

*Full Length Research Paper*

# Advancing adoption of genetically modified crops as food and feed in Africa: The case of Kenya

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Genetically modified organisms (GMOs) and Genetic Engineering (GE) technology has been around since mid 1990s. Numerous successful applications of genetically modified (GM) crops have been recorded in different parts of the world. The technology has been adopted steadily in several countries with acreage under GM crops steadily increasing in many cases. Socio-economic studies show GMO adoption result in improved productivity, reduced cost of labour, and reduced pesticide use. More than 20 years later and in spite of the foregoing, opposition to GMO remains almost the same especially in Kenya. Although the past few months have seen a move toward favourable enabling and political good will, a current report published in the economist magazine indicated that agricultural productivity in Africa and Kenya in particular has remained stagnant for the last 40 years. This points to the vulnerability of Kenya in ensuring food security for its growing population which has actually increased at least 6 folds since 1960s. For food security to be achieved, considerations should be given to traditional as well as modern technologies that can greatly increase productivity, in the shortest time possible, while also taking care devastating effects of pests, diseases, drought, poor soils, and climate change. The genetically engineered crops have been eaten by millions of people from around the world, and have also been fed to millions of animals and poultry all over the world. For Kenya to move forward toward sustainable food security, bold, deliberate actions based on sound science and embedded in the uniqueness of the Kenyan agricultural systems and culture ought to be taken into consideration. This paper reviews the matter of GM foods, their implications for Kenya and all the underlying factors meriting consideration.

**Key words:** Genetic engineering, Genetically modified organisms, Biotechnology, Biosafety, Public Acceptance, Kenya.

## INTRODUCTION

### What is the GMO technology: Process or product?

Humans have been improving the quality of domesticated crops for thousands of years and this has mostly been through conventional breeding where important traits are

encouraged, picked, and passed down from one generation to the next (Keetch et al., 2014; European Safety, 2019). Genetic engineering however picks over from here and aims to achieve the modification of the crops by selecting novel genes from other crops or

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organisms and incorporating these into the gene of interest of distantly related species (Weebadde and Maredia, 2011). This has proven to be a faster way than the 10 to 15 years of conventional breeding often required to improve a crop for general release. Whereas with conventional breeding, over 1000 to 10,000 genetic material is transferred between species, the genetic engineering aims at a single gene or few well selected novel genes to be moved across species (Baudo et al., 2006). The resulting food crops are referred to as genetically engineered (GE) or genetically modified (GM) foods. To this extent, genetic engineering has been lauded by proponents as faster, more targeted, more precise and efficient way of acquiring intended traits than through conventional breeding (The Royal Society, 2020).

So far, many crops have been modified by genetic engineering technology to provide beneficial traits to farmers (GMO Answers, 2019). Most of the crops have been modified for, herbicide tolerance, insect pest resistance, disease resistance, among other farmer benefiting traits (GMO Answers, 2019). The most widely grown GM crops by acreage have been maize or corn, cotton, soy bean, and canola, while other crops are also being grown such as *brinjal*, papaya, and others (GMO Answers, 2019). In Kenya, several applications have been made for commercialization of GMO crops (National Biosafety Authority, 2019). Top among them being *Bacillus thuringiensis* (Bt) maize, *B. thuringiensis* Cotton, Water Efficient Maize for Africa (WEMA) maize, virus resistant cassava, virus resistant bananas, late blight fungal disease resistant potatoes, among others (National Biosafety Authority, 2019). The WEMA project mainly focused on drought tolerance technology through conventional breeding. Its successor, the TELA is working toward introducing the Bt. gene to WEMA varieties. Yet, none of these applications have ever gone past field trials and unto commercialization, except for *B. thuringiensis* cotton which only recently got the go ahead for commercialization through cabinet approval in December 2019 (Vijida, 2019).

