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FOOD SECURITY IN AFRICA SERIES: SMALLHOLDER VULNERABILITY IN AFRICAN AGRICULTURE

EXECUTIVE SUMMARY

The *CCAPS Food Security in Africa Series* is composed of four briefs that focus on combating food security vulnerability in Sub-Saharan Africa. This second brief in the series explores the political, economic, and ecological pros and cons of biotechnology in African agriculture and the critical role of smallholder farmers in the decision-making process. Biosafety hazards, climate resilience, and seed systems are discussed to explain biotechnology risks, followed by a discussion of current biotechnology and biofortification uses in Africa to understand regional trends. The sensitive political and economic debates surrounding this technology will be discussed in order to shed light on various perspectives. Finally, the brief will highlight the most useful and sustainable applications of biotechnology that may be suitable for smallholder farmers.

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Since the Green Revolution of the 1960s and 70s, applying technological innovation to agricultural production has been a successful strategy in some developing countries, primarily in Asia and Latin America.[1] However, in recent years biotechnology has sparked a highly polemical debate among policymakers, farmers, the private sector, and academics both inside and outside Africa. Agricultural science invents, develops, and disseminates biotechnology to create climate-resilient crops as an attempted solution to food insecurities. The 2006 United Nations Framework Convention on Climate Change (UNFCCC) stressed in its *Technology for Adaptation to Climate Change* report that technology is the key to adaptation strategies and food security. But the debate over whether African governments should adopt genetically modified organism (GMO)[2] technology is a contentious one that has been largely driven by transnational agribusinesses, international organizations, and U.S. and EU non-governmental organizations (NGOs).[3] This brief explores the political, economic, and ecological pros and cons of biotechnology in African agriculture and discusses applications of biotechnology that may be suitable for smallholder farmers in Africa.

ACCESS TO BIOTECHNOLOGY IN AFRICA

Increasing African nations' agricultural productivity is the most sustainable approach to food security, yet these agricultural systems are greatly affected by unpredictable weather patterns, pests, crop diseases, droughts, floods, and land restrictions. Despite development efforts and agricultural extension services, the majority of Africa's smallholder farmers still lack access to the reliable markets, high-quality seeds, and fertilizers that would enable farmers to grow high-yield, low-maintenance crops. Biotechnology could be a powerful tool in addressing Africa's barriers to food security, but not without considering the environmental, social and political risks unique to each country.

The majority of Africa's smallholder farmers still lack access to the reliable markets, high-quality seeds, and fertilizers that would enable farmers to grow high-yield, low-maintenance crops.

Biotechnology is the scientific manipulation of genes to create new characteristics in certain plants not typically found in nature.[4] Scientists take desirable genetic characteristics from one plant and add them to plants not already displaying those characteristics. Genetic modification happens naturally through adaptive evolutionary strategies that plants use to survive. With modern technology and science, it is now possible to accelerate this process for more immediate genetic adaptation. Common examples of GMOs are pest-resistant cotton, drought-resistant maize, or mold-resistant cassava. Private GMO seed companies place restrictive patents on their seeds in order to protect their specific genetic patterns. Unmodified plants or crops in nature cannot be patented as inventions so there is little incentive for companies to protect these seeds, resources, and genetics. This leads biotechnology developers to engineer patented seed varieties, which must be re-purchased annually, where patent laws apply.[5] For this reason, *genetically engineered* (GE) crops and seed patents have become a controversial form of biotechnology.

A form of biotechnology that is less controversial as a food security and nutrition development initiative is *biofortification*.[6] Farmers, NGOs, and governments have worked together to pilot successful food and nutrition programs using biofortification techniques. Biofortification of crops involves inserting genes that carry specific fortifying nutrients and minerals into staple crops for improved nutritional outcomes.[7] This form of biotechnology is slightly less contentious than GE crops and seed patents. Biofortification is the topic of fewer international debates and is mostly applied to staple crops in developing countries; little to no biofortified produce reaches consumers in the developed world. However, developed countries have approved and adopted other types of fortified foods for increased nutrient consumption, such as processed cereals, formula, oil, and juices. This involves fortification in the form of additives, rather than genetic manipulation of the food source. Additionally, the pressure to produce biofortified crops may increase as demand for nutrient-dense staple crops increases locally.

Biotechnology and plant science have potential to contribute to solving Africa's food insecurities. However, there are many risks associated with the adoption of biotechnology and many unknowns for African governments, economies, citizens, and smallholder farmers.

