Fixing Famine

How Technology and Incentives Can Help Feed Africa

JASSON URBACH
PRIMARY FIELD RESEARCHER

DANIEL SACKS
RESEARCH ASSOCIATE

International Policy Network

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International Policy Network
Rooms 200–205, Temple Chambers
3–7 Temple Avenue
London EC4Y 0HP
United Kingdom
t: +4420 3393 8410
f: +4420 3393 8411
e: inquiries – at – policynetwork.net
w: www.policynetwork.net

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info@macguru.org.uk

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About the authors

Jasson Urbach

Jason Urbach is a primary field researcher for Enterprise Africa! He is a South African and has a masters degree in economics and a bachelors of commerce with majors in finance and economics from the University of Natal in Durban, South Africa. His masters thesis was on "The Determinants of Labour Force Participation of the Elderly."

He works as an economic researcher at the Free Market Foundation and for Africa Fighting Malaria and has published both in academic papers and in the popular media.

Daniel Sacks

Daniel Sacks is a research associate working on the Global Prosperity Initiative and Enterprise Africa! Mr. Sacks has conducted field research in Malawi, Kenya, and Namibia, and within the United States, examining issues including economic development, agriculture, and wildlife conservation. Mr. Sacks graduated from McGill University with an honors degree in political science and minors in economics and psychology.

Fixing Famine: How Technology and Incentives Can Feed Africa

Executive summary

The food crisis in mid-2008, which caused riots and protests around the globe, was felt especially hard in Africa. Though food prices have now declined, Africa's struggles with hunger are far from over.

Africa's ability to feed itself has been in decline for the past four decades. To combat hunger and to encourage economic development, this trend needs to be reversed. In the short run, simple technology can make a difference in the lives of Africa's millions of rural farmers by increasing the productivity of their land and thereby increasing incomes.

This study, based on fieldwork conducted in Malawi and Kenya, profiles four simple technologies that have major benefits for smallholder farmers. Hybrid and genetically modified seeds, greenhouses, irrigation, and plug seedlings all increase farm outputs and allow farmers to harvest multiple crops a year.

Though these technologies have the potential to be very successful, there are several barriers that prevent their greater use: lack of credit, poor infrastructure, high transaction costs, and educational and cultural barriers. This Policy Comment proposes solutions to these problems.

A. Introduction

Beginning in 2005, global food prices increased dramatically, culminating in worldwide food shortages in 2008.[1] The strain of rising food prices and severe shortages caused riots and protests in a number of countries across the globe – including in Cameroon, Burkina Faso, Haiti, and Egypt – and contributed to civil unrest in several others. World Bank President Robert Zoellick warned, "[The] doubling of food prices over the last three years could potentially push 100 million people in low-income countries deeper into poverty."[2] Though world food prices have decreased since the summer of 2008, many millions of people around the world remain vulnerable.[3]

Agriculture forms the backbone of many African economies. In sub-Saharan Africa (SSA) 70–80 percent of employment and 30 percent of gross domestic product (GDP) are derived from agriculture.[4] However, African countries generally suffer from very low agricultural yields compared to the rest of the world, which contributes to Africa's poverty and lack of economic development. When food prices rise, as in recent years, the rural poor's risk of malnourishment increases; even without major price hikes, many of these people live in hunger. A revolution in SSA's agricultural productivity can help to overcome this poverty.[5]

A number of systemic problems, including land tenure, government involvement in agricultural markets, and lack of education, are preventing drastic, long-term improvements. Because SSA needs relief immediately, however, this Policy Comment focuses on short-term solutions that will increase the availability and use of agricultural technology in order to alleviate food shortages and spur economic development. New technologies can make small plots of land more productive, increase farmers' outputs, and increase farmers' incomes. Over time, the alleviation of food shortages may allow people to focus on the larger systemic problems that must be addressed.

This study investigates the use of agricultural technology by rural farmers in Africa, including specialized seeds, irrigation, and greenhouses. Fieldwork and interviews conducted in Malawi and Kenya show that farmers are

using these technologies to improve their agricultural productivity and their standards of living. However, farmers face obstacles in using these technologies, including barriers to trade, unavailability of credit, and lack of access to markets. This study also proposes policy changes to address these obstacles.

