Undergraduate Research Fellowship Working Paper Series

Title:

"The Influences of Genetic Engineering within Kenya's Agricultural Sector"

Author(s):

Yvonne Thuo
2022-2023 Undergraduate Research Fellow

2022-2023

The Influences of Genetic Engineering within Kenya's Agricultural Sector

Yvonne Thuo

Department of Economics, Kennesaw State University

Abstract

This paper relates how advanced biotechnology can influence Kenya's agricultural sector to the benefit of its economy. With another severe drought affecting Kenya's crops, a new method of growing crops must be administered. Research involving genetically modified organisms (GMOs) supports that the usage of genetic engineering may be Kenya's best option for increasing agricultural output. With other countries utilizing GMOs for agricultural practices, Kenya can adopt the technology and produce crops despite drought conditions.

The Influences of Genetic Engineering in Kenya's Agricultural Sector

Introduction

While genetically modified organisms (GMOs) may be a familiar concept to some, what exactly are they? According to National Geographic (2022), "a genetically modified organism (GMO) is an animal, plant, or microbe whose DNA has been altered using genetic engineering techniques." GMOs were created to breed organisms that produce offspring or seeds with desirable traits. This allowed scientists to produce a derivative of an organism that is composed of a desired gene code. GMOs have been studied and experimented on in the agricultural field in hopes of effectively altering the genes of a crop to produce more optimal yields.

Kenyan farmers undertake an arduous process to cultivate crops that requires daily labor from start to finish. Factors such as weather conditions, pest infestation, disease, and low soil fertility can affect cultivation. GMOs may be able to alleviate many of these problems by providing a more resilient alternative for agricultural production. When deciding whether Kenya should utilize GMOs to restore its national agricultural output, knowing the history behind genetic engineering and its potential influence on Kenya's agricultural sector is fundamental.

The study and findings of GMOs

Long before the recent advancements in biotechnology, genetic engineering began with selective-breeding and crossbreeding. Certain traits of specific animals and plants were favored so the practices of selective breeding and crossbreeding were methods that allowed humans to produce organisms with these desired traits. In 1866, Gregor Mendel was able to identify the basic processes of genetics. Mendel made this discovery by cultivating numerous pea plants and statistically analyzing the patterns that occurred. His experiment began with cross-fertilized pea

plants that had apparent different characteristics, which led him to develop three laws of inheritance: the Law of Segregation, the Law of Independent Assortment, and the Law of Dominance.

The Law of Segregation established "that every individual organism contains two alleles for each trait, and that these alleles segregate (separate) during meiosis." The Law of Independent Assortment establishes that "alleles for separate traits are passed independently of one another." Lastly, the Law of Dominance establishes that there are dominant and recessive traits, where "the dominant allele will hide the phenotypic effects of the recessive allele" (Aryal, 2022). Mendel's study of biological inheritance established a framework for genetic science and the theory that all living things have traits. Although Mendel's discovery was a major achievement, his findings and genetic models were classified as hypothetical entities, and it was not "until 1900, when the same conclusions were reached by several other investigators… [following] hundreds of papers showing Mendelian inheritance in a wide array of plants and animals, including humans" that his achievements were accepted (Winchester, 2022). This widespread approval led to more research being conducted in fields related to Deoxyribonucleic Acid (DNA) and genetic codes.

The significant discovery of DNA by James Watson and Francis Crick in 1953 was a milestone in genetic science history. With preceded research from Rosalind Franklin, who used x-ray crystallography, Watson and Crick were able to discover the helical shape of DNA. The helical structure of DNA revealed the capability of "self-replication by separating its complementary strands and using them as templates for the synthesis of new DNA molecules" ("Britannica," 2022).

Understanding how genetic replication worked was the first step to creating GMOs. By noting the inheritance of genes from one organism to another, scientists could identify which of those genes was producing the desired trait. This was first discovered by Herbert Boyer and Stanley Cohen when they engineered the first successful genetically engineered organism. Boyer and Cohen achieved this by cutting out a gene from one bacterium and pasting it into another. By using this method, "they transferred a gene that encodes antibiotic resistance from one strain of bacteria into another, bestowing antibiotic resistance upon the recipient." (Harvard, 2022). Boyer and Cohen's advancement in genetic engineering prompted bioengineers to practice the genetic modification of organisms.