### What are the motivators of this technology?

Farmers had been losing money for years from their crops due to attacks from pests, diseases, and weeds while yields were stagnating or diminishing following success with *green revolution* (GMO Answers, 2019). To continue improving farm productivity means finding remedies to the pests and diseases devastating the crops and better ways to reduce farm expenses especially labour; given the increased cost of labour in many parts of the world (Alhassan and Adekunle, 2014). On the other hand, the industry supplying the agro-chemicals have been under pressure regarding the toxic nature of the insecticides and herbicides (especially given that a majority of the insecticides and herbicides residues end

in water ways, and polluting the soils since a very small percentage is actually being absorbed by plants). Furthermore, farmers have realized the fact that some of the target insects and weeds have developed resistance to the insecticides and herbicides. Alternatives to both challenges occupied the minds of the industry for a while and by the time the agro-chemical industry revealed that they could actually transform plants with the *B. thuringiensis* gene, so the crop will produce the toxin by itself. This means farmers could stop heavy reliance on chemical applications, this was received as extremely good news. However, control of weeds was still a major challenge especially in large scale farms. Herbicides especially glyphosates were being used in large scale but they could not be used on the crops because they would kill them too since the active ingredient is a broad spectrum and systemic to plants. A herbicide tolerant and insect resistant *B. thuringiensis* maize was the novel answer the industry introduced for the farmers who were yearning for a way to reduce not just cost of pesticides but more so, labour and mechanical costs of controlling weeds.

The glyphosate tolerant and insect resistant *B. thuringiensis* crops were well received by farmers and contributed to ease the need for weed control and insect control by mechanical or by manual and other means. In retrospect, the farmers may have been over motivated by this prospect resulting into planting much *B. thuringiensis* and herbicide tolerant crops and ignoring the other Integrated Pest Management Practices (IPM) that would have helped to prevent or delay the development of resistance for much longer. Despite this challenge, farmers in many countries around the world including Canada, USA, Japan, Argentina, India, and the Philippines have enjoyed the advantages brought about by GMOs for more than two decades (ISAAA, 2019).

### Enumerated benefits of adoption of GMO crops in different countries

A study sponsored or conducted by the European Commission to trace the benefits of GM crops for past 19 years from 1996 to 2014 suggested a drastic reduction in use of pesticides by 581 million kg thus reducing environmental footprint associated with GMO by 20% (Brookes and Barfoot, 2017). In USA alone, planting GMOs reduced pesticide use and resulted in reduction of 46.4 million pounds in 2003. The *B. thuringiensis* cotton in China resulted in reduced use of formulated pesticides by 78,000 tonnes in 2001 an equivalent of a quarter of all the pesticides sprayed in China in the mid-1990s (European Commission, 2010). With reduction of pesticide use, comes the reduced exposure and potential poisoning of farmers and farm workers. Insecticide used in control cotton bollworms reduced from as much as 5,748 metric tons of active ingredients in 2001 to as low as 222 metric tons of active ingredients in 2011; a 96%

reduction (Perry et al., 2016). The adoption of GMO technology equally contributed to continued expansion of no-tillage agriculture in the U.S. saving 1 billion tons of soils through herbicide tolerant crops (Perry et al., 2016). *B. thuringiensis* Cotton in US and Australia has been documented to result in improved number and diversity of beneficial insect in the cotton growing fields (Qaim and Klumper, 2014).

Even with all the enumerated benefits of GMOs, Kenyan farmers were not sure how much longer they will have to wait until they grow these crops in their fields. Thankfully, the cabinet approval of *B. thuringiensis* cotton's commercialization was well received; and seen by many as a positive step toward ensuring the much-needed progress. In deed, the country has made good progress since then by flagging off of the planting of GMO cotton in selected farms by the Cabinet Secretary for Agriculture. The pressing question remains: How did a country with such great enthusiasm about the promises of biotechnology turn to one of such skepticism after all the research available for consideration? Kenya was one of the first countries in the world not just in Africa to ratify the Cartagena Protocol on Biosafety to the Convention on Biological Diversity in the Route to Food (Mungai, 2019). The National Biosafety Authority website and documented regulations show that, there is enough preparation to proceed with the aspects of ensuring GMO adoption. In spite of the efforts of investors, scientists and GMO enthusiasts, lack of a favourable environment has led to some of these pro-GMO crusaders developing a cold feet with their efforts in the country. As a matter of fact, Kenya is experiencing loss of opportunity to attract additional investment for the continuous development of the technology as most organizations shift their support to countries with favourable political climate (National Biosafety Authority, 2019).