B. Background

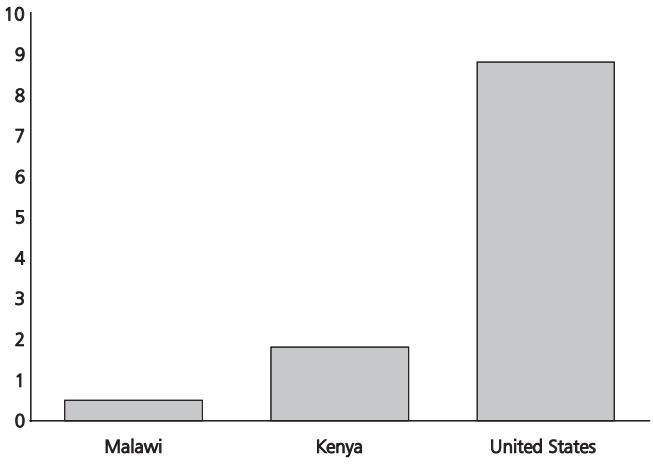
Africa's agricultural productivity has been declining since the 1970s.[6] Compared even to other developing regions, Africa's agricultural productivity is frighteningly low – grain productivity per capita is a mere 40 percent of other developing areas (see figure 1).[7] This gap is widening as other regions improve and Africa continues to lag behind.

Africa's lagging agricultural productivity is, in part, a legacy of colonial times, when European governments intervened in national economies across Africa, particularly in agricultural sectors.[8] Agriculture was the main economic activity of most African nations, and government interventions made agriculture markets the main source of government revenues.[9] After African countries achieved independence and embarked on economic reforms, agriculture remained the target of government interference. Governments set prices, taxed exports, and nationalized land, which discouraged commercial farming and private investment in agriculture.[10]

Limited private-sector investment in agriculture led to limited investment in new technology. In Asia, 82 percent of land is planted with modern (hybrid) seed varieties that are bred to withstand specific diseases or environmental conditions. In Africa, only 27 percent of land is planted with modern seeds.[12] Not using the best inputs and equipment available, such as hybrid seeds and basic irrigation systems, prevents African farmers from maximizing the productivity of their land.

Today's agricultural technology can make millions of rural poor more food secure and economically better off. According to the World Bank, a 10 percent increase in crop yields leads to a 9 percent decrease in the percentage of people living on less than $1 a day.[13] It is essential, however, that increased agricultural productivity be derived from the better use of existing agricultural land and not from an expansion of agricultural land as in the past. Over the last 40 years, increasing amounts of land have been put to use for farming, to the detriment of forests, soil, and water.[14] Some small-scale farmers in Malawi and Kenya provide examples of how to improve the productivity of existing agricultural land: they have embraced new technologies and are using them to increase their harvests, incomes, and standards of living.

Figure 1 **Maize productivity**
Kilograms per hectare



Source: U.N. Food and Agriculture Organization's statistics group (FAOSTAT)[11]

C. Technology in use in Malawi and Kenya

Though Kenya and Malawi are at different points in their economic development – Kenya's GDP is approximately six times higher than Malawi's – agriculture is a large part of both countries' economies.[15] Farmers in both countries are using agricultural technology to improve productivity and increase their standards of living.

C1. Agricultural technology in Malawi – hybrid seeds

Malawi is a small, landlocked country with a population of approximately 14 million people. Its economy is extremely small, and agriculture accounts for more than

Genetically modified seeds

Like hybrid seeds, genetically modified (GM) seeds have the ability to improve the livelihoods of all farmers in Africa. Similar to hybrid seeds, GM seeds are designed to perform in specific environmental conditions and to survive droughts, disease, and insects. Unlike hybrid seeds, these traits are introduced at the genetic level in a laboratory instead of by cross-pollination. The GM technique produces stronger traits than those found in hybrid seeds, ultimately leading to greater productivity. Globally, the use of genetically modified seeds is booming. According to the International Service for the Acquisition of Agri-biotech Applications, in 2007, "growth continued at a sustained double-digit growth rate of 12 percent, or 12.3 million hectares (30 million acres) – the second highest increase in global biotech crop area in the last five years – reaching 114.3 million hectares (282.4 million acres)."[21]