The modern GMO process

The process of producing, finalizing, and issuing a genetically modified organism can take several years. According to the "Food of Drug Administration" (FDA) (2022), creating a genetically engineered plant begins with scientists identifying which desirable trait the studied plant should have. Then, the scientists search for a plant with that trait within its genetic code to copy. Next, the copied gene is inserted into the DNA of the plant and remains in the laboratory to grow. The new plant is observed to confirm that it has adopted the trait. If successful, scientists will first grow and monitor the new plant in greenhouses and then in small field tests before moving it into larger field tests. Before being available on the market for farmers, GMO plants go through in-depth review and safety tests. This lengthy process takes trial and error to achieve optimal results, but when scientists are ultimately able to produce plants with more desirable and useful traits, both farmers and consumers of those plants can benefit.

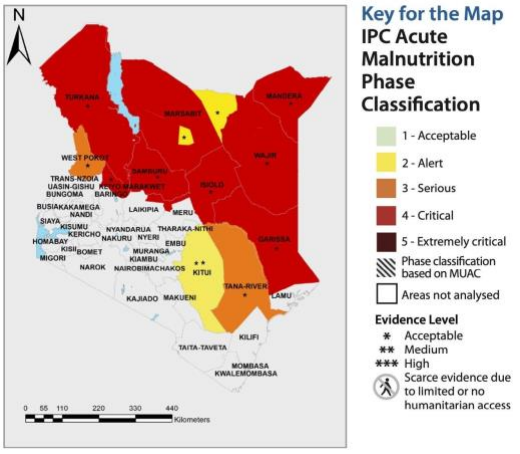
Kenya's background

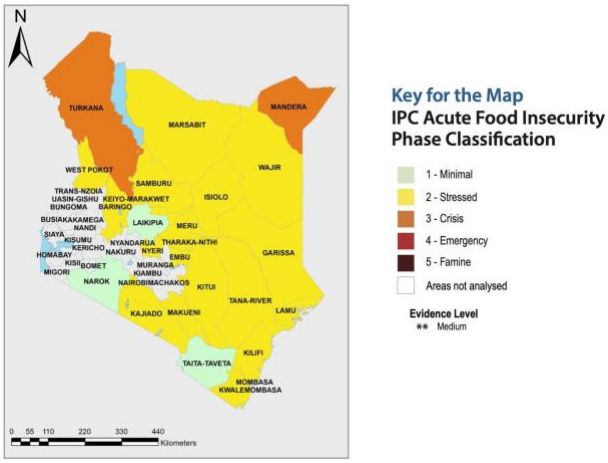
Kenya is located in east Africa on the equator where approximately 53 million Kenyans reside ("The World Bank," n.d.). The country declared independence from Britain on December 12, 1963, allowing the country to create a new constitutional democracy. The primary languages spoken are Swahili and English, but Kenyan native languages can be divided into three groups: Cushitic, Nilotic, and Bantu (the largest group). The country has a multiparty political system and is a presidential, representative democratic republic.

The current president, William Ruto, who was elected in August 2022, is the head of state, which was the position held by Queen Elizabeth II of England until shortly after Kenya's independence. He is also both head of the government and commander-in-chief of the military, making him a powerful leader of the executive branch of government. Ruto's victory was in part due to his ability to identify with a large part of Kenyan populace, as he came from poverty which relates to the many Kenyans continuing to live in difficult economic conditions. Ruto declared that he wants to support the percentage of adults between 18 and 34 who are unemployed, which is nearly a 40% rate (Musambi, 2022). Such changes will require innovation in agricultural technology, as about 60% of Kenya's workforce is employed in agriculture ("Central Intelligence Agency," 2023). President Ruto faces this challenge while also confronting growing national debt and increases in food and fuel prices creating widespread food insecurity in Kenya.

Kenya's climate and agricultural condition

Kenya is historically known for recurrent droughts, and with the dry, arid climate, water is an essential need for all individuals. Without a minimum amount of rainfall during the rainy seasons, citizens are expected to minimize usage of their water resources until the situation is improved. Idris Mukhtar (2022), *Hundreds of elephants, wildebeests and zebras dead in Kenya amid prolonged drought,* explains how the current drought is affecting Kenya's ecosystem. Mukhtar states, "Prolonged drought across the Horn of Africa over the past four consecutive rainy seasons has left some 18 million people affected by food shortages…" highlighting how the absence of water is causing severe food insecurity and famine for Kenya and surrounding countries. Affected citizens facing water shortages suffer widespread livestock mortality and crop failure. The drought has severely affected 23 counties in Kenya's arid and semi-arid lands (ASALs), compelling massive migration by families in search of water, food, and supplies in secure locations.





