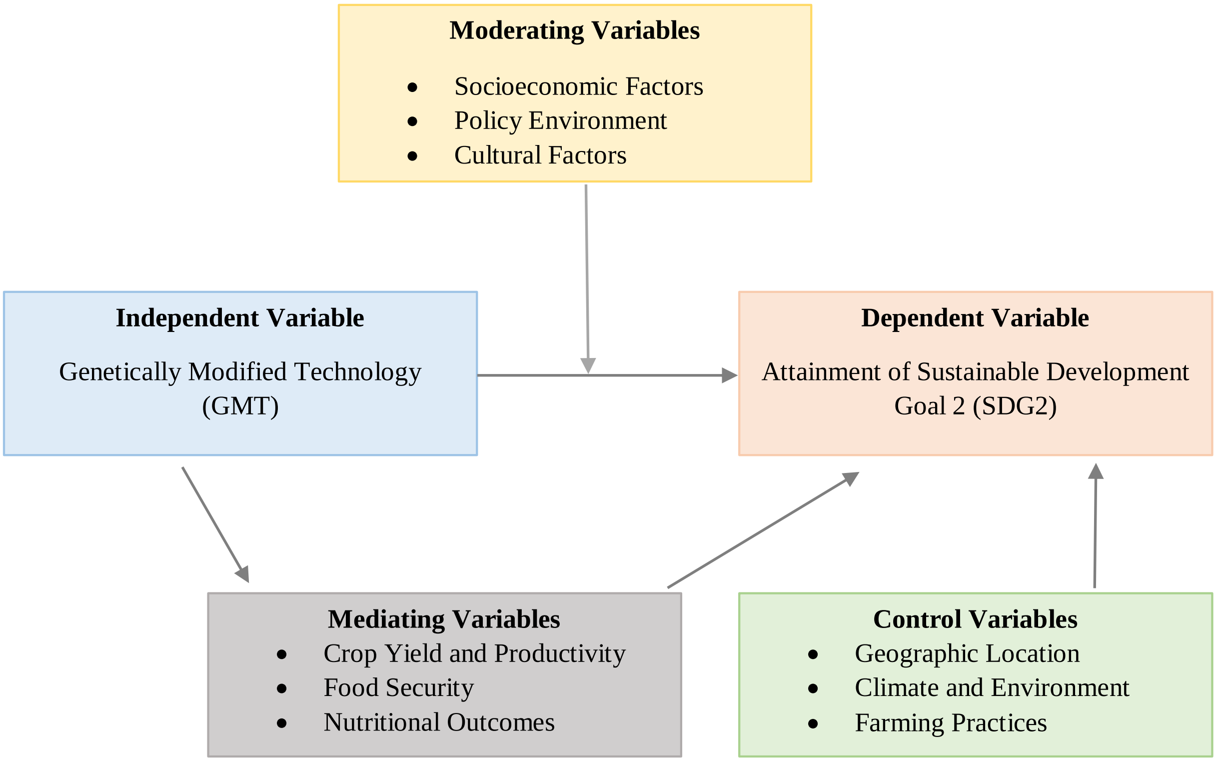
The study will provide the public with valuable insights into how genetically modified (GM) technology influences food security and sustainable agriculture in Africa. Through a comparative examination of South Africa and Kenya, this research will enhance understanding of how GM technology affects food security, its environmental and health consequences, and its socio-economic impacts. This knowledge will empower the public to make informed choices about food production, consumption, and policy formulation, eventually leading to better food security, more sustainable agricultural practices, and increased economic opportunities. The study will also encourage the sharing of knowledge and informed public discourse, enabling citizens to actively participate in shaping policies and practices related to GM technology in agriculture. In the end, this will contribute to a more prosperous and food-secure future for African communities thus achieve zero hunger by 2030.

1.8 Conceptual Framework

A conceptual framework delineates the connections between various elements within a research inquiry as described by stated by scholars, Anfara and Mertz. These connections serve as a guiding compass for the researcher's methodological approach to the research, influencing the selection of data to be collected and the method in which this information is to be analyzed. By explicitly elucidating the interrelationships among these concepts, researchers can substantiate the significance of their study and the meticulousness of their research design. Equally crucial, these frameworks aid readers in comprehending why certain aspects of a system were left unexamined in the study.

This study employs a conceptual framework that provides a systematic technique for appreciating the complicated interplay between genetically modified technology and SDG2 success in Africa, with a particular emphasis on South Africa and Kenya. The study aims to give significant insights into the policy and implementation of GM technology in agriculture to support sustainable development by exploring these relationships.

Figure 1.1: The Relationship between GMT and Attainment of SDG2 in Africa



The research findings present a complete framework based on critical variables. Genetically Modified Technology (GMOs) is the usage of chromosomal engineering methods to change the genetic composition of organisms, primarily crops, for a variety of agricultural applications. The dependent variable is the achievement of SDG 2 in Africa, with the purpose to eradicate hunger, provide food safety, increase nutrition, and encourage sustainable agriculture across the continent. This framework involves several intervening factors of significant importance. To begin with, the efficiency and yield of GM crops in comparison to traditional crops directly impact food production and, thus, hold the potential to influence the achievement of SDG2. Additionally, the research addresses the evaluation of GMOs' ecological effects on soil health, biodiversity, and overall environmental sustainability.

Social and economic factors are equally important. These include the analysis of market dynamics, resource accessibility, and farmers' livelihoods—all of which are closely linked to the uptake of genetically modified organisms (GMs). Additionally, each nation's laws and regulations pertaining to genetically modified organisms (GMOs) have the power to influence the rate at which these organisms are adopted and, in turn, the way in which SDG2 advances. The degree of public knowledge and opinion about genetically modified organisms (GMOs) in the agricultural context can have a big impact on whether or not they are accepted and included into farming methods, which in turn can have a big impact on the final results of SDG2 in Africa.

1.9 Research Methodology

The methodology of this study will involve scrutinizing the adoption of genetically modified (GM) technology and its influence on the achievement of SDG2 in South Africa and Kenya. This study will employ primary and secondary data will complement each other and so enrich the study. The composite technique provides an all-encompassing portrayal by recognizing patterns and generalizations while also offering a complete comprehension of the participants' points of view. The approach will outline the primary and secondary data gathering techniques that will be used in this study. Interviews and participant questionnaire distribution will be the main approaches used to collect data for this research. The approach will include the methods for choosing participants, gaining their consent, and ensuring that ethical concerns are addressed.

Secondary data collecting approaches for this study, on the other hand, will include gathering information from published academic literature, reviewing reports, and searching publically available government and organization databases. The technique will go over the criteria for choosing appropriate secondary sources, data extraction processes, and data analysis. The approach will also include the study design, data collection, and analysis procedures that will be used in this study.

1.9.1 Research Design

According to Creswell and Clark, study design is "the techniques used in gathering, analyzing, interpreting, and presenting data in research investigations." According to Grey, the study design specifies the method for getting relevant data, the tools for collecting and evaluating such data, and how these activities will help to answering the research question. Because this is a case study, the research design will be qualitative. The qualitative technique might disclose the target audience's behavior and perceptions. The research will determine the utilization of GM technology and its influence on SDG2 indicators in South Africa and Kenya.

1.9.2 Research Site

Research site refers to a physical, social and cultural setting which a study is conducted. The study will be conducted in Kenya and High Commission of South Africa. The study will be conducted with a focus on participants from national government, Ministry of Agriculture-State Department for Crop Development, The Kenya Agriculture Reforms & Innovations (KARI), Kenya Agricultural and Livestock Research Organization (KALRO) and INGOs such as FAO, WFP and other NGOs in support of Agriculture in Kenya and South Africa.

1.9.3 Study Target Population

According to Onen, the word "target population" refers to the entire population or things to whom a researcher hopes to apply the results of their research. This group must fulfill specific parameters that the researcher is interested in. The research's target demographic will include three departmental-level employees from the Ministry of Agriculture, Livestock, Fisheries, and Co-operatives, ten employees from KARI and KALRO, three departmental heads from FAO, and nine employees from the Nairobi County Department of Agriculture, Irrigation, Livestock, and Fisheries. This brings the total population of the target population to 100. Primary data from the target population will be collected through interviews and questionnaires. Further, secondary data on GMTs will be acquired via open access government databases and official papers.

1.9.4 Data Collection

The study aims to collect primary data in South Africa and Kenya by utilizing surveys, interviews, and field visits. It will involve farmers, scientists, policymakers, and other stakeholders to gain valuable insights into the influence of genetically modified (GM) Technology on achieving SDG2. The surveys will employ structured questionnaires to quantitatively gather information from relevant key-informants regarding their knowledge, perceptions, and adoption of GM technology, as well as the effects on their agricultural practices and SDG2-related outcomes. Key informant will be interviewed in-depth and experts to qualitatively explore their viewpoints, experiences, and challenges associated with GM technology and SDG2 progress. Moreover, secondary data of existing policy documents, reports, and scientific literature will be carefully examined to comprehend the regulatory frameworks, policy context, and scientific evidence concerning GM technology and its relationship with SDG2 in each country.

1.9.5 Research Sample Size

For data collection using questionnaires, a sample size of 20 respondents in the Nairobi and South Africa were explored. Ten important informants from various government and non-government groups were also interviewed using an interview schedule.

1.9.6 Data Analysis

Analyzing data entails using numerical and factual information to meet the study question. It aids in providing solutions to research issues by recognizing, converting, and giving cohesiveness to a study. The data will be examined in line with the study's objectives. The study will employ qualitative data analysis, enabling the collection of rich and nuanced information. This approach will facilitate a comprehensive exploration of individuals' thoughts and behaviors concerning the research topic, providing a deeper understanding of the research topic.

1.9.7 Research Ethical consideration

As the cornerstones to guide a researcher around designing an ethically acceptable research, Fleming and Zegwaard highlight informed consent of participants, protection of participants from risk of harm, anonymity of participants and confidentiality of participants, and lack of conflict of interest from the researcher. According to Bryman and Bell, research ought not to damage participants; it should respect their dignity and privacy, acquire consent and maintain confidentiality, and prevent bias throughout data collection, analysis, and presentation. Recognizing the sensitive ties between the researcher and respondents, the study will take ethical issues and regulations into account. To that end, adequate safeguards will be put in place to ensure the security of the information given by respondents during the research. In this regard, all respondents received an introduction letter before the interview, which will be given to them with permission from the University of Nairobi and NACOSTI. The study will be conducted with the informed consent of the respondents, ensuring that they had access to the necessary information and the freedom to actively agree to or deny involvement in the research.

1.9.8 Scope and Limitation of the Study

This project focuses on GMT policy developments in South Africa and Kenya from the late 1990s, when research into GMOs began in Kenya and South Africa, to the present. The work will primarily focus on the SDG2 debate, which has gained traction among many researchers and policymakers. The study will extensively investigate the question of whether genetically modified technologies (GMTs) have the likely to facilitate sufficient food production to feed the global population, the goals of eliminating hunger, assuring food security, enhancing nutrition, and progressing sustainable agriculture are also addressed. This study will primarily investigate GMTs and the achievement of SDG2. However, the following issues will limit the research. First of all, the research will be confined to the opinions of the study participants, and hence may not represent the views of the larger public. Second, the study will be constrained by the availability of relevant data and resources, and it may be unable to capture all important determinants affecting GMTs in SDG2 achievement. Furthermore, the investigation will be constrained by time restrictions.

1.10 Chapter Outline

This section outlines the structure of the research study and establishes the order in which the chapters will be presented throughout the entire research project.

Chapter One, serves as the introductory section of the research study, providing an overview of the broad context within which the study is placed. This chapter encompasses the statement of the problem, the justification of the study, the theoretical framework, an wide-ranging evaluation of the present texts, and ultimately, the methodology employed in the study.

Chapter Two centers on examining the Acceptance of Genetically Modified Technologies in Africa and its contribution to the realization of Sustainable Development Goal 2 (SDG2).

Chapter Three, looks at the extent of how policies and regulations governing the use of genetically modification technology in agriculture in Kenya and South Africa.

Chapter Four, discusses the challenges South Africa and Kenya face in Adopting GM Technology for the achievement of SDG2.

Chapter Five constitutes the study's conclusion, summarizing the major findings from the research.

CHAPTER TWO

IMPLEMENTATION OF GENETICALLY MODIFIED TECHNOLOGIES IN AFRICA AND ACHIEVEMENT OF SDG2

2.0 Introduction

This chapter delved into the implementation of genetically modified technologies in Africa and their role in advancing Sustainable Development Goal 2 (SDG2). It also discussed the efforts of African nations in developing and embracing GM technologies to make progress toward achieving SDG2. Agriculture is crucial for African economic development, contributing about 35% to the GDP and employing around 70% of the workforce. However, the sector faces significant challenges and disappointing statistics. Approximately one-third of African countries suffer from drought and chronic hunger, despite 70% of the population being involved in agriculture. The continent still imports 25% of its food, and farm productivity is declining, with limited access to better seeds for less than 30% of farmers. The hesitancy to embrace the "gene revolution" in agriculture is puzzling. While some factors explain this, transforming traditional techniques is essential. Unlike other emerging economies, Africa's adoption of genetically modified (GM) technology has been low. The debate over GM technology remains unresolved. A distinguished African panel on genetically modified (GM) technology has urged the African Union (AU) to support informed regional multi-stakeholder talks within the Consolidated Plan of Action (CPA) for Science and Technology in order to resolve these issues.

2.1 Genetically Modified Technology: Conceptual Analysis

2.1.1 Synopsis of the Agricultural Sector in Africa

Africa's economy depends heavily on agriculture, yet the continent's unrealized potential has resulted in continued poverty and deteriorating food security. By 2025, there are expected to be 320 million undernourished individuals, up from roughly 240 million in 2015. African nations are facing increasing pressure to diversify their exports and reduce trade deficits due to the declining prices of commodities. Nonetheless, the upward trend in net food imports, projected to reach $110 billion by 2025, can be attributed to the increasing need for food driven by urbanization and population increase.[38]

To tackle these challenges, there is an opportunity to transform agriculture into a thriving business. The key is to stimulate a vibrant private agribusiness sector that can cater to the growing demand for food imports. Successful transformations in other countries like Brazil, Malaysia, and Vietnam provide valuable lessons. Three simultaneous conditions are required for success: widespread adoption of productivity-increasing technology, development of market structures to realize enhanced output value, as well as a well-functioning private sector, will fuel long-term agricultural growth. These circumstances are made possible in large part by the public sector, through reforms, liberalization of input markets, innovative financing, and infrastructure development. Coordinated efforts involving both public and private sectors are needed, considering the substantial resources required for the transformation.[39]

The strategy proposes concentrating on specific value chains and agro-ecological zones to cultivate markets worth $85 billion annually by 2025. Due to the escalating consequences of climate change, the adoption of climate-smart agriculture becomes imperative. The plan aspires for inclusive and green growth, with an emphasis on historically neglected people and climate-

[38]AFDB, *Feed Africa Strategy for agricultural transformation in Africa 2016–2025,* https://www.afdb.org/fileadmin/uploads/afdb/Documents/Policy-Documents/Feed_Africa-Strategy-En.pdf
[39]*ibid*

smart practices. Agriculture holds great potential to drive inclusive growth and improve livelihoods in Africa, particularly for those in rural areas, women, and youth.[40]

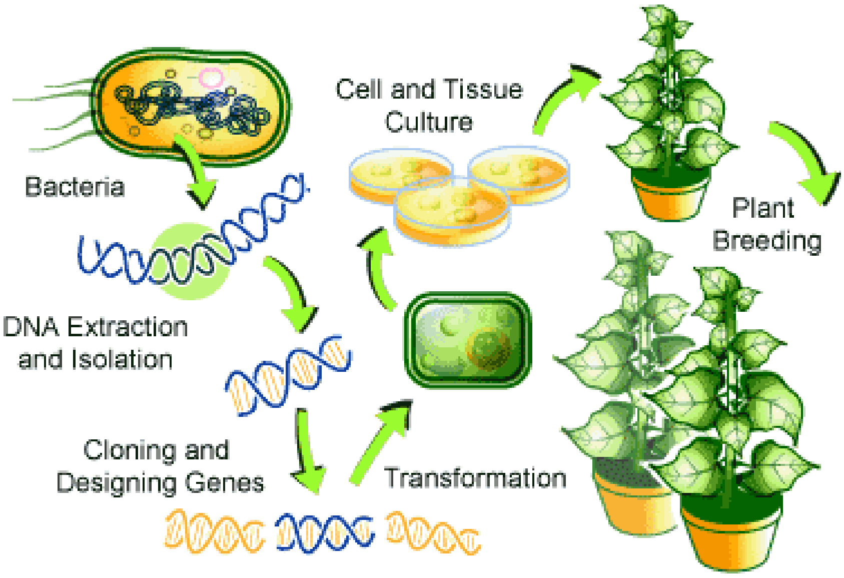
2.1.2 Definition and Principles of GM Technology

Throughout history, humans have cultivated plants with desirable traits, like higher yields, disease resistance, and improved nutrition. Early civilizations practiced artificial selection, leading to the rapid development of advantageous plant varieties. Lately, genetically modified (GM) crops have been created by introducing specific genetic material to confer beneficial features, such as environmental resilience, pest resistance, and improved quality. GM crops can withstand herbicides, pests, drought, and produce higher yields. Importantly, these modified foods retain their nutritional value, making them valuable for ongoing use while maintaining their beneficial properties.[41]

The term "genetically modified" (GM) denotes the “relocation of genes from one species to another via laboratory techniques such as cloning and DNA splicing”. This is also referred to as recombinant DNA technology. While "genetically modified" can be ambiguous, it commonly denotes the use of recombinant DNA technology. It's essential to recognize that most of our food has been genetically modified through domestication and selective breeding for desired traits. This phrase is used due to its association with recombinant DNA technology.[42]

[40]Abdallah, N. A., Moses, V., and Prakash, C. S., The impact of possible climate changes on developing countries: The needs for plants tolerant to abiotic stresses. *GM Crops Food 5* (2), 77–80 (2014). doi:10.4161/gmcr.32208
[41]Sprink T, Eriksson D, Schiemann J and Hartung F., Regulatory Hurdles for Genome Editing: Process- Vs. Product-Based Approaches in Different Regulatory Contexts, *Plant Cell. Rep*. 35 7 1493–506 2016
[42]Federoff, N., *Mendel in the Kitchen: A Scientist’s View of Genetically Modified Food*. (National Academies Press, Washington, D.C, 2004) Available at www.nap. edu/catalog.php?record_id=11000

Figure 2.1: illustrates how a gene may be modified genetically by being isolated and then inserted into the genetic code of a host organism.