Malawi

one-third of GDP, approximately 90 percent of export revenues, and 90 percent of employment. The average GDP per capita is $230, and much of the population consists of subsistence farmers.[16]

Hybrid seeds are the most common form of agricultural technology used in Malawi.[17] Though not ubiquitous, hybrids are used across the country, in part due to an effort by the government and donors to subsidize their use.[18] Using hybrid seeds instead of local, traditional, open-pollinated variety (OPV) seeds (also known as heirloom seeds) has many advantages, but the most significant is the superior yields. No agricultural practice (including weeding, irrigation, fertilizer application, or pest control) can improve a crop beyond the limit set by the seed planted.[19]

Traditional OPV seeds typically produce lower yields, but the seeds can be saved and planted the following season, while hybrid seeds' yield are greatly diminished if replanted. However, farmers choose to plant hybrid seeds, demonstrating that farmers understand the benefit of the better seed and are willing to pay more for higher quality. When both hybrid and OPV seeds were made available for purchase as part of a subsidy program, approximately 75 percent of coupon recipients chose hybrid seeds even though the cost of the seed was higher for a smaller amount.[20]

The increased productivity of hybrid and GM seeds gives subsistence and small-scale farmers huge advantages. High-tech seeds substantially increase crop yields and reduce farmers' workloads, leading farmers to produce more than they consume and to be able sell their excess product. The use of hybrid seeds by farmers in Malawi, some of Africa's poorest, suggests a great potential for hybrid and GM seeds in Africa. Unfortunately, few African countries allow the use of GM seeds today.[22] This presents a major obstacle to improving agricultural productivity and livelihoods (see *Opposition to GMOs*, p. 9).

C2. Agricultural technology in Kenya

Kenya is located in East Africa, on the Indian Ocean, and is bordered by Somalia to the north and by Tanzania to the south. Almost 40 million people live in the country, which is twice the size of Nevada. Kenya's GDP per capita is $1,800, though there is a wide disparity between rich and poor.[23]

Agriculture employs approximately three quarters of Kenya's workers. Kenya's main exports include tea,

Kenya

horticultural products, and coffee. Though much of its trade is with its neighbors, Uganda and Tanzania, Kenya also exports heavily to the United Kingdom and to the Netherlands. Kenya's highlands are some of the most productive agricultural lands on the entire African continent.[24]

Despite great poverty, Kenya is home to some agricultural successes. Subsistence farmers and small-scale farmers across Kenya have embraced new technology in order to improve their productivity and their incomes. Plug seedlings, greenhouses, irrigation systems, and hybrid seeds are examples of technologies being used today to improve outputs.

C2A. Plug seedling technology

The Longonot Farm in Naivasha, Kenya, grows and sells plug seedlings (young, recently germinated plants, the roots of which are "plugged" into the ground). Since 1996, when it began growing seedlings, Longonot Farm has been Kenya's only plug seedling producer. The farm grows plug seedlings of a variety of different vegetable plants using both OPV and hybrid seeds.[25] Hybrid seedlings are popular, as the benefit of better seeds is magnified by the plug seedling method.

Vegetable plant seedlings are used by farmers in place of seeds because the already-germinated plants are much more likely to produce a harvest. On average, 80 percent of plugs can be harvested, while only 20 percent of seeds typically reach maturity.[26] Farmers pay more for the seedlings because they can be guaranteed a predictable harvest, making planning easier. Plug seedlings also mature two weeks earlier than traditional field-planted seeds because the seedlings are grown in greenhouses

Paul Donde, manager of Longonot Farm, in the greenhouse with the plug seedlings

where moisture content and fertilizer are strictly monitored. This allows farmers to sell their crops sooner and receive a return on their investments faster.

Though the benefits of the seedlings are noticeable to those who use them, Longonot faces some problems in expanding its sales. Paul Donde, the farm's manager, suggests that "the biggest obstacle preventing Longonot from further penetration into the smallholder agricultural market is the cost of transportation and packaging." According to Paul's estimates, transport and packaging double the cost of the seedlings to farmers. Also, poor roads and long distances prevent Longonot from serving the entire country and constrain its sales to a relatively small area near the farm.