The above images from the Integrated Food Security Phase Classification maps out how different areas are affected due to the drought in 2021. In the first image, it is evident that majority of Kenya's northern areas are critically malnourished because of the lack of nutrients

from the decline in crop production. Based on the second image, the larger cities in the south (mainly Nairobi and Mombasa) currently are facing less food insecurity while northern areas are facing a food crisis. Migration from north to south will likely cause economic stress and tensions in the south.

While the change in climate impacts Kenya, prices in the market economy have also reacted to these occurrences. The reduced supply of staple crops causes the poorest households, who usually rely on home production, to depend on market supply since their home food stocks are depleting. But, with reduced national supply comes increased food prices, and with poor pasture conditions (due to drought), milk production in the Mt Kenya region has dropped by about 40% (Marete, 2022). This creates higher production costs for dairy farmers who must adapt to the effects of the drought, resulting in staple food items, such as milk, becoming more expensive and less accessible for households, especially low-income households. Environmental issues are causing prices to increase, but with no improvement in crop production efficiency, Kenya's population may encounter famine.

In the past, drought management responses have been administered primarily by the Intergovernmental Authority on Development (IGAD) to reduce environmental impacts. This organization implements a multitude of campaigns, including Ending Drought Emergencies (EDE), which strategizes methods for helping pastoralists and ASAL communities. By cooperating with organizations such as the National Drought Management Authority (NDMA) and the Intergovernmental Committee, the EDE can legislate drought issues. This campaign helps to mitigate the effects of the drought, but primarily recognizes community awareness, preparedness, and resiliency to droughts rather than production efficiency in the face of drought conditions. With limited funding, Kenya's problems of widespread famine, ecological

degradation, and economic hardship will not be resolved by supplying food and other needs to millions of suffering households, but instead by having an efficient production system during drought conditions.

Introducing GMOs in Kenya

Although the Kenyan government has now decided to inaugurate GMOs, this would not be the first time that the technology was introduced in the country. In 2010, genetically modified testing for maize began in Kenya but this study soon stopped in 2013 as a result of a proposal that was formed by the then Public Health Minister, Beth Mugo, to ascertain the preparedness of Kenya to embrace GMOs. The technology was questioned regarding the banning of GMOs in other countries due to potential unnatural, carcinogenic properties. When analyzing how GMOs affect the health of humans, the U.S. Food & Drug Administration states, "GMO foods are as healthful and safe to eat as their non-GMO counterparts" (2022), claiming the safety of GM crop intake.

More importantly, however, the main concern with the utilization of GMOs was how it would affect Kenya's farmers when considering the limitations arising from the Seed and Plant Varieties Act of 2012. This act prevents farmers from exchanging or selling indigenous seeds and creates a dependency on multinational companies by smallholder farmers "demolishing self-sufficiency" (Nasike, 2022). The establishment of GMO seeds in Kenya raises questions about the farmer and seed company dynamic, discouraging Kenyan farmers from the utilization of GMO crops. Ultimately, Kenyan citizens opposed the technology due to ethical beliefs and lack of clarity concerning the science supporting-arguments accounting for GMOs. Consequently, Kenya's government banned GMO imports and resorted to studying genetic engineering rather than allowing the implementation of this new technology.