## MATERIALS AND METHODS

The results presented is a culmination of over 3 months of research involving in depth discussions with various stakeholders including farmers, seed industry representatives, academia, biotechnology industry visits, lectures by prominent industry players in GMO technology and participating in international short courses and training offered by the World Technology Access Program (WorldTAP) during the senior authors stay at Michigan State University through the Norman E. Borlaug Fellowship Programme.

## RESULTS

From the results of this study, it is clear that there are several reasons that stand in the way for adoption of GMOs in Africa in general and Kenya in particular. The issues range from felt or unfounded fears regarding effect of GMO, the mixed signals from EU about health and safety of GM foods, the potential risk of GMOs to the environment and biodiversity. Other reasons include the

fear of possible effect on non-target organisms and potential development of resistance to insect-pests by the GM crops. Lastly, food safety fears of GMOs remain pertinent in some parts of the continent. These cases are presented in detail in the following.

### Unearthing the fears of GMO adoption

Kenya already drafted Regulations on Biosafety in 1998 and was poised to be one of the few counties to take advantage of the new technology when it was first released to this part of the world. However, the moratorium placed on GMOs in 2012 by the Ministry of Health, dealt a big blow to continued development, promotion, and adoption of GMO crops in Kenya (Ministry of Sanitation and Public Health (MoSPH), 2012). The ban has stayed on seven years later and with the latest direction from government being that GMO activity in the country will be handled on case by case basis. This is what delivered the cabinet approval for the commercialization of the *B. thuringiensis* cotton in December, 2019 (Vijida, 2019). There is evidence of many promising projects and opportunities to improve on African crops and especially so from the public research institutions especially, Kenya Agricultural and Livestock Research Organization (KARLO), International Livestock Research Institute (ILRI) and International Centre for Insect Physiology and Ecology (ICIPE). However, lack of funds and expertise, have been noted as a bottle neck to unveiling technology due to the highly regulated nature of biosafety (Wambugu and Kamanga, 2014). It is also vital to note that the appropriateness of specific technologies depend on current agricultural systems, practices, and surrounding natural environment especially with regard to environmental safety (Wambugu and Kamanga, 2014). This fact tends to be ignored and instead the opponents of biotechnology prefer to wholesomely dismiss the technology without considering socio-economic benefits, and utility of the technology as an option for safeguarding environmental resources.

### The mixed signal: EU, WHO and UN? To follow the science or the politics?

The European Food Safety Authority (EFSA) studies have repeatedly demonstrated that the GMO foods are as safe both to environment and to humans as their conventional counterparts (European Commission, 2010). Yet, the European Union (EU) still has restrictions on growing of GMO crops in Europe. This stance has bewildered many observers (Tagliabue, 2017). The European Commission grants authorizations to place GM food and feed on the European market for a period of ten years, yet they have constantly requested EFSA to publish as much as about 5 new guidelines just in the past 5 years alone and then for some reason repeatedly

ignoring the EFSA opinions that demonstrate that GMOs are just as safe as their conventional counterparts. Whereas the EU may be justified to call for these improvements, to the casual observer, the EU may simply be doing these to avoid the backlash from the technology developers or simply laying more layers of roadblocks through over regulations. This leaves developing countries especially those with limited capacity at a point of confusion as it seems the European Commissions' decisions on GMO crops are rather the result of political than science-based decisions. But this is where developing countries ought to break from the mold and begin to chart their own course because they must realize the priority for Europe and Africa are different. This realization would help developing countries handle the mixed signals not just coming from EU, but also from the WHO and FAO-UN. The FAO-UN is on one hand calling for addressing of malnutrition by the developing nations based on modern biotechnology (FAO, 2013). While on the other hand, is warning of the dangers of GMO to the environment (FAO, 2013).