Another factor that increases the cost of plug technology is the tariffs levied on the trays in which the seedlings are grown. Longonot must import the trays, as there are no manufacturers in Kenya capable of producing them, and state-imposed import tariffs on the trays raise the cost of producing the seedlings.

Longonot focuses on the smallholder market because subsistence farmers make up so much of Kenya's agricultural sector. If tariffs on the trays could be reduced and the roads improved, the seedlings could be sold at lower prices and would be more accessible to subsistence farmers.

Drip irrigation pipes run along the roots of tomato plants

C2B. Drip technology

Drip irrigation uses a system of small pipes (called drip tapes or drip lanes) to deliver water directly to the roots of plants instead of irrigating the entire surface area of a field. Drip irrigation's great benefit is that it saves large amounts of water while allowing the farmer to supply water and vital nutrients directly to the crop. When the crops need to be watered, farmers turn a tap, allowing water to flow through the drip tapes. Drip tapes can also be used to carry fertilizer and chemicals directly to the root system, helping to reduce the use of pesticides and fertilizer. Drip technology allows farmers to grow crops throughout the year (if they save water during the rainy season or have a permanent source of water) and to substantially improve their yields. Once installed, the drip irrigation system saves time over other manual methods of watering plants, as water flows at the turn of a tap.

Access to water and irrigation make a large difference in productivity and yields.[27] Indeed, irrigated land is twice as productive as rain-fed land.[28] According to a report by the Commission for Africa, poverty can be as much as 20–30 percent lower in areas where a higher proportion of land is irrigated, as rain-fed agriculture is far more vulnerable to climatic variability, which Africa is fraught with.[29] The demand for irrigation is high in SSA, as only 4 percent of the area in production is irrigated.[30]

Five drip tapes, stretching approximately 30 meters, typically cost about 1,700 Kenyan shillings (approximately $27). This investment, approximately 2 percent of average annual GDP per capita, can lead to significant returns, particularly when one considers the savings in chemicals and fertilizers and the increased yields. If farmers can afford to make the investment and know how to use it, there is a great benefit to using irrigation equipment.

C2C. Greenhouse technology

Greenhouses were used as long ago as 30 A.D. when the Roman emperor Tiberius demanded cucumbers in the off-season.[32] Greenhouses have evolved substantially since the days of Tiberius, but the basic premise remains the same. Though a fairly simple technology, greenhouses increase outputs while decreasing inputs. Greenhouses also offer the farmer the potential to grow produce all year in a controlled environment, sheltered from the elements. The opportunity to grow high-quality produce in the off-season when supply is limited and prices are higher allows farmers to increase their incomes.

In Kenya, a typical greenhouse's walls and roof are made

Drip irrigation and hybrid tomato seeds: a productive combination

The Kuria district is home to the Muchui Women's Group, which was established in 1992 and consists of 62 members that support approximately 550 family members. Recognizing the importance of irrigation for food security, the Muchui Women's Group decided to adopt drip technology on their small plots. The results have been remarkable: the women and their dependents are food secure, and they have helped others in the area increase their production as well.

The Muchui Women's Group plots showcase the productive capabilities of new technologies to other farmers in the area. According to Teresa Mellish of Farmers Helping Farmers (a Canadian NGO that supports and works with the Muchui group), when Seminis (a division of Monsanto) introduced a new hybrid tomato in the area, approximately 500 people from surrounding areas came to see the Muchui Women's Group's crop demonstrations.[31]

of plastic sheeting. The plastic filters harmful ultraviolet rays from the sun that would otherwise damage the crop and, in the rainy season, keeps the produce dry, preventing spoilage. The structure is small enough to fit on any smallholder's plot and even in an urban garden.

Greenhouse farming requires less water than farming in an open field, as water lost to evaporation is dramatically reduced. When drip irrigation technology is used within a greenhouse, farmers use only a tenth of the water needed for an equivalent open field.[33] The greenhouse not only helps with water conservation during the dry season, but also reduces the amount of water going directly onto the crop during the rainy season, decreasing the probability of the crop spoiling.