Source: Oregon State Education

The Flavr SavrTM tomato, which marked the first commercially available genetically modified product, had a gene inserted to slow down ripening while preserving its original color and taste. It gained resistance to spoilage and softening, authorized by the US FDA in 1994. Common GM crops include oilseed rape, soybean, corn, and cotton, with added herbicide and pesticide resistance.[43]

"Golden Rice" is another example of a genetically modified crop designed to produce 20 times more beta-carotene than other rice types. This essential nutrient can be generated by incorporating genes from both bacteria and daffodils, which the human liver subsequently converts into vitamin A. Another strain of genetically modified rice uses genes from Aspergillus fumigatus and Phaseolus vulgaris to counteract iron deficiency. These genes enhance iron absorption by producing a protein that binds iron and an enzyme that breaks down

[43]Schmidt C W., Genetically modified foods: breeding uncertainty *Environ. Health Perspect*. 113 8 A526–A33, 2005

phytate, an iron inhibitor. These advancements in genetic modification offer potential solutions to address nutritional deficiencies in rice consumption.[44]

Figure 2.2: Golden rice grains (left) have been genetically engineered to be enhanced with beta-carotene. White rice grains on the right.

Source: International Rice Research Institute/Isagani Serrono

2.1.3 GM Technology Development and Adoption in Africa

Africa faces a paradox of food insecurity amidst rapid advancements in agricultural technology. While other developing regions embrace modern biotechnologies like GM technology, Africa is still embroiled in controversies concerning its function and safety in food production and long-term development. Mixed reactions from the EU regarding GM technology, as Africa's major trade partner, has influenced African politics. Nevertheless, African decision-making should consider local contexts and prioritize what is best for the continent.[45]

Subsequently the introduction of the first genetically modified crop and the development of GM technology, have seen few African countries get involved in the investigation, growth, and commercialization of genetically modified crops. Despite facing agricultural challenges and food poverty, African funding for agricultural genomics research remains minimal. South

[44]ISAAA., Global status of commercialized biotech/GM crops *ISAAA Brief* no. 54. ISAAA Ithaca NY, 2018
[45]Lassoued, R., Phillips, P. W., Macall, D. M., Hesseln, H., and Smyth, S. J., Expert opinions on the regulation of plant genome editing. *Plant Biotechnol.* J. 19 (6), 1104–1109. (2021). doi:10.1111/pbi.13597

Africa, the leading adopter of GM technology on the continent, invests far less in GM Technology research, particularly genomics, in comparison to states like South Korea, China, India and Brazil. This lack of investment hinders Africa's potential to address agricultural issues through genetically modified crops, leaving the continent significantly behind in global GM Technology research efforts.[46]

Research on genetically modified (GM) agriculture in Africa primarily takes place in South African public universities and national agricultural research institutes. Other active countries include Nigeria, Kenya, Egypt, Uganda, and Mauritius. International and regional organizations also play a role in GM crop research on the continent. South Africa, Egypt and Burkina Faso lead in adopting agricultural GM Technology, with significant areas of GM crops planted. Under 0.1 million hectares of Bt maize were grown in Egypt in 2011, 0.3 million hectares of Bt cotton were cultivated in Burkina Faso, and 2.3 million hectares of genetically modified cotton, soy beans, and maize, were grown in South Africa. These figures highlight the significant role these countries played in embracing GM technology in Africa.[47]

2.1.4 Africa GM Technology Regulatory Framework

A greater number of African nations are enacting GMO rules and restrictions, however, the extent of development and application varies. Numerous African nations have ratified the Cartagena Protocol on Biosafety, mandating the establishment of suitable legal and administrative frameworks to effectively regulate GMOs. By 2009, eleven nations had national

[46]FAO., How to Feed the World in 2050. Report of the High-level Experts Forum, *UN Food and Agriculture Organisation (FAO)* 2009, Rome.

[47]Makinde, D. et al.., Status of GM Technology in Africa: Challenges and Opportunities. *Asian GM Technology and Development Review*, Vol. 11 No. 3, pp 1–10. 2009

biosafety frameworks in place, with twelve having interim frameworks. By the end of 2011, fourteen countries have fully implemented GMO laws.[48]

2.1.4.1 The Cartagena Protocol on Biosafety

The main goal of the 1996-established Cartagena Protocol on Biosafety (CPB), a trade pact linked to the Convention on Biological Diversity, is to guarantee the secure handling and cross-border transfer of living organisms altered by modern biotechnology (LMOs). Its main goal is to stop these genetically modified organisms from travelling across international borders in a way that could endanger human health or biodiversity. With 160 parties—including the European Union—the protocol went into effect in 2003. Notable exceptions include the United States, Canada, and Russia. The Cartagena Protocol is noteworthy for having been signed by 52 African nations, including South Africa, Kenya, Algeria, Angola, Uganda, and Tanzania, demonstrating its importance in the region.[49]

The CPB shapes national regulatory systems for genetically modified organisms (GMOs) and covers liability, socioeconomics, public participation, labeling, and GMO detection, triggering debates among parties. It mandates international rules for compensating damages from GMO movements, with three types of liability: civil, administrative, and strict liability. The Supplementary Protocol on Liability and Redress (SP-NK) specifically addresses issues related to administrative liability, guiding damage assessment and response measures.[50] African countries face challenges adopting biotechnology due to insufficient regulatory systems, capacity, transparency, and historical trade ties with Europe and food security concerns. The CPB supports capacity-building projects spearheaded by the UN Environment Programme-

[48]Jones, H. D., Regulatory uncertainty over genome editing. *Nat. Plants*, 1(14011), 10-1038. (2015).
[49]African Agricultural Technology Foundation (AATF), Practical solutions for farmers. *Annual Report*. AATF, Nairobi (2020)
[50]Juma, C., *New Harvest: Agricultural Innovation in Africa*. (Oxford University Press, 2011)

Global Environment Facility (UNEP-GEF). The CPB significantly impacts biotechnology regulation in Africa, shaping national legislation and fostering participation in biosafety efforts.[51]

2.1.4.2 African Union (AU) Model Law

The Organisation of African Unity (OAU) hosted a conference in Addis Ababa in 1999 where the African Union (AU) Model Law on Safety in Biotechnology—previously known as the African Model Law on Safety in Biotechnology—was developed. It guides biosafety regulatory policy in Africa and was proposed by the African Group to the CBD Secretariat in 1996. The law aims to serve as a basis for national biosafety regulations among AU member states. Critics argue that the law is too restrictive, emphasizing risks over benefits of agricultural biotechnology. The AU acknowledges the need for a balanced approach, encouraging African countries to contribute to biotechnology advancements. Revisions have been made, and a final version was presented in 2008. The law covers various aspects of GMOs, including import, export, containment, release, and marketing. It enforces stringent regulations rooted in the precautionary principle, giving significant emphasis to public participation, traceability, labeling, and liability mechanisms.[52]

However, some provisions hinder progress for countries interested in adopting GM technologies. Case-by-case decision-making may not align with best practices in some countries, and regionally binding decisions conflict with national regulations. The strict liability stance raises concerns, as many countries haven't adopted it. Debates continue on the law's utility, leading to different regulatory schemes and potential trade issues due to porous

[51] *ibid*
[52] Ahteensuu, M., Assumptions of the deficit model type of thinking: Ignorance, attitudes, and science communication in the debate on genetic engineering in agriculture. J. Agric. *Environ. Ethics* 25, 295–313. (2012). doi:10.1007/s10806-011-9311-9

borders and weak enforcement. Adaptations and ongoing discussions are vital to address limitations and promote biotechnology's safe development in Africa.[53]

2.1.4.3 Regional Approach-The Economic Community of West African States (ECOWAS)

In order to address biosafety issues in the region, the Common Market for Eastern and Southern Africa (COMESA) launched the Regional Approach to Biotechnology and Biosafety Policy (RABESA) initiative in 2003. Partner organizations such as ASARECA, PBS, and ISAAA provided their support to COMESA in this endeavor. To effectively execute the RABESA project, ACTESA was established in 2009 as a specialized entity under the COMESA framework.[54]

For a unified regional biosafety strategy, RABESA concentrated on three important areas: (1) commercial GM crop planting; (2) GM product trading; and (3) GM-containing emergency food relief. For each topic, officials from each nation and regional specialists worked together to establish policies and guidelines. For commercial planting, a regional committee conducted risk assessments of GMOs intended for planting within the region. This evaluation was used by state officials to help them make authorization decisions. Different policies applied to the trade of genetically modified (GM) products based on whether they came from within or outside the COMESA region. Guidelines for examining and authorizing emergency food aid including genetically modified organisms (GMOs) were also created for both COMESA and non-COMESA nations.[55]

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[53]Clark, N., Mugabe, J., and Smith, J., *Governing agricultural biotechnology in Africa building public confidence and capacity for policy-making*, (2014).
[54]African Union Agenda 2063., The Africa we want. *African Union Commission*. 978-92-95104-23-5. (2015)
[55]*ibid*

A regional biosafety council and a Panel of Biotechnology and Biosafety Experts were formed in 2007 with approval from COMESA (Common Market for Eastern and Southern Africa) ministers in order to offer technical regulation. This process included technical evaluations and national workshops for feedback and endorsements. By July 2011, most member states had taken part in these workshops, and the finalized biosafety policies received official endorsement in September 2013 in Addis Ababa. The policy proposals were ratified by the COMESA Council of Ministers during their meeting in Kinshasa in February 2014. This regionalized risk-assessment procedure streamlined the approval of GMOs' regulation in member states and promoted uniform standards for regional trade, including emergency food aid involving genetically modified products.[56]

2.1.4.4 The West African Economic and Monetary Union (WAEMU)

In 2008, WAEMU and ECOWAS forged a partnership to initiate a regional biosafety project. Initially, the project's primary objective was to develop biosafety regulations for WAEMU member states. Nevertheless, as the project progressed, both organizations mutually decided to cooperate on a unified regional biosafety framework applicable to all West African nations. They conducted consultative meetings in member countries to gather input on the draft framework.[57]

The draft of the regional biosafety framework for ECOWAS/WAEMU was released to the public in 2012, marking the national consultation phase. This draft was notably different from the earlier version created with CILSS. For the purpose of certifying commercial GMO goods

[56]Bediako, Y., *African biotech holds the key to transforming not just the health of African people, but our economies as well* (2022). Accessed: https://speakingofmedicine.plos.org/2022/11/29/african-biotech-holds-the-key-to-transforming-not-just-the-health-of-african-people-but-our-economies-as-well/.
[57]Egwang, T. G., Biotechnology issues in Africa. Electron. *J. Biotechnol*. 4 (3), 23–24 (2001). doi:10.2225/vol4-issue3-fulltext-12

and promoting commerce, it suggested a centralized organization with substantial decision-making authority. Nonetheless, the proposed document included contentious topics such as considering socioeconomic and ethical aspects in the licensing process and creating rigorous accountability and compensation measures for any harm caused by GMOs.[58]

Feedback on the draft framework from member states and international stakeholders was mixed, leaving its future progress and potential changes uncertain. It remains unclear whether the document will advance in its current form or undergo modifications based on the consultation process.

2.1.4.5 The Southern African Development Community (SADC)

The fifteen member nations that make up the Southern African Development Community (SADC) created an Advisory Committee on Biotechnology and Biosafety in 2003. The committee's major purpose was to synchronize regional plans pertaining to biosafety laws, capacity building, and public awareness. The committee adopted a cautious approach when creating its biosafety rules, using ideas from the African Model Law. These regulations attempted to shield participant nations against possible dangers associated with genetic resource contamination, the safety of food for humans and animals, and ethical and trade-related issues, such as consumer anxieties.[59]

However, in recent years, the effort to achieve regional harmonization has faced challenges due to divergent and polarized viewpoints among member states. The inability to reach a consensus has hindered progress in implementing the recommended biosafety guidelines.[60]

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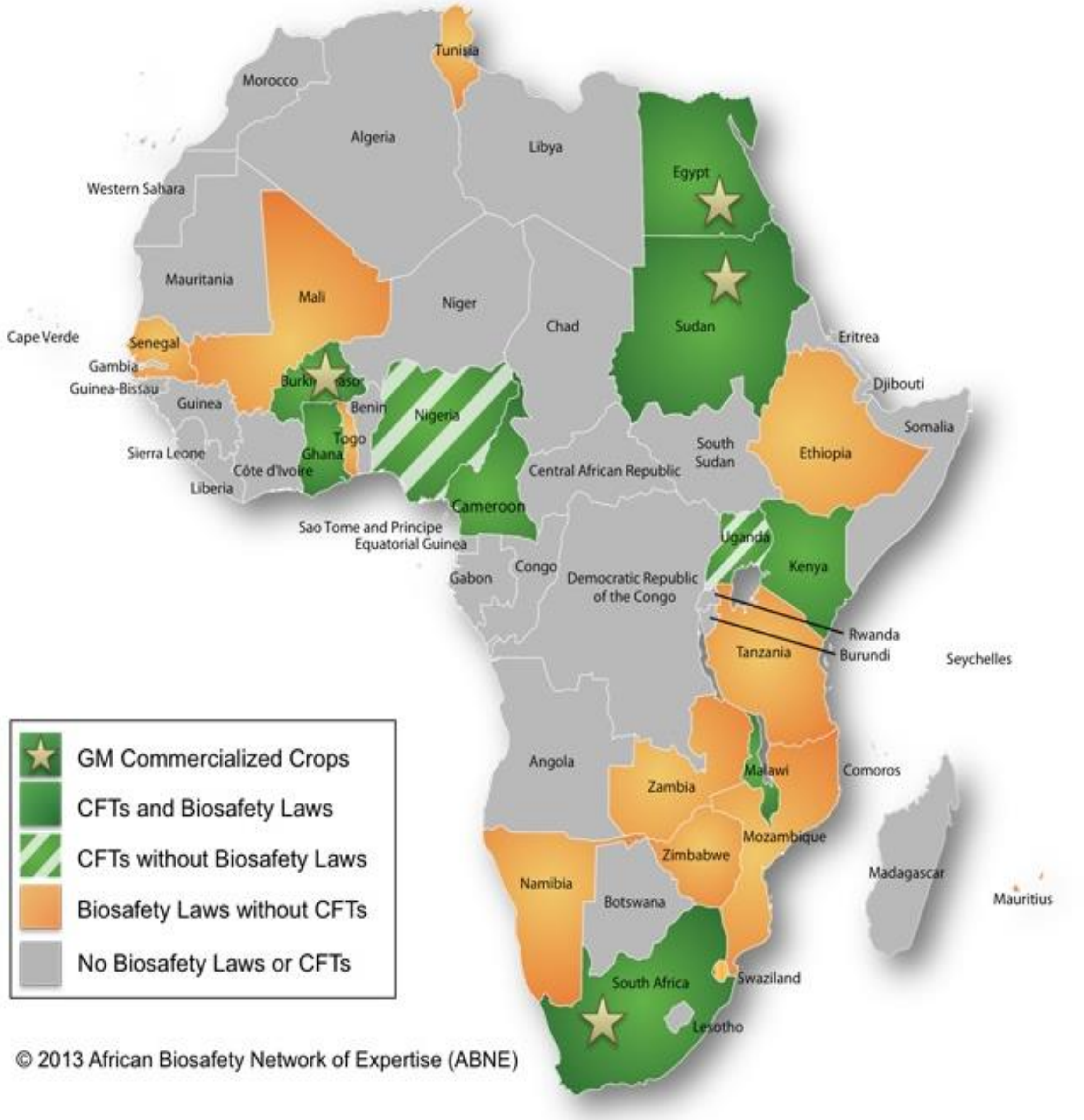
[58] *ibid*

[59] Gbadegesin, L. A., Ayeni, E. A., Tettey, C. K., Uyanga, V. A., Aluko, O. O., Ahiakpa, J. K., et al., GMOs in Africa: Status, adoption and public acceptance. *Food Control*.109193. (2022)

[60] *ibid*

Figure 2.3. Status of Biosecurity Frameworks in Africa



Status of Crop Biotechnology in Africa

Source: African Biosafatey Network of Expertise (ABNE)

Table 2.1: GM agricultural research experiments documented in Africa

Country	GM crop
Burkina Faso	Bt cotton (approved for commercialisation), cowpea (insect resistance)and sorghum (biofortified)
Egypt	Maize, (insect resistance; approved for commercialisation), cotton (salt tolerance), wheat (drought tolerance), potato (viral resistance), cucumber (viral resistance), melon (viral resistance) and tomato (viralresistance)
Kenya	Maize (insect resistance), maize (Striga resistant), maize (drought tolerance), cotton (insect resistance), cassava (viral resistance), sweet potato (viral resistance) and sorghum (biofortified)
Mozambique	Maize (drought tolerance)
Nigeria	Cassava (nutrient enhancement), cowpea (Maruka insect resistance), sorghum (biofortified)
South Africa	Maize (drought tolerance), maize (herbicide tolerance), maize (insect resistance), maize (insect and herbicide tolerance), maize (viral resistance), potato (insect resistance), cotton (insect and herbicide tolerance), soybean (herbicide tolerance), sugarcane (insect and herbicide tolerance), sugarcane (viral resistance, increased yields and alternative products), cassava (biofortified), cassava (modified starch),sorghum (biofortified)
Uganda	Banana (fungal resistance), banana (biofortified), maize (drought tolerance), maize (Striga resistance), Bt cotton (insect resistance), cotton (herbicide tolerance), cassava (viral resistance), cassava (insectresistance) and sweet potato (weevil resistance)
Zimbabwe	Cowpea (insect resistance)

Source: African Biosafety Network of Expertise (ABNE) Database, AU/NEPAD

2.2 Sustainable Development Goals (SDGs)

The SDGs were formed in response to the completion of the Millennium Development Goals (MDGs) in 2015. The SDGs emerged due to the failure of many countries to meet the 2015 deadline set by the MDGs. They emphasize sustainability and aim to address the shortcomings of the MDGs. Building upon the progress and knowledge gained during the MDGs' existence from 2000 to 2015, the SDGs expanded upon these achievements. There are significant differences between the two initiatives. While most of the MDGs were mainly directed at developing countries, the SDGs are designed to be relevant to all governments and citizens worldwide. The SDGs consist of seventeen goals, in contrast to the eight that composed the MDGs. In the next decade, UN member states are required to incorporate these 17 goals, which constitute agreed universal objectives with specific objectives and pointers, into their national agendas and programs. While these objectives are integrated into the national development plans of most UN members, it remains to be seen whether these governments will be able to achieve these targets by 2030.[61]

In September 2015, the historic United Nations General Assembly summit saw an overwhelming approval of the 2030 Agenda for Sustainable Development by all 193 member states. This agenda encompasses 169 targets associated with the 17 goals. The UN SDGs signify a universal initiative intended to eradicating poverty, preserving the environment, and guaranteeing prosperity for everyone. Adopted unanimously by all UN Member States in 2015 through Resolution 70/1, these goals set 2030 as the target year. The SDGs have a broader scope than the Millennium Development Goals (MDGs), addressing a wider range of issues such as poverty, inequality, economic growth, quality employment, industrialization, urbanization, ocean conservation, ecosystems, energy, sustainable production and consumption, justice, and peace. Importantly, the SDGs are not restricted to specific countries; they are applicable to all nations.[62]

The Addis Ababa Action Agenda provides specific policies and initiatives to ensure the realization of the 2030 Agenda. There are 232 indicators used to monitor and evaluate progress as these goals are pursued. Annually, the global advancement towards achieving the SDGs is assessed at the High-Level Political Forum on Sustainable Development (HLPF). Additionally, the UN Secretary-General issues an annual report that comprehensively outlines the goals that have been accomplished.[63]

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[61]World Health Organization. Health in 2015: from MDGs, Millennium Development Goals to SDGs, *Sustainable Development Goals*. 2015. Available from: https://apps.who.int/iris/handle/10665/200009 (cited 8 February 2021).