### **GMO for Africa: What are the drivers and opposition?**

Unintended and adventitious harmful effects of GMOs on the environment are one reason of the fiercest oppositions raised by opponents of GM crops (Wambugu and Kamanga, 2014). Yet, more than 100 independent, U.S. European, and international scientific societies have addressed the relative safety of GMO and their conventional counterparts and arrived at the conclusion that properly regulated GMOs, pose no new risk to the environment and human health as compared to conventional counterparts (The National Academies of Sciences Engineering Medicine, 2016). Studies have also revealed that farming insect resistant *B. thuringiensis* corn in the Philippines has not demonstrated reduced number and diversity of insects (Pringle, 2013). A 10 year study commissioned by USDA in 2006 demonstrated that there is no increased risk of invasiveness or persistence in wild habitats for GM crops (oilseed rape, potatoes, corn, and sugar beet) and traits (herbicide tolerance, insect protection) (Fernandez-Cornejo and Caswell, 2014). The same conclusions were arrived at on the basis of a study by the European Commission (European Commission, 2010). These studies do not conclude all possibility for crops to form persistent weedy relatives only that the productive GM crops are unlikely to survive out of cultivation conditions. The more reason the studies have always focused on case by case evaluation and recommend need for post release Monitoring and Evaluation for 10 years or more after release (European Commission, 2010).

From a development point of view however, it is critical to place the opposition to GMOs in the context of opposition to other technologies that experienced similar

if not even worse opposition. Normally, there are many reasons why societies oppose and block new technology besides the inherent nature of the technology itself. Most of the initial opposition has to do with the creative disruption that new technologies embody across a number of different fields. That is the sole reason why society must not discourage the uncharted voices of our time. They may be the best people we need to leapfrog the current set of challenges and have a quantum leap (Juma, 2016). As Einstein once said, 'Problems cannot be solved at the same level of thinking that created them in the first place'. Innovations and inventions are how we circumvent this closed thinking by employing a different way or approach to solving our current problems. The apparent opposition to new technologies including GMOs may need to be understood in this context. This may be the reason Wambugu and Kamanga (2014), conclude that without serious investment, the support of critical mass at regulation, astuteness on government political affairs in gaining good will, excellent issue management of GMO lobby groups, and well-resourced outreach, GMOs are likely to fail. This list is a true reflection of the matters that are not part of the GMO science yet must be tackled to address the challenges and drive adoption of the technology.

### **How about direct effects on the non-intended/targeted organisms?**

The early warning of *B. thuringiensis* crops possible impact on *Monarch butterfly larvae* caused panic and many people begun to wonder whether there be any possibilities that the GMO crops were actually causing death of the USA's most loved butterfly (Holt-Giménez, 2019). In 2001 a collaborative research by Scientists from Canada and U.S. observed that the possibility was negligible (Sears et al., 2001b). Report by U.S. Environmental Protection Agency (EPA) stated that according to data presented, *B. thuringiensis* did not present any unreasonable adverse effect on the unintended wildlife in the environment (Sears et al., 2001a). Despite this, opponents are still raising the same questions (Sears et al., 2001a).

### **How about development of insect-pest resistance?**

The management of insect resistance is a concern for scientists and governments including regulatory authorities (Purdue University, 2019). The recommendation of biosafety practice is ensuring that there must be a provision for associate refuge of non-GMO crops so the insects grow without selection pressure to insect resistant varieties (Difonzo, 2019). Post release monitoring and evaluation of GM crop and surrounding environment also acts as a tool to control

any resistance. Post release monitoring requires a well-trained and coordinated effort and an information sharing forum all across the country. Recent GMO developments now use a multiple number of genes conferring different types of traits (stacked genes) and these can help discourage the selection pressure burden that would lead to development of resistance. For this to work, county governments in Kenya must be empowered to report any early cases of potential 'exhaustion' of resistance and appropriate action to be taken before it gets out of hand (Difonzo, 2019). The best agronomic practices and integrated pest management (IPM) strategies are vital for resistance management (Difonzo, 2019).