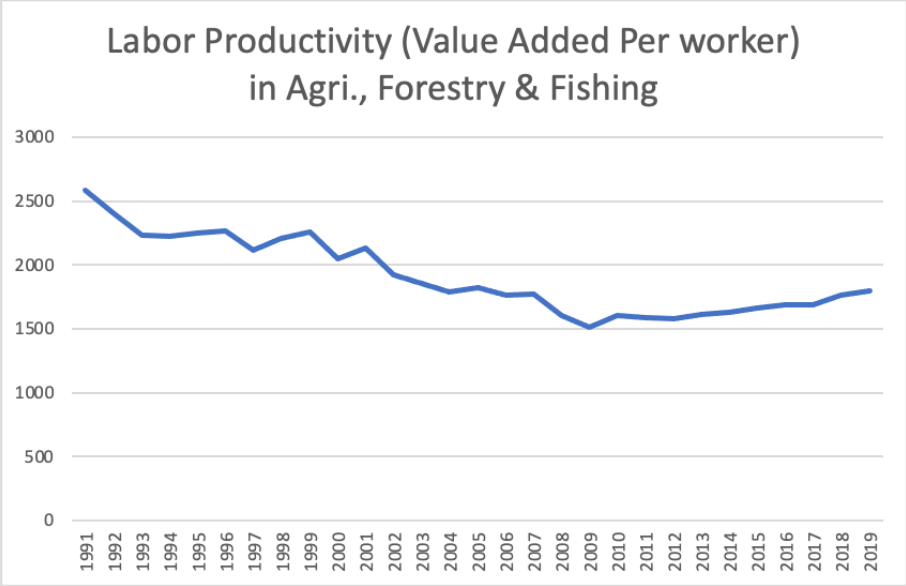
Unexpectedly, in 2019, the Kenyan Cabinet approved the commercialization of genetically modified pest resistant cotton, known as Bt cotton, commencing the reinstatement of GMOs into Kenya's economy. Then, later in 2020, Bayer, a pharmaceutical company known for supplying GMO seeds, donated maize and vegetable seeds to relieve smallholder farmers from the impacts of COVID-19 and to prevent the pandemic health crisis from turning into a hunger crisis. It was not until last year, 2022, that the newly elected President William Ruto declared that the ban on GMOs in Kenya was lifted.

This created immediate havoc among the people of Kenya. The essential question was "what changed the minds of the Kenyan government?" Initially, Kenya passed the Biosafety Act in 2009, which granted the National Biosafety Authority (NBA) the power to "exercise general supervision and control over the transfer, handling and use of genetically modified organisms…" with a view to ensuring: safety of human and animal health; and provision of an adequate level of protection of the environment ("National Biosafety Authority," n.d.). This act was established to restrict and oversee any usage of GMOs in Kenya for the safety of the people. However, in October 2022, Kenya re-established GMOs to alleviate the effects of severe drought. This decision was made after Kenya's cabinet factored in biotechnology reports from scientists, doctors, and global agencies including the United Nations. By reviewing the utilization of GMOs around the world, Kenya's government justified its newly developed determination that biotechnology is beneficial for helping eliminate the water shortage in Kenya.

The influence of GMOs on Kenya's economy

Analyzing Kenya's economic history helps identify how the country is likely to flourish or suffer in the face of a changing climate. According to USAID (2022), Kenya has a GDP of

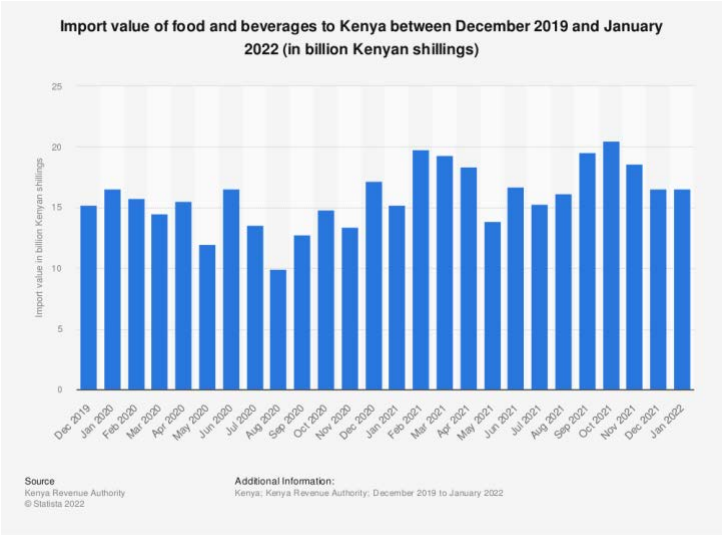
$95 billion with the agricultural sector contributing approximately 33% to this figure. Additionally, this sector employs more than 40% of the total population and 70% of the rural population. Evidently, agriculture is the primary sector that many Kenyans partake in to make a living, but with "46% of the population living on less than 1 USD," the government must take action to reduce food insecurity, unemployment, and general poverty ("Food and Agriculture Organization of the United Nations," n.d.).



This image from The World Bank presents the alarming fall in labor productivity in Kenya over the past 28 years. Based on the graph, labor productivity has declined since 1991, falling to its lowest point during the financial crisis in 2009, with a slight increase since that time. Globalization and modern economic developments have decreased youth participation within the agricultural sector, but that is likely a result of the decrease in labor productivity in the sector.