BIOTECHNOLOGY DEBATE

Protections against the dangers associated with biotechnology were first codified in an international treaty by the Cartagena Protocol on Biosafety to the Convention on Biological Diversity, adopted in January 2000 and effective in September 2003. Thirty-seven African countries became signatories. The Protocol was enacted "to ensure the safe handling, transport and use of living modified organisms (LMOs) resulting from modern biotechnology that may have adverse effects on biological diversity, taking also into account risks to human health."[8] The Protocol allows countries to take precautionary actions towards GMO seeds, products, imports, and technology that encroach on the safety or health of their population. The protocol mandates that all countries are provided substantial information and assessments about the LMOs in order to determine risks and dictate which commodities can and cannot be traded or used within their borders. African governments can enact the Protocol to ban or restrict GMO food aid or imports into their countries.

Biosafety Hazards

Weak, underdeveloped, or unenforced biosafety regulations can lead to detrimental biohazards.[9] Hazards related to GMO crops include cross contamination of GMO and non-GMO crops, stealing of patented seeds, and even pest or disease immunity to GMO crops. Similar to antibiotics, which over time become less effective due to increased resilience of the bacterial strand, GMO crops' resilience to pests, drought, and disease weakens overtime. Additionally, when GMO crops cross-pollinate with non-GMO crops, it creates a hybrid varietal, which can further dilute the effectiveness of the GMO crop and have negative side effects on existing healthy, unmodified crops.

Scientists have not researched all possible plant combinations, reactions, and cross-contamination scenarios specific to each crop or climate. This will require seed companies and research institutes to continue intense research and confined trials to maintain high-yielding GMO crops that are resilient to evolving pests and diseases. All of these hazards comprise only a part of the risks associated with biotechnology. The United Nations Environment Program warns that, "responsible deployment of GMO crops needs to encompass the whole technology development process, from the pre-release risk assessment, to biosafety considerations, to post-release monitoring."[10]

Smallholder Vulnerability

Increased agricultural productivity could lead to food security, economic productivity, and political stability for many African countries. A stable political environment and strong economy can enable the implementation of social protection and social safety nets to help the poor survive price shocks and natural disasters, as well as remain generally food secure and well nourished. The question is whether biotechnology can, or should, be a part of this virtuous cycle.

Biotechnology has proved successful in increasing agricultural productivity in certain crops and contexts, such as cotton, maize, and soybeans in South Africa. An International Food Policy Research Institute (IFPRI) report summarizes that, depending on the farm size, location, and season, farmers reported a 14 to 23 percent yield increase when using pest-resistant cotton and significant savings on insecticides.[11] However, the use of biotechnology to ensure African food security is under-researched and often criticized as being inaccessible to smallholder farmers. The report states that, "although technical solutions can help address problems (such as lack of knowledge regarding insects and pest control, limited access to inputs, or evolution in pest pressure), no technology (GM or otherwise) can resolve the fundamental institutional challenges of smallholders and agriculture in Africa."[12]

Exacerbating challenges for smallholder farmers is the state of Africa's formal seed sector, which is complex, underdeveloped, and fragmented.[13] The sector is "constantly changing to cope with the dynamic macro-environment which includes seed policy and regulations, agro-ecological conditions, donor initiatives and investments, advocacy/special interest groups, and socio-economic factors."[14] Seed saving, to avoid annual purchasing costs, is a key strategy employed by smallholder farmers for millennia. Natural ecological diversity in farming systems has allowed this self-regenerating seed cycle to function.[15] However, seed saving always reduces productivity with each crop cycle and thus farmers prefer to re-purchase seeds annually, when financially possible.

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GMO seeds are more expensive than traditional seeds, meaning farmers must maintain enough profit at the end of every harvest to re-purchase the seeds and inputs. To ensure high productivity, patented seeds must be re-purchased annually. The price of patented seeds, and the quantity supplied, is determined by a few or even a single agribusiness company rather than the market. This creates a system that makes smallholder farmers vulnerable to unpredictable seed prices and seed delivery schedules, often pushing farmers either into debt or out of business. Given increased annual purchasing demands, farmers must finance the seed and fertilizer inputs through loans—often offered by the agribusiness themselves—in order to ensure a high yield and competitive crop to sell at market.

Biotechnology can thus cause dependence on large agribusiness seed suppliers and research corporations, should farmers begin to rely on this technology. GMO technology is not stable enough to guarantee a flawless harvest, thereby increasing risks for farmers. If seeds cross-pollinate with non-GMO crops or if a natural disaster hits, these crops are still subject to failure. For a smallholder using GMO seeds, a crop failure means huge debts owed to the transnational seed and fertilizer supply companies.