### Safety of GMOs

One critical requirement of food and any new products is that it must not just satisfy hunger. It must be safe, nutritious and acceptable by consumers as a legitimate source of food for which the consumers make independent choices and not out of coercion. The GMO foods have not escaped this aspect one bit. The main opposition that has been witnessed as far as GMO foods is concerned has centered around the three major areas: food safety, environmental safety, and socio-cultural aspects (The National Academies of Sciences Engineering Medicine, 2016). Food safety is the most critical of these factors while talking purely from a science-based perspective. Whereas in many cases there are ways those food scientists and safety experts use to test safety of products including chemical, biological and physical testing. Such approaches are best usable where a single ingredient is at stake. This case is not very effective for whole foods and hence the reason why scientists have resorted to other means to arrive at a determination of safety of GMO to plants and feeds. This concept that was embraced and ratified by Cartagena Protocol for Biosafety, is the concept of substantial equivalence. The aim is not to determine the absolute safety of a GMO but to compare its main food nutrition and safety related attributes to the conventional counterpart. Of all the over 10 most commercially grown GMO foods, scientific consensus so far reported indicate that there are no significant harmful effects on health of both food and feed attributable to the consumption of GMOs (The National Academies of Sciences Engineering Medicine, 2016).

## DISCUSSION

### Decision making parameters for accelerating GMO adoption in Kenya

From the results it is evident that fear presents one of the

most prominent reasons for negative view of GM crops in the world and especially in Kenya. The fear may be real or imagined. To address these issues, the proper understanding of potential risks and benefits of GMOs, the nature of the forgone opportunity cost is vital. Furthermore, the potential risks must be stated clearly and the role of politics in enhancing or hindering steps in the GM adoption process. It is only by doing this that the countries can make informed choices as unfounded fear is cleared. Any real fears will then be evaluated by informed decision based on risk assessment and characterization. The discussion dissects the issues and offers information that can be considered in respect to decision making on GMOs in Kenya and Africa.

### The benefits of biotechnology

One of the factors that do not get much attention in the GMO debate is the attendant benefits that many countries have enjoyed due to the introduction of biotechnology. A study assessing the global economic and environmental impacts of biotech crops for the first twenty-one years of adoption (1996-2016), showed that biotechnology has reduced pesticide spraying by 671.2 million kg and has reduced environmental footprint associated with pesticide use by 18.4% (Perry et al., 2016). The technology has also significantly reduced the release of greenhouse gas emissions from agriculture equivalent to removing 16.75 million cars from the road (Brookes and Barfoot, 2017). At the same time, a meta-analysis by of the impact of biotechnology (Qaim and Klumper, 2014), reported that GM technology has reduced pesticide use by about 37%. In the USA alone between 1998 and 2011, non-adopters of herbicide resistance corn reduced their herbicide use by 1.2% while adopters of insect tolerant crops reduced insecticide use by 11.2% (Perry et al., 2016). Other studies detailing the impact of GMOs in China, reported that the use of *B. thuringiensis* cotton resulted in reduction in pesticide use of 78,000 tons of formulated pesticides in 2001. This value accounted for about 25% of all the pesticides sprayed in China in the mid-1990s (Tao and Shudong, 2006). In yet another important study by the USDA covering data collected from 1999 to 2012, it was shown that *B. thuringiensis* cotton adoption has caused a significant reduction in pesticides use in India (Fernandez-Cornejo and Caswell, 2014). There are many other benefits that go unmentioned as opponents lure the public to most controversial and sometimes immeasurable issues which appeal to feelings and emotions other than facts.