Kenya's climate change is reflected in the decline in labor productivity which hinders farmers' income and agricultural practices. The fall in agricultural output means that the government must spend more on imports of food and other agricultural products. With the water shortages preventing normal crop production, Kenya must import maize from countries that have

suffered less from the droughts of climate change. One country that provides Kenya with maize is Zambia, charging "6,000 Kenyan shillings ($55) per 90-kilogram (198 pounds) bag" (Langat, 2022). This reveals how costly it is to import a staple crop such as maize during off-season.



The above image from the Kenya Revenue Authority depicts how much food and beverages the country has imported. Ultimately, the value of imports seems to fluctuate around $20 billion shillings ($155,698.52 USD). When factoring in Kenya's failed rainy seasons (March-May), the graph presents how imports tend to increase during those month intervals.

Instead, Kenya's government can redirect these finances into GMO production, which when compared to non-GMO production "the average price difference is roughly 12.5%" (Spectrum Nation, 2019). This contrast provides Kenya with a profitable margin where importing GMO crops yields more value. GM crops will also help combat the estimated decrease in economic growth from 5.9% in 2022, to 5.7% in 2023, which is fueled by the decline in "domestic and external demand caused by lower income and…the increase in food and import costs" ("Kenya Economic Outlook," 2022). Accordingly, the Kenyan cabinet has initiated the arrangement of duty-free importation of 10 million bags of GMO maize over the next six months in hopes of relieving the citizens of Kenya. The performance of this arrangement will help

determine whether Kenya made the right judgment call on inaugurating GMOs. By adopting GM crops, Kenya will hopefully help millions of its citizens who have been directly affected by the drought and facing food insecurity every day.

Bayer (Monsanto) Controversy

Despite the authorization of GM maize imports, Kenya's government is facing backlash from citizens. More than half of the Kenyan population opposes the inauguration of GMOs in Kenya. There are three main reasons for this opposition: 1) the lack of knowledge behind the technology, 2) the fear that Bayer Corporation, the multinational GMO seed company, will dominate the agricultural sector in Kenya, and 3) the risk of sickness or disease from digestion of modified crops. While individuals can educate themselves on GMO technology, the contracts between farmers and the Bayer Corporation, the intended GMO seed company supplier, are undefined. Kenyan farmers fear that once GM crops are grown, they will be in debt to Bayer due to Intellectual Property Laws, which recognize the GMO patents held by Bayer and other multinational corporations. Kenyan farmers must abide by the set of rules classified by Bayer regarding the property of their seeds, if not, disputes could arise. This would cause the parties of the contract to become adversaries in a court of law and decisions affecting Kenya's economy could take place in legal jurisdictions outside of Kenya.

In the past, Bayer, who acquired Monsanto, the primary GMO seed supplier, has had controversies where farmers were sued for violating patent rules. In Brazil, Monsanto won a $7.7 billion dollar lawsuit against Brazilian farmers after the court ruled that Monsanto's patented seeds could not be saved and replanted (Nasike, 2022). This case exposes how stringent the collaboration between farmers and Bayer is, explaining the fear that Kenyan farmers have with the introduction of GM crop seeds and consumption imports.

To understand the outlines of the anticipated contract, reviewing Bayer's public guide for GM corn is beneficial. The guide explains the practices, requirements, and management for the crop along with the statement that farmers should "return leftover seed[s] to its original containers if seed is intended for storage and use at a later date" ("Insect Resistance Management Guide", 2023). This guide identifies how farmers are obligated to store GMO seeds without replanting, to conserve Bayer's patented seeds without violation of the Intellectual Property Rights. Based on Bayer's outlined guide, their genetically modified seeds would have to be handled precisely according to their directions, therefore Kenyan farmers would have to acknowledge and abide by these standards.

Conclusion

Genetically modified organisms present Kenya with abundant opportunities for its agricultural sector, which is in desperate condition because of severe droughts that are likely, at least in part, the result of worldwide climate change. A farm well integrated into the environment is needed for farmers to produce crops in a cost-effective manner. Within the environment of drought and water shortages, the country must adopt new agricultural practices. With GMO technology, Kenya's environmental and economic development has the potential to grow. The establishment of GM crops could serve as a long-term solution for Kenya's drought situation; however, the financial resilience of farmers and households in relation to large muti-national corporations must be addressed when finalizing any government policies. Research on GMO activity helps to identify how areas of a country, such as Kenya, can drastically change and, in turn, improve the standard of living for individuals in crisis.