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Additionally, fertilizer inputs are subject to volatile market fluctuations and vary dramatically between countries. In Kenya, a farmer pays $330 per ton, while an Angolan farmer pays $830 per ton.[16] Transporting fertilizer from ports into landlocked regions is costly and severely limits access for many farmers.[17] While 60 percent of global agriculture yield increases are attributed to fertilizer, "Africa accounts for less than 1% of the global fertilizer market."[18] Unless governments can protect their smallholder farmers from this vicious cycle of further unpredictable supply and prices, GMO crops may not be the answer for their food security stresses. This is a point of contention surrounding the biotechnology debate that dramatically polarizes both activists and policymakers.

Allowing GMO technology into an agriculture-based economy with little social protections can propel smallholder farmers into inescapable cycles of debt and dependence on international agribusinesses for supply of seeds and financing. Furthermore, if these crops are used in systems that lack capacity to adequately monitor and reduce biohazard risks, the use of GMOs could have negative effects on food security and stability for all farmers and citizens.

Climate-resistant crops provide an example of the potentially conflicting impact of biotechnology. On the one hand, climate-resistant crops can help improve food security by helping smallholder farmers make rapid strides towards increased agricultural production if they gain access to safe seeds and inputs. On the other hand, GMOs in commercial agricultural production could create unnatural dependencies and reduce ecological biodiversity—a detrimental side effect, especially for smallholder farmers. Biotechnology opponents cite such possibilities in asserting that GMOs are not the answer to food security but rather a scheme to make agribusiness corporations wealthier.[19]

CURRENT APPLICATIONS IN AFRICA

Genetically Modified Crops

Currently only four African countries allow GMO crops on their soil for commercial production. Burkina Faso, Egypt, South Africa, and Sudan all commercially produce Bt cotton, a pest-resistant strand.[20] South Africa is the world's ninth largest producer of GMO crops, including cotton, maize, and soybeans,[21] yet citizens remain divided on their use. As a regional leader both economically and politically, South Africa often sets the trend for other African countries in long-run development initiatives. However, "there is growing public opposition to GM crops in Africa that is best described as a fear of the unknown."[22]

Confined research trials are being conducted in Kenya, Tanzania, and Uganda, exploring the possibility for GMO bananas, cassava, maize, cotton, and rice to produce climate-resilient and high-yielding seed varieties. As African governments weigh the pros and cons of allowing GMO crops within their economies and soils, the research and development of these crops is occurring simultaneously. The pace of this technology research and development does not afford governments enough time to put adequate regulations in place to address biosafety hazards, should they arise during the confined research trails.

Kenya recently passed a law requiring mandatory labeling of any GMO products. EU officials are reluctant to import commodities from Kenya under the mandatory GMO labeling law because they seem "less safe."[23] The Kenya Agricultural Research

Institute (KARI) is one of the most well-developed and advanced biotechnology testing departments run by an East African government. In this instance, even domestic or international labeling laws will not suffice for GMO products on wider markets. If this or other international regulations on GMO products are enforced, it will most likely be the farmers, exporters, and less-developed countries footing the bill. These exporting African countries would have to establish labeling systems, inspections, quality assurance standards, and other consumer protection measures in order to ensure their crops are accepted in international markets and meet demands of importing country governments.

During debate about GMO adoption in Africa, farmers, policymakers, and activists often point to the fact that major export markets, especially to the EU, could diminish or halt with the acceptance of GMO crops.[24] This is difficult to measure or predict; however, a recent trade analysis report by the Center for Strategic and International Studies (CSIS) claimed that the amount of exports of bananas, cotton, cassava, maize, and cattle meat—the five most likely exports to become GMO products—to the EU is an insignificant proportion of total export volumes.[25] The report notes that, in all East African Community (EAC) countries, the "monetary value and volume of exports to GM-sensitive destinations is very small and in most cases negligible."[26] For example, the export value of maize and cassava to Europe from the EAC is "0.12 and 0.85 percent of total export value, respectively."[27] However, bananas do comprise 56 percent of exports from the EAC to Europe; making them more susceptible to negative ramifications of GMO-sensitive markets.[28] The CSIS report explains that the adoption of GMO crops would outweigh the opportunity costs of continuing to trade in restrictive export destinations.[29] This is a predicament for African governments who must work to preserve these trade relationships and markets while also making the best decision—food security wise—for their people.