### Opportunity cost of delayed use or adoption of biotechnology

Studies have tempted to address the matter of forgone

benefits of delayed adoption of important food crops improvement by GE technology in Africa. One of such papers reported work done by Wesseler et al. (2017) in which they examined the opportunity cost for delay in adoption of biotechnology in several countries in Africa. Under their estimation, their model projects such a delayed cause of action in implementing GMO technology to be very substantial. For example, they estimated that the cost of one year delay in approval of the pod-borer resistant cowpea in Nigeria would cost the country about USD 33 million to 46 million and result in loss of 100 and 3,000 lives hypothetically. Given that Kenya too had an opportunity to adopt GMO crops after South Africa, Wesseler et al. (2017) estimated the forgone benefit of that delay too to the Kenyan economy. According to report by Insect Resistant Maize Insect Resistant Maize for Africa (IRMA), it was very possible that Kenya would have adopted GMO technology soon after South Africa but this did not happen and hence, up to 4000 lives could theatrically have been saved. However, this must be looked at in the context of complacency in government and where all other factors like improved production systems, irrigation use of improved seeds among other factors are kept constant (Wesseler et al., 2017).

### **Risk assessment and capacity of adoption of GMO in the Kenya**

The Kenya National Biosafety Authority was established by the Biosafety Act No. 2 of 2009 to exercise general supervision and control over the transfer, handling, and use of genetically modified organisms (GMOs) (National Biosafety Authority, 2019). Because of the nature and the complex matrix of food, the purpose of safety tests is to evaluate that the GM crop is just as safe as its widely consumed relative both to humans and to the environment. The safety assessment criterion is based on internationally developed and agreed guidelines, and best practices by UN-FAO, WHO, Codex Alimentarius and other respected global organizations. According to the procedures published by the National Biosafety Authority, once the committee has received an application for evaluation of a request to commercialize a GMO crop (dossier), they must publish it within 14 days to the public. This is where the competence and systems based functioning regulatory authorities come into play. The Biosafety Authority does not only need to understand all the requirements of the dossier, but also must be able to determine based on sound science whether the application has captured sufficient data and material as to allow unbiased assessment of the application. The National Biosafety Authority of Kenya can request for additional data, should they need it to help with a determination about a product. Furthermore, they have access to expert resources not just from the pool of scientists in Kenya but

even from the African Union and other Biosafety Networks in Africa who can help with specific expertise necessary for the evaluation (Wangari, 2019).

The NBA will then request for written comments from public, scientists, and other interested parties to be submitted within 21 days of their publishing the dossier. After this, the evaluation is done and the NBA stipulates to communicate back to applicant within at least 90 days of the application and not more than 150 days after the receipt of the complete application (National Biosafety Authority, 2019). There are two important fundamentals of science that allows such a system to work and provide checks and balances along the process of commercialization of GMO used as food and feed. The first, is the concept of good laboratory practice (GLP) that is done to ensure reproducibility of test results. Second, is the principle of direct data entry which stipulates that any resulting data must be entered as to and when an observation is made. Lastly, scientific results go through a rigorous double blinded peer review which often removes bias and allow for work to be examined on the basis of its own scientific merit and not based on subjective means such as consideration of who the authors are.

Whereas the regulatory demands of GMOs have created a scenario where it is very expensive currently to deregulate (commercialize) the crops, a case for joint Risk Assessment body to service the continent and allow countries share the burden of the regulatory process of GMOs such as establishment of East Africa Food Safety Authority (EFSA) seems a plausible idea. Africa may benefit greatly from the creation of an Africa Biosafety Authority body that resembles the EFSA that can at least reduce the burden on the less developed countries to afford commercializing of GMOs. By so doing experiences can be quickly shared and expertise quickly deployed among countries as desired.

### **Harnessing the political will**

Many people from several quarters all over the world and especially the scientific community have relegated the debate and final blockade to utilization of GMO foods in the developing countries to the presence or absence of the 'political will'. In their book chapter '*Does Africa Need political Will to Overcome Impediments to GM crop*' (Alhassan and Adekunle, 2014) reported that countries like Brazil, Argentina, India, and the Philippines developed the political will to engage. However, they make this assertion without defining what is the political will, how did these countries develop it, and how the other countries can develop it as well? The matter of relegating the challenge of biotechnology adoption in Africa and Kenya especially to political will needs a careful attention. The reason being that whereas at this stage the political will is needed to help adopt the GM crops, leaving such a decision to political will is

dangerous where the politics takes over and runs amok and announces support for the adoption of a harmful or irrelevant technology. Anchoring anything such as GMO development on politics is one sure way to embed the technology on *quick sand*. The point ought to be the pursuit of political will to promote sound scientific evidence, strong and effective biosafety institutions. Since these are embedded in law, ensuring laws of the nation are respected and upheld irrespective of the political office bearer is a much better guarantee to the kind of investments undertaken to commercialize the technology, than can be offered by any political will.