References

Aryal, S. (2022, May 18). *Mendel's 3 laws (segregation, independent assortment, dominance)*. The Biology Notes. Retrieved March 13, 2023, from https://thebiologynotes.com/mendels-experiment-and-laws/.

CIA. (2023, March 31). *Kenya*. Central Intelligence Agency. Retrieved April 7, 2023, from https://www.cia.gov/the-world-factbook/countries/kenya/.

FAO. (n.d.). *Kenya at a glance.* Food and Agriculture Organization of the United Nations. Retrieved April 6, 2023, from https://www.fao.org/kenya/fao-in-kenya/kenya-at-a-glance/en/.

Farrar, J. (2019, July 9). *Is organic food worth the price?* Expert Nutrition & Dietetics Service. Retrieved March 13, 2023, from https://www.spectrumnutrition.ie/blog/2019/7/9/is-organic-food-worth-the-price.

FDA. (2022, August 3). *Agricultural Biotechnology*. U.S. Food and Drug Administration. Retrieved April 6, 2023, from https://www.fda.gov/food/consumers/agricultural-biotechnology?utm_source=Google&utm_medium=search&utm_campaign=feedyourmind2023.

FDA. (2022, August 3). *Science and history of GMOs and other food modification processes*. U.S. Food and Drug Administration. Retrieved March 13, 2023, from https://www.fda.gov/food/agricultural-biotechnology/science-and-history-gmos-and-other-food-modification-processes.

Langat, A. (2022, October 12). *Kenya lifts ban on genetically modified foods despite strong opposition*. Devex. Retrieved March 14, 2023, from https://www.devex.com/news/kenya-lifts-ban-on-genetically-modified-foods-despite-strong-opposition-104170.

Marete, G. (2022, September 15). *Milk production in Mt Kenya drops due to drought*. Nation. Retrieved March 30, 2023, from https://nation.africa/kenya/counties/meru/milk-production-in-mt-kenya-drops-due-to-drought-3949948.

Mukhtar, I. (2022, November 5). *Hundreds of elephants, wildebeests and zebras dead in Kenya amid prolonged drought*. CNN. Retrieved March 13, 2023, from https://www.cnn.com/2022/11/05/africa/elephants-dead-kenya-intl/index.html.

Musambi, E. (2022, September 13). *William Ruto's rise from chicken seller to Kenya's president*. BBC News. Retrieved April 3, 2023, from https://www.bbc.com/news/world-africa-24017899.

Nasike, C. (2022, August 2). *Whose interest does the Kenyan seeds law protect?* The Environment Enthusiast. Retrieved March 13, 2023, from https://conservationatheart.wordpress.com/2022/08/02/whose-interest-does-the-kenyan-seeds-law-protect/.

Nasike, C. (2022, October 13). *GMOs: A neo-colonial technology undermining food and seed sovereignty in Kenya*. Greenpeace Africa. Retrieved March 13, 2023, from https://www.greenpeace.org/africa/en/publications/52437/gmos-a-neo-colonial-technology-undermining-food-and-seed-sovereignty-in-kenya/.

Rangel, G. (2015, August 9). *From Corgis to corn: A brief look at the long history of GMO technology*. Science in the News. Retrieved March 13, 2023, from https://sitn.hms.harvard.edu/flash/2015/from-corgis-to-corn-a-brief-look-at-the-long-history-of-gmo-technology/.

Society, N. G. (2022, May 20). *Genetically modified organisms*. Education. Retrieved March 13, 2023, from https://education.nationalgeographic.org/resource/genetically-modified-organisms.

The World Bank. (n.d.). *Population, total - Kenya*. Data. Retrieved April 3, 2023, from https://data.worldbank.org/indicator/SP.POP.TOTL?locations=KE.

Welcome to National Biosafety Authority. National Biosafety Authority. (n.d.). Retrieved March 13, 2023, from https://www.biosafetykenya.go.ke/index.php?option=com_content&view=article&id=6&Itemid=

Winchester, A. M. (2023, February 15). *Microbial genetics*. Encyclopædia Britannica. Retrieved March 13, 2023, from https://www.britannica.com/science/genetics/Microbial-genetics.