Biofortification

Biofortification is another form of biotechnology being applied in Africa. It has been successfully implemented in Mozambique and Uganda through the HarvestPlus Program, which provided seeds for sweet potatoes fortified with Vitamin A. HarvestPlus is part of the Consultative Group on International Agricultural Research (CGIAR) Program on Agriculture for Nutrition and Health, coordinated by the International Center for Tropical Agriculture and IFPRI.[30] HarvestPlus distributed the biofortified seeds as a development intervention, making the seeds more accessible for farmers. Vitamin A levels doubled for all identified target groups (children 6-35 months and adult women) in Mozambique, while "in Uganda they increased by two-thirds for younger and older children and nearly doubled for women."[31]

If these crops are used in systems that lack capacity to adequately monitor and reduce biohazard risks, the use of GMOs could have negative effects on food security and stability for all farmers and citizens.

POLITICAL AND ECONOMIC IMPLICATIONS

Currently there are public entities, private firms, aid organizations, and bilateral aid agreements that fund GMO research and development in Africa.[32] This complex web of trade and relationships exacerbates the challenges that African governments face in determining whether or not GMO production is suitable for their country, land, economic size, and especially their geopolitical positions. Compromises and integrated strategies for thorough GMO research, development, and regulations are hard to achieve with such a variety of stakeholders pursuing their own political and economic incentives in the debate.

There are high stakes for African governments as they develop biosafety standards, educate citizens, and build capacity to manage biotechnology. While there is still relatively little research on the economic trade ramifications, some African governments fear that their export economies and trade relationships would be jeopardized when selling to partners who have banned GMO products, meaning that African governments would be putting their country at risk by adopting GMO crops.[33] According to the Biosafety Protocol, countries can restrict imports if they believe the products will do harm to the health or safety of their people, animals, or plants. However, preventing "un-duly trade restrictive measures" or minimizing the extent to which import bans of GMO goods can be imposed is an agreement of all World Trade Organization (WTO) members—even those enacting the Biosafety Protocol.[34] The WTO is tasked with determining a balance of protection for human, animal, and environmental health and healthy international trade policies for all members.

The complex web of trade and diplomatic relationships creates challenges for African governments determining whether or not GMO production is suitable for their country, land, economic size, and especially their geopolitical positions.

At present, there are no Africa-wide biotechnology standards and each country context will dictate different rules and regulations on biotechnology. Varying donor and trade partner restrictions on GMOs will likely be the most notable conflict each government will confront. The U.S. actively promotes and uses GMO technology to improve agricultural yield, whereas the U.K. and the EU have banned all GMO products from their shelves, from food aid, and from all agricultural research and development practices they fund. This has significant impacts for most African countries, which have bilateral and multilateral trade agreements with EU nations.

The cost and benefit of GMO production, in terms of exports versus domestic consumption, are still relatively unknown. One research study calculates that of potential GMOs used in production worldwide—such as maize, rice, cassava, and bananas—almost 95 percent would be for domestic consumption, implying there would be little impact on international export agreements.[35] However, from a nutritional health perspective, increasing domestic consumption of high-calorie, high-starch, low-nutrient staple crops through GMO production is not sufficient, or even desired, for real long-term food security.

The UNFCCC concluded that, "even if new technologies are devised, and are suitable for local conditions, it can be difficult for the poorer farmers to adopt them. With small farm sizes and limited access to credit, they may have neither the ability nor the inclination to invest in new technology."[36] GMO seeds are a new technology that must be taught and tailored to meet the specific needs of each user population and climate context. Policymakers desiring biotechnology adoption should seek to educate, train, and provide more consistent input supports for farmers to learn the most advanced and safe ways to use this technology to their advantage.

POLICY RECOMMENDATIONS

Four principles that governments, citizens, farmers, and activists could consider to address smallholder vulnerability and food security projections in Africa are outlined below.

Biosafety regulations must be established and enforceable before, during, and after any GMO crops are introduced commercially. Even in countries like Kenya and Uganda that are conducting biotechnology research but have not released seeds into the market, biosafety standards must be more rigorous to protect their citizens. Agricultural ministries and farmers alike need to be well informed about potential risks and safety precautions necessary for the safe use of GMOs.

Smallholder farmers must be integrated into the central decision-making process. Continued education, capacity building, and access to affordable agricultural inputs must be included in any agricultural development models, whether choosing to employ GMOs or not. Smallholders must be able to voice the pros and cons they will face and be ensured the right to choose whether or not they want to use GMO seeds.