It is also very important that the political and policy makers look at the alternative scenarios. Failing to adopt GMOs or even to review the ban would mean continued status quo. In an honest evaluation we must realize that we are not just avoiding risk, since nothing is risk free, even continuing the ban exposes us to risk of some kind especially of very limited markets for imports in case of drought. The aim must be risk balancing. The overarching question may need to be where we would be if we continue what we are doing now? And whatever the scenario happens to be the country must then ask, can it afford that position? The answers countries get from these questions should provide the best impetus for driving adoption or continuation of the moratorium on GMO and GE crops.

One of the areas that have been suggested is harnessing of the technology for addressing very pertinent and closer issues to the country in question. For example, the development of the Water Efficient Maize for Africa, Insect Resistant Maize for Africa, and other local crops being modified to provide for more beneficial effects, that can directly address the consumers' needs are more welcome (CYMMIT, 2018). This initiative has the advantage that it is being supported through philanthropic means and National parastatals which are public institutions. The sponsors of this project include Bill and Melinda Gates Foundation, Howard G. Buffett Foundation and the U.S. Agency for International Development (CYMMIT, 2018).

On one hand, one cannot fail to realize that government officials of developing countries are overwhelmed by the weight of all the information either for or against the technology. This can be very disturbing especially for those in leadership. It seems that the scientific community has not done a good job of convincing the decision makers at the political level about the safety and attending benefits of GMO crops for the people and the economy of these nations. At the same time, government officials ought to carry out independent research, practice critical thinking which goes beyond what is said to why it is said, beyond who is offering the report to why the report. At least the relevant GMO technology should be selected for use in Kenya given that some of the foremost Biotech crops being fronted were grown in some countries decades ago and newer and superior GMO offerings are currently available in the

developed countries. The question is whether these first-generation GMOs are the appropriate ones for Kenya or by adopting them, will we be repeating the mistakes that led to their being abandoned or up graded for farmers in the developing countries.

In closing, going through the 'Regulations and Guidelines for Biosafety in Biotechnology for Kenya', it is difficult to see where any issues of lack of safety should be raised if the process detailed in the documents were followed. It goes to prove that there is a tendency to bash the GMO crops without necessarily having had a chance to read through the regulations in place. But there is also a possibility that the level of trust that countries have on their governments, and attending institutions, have a direct bearing on their trust about GMO technology irrespective of the facts as outlined in science.

## Conclusions

Decades of growing of GM crops have allowed millions of farmers around the world to not only increase productivity, but also have control of some serious insect pests, diseases and weeds in the fields, resulting in reduced use of pesticides, increased productivity, and hence profitability. Kenya has made slow but steady progress with GMO crops' commercialization with *B. thuringiensis* cotton being approved for field trials and later on released to farmers in 2020. There are other beneficial GM crops (Bt. Maize and Bacterial wilt Resistant Cassava) in the pipeline for NBA regulatory process and hopefully release into the environment in the future. In encouraging adoption of GMO crops, capacity building and taking into account the uniqueness of the agro-ecological conditions and farming systems of the country is vital. Kenya's NBA, and relevant authorities, must ensure farmers' ability to afford seeds, and responsive regulation of GMOs which both are critical factors to bear in mind. Perhaps the lifting of the existing ban based on evaluation of available scientific evidence will provide a conducive environment for full exploitation of the biotechnology and encourage rigorous research to deal with any unfolding safety situation. With the bold step the government has taken of commercializing *B. thuringiensis* cotton technology in 2020, there can be no reason why the progressive adoption of the technology in Kenya cannot be realized. This will also allow the country to be better prepared to take advantage of available food grains for importation in the unfortunate incidence of drought resulting in hunger and starvation.

## CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest whatsoever.

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