[62]Alkire, S., and E. Samman., *Mobilising the Household Data Required to Progress Toward the SDGS*. (Oxford: Queen Elizabeth House, University of Oxford, 2014)

[63]FAO.,An introduction to the basic concepts of food security. *Food Security Information for Action. Practical Guides*. EC— FAO Food Security Programme 2008

While the SDGs do not impose legal obligations at the national level, governments are encouraged to adopt sustainable development strategies specific to their countries, such as resource mobilisation, financing plans, and the development of national indicators to track success. SDG 17 emphasises the importance of multi-stakeholder partnerships made up of public sector, private sectors and civil society groups in order to achieve the goals. The overall pace and scope of the SDGs' implementation have not yet been reached, despite advancements in a number of sectors. Therefore, this decade will need to see bold and urgent initiatives if we are to meet the SDGs by 2030.[64]

2.2.1 What are the Sustainable Development Goals?

The 2030 Agenda for Sustainable Development, which was endorsed by all UN Member States in 2015, offers a common road map for promoting peace and prosperity for people and the environment both now and in the future, according to the UN. The 17 Sustainable Development Goals (SDGs), which represent an urgent call to action for all nations—developed and developing—in a global partnership, are at the centre of it. They understand that eradicating poverty and other forms of deprivation requires concerted efforts to combat climate change, protect our seas and forests, and enhance health and education, and lower inequality in addition to promoting economic growth. Below is a figure that presents the SDGs.

[64]UN.,*Transforming Our World: The 2030 Agenda For Sustainable Development*. (New York: United Nations, Department of Economic and Social Affairs, 2015)

Figure 2.4: UN Sustainable Development Goals 2015

SDG	Objective
Goal 1	End poverty in all its forms everywhere
Goal 2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3	Ensure healthy lives and promote well-being for all at all ages
Goal 4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5	Achieve gender equality and empower all women and girls
Goal 6	Ensure availability and sustainable management of water and sanitation for all
Goal 7	Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 10	Reduce inequality within and among countries
Goal 11	Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12	Ensure sustainable consumption and production patterns
Goal 13	Take urgent action to combat climate change and its impacts
Goal 14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17	Strengthen the means of implementation and revitalize the global partnership for sustainable development

Source:Elsevier, 2023

2.2.2 Sustainable Development Goal 2 –Zero Hunger

Sustainable Development Goal 2, also known as 'Zero Hunger,' aims to eradicate global hunger by 2030. This goal addresses the urgent issue of hunger and food insecurity, which has dramatically worsened since 2015. Several factors, including increasing inequality, conflicts, and climate change, contribute to this concerning trend. Approximately 2 billion persons globally lack constant access to adequate, safe, and nutritious food. In 2022, 45 million kids below five experienced wasting, a condition where the body deteriorates due to insufficient food, and 148 million children suffered from stunted growth.[65]

[65]UN General Assembly., *Transforming our world: the 2030 agenda for sustainable development*. 2015. Available from: https://www.refworld.org/docid/57b6e3e44.html (accessed 10 October 2023).

By guaranteeing that everyone has access to enough nourishing food, achieving zero hunger entails ending world hunger, lowering global rates of malnutrition, and improving the efficiency of food production. When a person is malnourished, it can result from either excess or deficiency in the nutrients required for a healthy diet. Eliminating world hunger, however, is a huge task that involves many parties involved in the markets, delivery, and production of food. In contrast, wasting happens when the body weakens and deteriorates as a result of starvation, underscoring the vital significance of tackling these problems in their entirety in order to reach the objective of zero hunger.[66]

There are specific elements that highlight the importance of SDG 2 within its scope. First, there is the imperative of "Ending Hunger," which aims to completely eradicate hunger and guarantee that no one goes without food. This means guaranteeing that there is always enough nutrient-dense food available to everyone. Second, "Achieving Food Security" is a crucial component that goes beyond just having food available to include making safe, wholesome food affordable and accessible to everyone. It means that people and communities should always have access to a consistent supply of food.[67]

Thirdly, the goal of SDG 2 is "Improving Nutrition." This part promotes healthy eating habits and balanced diets in an effort to prevent stunting and malnutrition, with an emphasis on vulnerable populations like children and expectant mothers. Last but not least, "Promoting Sustainable Agriculture" is acknowledged as a crucial component of the objective, recognising the connection between sustainable farming methods and hunger. This entails helping small-

[66]*ibid*

[67]World Health Organization, *Malnutrition – Health Topics*. Available at: http://www.who.int/topics/malnutrition/en/

scale farmers, protecting ecosystems, and promoting ethical farming practises that guarantee continuous food production while preserving the environment.[68]

After a notable pandemic-related spike in 2020 and a slower increase in 2021, the prevalence of undernourishment stayed stable in 2022 when compared to the figures from 2021. Globally, 7.9% of people in 2019 and roughly 735 million people experienced chronic hunger; this percentage increased to 9.2% in 2022. Compared to 2019, this represents an increase of 122 million. Furthermore, it was estimated that 2.4 billion people, or 29.6% of the global populace, experienced moderate to severe food insecurity, which is an indication of sporadic access to enough food. In comparison to other regions, Africa had a higher percentage of its population experiencing hunger, but the bulk of those affected lived in Asia. Estimates suggest that over 600 million individuals globally will be struggling with hunger by 2030, highlighting the enormous task of attaining the zero hunger goal.[69]

The global patterns of hunger and food security are influenced by a intricate interplay of two conflicting factors: economic recovery, which has increased incomes and enhanced food accessibility, and food price increase, which has battered these income improvements and stalled food access. These issues have displayed in their own way in various regions. For instance, hunger rates have increased in Africa, the Caribbean, and Western Asia. Equally, most areas in Latin America and Asia have seen expansions in food security.[70]

Investing in agriculture plays a crucial role in enhancing efficiency, productivity, income growth, and addressing issues related to hunger and poverty. In 2021, the government allocated

[68] *ibid*

[69] Sachs J. D., From Millennium Development Goals to Sustainable Development Goals. *Lancet* 2012; 379: 2206–11. doi: 10.1016/S0140-6736(12)60685-0

[70] Tremblay D, Fortier F, Boucher JF, Riffon O, Villeneuve C. Sustainable Development Goal Interactions: An Analysis Based on the Five Pillars of The 2030 Agenda. *Sustain Dev 2020*; 28: 1584–96. doi: 10.1002/sd.2107

a record-high amount of $700 billion to agriculture during the pandemic. However, the agriculture orientation index (AOI), which compares government spending on agriculture to the sector's GDP input, dropped from 0.50 in 2015 to 0.45 in 2021. This decrease was observed in all regions except Northern America and Europe, where substantial stimulus plans were implemented. Latin America and the Caribbean experienced the most significant drop in AOI, falling from 0.33 in 2015 to 0.21 in 2021.[71] Amid 2015 and 2021, the overall aid allocated to agriculture in developing countries improved by 14.6%, rising from $12.8 billion to $14.2 billion in 2021 prices. A significant surge in assistance to agriculture occurred in 2020, increasing by almost 18% due to concerns about food security for the duration of the plague. However, in 2021, there was a 15% decrease, bringing the aid levels back to pre-pandemic levels.[72]

Children who are wasted are immediately at risk for malnourishment, reduced immunity, delayed development, and even death. It is frequently linked to illnesses and diets deficient in vital nutrients. Children under five approximately 45 million, or 6.8% of the population, were wasting in 2022, down from 7.7% in 2010. At the same time, 37 million kids, or 5.6%, were overweight. Since 2012, the percentage of overweight children worldwide has remained stable at 5.5%, requiring increased effort to meet the 3% target by 2030.[73]

Moreover, the concerning high frequency of anemia among women of child-bearing age has not changed significantly since 2000, circling around 30%. Women who suffer from anemia are more likely to experience unfavorable outcomes during gestation and the post-delivery period, which emphasizes the significance of treating this condition for the well-being and

[71]Ritchie R, Mispy O.-O. *Measuring Progress towards the Sustainable Development Goals*. 2018. Available from: https://sdg-tracker.org
[72]*ibid*
[73]*ibid*

nourishment of women as well as children. A healthy environment must be established, adequate maternal nutrition must be ensured, optimal breastfeeding must be encouraged, early childhood foods must be safe, diversified, and nutritious, and early childhood care must be provided. In addition to opportunities for safe physical activity, this environment should include access to basic health services, clean water, hygienic conditions, and sanitation facilities. In the worst-affected areas, coordinated initiatives involving the nourishment, well-being, and social protection sectors are especially vital to lower child and maternal malnutrition.[74]

Figure 2.5: Infographics –Zero Hunger

Source: UN Website

[74] Creegan E. F, & Flynn R., SDG 2 Zero Hunger. Actioning the Global Goals for Local Impact. Singapore: *Springer*, 2020; pp. 23–37.

2.2.3 What are the Targets and Indicators for SDG2?

By 2030, the world purposes to eliminate hunger, increase food safety, increase nutrition, and encourage sustainable agriculture. SDG 2, or "Zero Hunger," is a set of precise targets and indicators that tracks these efforts. The objectives and metrics for SDG 2 comprise.[75]

Table 2.2: Targets and Indicators for SDG2

Target name	Target	Indicators
1: Universal access to safe and nutritious food.	Target **1** aims to end hunger by 2030 by providing everybody access to sufficient and nutritious food all year round.	This is measured through the prevalence of undernourishment and food insecurity based on the Food Insecurity Experience Scale.
2: End all forms of malnutrition.	Target **2** focuses on ending malnutrition of children under 5 years old and meeting the nutritional needs of pregnant and lactating women, adolescent girls, and older people by 2030.	There are two indicators; the prevalence of stunting among children under 5 and malnutrition[5].
3: Double the productivity and incomes of small-scale food producers.	Target **3** is to double the agricultural productivity and income of small-scale food producers with equal access to land and opportunities by 2030[5].	There are two indicators; one is according to the classes of farming, forestry, pastoral enterprise size, and the volume of production. Another is the average income of small-scale food producers.
4: Sustainable food production and resilient agricultural practices.	Target **4** is to have sustainable food production systems and resilient agricultural practices put into place, to ensure growth in productivity and production in a sustainable manner by 2030.	The indicator is the proportion of agricultural area that is productive and sustainable agriculture.
5: Maintain genetic diversity in food production.	Target **5** is to maintain the genetic diversity of cultivated plants, seeds, and farmed and domestic animals by 2030.	One of the indicators is the number of conservation facilities for plant and animal genetic resources of food. Another is the proportion of local breeds at risk of extinction.
a: Invest in rural infrastructure, agricultural research, technology, and gene banks.[5]	Target ***a*** focuses on increasing investment in rural infrastructure, agricultural research, technology, and gene banks.[5]	The two indicators are the Agriculture Orientation Index for government expenditure, and total official flows to the agricultural sector.
b: Prevent agricultural trade restrictions, market distortions, and export subsidies.[5]	Target ***b*** is to reassess and correct the trade restrictions and distortions in world agricultural markets for the accessibility of food.	There are two indicators; one is the Producer Support Estimate. It is an indicator that shows the annual gross transfers of taxpayers and consumers to agricultural producers. Another is Agricultural Export Subsidies.
c. Ensure stable food commodity markets and timely access to information.[5]	Target ***c*** is to have measures that stop food price volatility by ensuring the functioning of food commodity markets and that market information is provided in a timely manner.	The indicator for target *c* is food price a

Source: Swedish Nutrition Foundation website

[75] United Nations. *The Global Goals for Sustainable Development. 2020*. Available from: https://sdgs.un.org/goals (cited 28 February 2021).

2.2.3 Importance of SDG2

"Zero Hunger also known as SDG2," is a key element of the United Nations' 2030 Agenda for Sustainable Development. This goal comprises ending hunger in all of its manifestations by guaranteeing that everyone, irrespective of circumstances, has access to enough nourishing food. It also entails supporting sustainable farming methods, encouraging balanced diets, especially for exposed populations like children and expectant women, and guaranteeing regular access to a sufficient supply of food. The significance of addressing hunger in the 21st century cannot be overstated. It is a moral imperative, with far-reaching implications for human health, economic development, social stability, and environmental sustainability. Hunger, malnutrition, and food insecurity undermine individual well-being, economic progress, and social harmony, and are intricately linked to other Sustainable Development Goals. Thus, achieving Zero Hunger is not only a humanitarian duty but also an essential driver of global progress in the 21st century.[76]

The United Nations recognizes a strong interconnection among the sustainable development goals, considering them as inseparable and applicable worldwide. These goals are thoughtfully crafted with respect to individual country capacities, developmental stages, and specific national policies and priorities. While there is a global level of ambition, practical considerations within each country have led to the definition of global targets and aspirations, allowing governments to tailor and adapt these objectives to their unique circumstances. This approach acknowledges the diversity of each nation's capabilities.[77]

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[76]World Food Programme. *Zero hunger 2020*. Available from: https://www.wfp.org/zero-hunger (cited 28 February 2021).

[77]Fernandez R M., SDG3 good health and well-being: integration and connection with other SDGs. Good Health and Well-Being. *Elsevier:* Good Health and Well Being*; 2020, pp. 629–36.*

Figure 2.6: SGD2 Zero Hunger

Source: EU trend of SDG 2 on zero hunger

2.2.4 Role of GM Technology in Achieving SDG2

Agricultural technology is essential to advancing the SDGs and advancing global development. Among the variety of agricultural technologies, genetically modified organisms (GMOs) stand out as a major contributor to the achievement of SDG2 (zero hunger) and other related SDGs. However, the continued resistance to genetically modified organisms (GMOs) in Europe has repercussions in Asia, Africa, South America, and Latin America. In turn, this resistance makes it more difficult for developing countries to adopt this game-changing technology.[78]

[78] *ibid*

The approval of GM biofortified crops could help address malnutrition and achieve the nutrition targets of SDG2,[79] especially in developing countries. Despite progress in reducing micronutrient deficiencies, billions of people still suffer from such deficiencies, necessitating additional strategies alongside existing interventions like vitamin A or iron supplementation.[80] Conventional biofortification has made significant progress, implementing nutrient-enriched crops in over 50 priority countries and proving to be a cost-effective approach to improving micronutrient status. Similarly, the future implementation of GM biofortified crops shows promise in contributing to SDG2 targets. Research indicates that allocating resources to genetically modified (GM) biofortified crops, such as Golden Rice, would represent a highly cost-effective approach to combat vitamin A, iron, and zinc deficiencies.[81]

Implementing policies that focus on various types of biofortified crops could yield economies of scale, delivering more benefits at a reduced cost. Despite genetically modified crops with advantageous agronomic traits being approved for cultivation, those addressing common vitamin and mineral deficiencies have faced challenges due to regulatory hurdles and anti-GMO lobbying efforts. Nonetheless, proof of concept for several nutritionally enhanced GMOs has been established, leading to an expansion in the number of nutritional traits within the global GM crop pipeline. Consumer attitudes toward GM biofortified crops have been positive, mirroring their acceptance of conventional biofortified crops. This suggests that the applied technology does not significantly impact their perception of nutritious crops.[82]

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[79]Fullman, N., Barber, R. M., Abajobir, A. A., Abate, K. H., Abbafati, C., and Abba, K. M., *Measuring progress and projecting attainment on the basis of past trends of the health related sustainable development goals in 188 countries: an analysis from the global burden of disease study 2016*. The Lancet 390(10100), 1423–1459. (2017).
[80]Wesseler, J., Smart, R. D., Thomson, J., and Zilberman, D., *Foregone benefits of important food crop improvements in Sub-Saharan Africa*. PLoS ONE 12(7): e0181353. (2017)
[81]Moghissi, A. A., Pei, S., and Liu, Y., *Golden rice: scientific, regulatory and public information processes of a genetically modified organism. Critical Reviews in GM Technology* 36(3), 535–541(2016).
[82]De Steur, H., Mehta, S., Gellynck, X., and, Finkelstein J. L., *GM biofortified crops: potential effects on targeting the micronutrient intake gap in human populations.* Current Opinion in GM Technology 44, 181–188 (2017).