Governments should seek integrated and intensive solutions to agricultural productivity. The answer is not pro-GMO or anti-GMO; the answer is ensuring smallholders have access to affordable and sustainable inputs, adaptation tools for unexpected exogenous shocks, social protections, and safety nets. Governments may choose to seek a harmonized blend of traditional agricultural system intensification, innovation, and extension services along with some climate-resilient biotechnology strategies for higher yield.

Unbiased education about biotechnology risks and potential benefits should be widely disseminated to ensure citizens are making informed decisions on the debate. The decision of whether or not to allow GM products into African countries must be a dialogue between, and a decision taken by, African citizens. Each country and each region in Africa will need to evoke context-specific decisions about GMO regulations depending on its size, climate variability, economic and political strength, and export and import commodities.

Regulatory frameworks and biosafety standards add to the complexity of Africa's food security issues. Thus, it is crucial for general citizen safety that trial-stage GMO crops are securely guarded, well maintained, and most importantly, sufficiently regulated. In the case of Uganda, among others, the move for biosafety regulations has caused political stress and policy stasis, leading to regulatory repeals and strongly polarized public opinion about biotechnology. Although research bodies are quickly moving forward in developing climate-specific crops for their respective regions, biosafety regulations remain insecure and underdeveloped due to political and economic tensions.

An alternative to the scenario of debt cycles and dependency for smallholders, coupled with biosafety hazards and political discontent regarding biotechnology, is possible. A lack of information and political will cloud the debate around what exactly it would mean for African countries to adopt GMO crops and how it would affect smallholders. Without bringing vulnerable smallholder farmers to the table and giving them a strong and central role in this debate, progress towards a healthy, sustainable, food secure Africa will continue to be stifled.

ENDNOTES

1 The Montpellier Panel, *Sustainable Intensification: A New Paradigm for African Agriculture* (London: Agriculture for Impact, 2013), 4.
2 The World Health Organization defines a GMO as the biological altering of genetic material in a way that does not occur naturally. The term GMO is often used interchangeably with genetic engineering (GE), and it allows scientists to select desirable genes from one organism and insert them into another to produce specific characteristics in the modified organism.
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4 United Nations Environmental Program (UNEP), *Strengthening the Ecological Foundation of Food Security through Sustainable Food Systems: A UNEP Synthesis Report* (Nairobi: UNEP, 2012).
5 UNFCCC, *Technologies for Adaptation to Climate Change* (Bonn: UNFCCC Secretariat, 2006).
6 IFPRI defines biofortification as the use of selective breeding techniques of biotechnology to create micronutrient dense staple crops.
7 The Montpellier Panel, 21-24.
8 "Cartagena Protocol on Biosafety," Convention on Biological Diversity, January 29, 2000.
9 The Biosafety Protocol defines biosafety as the governance of policies, procedures, and use of GMOs. Biosafety aims to avoid hazardous public health and environmental issues as a result of the use of GMO technology.
10 UNEP, *Africa Environment Outlook 2: Our Environment, Our Wealth* (Nairobi: UNEP, 2006), 322.
11 *Genetically Modified Crops in Africa: Economic and Policy Lessons from Countries South of the Sahara,* eds. José Falck-Zepeda, Guillaume Gruère, and Idah Sithole-Niang (Washington: IFPRI, 2013).
12 Ibid., 32.
13 Alliance for a Green Revolution in Africa, *Africa Agriculture Status Report: Focus on Staple Crops* (Nairobi: AGRA, 2013), 56.
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25 Komen and Wafula.
26 Ibid., 18.
27 Ibid.
28 Ibid.
29 Ibid.
30 HarvestPlus, *Disseminating Orange-Fleshed Sweet Potato: Findings from a HarvestPlus Project in Mozambique and Uganda* (Washington: HarvestPlus, 2012).
31 Ibid., 7.
32 For a comprehensive list of "Regulatory status of genetically engineered crops in the regulatory and development pipeline in Africa as of 2009," see Falck-Zepeda, Gruere, and Sithole-Niang.
33 Falck-Zepeda, Gruere, and Sithole-Niang, 143.
34 Chantal Pohl Nielson and Kym Anderson, *Genetically Modified Foods, Trade and Developing Countries: Is Golden Rice Special?* (Auburn: AgBioWorld, 2011).
35 Robert Paarlberg, *GMO Foods and Crops: Africa's Choice* (Amsterdam: New Biotechnology, 2010).
36 UNFCCC, 24.

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