GM biofortified crops hold promise in tackling malnutrition and achieving the nutrition goals of SDG2. Despite obstacles such as regulations and opposition to GMOs, evidence supports the effectiveness and cost-effectiveness of biofortification. Public perception towards GM biofortified crops can be influenced by information and lobbying. Further research is necessary to optimize the benefits of GMOs and enhance public health outcomes. By overcoming challenges, GM biofortified crops can make substantial contributions to reducing global malnutrition and help in achieving SDG2.[83]

2.3 Adoption of GM Technology and its Impact in Africa

Genetically modified (GM) technology's influence in Africa has undergone in-depth examination in four specific countries: South Africa, Burkina Faso, Egypt (up to 2012), and Sudan. Researchers have predominantly based their conclusions on studies centered on cotton and maize crops, along with prospective reports that assess potential benefits in other African nations. On the whole, the results reveal that embracing GM technology can bring substantial benefits to farmers, consumers, and agribusinesses in these regions.[84]

As the pioneering nation to introduce GM crops commercially in 1996, South Africa witnessed remarkable results with the adoption of Bacillus thuringiensis (Bt) cotton. These included significantly higher yields and gross margins when compared to conventional cotton cultivation. Moreover, the reduced use of pesticides due to GM technology had positive effects on health and the environment, leading to fewer pesticide poisonings and lower levels of aflatoxin contamination in food.[85] In additional African nations, such as Burkina Faso, the

[83]Arora, L., and Narula, A., *Gene editing and crop improvement using CRISPR-Cas9 system*. Front. Plant Sci. 8, 1932. (2017). doi:10.3389/fpls.2017.01932
[84]*ibid*
[85] Lassoued, R., Phillips, P. W., Macall, D. M., Hesseln, H., and Smyth, S. J., Expert opinions on the regulation of plant genome editing. *Plant Biotechnol. J.* 19 (6), 1104–1109. (2021). doi:10.1111/pbi.13597

introduction of Bt cotton also led to enhanced crop yields and greater net income per hectare for farmers. Ex-ante studies further support the idea that GM technology can yield substantial benefits for both producers and consumers, with the timing of adoption being a crucial factor. Delays in adoption can lead to significant economic penalties and diminish welfare benefits.[86]

According to various research, people in Africa have favorable opinions about GM technology and are prepared to buy GM products at the same price as conventional ones, especially when health and environmental concerns are taken into account. However, it's worth noting that opposition to GM technology among urban elites may influence policy decisions. The impact of GM technology in Africa has shown promising benefits, including increased yields, reduced pesticide usage, and positive health effects. However, the pace of adoption and careful attention to consumer perceptions are essential for realizing these benefits throughout the continent.[87]

2.3.1 Current Commercial Application

The analysis of GM technology adoption in Africa reveals that only four out of the 54 countries on the continent have commercially released genetically modified crops. These countries include Burkina Fasa, Egypt (up until 2012), South Africa and Sudan. Among them, South Africa has emerged as a leader in agbiotech, being the first to introduce Bt cotton in 1998, followed by Bt maize, herbicide-tolerant (HT) cotton, and HT soybeans. Significantly, South Africa achieved a milestone by becoming the first developing nation to commercially introduce a genetically modified food crop, Bt white maize.[88]

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[86]*ibid*
[87] *ibid*
[88]Ma, Q. P., *Technological Breakthroughs and Future Business Opportunities in Education, Health, and Outer Space*, 112–132. (2021). Biotechnology: Recent developments, emerging trends, and implications for business

While cotton holds significant economic value for many African nations, GM cotton adoption has been limited to Burkina Faso and, more recently, Sudan. In 2008, Burkina Faso introduced Bt cotton, and over the years, its adoption has steadily increased. By 2013, Bt cotton covered nearly 51 percent of all cotton-planted area in the country. Securing commercial approval for genetically modified (GM) cotton in Burkina Faso was a lengthy process spanning a decade, which included active involvement from various stakeholders such as local farmers. Companies like Monsanto played a crucial role in transferring the Bt gene to cotton varieties preferred by the local community. Moreover, establishing a regulatory framework posed a major challenge that had to be overcome before GM cotton could be commercialized in Burkina Faso. On the other hand, Egypt experienced a comparatively smaller adoption of GM crops, with Bt maize being cultivated on a limited scale between 2008 and 2012. During this period, the area under Bt maize cultivation increased from 700 hectares to 2,000 hectares in 2012.[89]

Despite the limited adoption, there is promise in the potential applications and ongoing projects in Africa. The Next Harvest project assessed the relevance of public-sector investment in GM technologies, revealing significant public-led research efforts in 16 developing countries involving 46 crops. Among African countries, Egypt and South Africa were actively engaged in 54 unique GM crop research projects. However, various obstacles, including inadequate human and financial resources and evolving regulatory hurdles, have hindered the progress of these projects.[90]

[89] *ibid*

[90] Paarlberg, R., *Starved for science: How biotechnology is being kept out of Africa.* (Harvard University Press, 2009).

Africa is going to witness the beginning of major projects in the next few years that are intended to address pressing agricultural problems. The Water Efficient Maize for Africa (WEMA) project, a well-known collaboration between the public and private sectors that involves Monsanto, CIMMYT, and numerous research institutions, is one notable endeavour. Its principal goal is to provide smallholder farmers in Africa with drought-resistant varieties of maize while absolving them of royalty fees through local seed companies. This strategy not only encourages small-scale farmers to adopt it, but it also has the ability to increase productivity in the maize seed industry in some African countries. The Improved Maize for African Soils (IMAS) project is another notable initiative that has the kind support of USAID and the Bill and Melinda Gates Foundation. The goal of this project is to improve the efficiency of nitrogen use in African maize varieties by using GM technology and marker-assisted breeding. Through tackling the issue of infertile soil, a significant barrier to agricultural output, the IMAS project seeks to improve food security in Africa.[91]

Another critical initiative is the African Biofortified Sorghum (ABS) project, which aims to create a sorghum variety that is both more nutritious and easier to digest. The primary goal is to boost levels of essential amino acids, vitamin A, iron, and zinc in the sorghum crop. By achieving this goal, the project has the potential to significantly improve the health of millions of Africans who rely on sorghum as a primary food source.[92]

Furthermore, the Biofortified Bananas for East Africa project, in collaboration with the Queensland University of Technology (QUT) and other partner institutes, focuses on developing GM high-iron, high-provitamin a bananas to address nutritional deficiencies in the

[91]*ibid*
[92] Tripathi, L., Dhugga, K. S., Ntui, V. O., Runo, S., Syombua, E. D., Muiruri, S., et al., Genome editing for sustainable agriculture in Africa. Front. *Genome Ed*. 4, 876697. (2022). doi:10.3389/fgeed.2022.876697

region. This innovative project has been estimated to be a cost-effective health intervention, with substantial potential benefits. HarvestPlus, a global leader in biofortified crop development, is actively involved in various initiatives across Africa. Although most of its work revolves around conventional breeding, some projects incorporate GM techniques. An example of such an initiative is the Nutritional Genomics for Micronutrient-Dense Cassava project, which seeks to utilize genomics tools to create a provitamin A-rich cassava variety. Moreover, another project employs transgenic technology to enhance the iron content in staple crops grown in Africa.[93]

2.4 Conclusion

In conclusion, African nations face the threat of hunger and significant malnutrition due to factors such as insufficient food supply, limited education, and financial constraints. This situation leads to food shortages and inadequate nutrition, especially in rural regions. Additional challenges encompass the lack of advanced food processing techniques, the adverse effects of climate change such as droughts, floods, and global warming, insufficient infrastructure, limited transportation systems, a shortage of modern agricultural resources, and ineffective governmental policies. GM Technology holds immense potential for Africa, offering solutions to agricultural challenges. It can enhance agricultural productivity, improve food security, and drive economic growth. However, several barriers hinder its full utilization. Financial constraints limit investment in research and infrastructure, while a lack of skilled expertise impedes effective application. Slow sector development further hampers progress and keeps Africa behind in global biotech advancements. To unlock the transformative power of GM Technology, African governments must provide conducive conditions by enacting beneficial policies and allocating resources. Regional organizations are taking steps toward

[93] *ibid*

harmonization, but progress is slow. To fully benefit from GM Technology, Africa needs concerted efforts at the continental level to address these challenges and foster a conducive environment for innovation. By embracing GM Technology responsibly, Africa can significantly improve agricultural productivity and overall socio-economic development and attain the SDG2 goal.

CHAPTER THREE

POLICIES AND REGULATIONS GOVERNING THE USE OF GM TECHNOLOGY IN SOUTH AFRICA AND KENYA

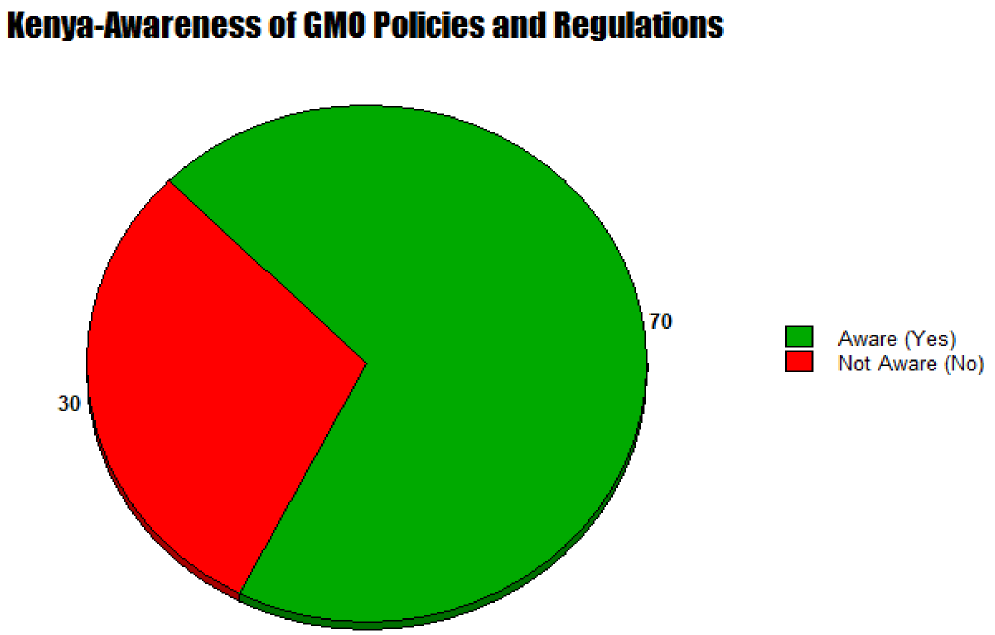
3.0 Introduction

The previous chapter delved into the adoption of genetically modified technologies in Africa, exploring their role in fulfilling Sustainable Development Goal 2 (SDG2). It focused on how African nations are progressing in the growth and acceptance of GM technologies to achieve SDG2. This chapter now narrows its focus to informed discussions about the benefits of GM technology in meeting the worldwide food demands outlined in SDG2. It examines policies, compares various approaches, and emphasizes differences in managing agricultural innovation in these states. South Africa and Kenya lead African nations in adopting and regulating GM technology to improve crop yields and combat pests. Concerns about safety and sustainability lead to comprehensive frameworks. Analyzing legal landscapes, approval processes, labeling requirements, and stakeholder engagement helps balance innovation, development, and public acceptance. International guidelines influence their GM regulations, aligning with global norms while considering local contexts. This chapter analyzed policies and regulations drawing from primary and secondary data sources in both Kenya and South Africa.

3.1 Response Rate on awareness of GMO Policies and Regulations in South Africa and Kenya

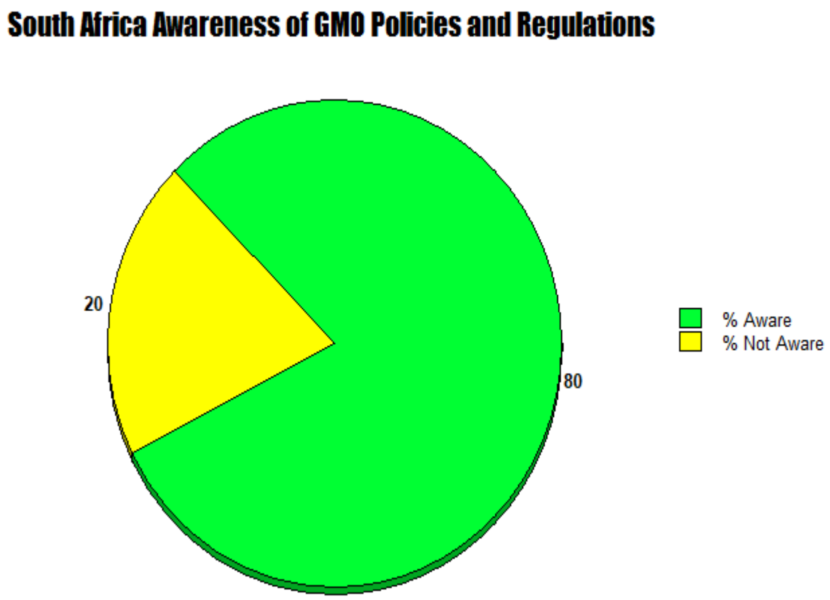
This section presents the demographic distribution of respondents' awareness regarding GMO Policies and Regulations in both Kenya and South Africa. The data indicates that South Africa has a higher percentage of respondents who are aware of GMO policies and regulations (80%) compared to Kenya (70%). This suggests that GMO-related information may be more widely disseminated or accessible in South Africa.

Figure 3.1: Kenya Awareness of GMO Policies and Regulations



Source: Researcher, Primary Data (2023)

Figure 3.2: South Africa Awareness of GMO Policies and Regulations

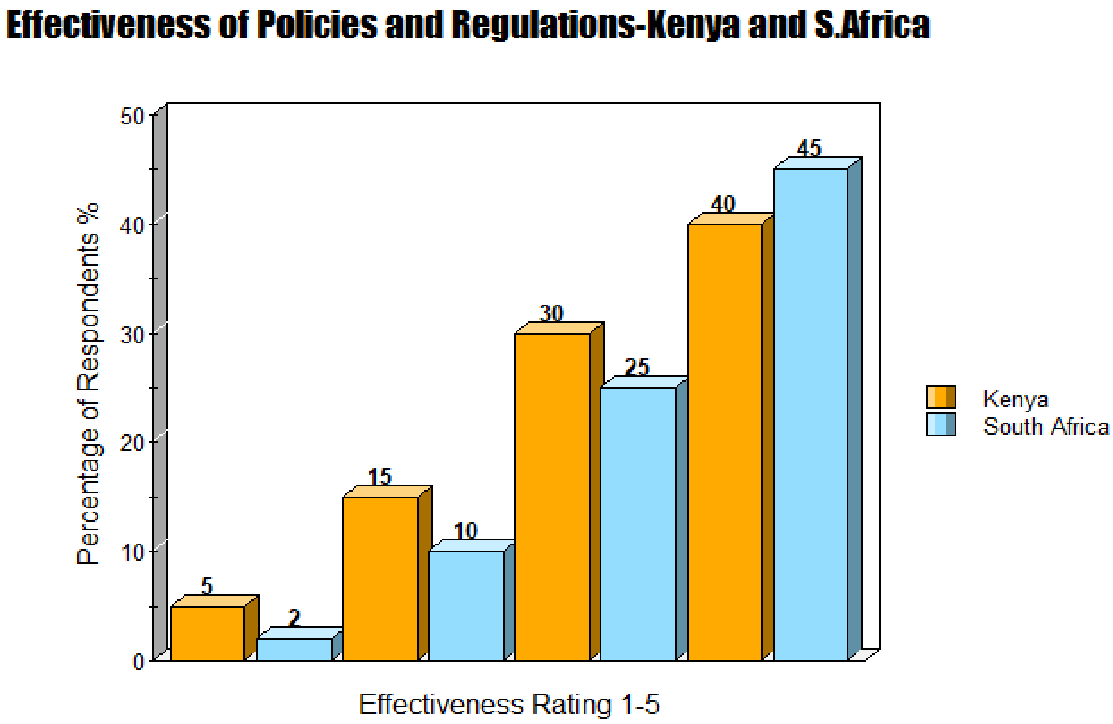


Source: Researcher Primary Data (2023)

3.2 Response rate on Effectiveness of Policies and Regulations in Kenya and South Africa

The response rate on the effectiveness of GMO policies and regulations in Kenya and South Africa highlights distinct patterns. In Kenya, 70% of respondents found the policies to be moderately effective (30% rated them as 3, and 40% as 4), with only 5% considering them ineffective (rated 1) and 10% highly effective (rated 5). In contrast, South Africa displayed a higher satisfaction level, with 45% rating the policies as quite effective (rated 4) and 18% as highly effective (rated 5), while only 2% found them ineffective (rated 1). Notably, both countries had a minority of respondents perceiving the policies as ineffective, suggesting overall effectiveness. The disparities between Kenya and South Africa may be attributed to differences in policy implementation, communication, or individual experiences. In summary, the data emphasizes that a significant proportion of respondents in both nations consider their GMO policies as effective in ensuring the responsible use of GMO technologies.

Figure 3.3: Effectiveness of Policies and Regulations –Kenya and South Africa



Source: Researcher Primary Data, 2023

3.3 Response on Strength and Weakness on GM Policies in Kenya and South Africa

The data gathered on strength and weakness on GM policies in Kenya and South Africa reveals a mixed picture as shown in Table 3.3 below. In Kenya, there are notable strengths in the form of strict regulations on GMO labeling, which contribute to informed consumer choices. However, a significant weakness lies in the limited public awareness of these policies, indicating the need for greater education and outreach efforts. On the other hand, South Africa exhibits strengths through its robust testing procedures, ensuring a thorough safety assessment of GMOs. Nevertheless, the country faces challenges related to the enforcement of these policies. Weak enforcement can lead to compliance issues and potential risks. The strengths and weaknesses in these policies underscore the importance of striking a balance between regulation and public awareness to ensure the safe and responsible use of genetically modified organisms, promoting public health, environmental protection, and food security in both countries

Table 3.3: Strengths and Weaknesses of GMO Policies in Kenya and South Africa

Country	Strengths	Weaknesses
Kenya	- Strict regulations on GMO labeling	- Limited public awareness
	- Enhanced food safety standards	- Limited research on the long-term effects of GMOs
	- Collaboration with international organizations	- Challenges in monitoring and enforcement
	- Potential economic benefits for farmers	- Concerns about GMO contamination in non-GMO crops
	- Engagement with stakeholders and public awareness	- Ethical concerns about GMO technology
	- Mechanisms for risk assessment and mitigation	- Public skepticism and mistrust of GMOs
	- Access to global markets for GMO products	
South Africa	- Robust testing procedures	- Enforcement challenges
	- Established regulatory framework and expertise	- Risk of transgenic contamination in the environment
	- Contributions to agricultural research and biotechnology	- Concerns about corporate influence on GMO policies

	- Economic growth and job creation in the biotech sector	- Potential effects on indigenous crops and traditional farming practices
	- Export opportunities for GMO agricultural products	- Socio-economic disparities in access to GMO benefits
	- Scientific advancements and partnerships	- Public perception challenges related to GMOs
	- Implementation of safety protocols and monitoring	- Ethical concerns about genetic modification

Source: Researcher Primary Data, 2023

3.4 Response on perception of policy impact on Agricultural Practices ad Food Security

In Kenya, the respondents reveal positive impacts of GMO policies on agriculture and food security, including increased crop yields, reduced post-harvest losses, economic benefits for farmers, and improved crop resilience. However, concerns were raised about potential environmental consequences, ethical issues, and health risks associated with GMOs, highlighting the importance of public perception and acceptance in shaping their impact. Conversely, in South Africa, respondents have a predominantly positive view of GMO policies. These policies have led to increased agricultural productivity, improved food security, and enhanced crop resilience. Nonetheless, concerns about health risks, environmental impacts, socio-economic disparities, and seed monopolies exist. These insights stress the need for balanced GMO policies, public awareness, and transparent communication to ensure responsible GMO use and sustainable agriculture.

Table 3.2: Perceptions of Policy Impact on Agricultural Practices and Food Security

Country	Positive Impact	Negative Impact
Kenya	- Improved crop yields due to GMOs	- Concerns about environmental impact
	- Enhanced food security through increased production	- Reduced biodiversity due to monoculture
	- Reduced post-harvest losses and food waste	- Potential cross-breeding of GMOs with native crops
	- Economic benefits for farmers through increased income	- Ethical concerns about tampering with nature
	- Decreased dependence on chemical pesticides	
	- Increased availability of specific nutrient-enhanced crops	

	- Potential drought-resistant crop varieties	
	- Improved disease resistance in certain crops	
	- Enhanced access to global markets	
South Africa	- Increased agricultural productivity	- Potential health concerns related to GMO consumption
	- Improved food security	- Environmental risks associated with GMO cultivation
	- Enhanced crop resilience to pests and diseases	- Impact on indigenous and traditional farming practices
	- Economic growth in the agriculture sector	- Socio-economic disparities in access to GMO benefits
	- Expanded crop diversity and availability	- Concerns about seed monopolies and patenting
	- Improved drought tolerance in certain crops	- Risk of loss of traditional crop varieties
	- Enhanced export opportunities for agricultural products	- Public perception and consumer acceptance issues

Source: Researcher Primary Data, 2023

3.4 Policies and Regulations Governing the use of GM Technology in South Africa and Kenya

3.4.1 South Africa Agricultural Sector

The agricultural economy in South Africa comprises an advanced commercial sector alongside a significant subsistence sector. The cultivation of key crops like maize, soybean, wheat, and cotton is primarily limited due to scarce arable land. The viticulture and horticultural sectors, particularly focused on Europe for exports, might face challenges in the export market due to the introduction of GM products. Small-scale and emerging farmers, who obtained land from the previous white-owned sector, encounter challenges in adopting new technologies to improve crop production. The adoption of GMOs presents both opportunities and barriers.[94]

The agricultural sector in South Africa is notable as the most modern, productive, and diverse compared to other African nations. Despite facing uncertainties in both the economy and weather, the well-developed agricultural sector is expected to provide stability. Several factors, such as credit rating downgrades, land reform challenges, fluctuating exchange rates,

[94] Viljoen, B., K. Dajee, and G. M. Botha., "Detection of GMO in Food Products in South Africa: Implications of GMO Labeling." *African Journal of Biotechnology* 5: 73–82, 2006.

persistent weather problems, and escalating input expenses, exert influence on the agricultural sector. South Africa has approximately 32,000 commercial farmers, with a smaller subset of 5,000 to 7,000 farmers accounting for roughly 80% of the country's agricultural output.[95]

3.4.2 Adoption and Regulation of GM Technology in South Africa

South Africa paved the path as the first African nation to adopt genetic engineering technology. Back in 1990, the country initiated field trials for genetically modified cotton and later, in 1997, became the first in Africa to authorize the commercial release of a genetically engineered product - GM cotton. Following this success, GM maize and soybean were also introduced to the market in 1998 and 2000, respectively. As of 2012, the adoption of genetic modification had grown significantly, with all cotton and a large proportion of soybean and maize crops in the country being genetically modified.[96]

In South Africa, genetic modification is seen as a technique that could greatly boost the nation's food production. It enhances poverty alleviation, revenue generation, and food security, especially for farmers with limited resources. One of the main objectives of the MDGs is the decrease of poverty. Moreover, the application of GM technology may lead to other advantages like enhanced health and a safer environment that supports sustainable agriculture. The first commercially cultivated genetically modified crops appeared about fifteen years ago, and genetically engineered crops have been around for more than twenty years. By 2009, there were over 140 million hectares of GM agricultural production worldwide, a significant increase from almost nothing in 1996.[97]

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[95]ITA, *South Africa-Country Commercial Guide*, 2023-05-06 https://www.trade.gov/country-commercial-guides/south-africa-agricultural-sector
[96]*ibid*
[97]Kirsten J, Gouse M. *Bt cotton in South Africa: Adoption and impact on farm incomes amongst smalland large-scale farmers 2006*; Available at: http:// croplife.intraspin.com/Biotech/papers/22article.pdf.

There are unintended health benefits for consumers of genetically modified (GM) crops grown in South Africa. Studies show that GM maize has lesser levels of chemicals linked to cancer than both conventional and organic maize. In addition, the use of insecticides and herbicides has decreased significantly as a result of GM technology; in South Africa, this reduction has reached 33%. Because it lowers the possibility of chemical poisoning in humans, this decrease is particularly important for the nearby farming communities. Overall, the introduction of genetically modified crops to South Africa has improved consumer health because less carcinogenic compounds are present in maize and less harmful pesticides are used.[98]

According to Brookes and Barfoot's global research, adopting genetically modified (GM) crops has environmental benefits. It reduces the need for pesticide and herbicide spraying on a regular basis and encourages new agricultural practises, resulting in lower fuel consumption and carbon dioxide emissions. Given the growing concern about climate change, this is a significant environmental benefit. These findings indicate a drop of greenhouse gas emissions and are consistent with the MDGs.[99]

It's important to highlight that, although GM technology leads to reduced pesticide usage, increased yields in fewer regions, and cleaner crops, it does not influence the demand for agricultural labor. Consequently, the adoption of genetically modified organisms (GMOs) does not directly affect labor requirements in agriculture. Moreover, GM technology provides other advantages beyond the realm of food production, although the provided material does not specify these additional benefits.[100]

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[98] Socio-economic impact of green biotechnology. Available at http://www.europabio.org/positions/GBE/PP_080110-Socio-economic-impacts-of-GMCrops-GMO.pdf.

[99] Brookes G, Barfoot P., *GM Crops: Global Socioeconomic and Environmental Impacts 1996–2008*. (PG Economics Ltd., UK 2010.)

[100] *ibid*

3.4.3 Impact of GM Technology on Agricultural Productivity and Food Security in South Africa

Genetically modified (GM) maize has considerably upgraded South Africa's food security, environmental sustainability, and income for substituent farmers, according to recent research findings. South Africa is the first country in the world to produce genetically modified subsistence crops after successfully cultivating insect-resistant Bt white maize. A study that was printed in Global Food Security estimates that between 2001 and 2018, South Africa's welfare benefits from genetically modified white maize totaled $694.7 million. These results cast doubt on the notion that GM crops increase neither producer profitability nor food security. In South Africa, GM cultivars are mostly used for white maize, which adds 4.6 million meals to the country's annual production.[101]

The report emphasizes the environmental benefits of growing GM maize. It reduces environmental damage by $0.34 per hectare, resulting in a $291,721 annual savings over conventional hybrid maize cultivation. The reduced need for pesticides in GM white maize farming enables these positive environmental outcomes. Despite South Africa's relative prosperity, there are still isolated cases of food insecurity. In addressing this challenge and improving local and regional food security, genetically modified maize has proven critical. According to the report, combining GM technology with other initiatives can play a critical role in combating food poverty, especially given the impact of climate change on agriculture in Sub-Saharan Africa.[102]

[101]Bouët, A., and G. Gruère. "Refining Estimates of the Opportunity Cost of Non-adoption of Bt Cotton: The Case of Seven Countries in Sub-Saharan Africa." *Applied Economic Perspectives and Policy* 33 (2): 260–279. 2011
[102]*ibid*

3.4.4 South Africa GM Technology Regulatory Framework

Utilizing genetically modified organisms (GMOs) is governed in South Africa by a number of national and international laws. The purpose of these regulations is to guarantee that before any GMO-related activity is carried out, it is thoroughly assessed to determine any potential risks to human health and the environment. Additionally, the purpose of these regulations is to guarantee that activities related to GMOs that are authorized are conducted under strict supervision, incorporating risk mitigation measures as necessary.[103]

Before implementing any regulations related to genetically modified organisms (GMOs), the South African government acknowledged the importance of taking proactive and cautious measures in its national policy. The primary objective of the government's efforts in formulating regulations for the handling, processing, utilization, and release of GMOs was to minimize potential risks to both biodiversity and public health. The regulation of GMOs in South Africa can be traced back to the late 1980s, a period when comprehensive biosafety legislation was not yet in place. During this era, oversight of transgenic research and testing fell under the Agricultural Pests Act of 1983, and the South African Committee for Genetic Testing (SAGENE) served as the scientific advisory body responsible for monitoring environmental releases.[104]

Transgenic organisms were initially introduced in 1997, and the GMO Act was officially ratified in the same year, however enforcement did not begin until 1999. To address specific issues not addressed by the GMO Act, the government enacted new GMO laws. The GMO Amendment Act was passed in April 2007. The GMO Act, which outlines the procedures and

[103]Anderson, K., and L. A. Jackson., "Some Implications of GM Food Technology Policies for Sub-Saharan Africa." *Journal of African Economies* 14 (3): 385–410, 2005.

[104]Falck-Zepeda, J. B., and P. Zambrano., "Socio-economic Considerations in Biosafety and Biotechnology Decision Making: The Cartagena Protocol and National Biosafety Frameworks." *Review of Policy Research* 28 (2): 171–195. 2011 http://dx.doi.org/10.1111/j.1541-1338.2011.00488.x

organizational frameworks for GMO regulation in South Africa, is under the jurisdiction of the Department of Agriculture (DOA). It's important to highlight that South Africa is currently the sole African nation involved in economically sustainable cultivation of transgenic crops.[105]

3.4.5 South Africa National Regulations

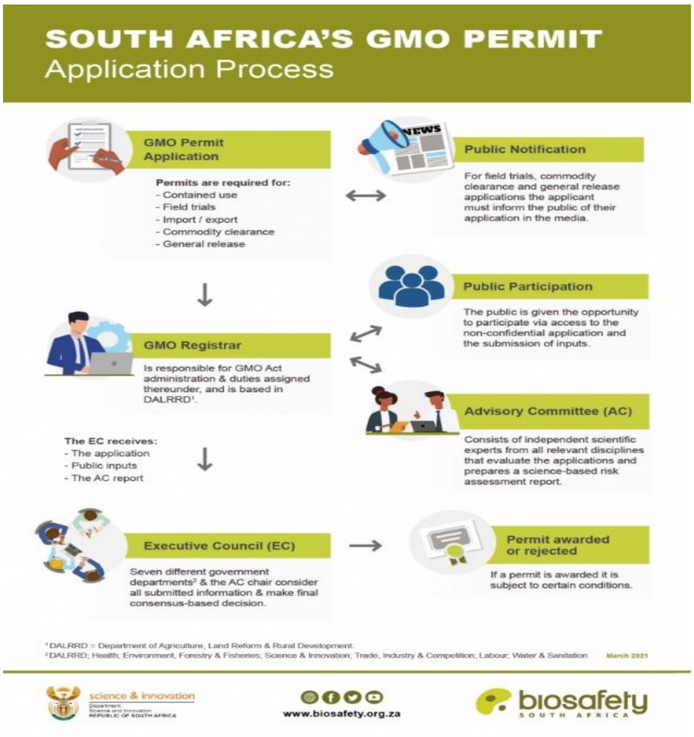
South Africa's legal framework, coupled with institutional support, has facilitated the commercial introduction of various genetically modified (GM) traits in crops like maize, cotton, and soybeans. The primary legislative instruments governing GMOs in South Africa are the Genetically Modified Organisms Act (GMO Act) and its subsequent revisions, notably the Genetically Modified Organisms Act of 1997 (Act No. 15, 1997) and the Genetically Modified Organisms Amendment (Act No. 23 of 2006). These regulations encompass all phases of GMO development, including research, production, import, export, transportation, and field applications. Their overarching objective is to mitigate potential risks to the environment, human health, animal welfare, and to consider socioeconomic factors. The GMO Act and its associated regulations rigorously oversee all GMO-related activities, necessitating permits for activities like importation, clearance, field trials, release, and controlled use. The implementation of the GMO Act falls under the Directorate Genetic Resource: Biosafety, which operates within the Department of Agriculture, Forestry, and Fisheries. Oversight of GMO Act compliance is provided by the GMO Act Registrar.[106]

In South Africa, two regulatory entities are involved in the examination and decision-making process for GMO permit applications: the Advisory Committee, which is responsible for risk assessment, and the Executive Council, which represents numerous government ministries.

[105] *ibid*
[106] *ibid*

After examining the conclusions of the Advisory Committee, public opinions, and trade issues, the Executive Council may grant a permission. Inspections by inspectors verify compliance with the GMO Act licences.[107]

Figure 3.4: South Africa's GMO Permit Application Process



Source: Biosafety of South Africa

3.4.6 The National Environmental Management Biodiversity Act (NEMBA)

The responsibility for overseeing the National Environmental Management Biodiversity Act (NEMBA), Act No. 10 of 2004, lies with the Department of Environmental Affairs (DEA). The DEA grants authority to the South African National Biodiversity Institute (SANBI) to monitor and assess the environmental consequences of GMOs released into the South African environment. This task is carried out by SANBI's GMO Research and Monitoring branch.

[107]Wilkins TA, Rajasekaran K, Anderson DM. Cotton biotechnology. *Crit Rev Plant Sci* 2000; 19:511-50.

Additionally, the National Environmental Management Act (NEMA), Act No. 107 of 1998, includes a provision that empowers the Minister of Environmental Affairs to request an environmental impact assessment (EIA) for GMOs.[108]

3.4.7 The National Environmental Management Act (NEMA)

The Department of Environmental Affairs (DEA) is responsible for administering the National Environmental Management Act (NEMA), which plays a crucial role in establishing fundamental principles for decisions affecting the environment. NEMA also advocates for the concept of participatory governance. This legislative framework consists of two components: the National Environmental Management Act, Act No. 107 of 1998, and the National Environmental Management Act Amendment Act, Act No. 8 of 2004. The DEA has issued comprehensive guidelines that outline the objectives of conducting Environmental Impact Assessments (EIAs) for genetically modified organisms (GMOs), the specific criteria necessitating an EIA, and the procedural steps to be taken in the event that these criteria are met.[109]

The National Environmental Management Biodiversity Act (NEMBA) presently does not mandate the necessity of Environmental Impact Assessments (EIAs) for genetically modified organisms. However, if an Environmental Impact Assessment (EIA) conducted in compliance with the National Environmental Management Act (NEMA) concludes that the GMO activity is deemed acceptable, the Executive Council (EC) of the GMO Act is responsible for reviewing and granting the required authorization. Nonetheless, in line with section 78 of NEMBA, the

[108]Bouët, A., and G. Gruère., "Refining Estimates of the Opportunity Cost of Non-adoption of Bt Cotton: The Case of Seven Countries in Sub-Saharan Africa." *Applied Economic Perspectives and Policy 33* (2): 260–279, 2011.
[109]*ibid*

EC retains the authority to instruct the Registrar to deny the permission if the EIA identifies an unacceptable level of risk.[110]

3.4.8 Consumer Protection Act

In 2008, the Consumer Protection Act (CPA, Act No. 68 of 2008) made it compulsory to label genetically modified (GM) products. As per Regulation R. 293 of 2011, food producers, importers, and packagers are obligated to use one of three specific labels for GM foods: "containing GMOs" when the GM content is at least 5%, "produced using genetic modification" for products directly sourced from GMOs, and "may contain GMOs" when it is scientifically challenging to test for GM content. There are other optional labels, such as "does not contain GMOs" for items with less than 1% GM content, "GM content is less than 5%" for products with 1% to 5% GM content, and "may contain genetically modified ingredients" for products with undetectable GM level. These labelling rules are intended to offer clear information to customers regarding the presence of GMOs in food items.[111]

The Department of Trade and Industry (dti) released a proposal in October 2012 on the labelling of genetically modified (GM) goods. "Labelling genetically modified organisms" was intended to be changed to "labelling genetically modified ingredients or components." This change would mean that instead of labelling the product as a whole, just the individual ingredients would need to be marked as "containing GM" in the ingredient list. It is noteworthy that these suggested modifications had not been formally implemented as of January 2016.[112]

[110]Mayet M "Analysis of the South Africa's GMO Act of 1997" *Biowatch South Africa*, (2000)
[111]*ibid*
[112]Gruère, G. P., and H. Takeshima., "Will They Stay or Will They Go? The Political Influence of GM-Averse Importing Companies on Biosafety Decision Makers in Africa." *American Journal of Agricultural Economics* 94 (3): 736–749, 2012.

3.4.9 South Africa International Regulations

3.4.9.1 Cartagena Protocol on Biosafety

In 2003, South Africa ratified the Cartagena Protocol on Biosafety, an international agreement under the Convention on Biological Diversity. The primary objective of this protocol is to regulate the global movement of living modified organisms (LMOs) to minimize potential adverse impacts on human health and biodiversity. The GMO Amendment Act of 2006 incorporated modifications aligned with the provisions of the Cartagena Protocol. These changes were designed to ensure compliance with the agreement and establish processes for making informed decisions regarding the importation of genetically modified organisms.[113] The Cartagena Protocol also gave rise to the establishment of the Biosafety Clearing-House (BCH), a mechanism for the exchange of information pertaining to genetically modified organisms (GMOs) to ensure compliance with protocol regulations. This clearinghouse streamlines the dissemination of information regarding the transboundary movement of GMOs across various domains, including science, technology, the environment, and legal matters. In South Africa, the Biosafety Clearing House (BCH) is overseen by the Department of Agriculture, Forestry, and Fisheries (DAFF) and serves as a central hub for sharing information about living modified organisms (LMOs), providing a platform for the vital exchange of such data.[114]

Uncertainty over the specific data required for the regulatory dossier is a serious challenge in South Africa. Even with regulations in place, it's not clear what data has to be sent to the GMO Act registrant. This uncertainty puts applicants at risk since they might be asked to provide further information that could take years to gather. The lack of clear communication and

[113] *ibid*

[114] Yousefi VO. *Agrochemicals in South Africa 2000*; Available at: http://www.occuphealth.fi/e/info/anl/199/agro03.htm.

interaction with authorities sometimes results in applicants being ignorant of the requirements for minimum permission. This is particularly crucial when evaluating the socioeconomic impact because it might be difficult to determine the exact needs.[115]

3.4.9.2 Codex Alimentarius

South Africa, as a member of the Codex Alimentarius Commission, adheres to the Commission's principles and standards for assessing the safety of genetically modified organisms (GMOs) in food and feed. This safety evaluation includes the investigation of potential allergenicity, toxicity, compositional analysis, metabolite analysis, the impact of food processing, nutritional changes, and other pertinent considerations. A full safety review of this type is required when applying for a Commodity Import Permit or a General Release Permit for GMOs in South Africa.[116]

3.4.10 Monitoring

Monitoring is an essential component of South Africa's laws and regulations for genetically modified organisms (GMOs). The government started the process of establishing a comprehensive monitoring system for both pre-commercial and post-commercial GMOs. To protect the environment from potential GMO-related hazards, Section 78 of the National Environmental Management: Biodiversity Act (NEMBA) was amended. Pre-release monitoring is handled by the Department of Agriculture, Forestry, and Fisheries (DAFF), while post-commercial general monitoring is handled by the South African National Biodiversity Institute (SANBI).[117]

[115] Ismael Y, Bennett R, Morse S. Benefits from Bt cotton use by smallholder farmers in South Africa. *AgBioForum* 2002; 5:1-5. Available at http://www. agbioforum.org
[116] *ibid*
[117] Gómez-Barbero M, Rodríguez-Cerezo E. *GM Crops in EU agriculture—A case study for the Bio4EU project* 2007; Available at http://bio4eu.jrc.ec.europa.eu/ documents/FINALGMcropsintheEUBIO4EU.pdf.

SANBI's tasks include reporting to the Minister on the environmental implications of genetically modified organisms (GMOs) after they have been commercialised. SANBI is also tasked with developing a surveillance programme customised to the South African environment and agricultural practises. This entails using structured risk analysis approaches and collaborating with stakeholders to identify critical biodiversity monitoring objectives. SANBI performs specialised research on genetically modified organisms (GMOs) and their possible environmental consequences in South Africa.[118]

South Africa faces difficulties in monitoring genetically modified (GM) crops due to a lack of resources and a scarcity of expertise in biodiversity. Only one crop (MON810) out of 129 characteristics is actively monitored, highlighting the need for increased resources. Despite this, South Africa has made significant economic gains with GM crops, supported by a regulatory framework allowing the release of multiple characteristics in major crops. However, the regulatory system is encountering difficulties in adjusting to the changing political and economic landscape. GM technology is now addressing complex concerns in health, social, and industrial sectors, aiming to enhance food crop quality and provide therapeutic proteins for humans and livestock through ongoing research.[119]

3.5 Kenya

3.5.1 Agriculture in Kenya

The agricultural sector is of significant importance to Kenya's economy, contributing approximately one-third (33%) of the country's Gross Domestic Product (GDP).It also serves as the primary employer for over 40% of the entire population and a significant 70% of those

[118]Genetically Modified Organisms Amendment Act, No. 15 of 1997; Available at http://www.info.gov.za/acts/1997/act15.htm
[119]*ibid*

living in rural areas.[120] However, in 2022, the agricultural sector experienced a slight decline of 1.9 percent, primarily due to the overall economic impacts of the COVID-19 pandemic. Kenya's agricultural territory covers about half of the country's land, but only 21 percent of this area is arable, limiting the potential for farming expansion. Additionally, the sector faces challenges from unfavorable weather conditions relying heavily on rainfall for irrigation. However, climate change has led to more frequent droughts, adversely affecting agricultural output. Moreover, locust infestations also disrupted agricultural production, resulting in constraints on crop and livestock yields, increased food prices, and threats to food security. For example, as of November 2021, nearly eight million people in Kenya were experiencing food insecurity, lacking sufficient food for consumption.[121]

In February 2023, Kenya confronted a severe drought, resulting in devastating consequences and pressing humanitarian needs for local communities. From March to June, over 5.4 million individuals faced severe acute food insecurity, including 1.2 million in the emergency phase. In comparison to the previous year, this constituted a 43% rise in food insecurity. Despite the growing need, drought response efforts in Kenya have been impeded by a lack of funds, reducing the efficiency of humanitarian organisations' activities.[122] The drought led to acute malnutrition affecting roughly 970,000 children and 142,000 pregnant or lactating mothers, compromising their immunity and making them more susceptible to diseases. Moreover, the drought caused the deaths of over 2.4 million livestock, impacting pastoralist families who depend on them for sustenance and livelihood. Drought-affected families resorted to desperate

[120]FAO, *The Agriculture Sector in Kenya*., Accessed on July 24 2023 https://www.fao.org/kenya/fao-in-kenya/kenya-at-a-glance/en/
[121]*ibid*
[122]*ibid*

and unhealthy coping strategies, increasing the likelihood of gender-based violence and hindering children's access to school.[123]

Kenya heavily depends on wheat and rice imports, resulting in food insecurity and hunger. The reliance on rain-fed agriculture, coupled with unpredictable rainfall patterns and crop diseases, further hampers food production. With the recent lifting of the GMO ban, there are prospects to enhance crop resilience, disease resistance, and yields.[124]

3.5.2 Kenya and GM Technology Adoption

Kenya holds a crucial economic position in East Africa region and the East African Community (EAC). It is acknowledged as the most industrially developed nation in both regions and serves as a central trade and financial hub in East Africa. The nation's economic foundation is primarily rooted in agriculture, with around seventy-five percent of its population engaged directly or indirectly in this sector. Kenya's geographical location, sharing borders with five countries (Somalia, Ethiopia, Tanzania, Uganda, and Sudan), makes it a significant transit point for the transportation of grains and agricultural products into East Africa.

Kenya approved the commercial production of Bt Cotton, a genetically modified crop trademarked by the Monsanto Company, in December 2019. This decision highlighted the government's growing commitment to commercialising genetically modified (GM) crops. Cassava (designed for resistance to cassava mosaic virus), Bt maize (modified for pest resistance), bananas, cowpea, pawpaw, sorghum, and other crops now in development for

[123]IRC., *Severe Drought is Projected To Leave About 5.4 Million People in Kenya Without Adequate access to Food and Water Between March and June 2023*, Accessed July 24 2023, https://www.rescue.org/press-release/irc-severe-drought-projected-leave-about-54-million-people-kenya-without-adequate#:~:text=Kenya

[124]Kimenju, S., and H. de Groote., *"Consumer Willingness to Pay for Genetically Modified Food in Kenya." Agricultural Economics* 38 (1): 35–46, 2008.

various GMO features are among the GM crops under consideration. The recent relaxation of the GMO restriction, along with the narrative emphasising the relevance of GMOs, highlights this technology's potential to solve food and nutritional poverty, notably by increasing agricultural output in the face of climate change difficulties.[125]

With the Kenyan Agricultural Research Institute (KARI) in the forefront, Kenya has become a leader in genetic modification and biotechnology research in East Africa. Over the last ten years, KARI has established collaborations with major private organisations and enterprises such as the Rockefeller Foundation, Monsanto, Syngenta Foundation, USAID, and others. Collectively, they have carried out studies and limited field tests with an emphasis on crops including cotton, sorghum, maize and cassava. In addition to KARI, Kenya is home to a number of other international research institutions, such as the Alliance for a Green Revolution in Africa (AGRA), the World Agroforestry Centre (ICRAF), the International Maize and Wheat Improvement Centre (CIMMYT), the International Livestock Research Institute (ILRI), and the International Food Policy Research Institute (IFPRI). These collaborations highlight Kenya's pivotal role in advancing biotechnological and genetic modification studies in the region.

3.6 Kenya GM Technology Regulatory Framework

Kenya has put in place a thorough framework that includes institutional, regulatory, and policy elements to support biotechnology innovation. In 2003, the nation ratified the Cartagena Protocol on Biosafety, which established guidelines for the establishment of national biosafety frameworks. The National Policy on Biotechnology Development, which provides a defined road map for biotechnology research and its commercialization, was adopted by Kenya in 2006.

[125] *ibid*

The Biosafety Act, which established institutional and legal frameworks to regulate contemporary biotechnology practises, was subsequently passed into law in 2009. As a result of this evolution, the National Biosafety Authority (NBA) was established in 2010 and given the responsibility of overseeing and governing biotechnology-related operations in the nation.[126]

3.6.1 National Regulatory

Kenya stands at the forefront of biotechnology and genetic modification research in East Africa. In 2006, the country introduced a National Biotechnology Development Policy, underscoring its dedication to advancing biotechnological progress, particularly in the field of agriculture. Genetically modified food safety in Kenya is overseen by the Kenya Biosafety Authority (NBA), which was established by the Kenya Biosafety Act No. 2 of 2009. The NBA is partnered with eight regulatory bodies, which are the Pest Control Products Board (PCPB), Department of Public Health (DPH), Kenya Bureau of Standards (KEBS), Kenya Plant Health Inspectorate Services (KEPHIS), Kenya Industrial Property Institute (KIPI), Kenya Wildlife Service (KWS), and National Environment Management Authority (NEMA). When these organizations work together, they guarantee the safe use of biotechnological advancements.[127] The National Biosafety Authority (NBA) has designed and implemented four biosafety laws encompassing genetically modified (GM) organism research, environmental discharge, export/import/transit, and labelling. When assessing the safety of genetically modified foods, the NBA follows the principles set in the International Food Code Codex Alimentarius and takes a case-by-case approach. The safety assessment method entails a thorough description and characterization of the genetic alterations, a thorough examination of possible allergies,

[126]Kadida, J. (2007, October 12). Court rejects bid to stop GMO debate. Daily Nation, p. 37.
[127]*ibid*

toxins, and nutritional components, and an assessment of the impact of food processing. The fundamental goal is to guarantee that GM foods are as safe as traditional foods, while taking into account the most recent scientific information and adhering to established standards and practices.[128]

The Kenyan Agricultural Research Institute (KARI) is a significant institution committed to the advancement of the country's agricultural sector. KARI has formed alliances with a number of firms and private organisations, including Monsanto, the Syngenta Foundation, the Rockefeller Foundation, and USAID, among others. These relationships are focused on performing research and controlled field experiments with crops including maize, sorghum, cassava, and cotton. Kenya is home to a number of international research institutions, including the International Livestock Research Institute (ILRI), the International Food Policy Research Institute (IFPRI), the World Agroforestry Centre (ICRAF), the International Maize and Wheat Improvement Centre (CIMMYT), and the Alliance for a Green Revolution in Africa (AGRA). These institutes provide major contributions to Kenya's agricultural development.[129]

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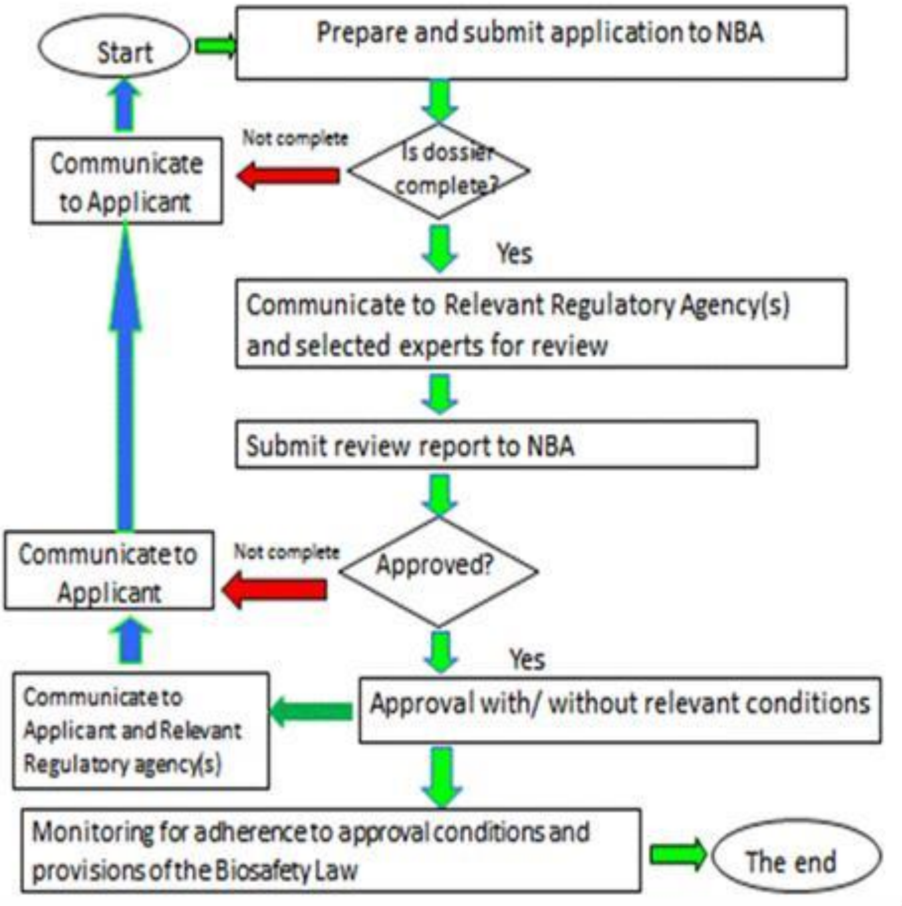
[128]Wambugu, F. M., Modifying Africa: *How biotechnology can benefit the poor and hungry,* a case study from Kenya. Nairobi, Kenya (2001).
[129]*ibid*

Figure 3.5: Process for approving production of GE Crops developed in Kenya



Source: National Biosafety Authority (Kenya)

3.6.2 International Regulatory

3.6.2.1 The Cartagena Protocol on Biosafety

Kenya has put in place a thorough institutional, legal, and policy structure to make it easier to incorporate biotechnology advancements. The Cartagena Protocol on Biosafety (CPB) under the Convention on Biological Diversity (CBD) is the principal international regulatory framework for Genetically Modified Organisms (GMOs). Kenya is a signatory to the CPB, having ratified it in 2003 after endorsing it in May 2000 and passing the Kenya Biosafety Act in 2009. Following the examples established by South Africa, Egypt, and Burkina Faso, this Act went into effect on July 1, 2011, making Kenya the fourth country in Africa to explicitly legalise the growing and importing of genetically modified (GM) crops. Kenya's biosafety legislation is set up according to the CPB's guiding principles.[130]

The National Biosafety Authority (NBA) is in charge of ensuring that genetic modification research is carried out under safe experimental circumstances. It also assesses the safety of open farming of genetically modified crops, with an emphasis on human health and the environment. Furthermore, the NBA regulates the safe transit of genetically modified materials into and out of the nation, as well as ensuring that consumers have access to correct information and traceability of genetically modified goods along the food supply chain. To protect consumer health and ensure fair food trade practises, the NBA employs suitable criteria for assessing the safety of genetically modified foods, based on sources such as the International Food Code Codex Alimentarius.[131]

The safety of genetically modified (GM) foods is assessed on an individual basis, taking into account both predicted and unanticipated effects in contrast to conventional equivalents with a history of safe use. The National Biosafety Authority rigorously administers the Cartagena Protocol on Biosafety in Kenya, with an emphasis on preserving human health and environmental safety in the arena of modern biotechnology..[132]

3.7 Kenya and controversies surrounding the Adoption of GMOs

Kenya’s “Vision 2030” aims to attain idle-income status by utilizing agriculture as a key economic driver. The country has made progress in accepting GMOs, establishing a biosafety regulatory authority, and signing the Cartagena Protocol on Biosafety. Kenya has approved

[130]Bett, C., J. Okuro Ouma, and H. De Groote., “Perspectives of Gatekeepers in the Kenyan Food Industry towards Genetically Modified Food.” *Food Policy* 35 (4): 332–340, 2010.
[131]*ibid*
[132]*ibid*

two GM crops for commercial use, but the acceptance process has been slow due to negative perceptions and a lack of monitoring data. The Kenya GMO Concern Group, comprising influential consumer interest groups, opposes the Biosafety Act as it removed restrictions on GMOs and allowed the import of GM grains into the market. In 2012, the government imposed a ban on GMO imports citing concerns about the safety of GM foods, leading to criticism from the National Biosafety Authority. The ban was lifted in 2019 for GM cotton, and in 2022, farmers were allowed to cultivate pest-resistant GM maize due to damage caused by fall armyworm moths. The ban's lifting aims to address agricultural challenges and enhance food production in Kenya through Research and Development. However, GMO acceptance still faces public skepticism and regulatory challenges in the country.[133]

3.7.1 Concerns about GMOs in Kenya

Concerns regarding the safety of GMO foods for human consumption continue to persist in Kenya, with 51% of respondents expressing apprehensions influenced by past studies, discredited by experts. Public education is needed to address safety concerns and provide accurate information about GMOs' scientific consensus. Around 51% of Kenyans fear GMOs may cause diseases like cancer, indicating a lack of trust in their safety, requiring comprehensive studies to assess health impacts. 59% worry about harmful genetic changes to the environment, highlighting the need for rigorous risk assessments before releasing GMOs. Approximately 25% believe GMOs have less nutritional value, necessitating better communication about their content. On the positive side, 48% acknowledge GMOs' potential to grow faster, 43% recognize enhanced drought and disease resistance, and 27% believe they

[133]*ibid*

could be less expensive, benefiting food affordability and security in a country facing rising living costs.[134]

3.7.2 Knowledge and apprehension related to GMO Foods and the approval of the Kenyan Government

In Kenya, concerns about the safety of GMO foods persist, with 51% of respondents expressing apprehensions based on past studies discredited by experts. Public education is needed to address safety concerns and provide accurate information about GMOs' scientific consensus. About 51% of Kenyans fear GMOs may cause diseases like cancer, indicating a lack of trust in their safety, necessitating comprehensive health impact studies. Moreover, 59% worry about potential harmful genetic changes to the environment, emphasizing the need for rigorous risk assessments before releasing GMOs. Approximately 25% believe GMOs have less nutritional value, highlighting the need for improved communication about their content. On the positive side, 48% recognize GMOs' potential to grow faster, 43% acknowledge enhanced drought and disease resistance, and 27% believe they could be less expensive, benefiting food affordability and security in Kenya's context of rising living costs.[135]

3.8 Conclusion

In conclusion, South Africa's agricultural sector benefits from a well-established commercial segment and substantial subsistence farming. The adoption of GMO technology has positioned the country as a global producer of crops like maize, soybean, wheat, and cotton, enhancing productivity, food security, and reducing pesticide use. In contrast, Kenya grapples with challenges in its agricultural sector, such as limited arable land, adverse weather conditions,

[134]Wrigley, A., "Proxy Consent: A Moral Authority Misconceived". *Journal of Medical Ethics*, Vol.33, pp.527-531, 2007.
[135]*ibid*

and pest issues, resulting in food insecurity. To tackle these challenges, Kenya needs to promote GMO adoption to enhance crop resilience and yields. Despite making progress in GMO adoption and possessing a robust regulatory framework, Kenya faces public concerns regarding GMO safety and environmental impact. Addressing these concerns necessitates comprehensive public education and transparent communication efforts. These initiatives are vital not only to foster broader acceptance but also to ensure a sustainable agricultural future for Kenya. Both countries encounter challenges in implementing biosafety regulations for GMOs under the Cartagena Protocol. Collaborative efforts within regional economic communities and support from the African Union are crucial recommendations to address these challenges effectively. Such efforts can promote sustainable development while managing GMO technology and trade, aligning with the goal of achieving SDG2.

CHAPTER FOUR

GMO TECHNOLOGY AND ATTAINMENT OF SDG2 IN AFRICA: KEY CHALLENGES AND LESSONS

4.0 Introduction

The previous chapter examined the laws and regulations that regulate the application of genetically modified technology in Kenya and South Africa. Genetically modified (GM) technology plays a significant role in advancing both Kenya and South Africa towards the ambitious aim of attaining zero hunger by 2030, a pivotal component of their sustainable development objectives. It can do this by boosting crop yields, increasing nutrient content, reducing food waste, and tackling the challenges posed by climate change. However, it's crucial to have effective regulations in place and make sure the public is well-informed for responsible GM technology adoption. To actually achieve zero hunger in Kenya and South Africa, it's essential for governments and international organizations to invest in agricultural infrastructure and encourage sustainable farming practices. This includes providing support to small-scale farmers through access to credit and training, promoting the adoption of research and technology, and implementing food security programs. Additionally, setting up trade policies, educating people about nutrition, establishing effective emergency response systems, fostering collaboration, and having robust monitoring mechanisms are all vital components of the strategy. These efforts, when combined, create a comprehensive approach to combat hunger and secure a future with ample food for both these nations and the broader African continent. However, as Kenya and South Africa work towards adopting GM technology to achieve Sustainable Development Goal 2, they face a range of challenges that hinder their progress. This chapter thoroughly analyzed these challenges, drawing upon a wide array of secondary and primary data sources. This chapter also takes a close look at these challenges extracting valuable lessons that provide a thorough understanding of the hurdles faced in adopting GM technology to achieve SDG2 in Africa.

4.1 Characteristics of the Respondents based on their demographics

This section describes the respondents' demographic characteristics, including information such as response rate, age, gender, and educational qualifications.

4.1.1 Response Rate

The responses were gathered using a combination of questionnaires and Google Forms. Employees of organisations such as the World Food Programme, the Food and Agriculture Organisation, KARI, and KALRO, as well as government officials, mostly from the Ministry of Agriculture, Livestock, Fisheries, and Co-operatives, were given these surveys. Google Forms was used to collect data from the general public. The data collected from the questionnaires, and Google Forms was then analysed using content analysis tools. According to the table 4.1 below, the response rate for this study was 65%.

Table 4.1: The Response rate from Questionnaires and Google Forms

Ser	Target Group	Questionnaire's Respondents	Response Rate
1.	The personnel from the World Food Programme	10	7
2.	The Staff from Food and Agriculture Organization	15	8
3.	The Staff from Kenya Agricultural and Livestock Research Organization (KALRO)	10	6
4.	The Staff from Kenya Agriculture Reforms & Innovations (KARI)	15	9
5.	The Government officials from the Ministry of Agriculture, Livestock, Fisheries and Co-operatives	10	7
6.	The Staff from High Commission of South Africa	10	5
7.	Academicians and researchers both in Kenya and South Africa	15	11
8.	General Public	15	12
Total		100	65

Source: Researcher, Primary Data (2023)

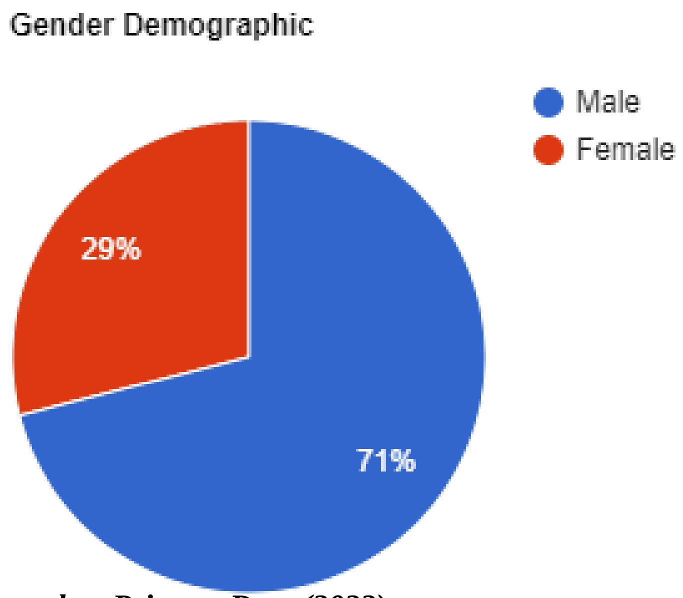
For data analysis, Mugenda & Mugenda state that a response rate of 50% is appropriate, a response rate of 60% is favourable, and a response rate of more than 70% is exceptional. The study's response rate of 65% to the questionnaires, and Google Forms is within the acceptable range, making the data analysis appropriate.

4.1.2 Gender

As seen in Figure 4.1.2 below, the information gathered from the questionnaire, and Google Forms showed that 71% of respondents were men and 29% were women. This distribution is mainly explained by the larger percentage of data collected from organisations where the majority of employees are men.

Figure 4.1: Gender of the Respondents

Gender Demographic

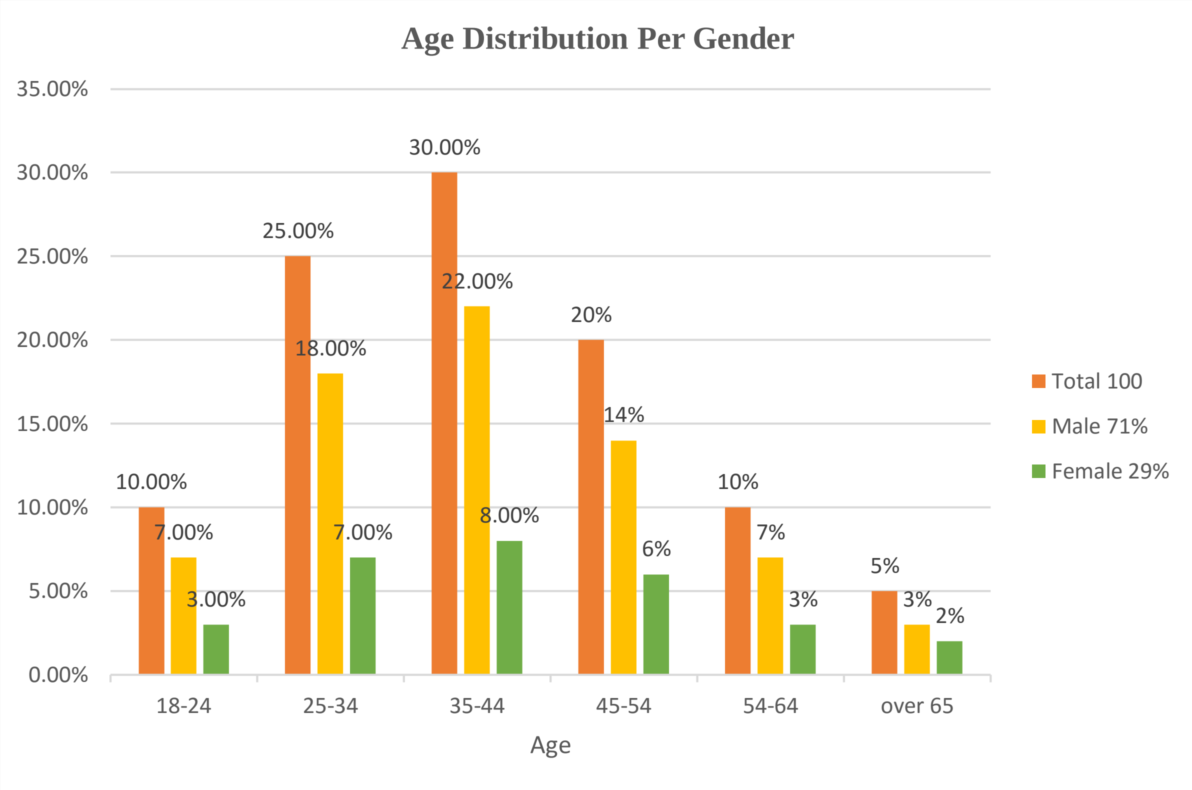


Source: Researcher-Primary Data (2023)

4.1.3 Respondent's Age

Approximately two-thirds of the 100 respondents were between the ages of 19 and over 65. 25% were between the ages of 25 and 34, while one-fifth were between the ages of 45 and 54. Thirty percent of those polled were between the ages of 35 and 44. It's worth noting that only 10% of the total sample was between the ages of 18 and 24 (see Figure 4.1.3 below). This demographic makeup reflects a survey sample with a wealth of information gained through life experiences.

Figure 4.2: Age per Gender



Source: Researcher, Primary Data (2023)

4.1.4 Respondent Level of Education

Table 4.2: Level of Education

Education Level	Percentage %
No Formal Education	0
Primary school	6.1
Secondary school	14.6
Diploma	19.2
Bachelor's Degree	30.2
Master's Degree	20.1
Other degrees	9.8

Source: Researcher, Primary Data (2023)

One important factor in this study was the individuals' educational backgrounds. The majority of respondents, or 14.6% of the sample, possessed secondary credentials, as shown in Table 4.2.4 above. Those with degrees and diplomas came next, making up 19.2% and 30.2% of the population, respectively. Due to their educational background, the respondents were considered acceptable for the study since they were knowledgeable.

4.2 Challenges African States face in the Adoption of GM Technology in the attainment of SDG2

There are several obstacles to the acceptability of genetically modified organisms (GMOs) in Africa, including practical, health, and socioeconomic issues. These barriers have prevented GMOs from being widely adopted in many African nations, despite the fact that they have the potential to improve food security and agricultural production in these countries.

4.2.1 Knowledge and Awareness of GMOs

The degree of public knowledge and comprehension about genetically modified organisms (GMOs) is a highly influential factor in society. It affects a number of aspects, including consumer acceptability, government laws, and farmers' adoption of biotechnological goods. Research have demonstrated that people's acceptance of genetically modified organisms (GMOs) tends to rise with increased knowledge about GMOs and biotechnology/genetic engineering. Insufficient dissemination of information about the lack of scientific proof regarding health hazards and the possible advantages of contemporary biotechnology in Kenya resulted in demonstrations and public fear about genetically modified organisms.[136] The Kenyan government announced a ban on the import of genetically modified foods in November 2012 without consulting the country's biosafety experts. This decision was partly motivated by

[136] *ibid*

a widely disseminated assertion that suggested a relationship between the ingestion of GM maize and probable long-term damage, particularly in animals such as cancer. The prohibition remained in effect until 2022, when President William Samoie Ruto lifted it.[137]

In South Africa, a government-sponsored poll of 7,000 citizens revealed that 8 out of 10 respondents were unaware about biotechnology and GMOs. According to the survey, 63% of individuals were unaware that they had ingested food products containing GM components. Acceptance of biotechnology and GMOs is expected to rise only when people understand that GMOs contribute to improved food security and sustainable development while posing no known risks to their general well-being.[138]

Current events suggest that Africans are becoming more conscious of GMOs and biotechnology. For example, the 2020 introduction of Bt cotton farming in Kenya has rekindled farmers' enthusiasm in growing lucrative cotton. In Nigeria, 88% of the 355 respondents to a survey evaluating public acceptance of genetically modified crops in the food market had prior awareness of GMOs. 23% of this group said they knew a lot, 56% said they knew a little, and 19% said they knew very little. Furthermore, 44% of participants said they would be willing to eat genetically modified crops once they were available, compared to 30% who said they wouldn't and 23% who weren't sure. Remarkably, 76% of respondents said they carefully read product labels before making a purchase, and 90% of them wanted food products containing genetically modified ingredients to be accurately labelled. Furthermore, 83% percent of the

[137] *ibid*

[138] Paarlberg, R., GMO foods and crops: Africa's choice. *New Biotechnology*, 27(5), 609–613. (2010). https://doi.org/10.1016/j.nbt.2010.07.005

participants said that they would be very interested in learning more about genetically modified organisms.[139]

It is anticipated that African farmers would use biotech crops more frequently as a result of growing understanding of the technology, which might benefit both their families and the continent as a whole. But it's important to understand that acceptance of GMOs in Africa is impacted by more than just awareness and understanding. In a 301-person survey done in Zimbabwe, the results showed that 92% of participants had prior knowledge of GMOs. Even with this knowledge, most respondents had negative opinions about the use of genetically modified organisms (GMOs) in food production. While raising public knowledge of GMOs is still crucial, concurrent attention should also be paid to other issues that influence GMO adoption and acceptability in African nations.[140]

4.2.2 Health and Safety issues

Safety concerns related to GMOs stand as a significant issue, leading to hesitancy in adopting these crops across many African nations. Despite comprehensive evaluations and safety protocols outlined in national and international biosafety frameworks, perceived risks, often lacking strong scientific basis, have hindered the adoption of GMOs in Africa. For instance, in a study conducted in Nigeria with 355 participants, 80% expressed apprehensions about GM crops, with 65% citing concerns about potential health risks. One significant safety concern revolves around gene flow, which encompasses the transfer of genetic material between distinct populations, potentially resulting in "genetic pollution" when GMOs crossbreed with wild counterparts. This genetic exchange can lead to the creation of more robust and fertile hybrids,

[139]Senghor, L. A., Ortega-Beltran, A., Atehnkeng, J., Callicott, K. A., Cotty, P. J., & Bandyopadhyay, R., The atoxigenic biocontrol product Aflasafe SN01 is a valuable tool to mitigate aflatoxin contamination of both maize and groundnut cultivated in Senegal. *Plant Disease*, 104(2), 510–520. (2020).
[140]*ibid*

potentially triggering ecological consequences such as increased weediness and the extinction of wild species. There have been reported cases of genes from GMOs escaping into the environment, with some instances persisting over time. Despite these concerns, scientific inquiries have not yielded substantial evidence of adverse health and environmental effects stemming from these genetic interactions.[141]

Numerous studies have provided evidence of GMO safety, with substantial equivalence being a key concept. Substantial equivalence involves comparing GM crops with their non-GM counterparts and has been accepted globally as a basis for assessing GMO safety. Some studies have found GMOs to be nutritionally and chemically equivalent to conventional varieties. However, not all studies support substantial equivalence, as genetic modification can lead to differences in metabolic pathways and protein profiles.[142]

Although debates about the safety of GMOs persist, their acceptance in Africa is undergoing a noticeable transformation. Developing countries, including South Africa, now account for more than 30% of global GMO cultivation. International organizations such as the FAO and WHO have asserted that there is no scientific evidence establishing substantial health or environmental risks associated with GMOs. Health Canada and the British government have also stressed the safety of GMOs. Safety concerns have played a substantial role in the reluctance of African nations to embrace GMOs. Nevertheless, ongoing debates notwithstanding, scientific evidence predominantly supports the safety of GMOs, and their acceptance in Africa is steadily increasing.[143]

[141]UN News. Sub-Saharan Africa faces grave hunger challenges in 2020. *UN food relief agency*. https://news.un.org/en/story/2019/12/1054571 (2019).
[142]*ibid*
[143]*ibid*

4.2.3 Policies and regulatory framework

In Africa, policies and regulatory frameworks provide a significant obstacle to the widespread use of GMOs. The acceptability, application, and market entrance of GMOs throughout the continent are significantly influenced by these laws and regulations. Robust regulatory regulations and procedures are important to guarantee the safety of both humans and the environment, promote research and development, and ease the commerce of genetically modified organisms. They enable African countries to take use of genetic engineering's benefits while also protecting their people and environment from possible GMO-related hazards.[144]

In many African nations, regulating genetically modified organisms poses significant hurdles. The International Food Policy Research Institute (IFPRI) and the African Development Bank (AfDB) noted in a 2014 research that local institutions in Africa are heavily impacted financially by the regulatory frameworks that are now in place. In addition, these systems frequently have inefficiencies, a lack of transparency, and a tendency to overestimate risks. At the moment, many African countries lack the basic elements and capability needed to set up comprehensive frameworks, rules, and policies for the use and oversight of genetically modified organisms.[145]

4.2.4 Political Will and External Influence

Adoption of GMOs in Africa is severely hampered by political decisions and outside factors. Politicians and decision-makers need to be knowledgeable about genetically modified organisms (GM) and prepared to defend their judgements to the general public. African officials' positions and decision-making processes surrounding GMOs are also influenced by

[144]Venter, C., *Quick overview of GMOs in South Africa*. Retrieved January 9, 2020, from https://www.agriorbit.com/quick-overview-of-gmos-in-south-africa/

[145]*ibid*

external forces, including the influence of non-governmental organisations (NGOs), Western nations, multinational companies, and other groups.[146]

In contrast to the US, where the commercial release of genetically modified organisms (GMOs) is contingent upon regulatory compliance and the results of standardised testing, the EU is able to forbid GMOs in situations where there is scientific ambiguity. Africa's position on genetically modified organisms has been greatly impacted by Europe's cautious attitude to GMO regulations. The European Union's strong commercial ties with African countries, especially in the agriculture sector, are responsible for this effect. For example, more than 25% of the exports from Central African countries were to the EU in 2016. African officials and politicians frequently place a higher priority on their official development aid (ODA) and commercial ties with Europe, which causes them to view genetically modified organisms (GMOs) with suspicion. It's worth noting that Africa's agricultural exports to Europe are six times greater than those to the US, while official development support from the US is around three times lower. African countries are concerned about jeopardising these advantages, encouraging them to agree with European states' stances.[147]

Non-governmental organisations (NGOs), such as Friends of the Earth, Greenpeace, GM Freeze, and ActionAid, have aggressively discouraged African nations from adopting GM crops, as have their African counterparts. Their arguments centre on fears that GMOs would jeopardise biodiversity, increase reliance on major multinational agri-business enterprises in developed nations, and pose health dangers to the people. The Alliance for Food Sovereignty (AFSA), a pan-African platform, promotes ecological land management and biodiversity in

[146]*ibid*

[147]WHO, *As more go hungry and malnutrition persists, achieving Zero Hunger by 2030 in doubt*, UN report warns. (2020). Retrieved August 11, 2023, from https://www.who.int/ news/item/13-07-2020-as-more-go-hungry-and-malnutrition-persists-achieving-zerohunger-by-2030-in-doubt-un-report-warns

Africa while fiercely opposing the use of genetically modified (GM) seeds. GMOs, according to AFSA coordinator Million Belay, are not a solution to Africa's famine. Greenpeace urges caution, opposing the release or commercialization of genetically modified organisms (GMOs) into the environment until adequate scientific data supports their safety.[148]

Some local officials, tribal authorities, and members of the general population are sceptical about GMOs, which stems from a widespread distrust of Western countries. They see GMOs as yet another example of Western influence, raising fears about bioterrorism, Western multinational corporations' economic domination of the African agriculture sector, and the widening socioeconomic difference between developed and developing countries.[149]

4.2.5 Environment and Intellectual Rights

GMOs offer valid environmental issues, such as genetic transfer to wild plant cousins or the growth of insect and weed resistance. These concerns underline the significance of extensive risk assessments and continuing environmental monitoring. Intellectual property rights associated with GMO technology complicate legal and financial issues for African farmers and academics. Patent and licencing issues limit access to GMO characteristics and technology, affecting their pricing and accessibility.[150]

4.3 Lessons African States can learn from GM Adoption

African nations, including South Africa and Kenya, have the opportunity to gain valuable insights from countries that have incorporated genetically modified (GM) technology into their agricultural systems. This collaboration is crucial as these nations strive to attain Sustainable

[148]UN News. Sub-Saharan Africa faces grave hunger challenges in 2020. *UN food relief agency*, (2019). https://news.un.org/en/story/2019/12/1054571
[149]*ibid*
[150]*ibid*

Development Goal 2 (SDG2), which is focused on eliminating hunger, enhancing food security, advancing nutrition, and fostering sustainable agriculture. To ensure a comprehensive and people-centered approach, it is essential to break down these lessons into key areas. First and foremost, South Africa's exemplary model for regulating GMOs shines as an instructive example in establishing a transparent legal and regulatory framework that guarantees the safety and effectiveness of GM crops. This regulatory structure, which South Africa has successfully implemented, should serve as a blueprint for Kenya, emphasizing transparency and involving the public to address any potential concerns.[151]

Secondly, it is imperative to enhance the capacity of farmers to enable them to fully leverage the potential of GM technology. Taking a cue from Ghana's Farmer-Based Organizations, the development of tailored training programs and educational initiatives is vital. These programs empower farmers with knowledge and skills while ensuring they align with local needs, languages, and traditional farming practices to foster comprehension and acceptance.[152]

Thirdly and equally important is public awareness and education, where Canada's public awareness campaigns offer a useful reference. South Africa and Kenya can adopt similar campaigns to inform the public about the benefits and potential risks of GM technology. Crucially, these campaigns must be culturally sensitive, addressing local concerns and amplifying local voices. Ensuring access to GM seeds is a significant consideration. Insights from Argentina's experience in commercializing GM crops can inform strategies to make these seeds more accessible to smallholder farmers. Policymaking should emphasize affordability

[151]Giller K. E., Delaune T., Silva J. V., Descheemaeker K., van de Ven G., Schut A. G., et al., The future of farming: Who will produce our food? Food Secur. 13 (5), 1073–1099. (2021). 10.1007/s12571-021-01184-6

[152]Groenewald H., "Chapter 5: The future: Induced genetic variation technologies, GMOs and responsible governance," in Masehela. et al. 2021, *an initial assessment of impacts on biodiversity from GMOs released into the environment in South Africa* (Pretoria: South African National Biodiversity Institute, an entity of the Department of Forestry, Fisheries and the Environment;), 84–91. (2021).

and availability, ensuring that marginalized and small-scale farmers can access these invaluable resources.[153]

Fourthly, research and development play a pivotal role in adapting GM crops to local conditions, and Brazil's investment in this area serves as a compelling model to emulate. Collaboration with local research institutions is essential for Kenya and South Africa to develop GM crops tailored to their unique climates and agricultural challenges. This research should particularly focus on staple crops and traditional foods, addressing specific nutritional requirements of the region.[154]

Fifthly, collaboration with international organizations is essential for leveraging knowledge and resources. India's successful collaborations with international organizations in accessing GM technology offer important lessons. These collaborations should be structured to benefit the local population and align with national development goals. Also the establishment of effective monitoring and evaluation systems is essential to assess the socio-economic and environmental impacts of GM technology. China's continuous monitoring and evaluation of GM crop adoption provides valuable insights, with a focus on local data collection and consulting with local communities to comprehend the on-ground effects.[155]

Sixthly, food security and nutrition are at the core of SDG2. Brazil's use of GM soybeans for livestock feed serves as a model to enhance food security through animal husbandry. South Africa and Kenya can explore GM crops that enhance both crop yield and nutritional content, emphasizing the connection between GM technology and improved access to nutritious food

[153]*ibid*

[154]Komen J., Tripathi L., Mkoko B., Ofosu D. O., Oloka H., Wangari D., Biosafety regulatory reviews and leeway to operate: Case studies from sub-sahara Africa. Front. Plant Sci. 11, 130. (2020). 10.3389/fpls.2020.00130

[155]*ibid*

for local communities. Additionally, sustainable agricultural practices are vital for ensuring the long-term viability of GM technology. The European Union's promotion of integrated pest management alongside GM crops offers guidance. This should include the incorporation of indigenous and traditional ecological knowledge into sustainable agricultural efforts.[156] By considering these lessons and adapting them to their unique contexts, South Africa and Kenya can advance their adoption of GM technology in a comprehensive and people-centered manner. This will support their endeavors to achieve SDG2 while ensuring the safety, accessibility, and equitable distribution of GM technology within their communities.

4.4 Conclusion

In conclusion this chapter explored the many obstacles African nations must overcome in order to implement genetically modified (GM) technology in order to fulfill Sustainable Development Goal 2 (SDG2). The obstacles that prevent GMOs from being widely accepted in Africa range from knowledge gaps and health concerns to regulatory difficulties and outside pressures. Despite these challenges, there is optimism because other countries' experiences offer invaluable lessons that African nations can learn from. The necessity of raising public knowledge and awareness of genetically modified organisms (GMOs) cannot be overstated, as demonstrated by the accomplishments of awareness efforts in Kenya and Nigeria. Addressing safety problems and integrating rules with international norms, as proven by South African states, appears to be a critical step. Furthermore, navigating political constraints and external influences necessitates strategic decision-making, which must balance international partnerships with the welfare of the local population. To limit environmental risks and make GMO technology available to rural farmers, rigorous risk assessments and monitoring methods, as well as intellectual property difficulties, are required. A road map is provided by

[156] *ibid*

learning from successful models in Ghana, Canada, Argentina, Brazil, India, and the European Union. By adopting these complex lessons and incorporating them into holistic, people-centered methods, African states can pave the road for long-term GM technology acceptance while also assuring food security, promoting nutrition, and increasing agricultural sustainability, all of which are linked with SDG2 objectives.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

Within the context of Sustainable Development Goal 2 (SDG2), this chapter included thorough study and in-depth analysis of the adoption of genetically modified (GM) technology in Africa. It starts with a summary of significant findings, emphasizing the various challenges revealed during the course of the study. The chapter then draws general conclusions based on the information and analysis offered in preceding chapters, providing a reflective perspective on the research objectives and larger implications. Following the conclusions, the chapter offers a collection of recommendations that turn the study findings into actionable insights and practical recommendations. These recommendations are intended not only for policymakers, but also for researchers, industry players, and advocates engaging in conversations about the critical role of GM technology in achieving food security (SDG2) in Africa. Each recommendation is carefully crafted to address recognized difficulties, capitalize on opportunities, and encourage sustainable practices in order to effect good change in African agriculture. This chapter's main objective is to present a broad perspective that encompasses the research's main findings and serves as a basis for informed decisions, innovative approaches, and joint initiatives to advance GM technology and the achievement of SDG2 in Africa and beyond.

5.1 The progress made by African states in developing and adopting GM technologies in the achievement of SDG2

According to research findings, hunger and malnutrition pose significant challenges for African countries, primarily because of factors such as constraints in food supply, inadequate education, and limited resources, especially in rural regions. Agricultural issues in Africa encompass climate change, inadequate infrastructure, and government policies. Genetically Modified

(GM) Technology holds promise for enhancing agriculture and food security, but its adoption is hindered by financial constraints and a shortage of expertise. The key to advancing GM technology and innovation across the continent lies in the active involvement of African governments and regional cooperation.

5.2 The policies and regulations governing the use of genetically modified technology in Kenya and South Africa

The study examined the adoption of genetically modified organisms (GMOs) in South Africa and Kenya. South Africa has a vibrant agricultural industry that uses GMOs, leading in increased production, food security, and lower pesticide usage. Kenya, on the other hand, confronts obstacles such as limited arable land and bad weather, resulting in food insecurity. According to the report, Kenya should accept GMOs to improve agricultural resilience and productivity. Both countries are dealing with public worries regarding the safety of GMOs and their environmental impact. The study underlines the necessity of public education and honest communication in achieving Sustainable Development Goal 2 (SDG2). It also emphasizes the importance of collaboration among regional economic communities and African Union support in addressing biosafety rules and promoting sustainable development using GMO technology.

5.3 The challenges South Africa and Kenya face in Adopting GM Technology for the achievement of SDG2

The study highlighted the importance of genetically modified organisms (GMOs) in achieving Sustainable Development Goal 2 (SDG2), which focuses on eliminating hunger, increasing food security, improving nutrition, and supporting sustainable agriculture. However, international policy restrictions, notably regulatory frameworks such as the Cartagena Protocol on Biosafety (CPB), are impeding worldwide acceptance of GMOs. To address these issues, the research recommends that international organizations such as the United Nations Convention on Biological Diversity, the United Nations Food and Agriculture Organization, and the World Trade Organization reconsider the CPB. It also suggests prioritizing risk-assessment methods that take into account local agricultural and environmental practices in less developed countries. African countries are urged to lead the way in developing a balanced approach to harnessing GMO benefits while addressing legitimate concerns. To achieve a successful and enduring agricultural future in Africa, policymakers are encouraged to actively engage, stay informed, and comprehend the multifaceted aspects of the GMO discourse.

5.4 Summary

The study examined at how African nations are utilizing genetically modified (GM) technology to help achieve Sustainable Development Goal 2 (SDG2), which is focused on improving nutrition, food security, and hunger reduction as well as promoting sustainable agriculture. The study's findings show that food shortages, especially in rural regions, limited educational possibilities, inadequate food supplies, and financial constraints are some of the causes of hunger and malnutrition that African countries face. These problems are made worse by obstacles like climate change, poor infrastructure, constrained transit systems, and restrictive government regulations. However, despite these hurdles, GM technology is acknowledged for its potential to boost agricultural productivity and economic well-being throughout Africa.

Nonetheless, budgetary constraints, a scarcity of professional personnel, and a lag in global biotech breakthroughs hampered its widespread implementation. Governments played a critical role in creating favorable conditions for fully using the benefits of GM technology through regulations and resource allocation, while joint actions at the regional and continental levels were deemed necessary to address the hurdles. Furthermore, the study demonstrated the disparities in GMO uptake in South Africa and Kenya. South Africa had a thriving agricultural sector that had profited considerably from GM technology, resulting in higher production, enhanced food security, and lower pesticide usage. Kenya, on the other hand, had difficulty due to limited arable land and poor meteorological circumstances, which exacerbated food insecurity. The study emphasized the need of Kenya embracing GMOs to improve crop resilience and productivity, emphasizing the importance of public education and open communication, particularly in Kenya, to overcome concerns.

Both countries had public concerns about the safety and environmental impact of GMOs, and they faced similar problems in implementing Cartagena Protocol biosafety rules. The research urged for coordinated initiatives across regional economic groups and sought African Union help to address these concerns. The study called attention to international policy constraints impeding global implementation of GM technology, notably regulatory frameworks like the Cartagena Protocol on Biosafety. It advised that international institutions conduct a full study of these policies, as well as the implementation of risk-assessment methods that emphasize local agricultural and environmental practices in developing countries, potentially easing poverty and hunger. The research recommend African nations to take the lead in charting a route that capitalized on the benefits of GM technology while addressing legitimate concerns. It stressed the critical need of overcoming regulatory and policy hurdles in order to achieve SDG2 and ensure a successful and sustainable agricultural future for the continent.

5.4 Conclusion

In conclusion, the study underlines the importance of overcoming limitations and challenges related to the adoption of GM technology in African nations to achieve SDG2 and establish a prosperous and sustainable agricultural future on the continent. It stresses the need for a balanced approach that harnesses the benefits of GM technology while ensuring its responsible and transparent implementation to address Africa's critical issues of food security and hunger. Ultimately, GMOs have the potential to significantly contribute to Sustainable Development Goal 2 (SDG2), which focuses on alleviating hunger, ensuring food security, improving nutrition, and promoting sustainable agriculture. However, the substantial policy barriers posed by international regulatory frameworks for GM crop approval pose significant challenges to the effective integration of GMOs into global agriculture.

Despite the growing cultivation of genetically modified (GM) crops, which provide higher yields and resilience against environmental problems, these rules have frequently hampered their global acceptability. The international community, including institutions like the World Trade Organization, the United Nations Food and Agriculture Organization, and the United Nations Convention on Biological Diversity, should thoroughly review the Cartagena Protocol on Biosafety (CPB) in order to fully realize the potential of genetically modified organisms and overcome regulatory obstacles. According to some analysts, poor countries may face more obstacles than they can overcome if the CPB is maintained, which would prevent them from accessing creative solutions that may support SDG2. Rather, they suggest implementing risk-assessment methods that give local farming and environmental practices in these areas first priority, potentially alleviating poverty and hunger. Although GMO technology holds tremendous promise for advancing SDG2, especially in sustainable agriculture and food security, prompt resolution of regulatory and policy obstacles is essential. African nations should take the lead in formulating a pragmatic strategy that addresses valid concerns while maximizing the benefits of genetically modified organisms. This appeal calls on policymakers to be proactive, well-informed, and mindful of the diverse factors influencing the GMO issue in Africa. It serves as a clear and urgent message to them. Ultimately, such proactive measures will guide the continent toward a more prosperous and sustainable agricultural future.

5.5 Recommendations

- ✓ Government Policy and Support: African countries have to be in the forefront of creating conducive environments for the acceptance of genetically modified organisms. This entails developing regulations that encourage GM agricultural research, production, and responsible usage in addition to providing funds to assist their adoption.
- ✓ Public Education and Communication: Initiatives should be launched to inform the public about GM technology, emphasizing its safety and potential benefits. Clear and concise communication can dispel myths and fears, building public confidence in genetically modified organisms.
- ✓ Capacity Development: Resources should be allocated to educational and training programs to address the lack of biotechnology expertise. The effective use of GM technology relies heavily on well-trained personnel.
- ✓ Cooperation at Regional and Continental Levels: African countries should collaborate on regional and continental projects. The African Union and regional economic communities can play a pivotal role in coordinating efforts, standardizing laws, and providing guidance for the ethical use of genetically modified organisms.
- ✓ Policy Reassessment: International policies like the Cartagena Protocol on Biosafety need to be reevaluated. This reexamination, especially for developing nations, should strike a balance between safety concerns and the potential benefits of GM technology.
- ✓ Risk Assessment Models: In developing nations, indigenous agricultural and environmental practices must to be given priority in risk assessment models. By using these models carefully, issues might be addressed and GM technology could be applied sensibly.

- ✓ African Leadership: African nations should lead in charting a balanced course that maximizes the benefits of GM technology while addressing valid concerns. This proactive approach has the potential to significantly influence the future of GM technology in the region.
- ✓ Partnership with International Organizations: Collaborating with international bodies like the World Trade Organization, the United Nations Food and Agriculture Organization, and the Convention on Biological Diversity can help eliminate global policy obstacles, creating a conducive environment for the responsible use of genetically modified organisms.

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APPENDICES

APPENDIX 1: LETTER OF INTRODUCTION

Mariah Faridah Muli
Department of Diplomacy and International Studies
P.O Box 30197-00100
Mobile: 0722419420
Email: mariah-faridah8@students.uonbi.ac.ke
NAIROBI-KENYA

Date:

Dear Respondent,

RE: REQUEST TO FILL QUESTIONNAIRE

I am a student at the University of Nairobi, Department of Diplomacy and International Studies pursuing a Master's Degree in Diplomacy. I am conducting research on *"Genetically Modified Technology and the Attainment of SDG2 in Africa: A Comparative Study of South Africa and Kenya."* The purpose of my study is to investigate the role of genetically modified technology (GMT) in achieving SDG2, particularly in South Africa and Kenya.

Your expertise would greatly contribute to the depth and richness of this research. Your participation involves completing a brief questionnaire.

All information collected will be treated with strict confidentiality and used solely for research purposes. Your input will greatly enhance our understanding of the benefits, challenges, and future prospects of genetically modified technology in relation to SDG2.

I kindly request a few minutes of your time to complete the questionnaire. Your prompt response would be highly appreciated. If you have any questions, please contact me.

Thank you for considering this request. Your contribution will significantly advance knowledge in this field.

Kind Regards
Mariah Faridah Muli
Registration Number: R51/40972/2021

APPENDIX II: RESEARCH LICENSE

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **757715** Date of Issue: **18/July/2023**

RESEARCH LICENSE

This is to Certify that Ms.. Mariah Faridah Muli of University of Nairobi, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Nairobi on the topic: GENETICALLY MODIFICATION TECHNOLOGY AND THE ATTAINMENT OF SDG2 IN AFRICA: A COMPARATIVE STUDY OF SOUTH AFRICA AND KENYA for the period ending : 18/July/2024.

License No: **NACOSTI/P/23/27816**

757715
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NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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See overleaf for conditions

APPENDIX III: QUESTIONNAIRE

PART I: DEMOGRAPHIC INFORMATION

Please provide the following demographic details:

Name: …………………………..

Designation: …………………

Gender:

Male: …………………………..

Female………………………….

Other (please specify)

Age:

(Tick where applicable)

18-25 years old

26-35 years old

36-45 years old

46-55 years old

56 years old or above

Educational Background:

- Primary school
- Secondary school
- Bachelor's degree
- Master's degree
- Other (please specify)

Country of Residence: ……………………….

SECTION 2: PROGRESS IN DEVELOPING AND ADOPTING GM TECHNOLOGIES FOR SDG2 BY AFRICAN STATES

1. Are you familiar with genetically modified (GM) technologies and their applications in agriculture and food security? (Yes/No)
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2. In your opinion, how successful have African states been in adopting and implementing GM technologies to achieve SDG2? Please explain your answer.
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3. What challenges do you perceive in the widespread adoption of GM technologies in African countries to promote food security and nutrition? (Please provide examples if possible.)
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SECTION 3: POLICIES AND REGULATIONS GOVERNING GMT IN KENYA AND SOUTH AFRICA

4. Are you aware of the existing policies and regulations governing the use of genetically modified organisms (GMOs) in Kenya and South Africa? (Yes/No)
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5. How would you rate the effectiveness of these policies and regulations in ensuring safe and responsible use of GM technologies? (Scale: 1 - Ineffective to 5 - Highly effective)
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6. What are some strengths and weaknesses of the current policies and regulations related to GMOs in these countries?
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7. How do you perceive the impact of these policies on agricultural practices and food security in Kenya and South Africa?
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SECTION 4: CHALLENGES IN ADOPTING GM TECHNOLOGY FOR SDG2 IN AFRICA

8. What are the primary challenges that South Africa and Kenya face in adopting GM technology for the purpose of achieving SDG2, especially related to food security? (tick where appropriate)
   - Technical challenges: Challenges related to GM technology development and application.
   - Socio-economic challenges: Economic and social barriers affecting GM technology adoption.
   - Environmental concerns: Environmental impacts or concerns related to GM technology.
   - Public perception and acceptance: Public attitudes and beliefs affecting GM technology adoption.
   - Regulatory hurdles: Legal and regulatory obstacles to GM technology adoption.

9. Can you identify any socio-economic or environmental concerns associated with GM technology adoption in these countries?

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10. How do public perceptions and attitudes towards GM technology impact its adoption in South Africa and Kenya? Do you see any strategies to address public concerns effectively? (tick where appropriate)
    - Yes, public perception is a significant factor: Acknowledging the importance of public perception.
    - No, public perception is not a significant factor: If you believe public perception has minimal impact.

11. What are the potential economic, social, and environmental benefits and risks associated with the adoption of GMOs for SDG2 in Africa?

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SECTION 5: GENERAL PERSPECTIVES ON GMO TECHNOLOGY

12. What are some common misconceptions or concerns related to GM technologies that you have come across in African communities?
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13. How can stakeholders, including governments, researchers, and non-governmental organizations, address these misconceptions and concerns effectively?
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14. Is there any additional information or insights you would like to share about the relationship between GM technologies, SDG2, and their impact in Africa?
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Thank you for your participation!

Your feedback is greatly appreciated and will contribute to my research efforts.

APPENDIX IV: ANTIPLAGIARISM REPORT

14/11/2023

MA Research Project

ORIGINALITY REPORT

8%	5%	5%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	biosafety.org.za	Internet Source	1%
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3	"GMOs", Springer Science and Business Media LLC, 2020	Publication	1%
4	Science Policy Reports, 2014.	Publication	<1%
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UNIVERSITY OF NAIROBI
APPROVED
DATE: 16/11/2023
INSTITUTE OF DIPLOMACY INTERNATIONAL STUDIES