Farming in a greenhouse also requires less labor than open-field farming – as a greenhouse can be as productive as a much larger open field, it is easier to weed, spray, and water (particularly with a drip irrigation system) within a greenhouse, requiring a few hours' work per day by a single individual. Farming an open field of equivalent productivity often requires a number of people working a full day, often for a smaller crop.

Further gains can be realized when farmers plant hybrid seeds within the greenhouse. In Kenya, a specific seed has been designed for use in a greenhouse (See box, Development of Hybrid Seeds), and a template of a greenhouse designed to encourage uptake of the seed. The greenhouse designed for use with the hybrid tomato seeds covers roughly 240 m^2 of ground but produces the same yield as a one-acre plot (approx. 4,047 m^2).[34] Only 2.5 grams of seed, retailing for approximately KSH 750 ($12.14), are needed to plant the entire greenhouse. An acre of open field using OPV seeds will typically require 100 grams of seed, which retails for approximately KSH 900 ($14.56)In addition to the productivity gains derived from the use of greenhouses, crops produced within a greenhouse are of significantly higher quality. The typical OPV tomato from the field will sell for KSH 15 ($0.24) per kilogram, whereas a hybrid tomato produced in a greenhouse sells for KSH 50 ($0.81) per kilogram. Bank officers who learn about the efficiency of greenhouses at field day demonstrations *(see section D4 or page 9)* are often willing to provide loans to farmers to build such greenhouses.[35]

A "tomato tunnel" greenhouse

Greenhouses contribute to food security by increasing productivity and quality while saving water, fertilizer, pesticides, labor, and land. Perhaps the greatest gain from producing crops within a greenhouse is the ability to reap the benefits of production in the off-season, ensuring that a high-quality product is available throughout the year. Growing and selling crops year-round increases farmers' incomes and raises their standards of living.

C2D. Kenya summary

Agricultural technology is increasingly common in Kenya, from hybrid seeds to drip irrigation, plug seedlings, and greenhouses. Using these technologies helps farmers increase their productivity and their incomes, and, therefore, their standards of living. Most importantly, much of this technology enables farmers to drastically increase the productivity of their smallholdings, allowing them to increase their incomes without having to acquire more land – a process that can be difficult in many African countries.

D. Obstacles to increased technology use and productivity

A number of obstacles are preventing the spread of agricultural technology across Africa. Many of these barriers can be solved in the short term, though some are of a more long-term, systemic nature. This section explains the problems, and the next section suggests policy solutions for each.

Development of hybrid seeds

Peter Randa directs Seminis' horticulture technology development in 16 east and central African countries. He aims to use his scientific knowledge and marketing acumen to improve small-scale and subsistence farmers' standard of living.

Because "a meal in Kenya is simply not a meal [without tomatoes],"[36] Randa chose tomatoes as a key crop to develop. To find the ideal plant, Randa searched through the existing hybrid varieties formulated by Seminis and selected varieties that would grow well in a greenhouse. Once Randa decided on a particular product, he named the winning plant Anna F1 because small-scale and subsistence farmers – predominantly women – could identify with the name Anna.

When Randa was satisfied with his choice of seed, he began field tests. 100 farmers across Kenya planted test patches with inputs provided by Seminis. The test plots were located in areas that were easily visible to the wider community so other farmers could see the success of the crop. Randa then organized field days to show off and market the Anna F1 seed to other farmers in the area.

In addition to marketing the seed, Randa also pushed farmers to adopt greenhouse farming in order to capture the full benefit of the seeds. Randa designed a greenhouse called a "tomato tunnel" that could fit on farmers' small plots and that could be built easily. To convince the farmers to construct and use the greenhouses, Randa coordinated suppliers to provide the materials to build the tunnels and the irrigation system and to provide fertilizers and pesticides at competitive prices.

Randa continually tours farms, instructing farmers on farming methods, and visits local markets to see if Anna F1 is being sold. By demonstrating to farmers the capabilities of hybrid seeds produced by Seminis coupled with greenhouse technology, Randa hopes farmers will become more prosperous and continue to purchase Anna F1 seeds.

Randa believes that in the future, all commercial production of tomatoes in Kenya will occur in greenhouses. However, his main task is to convince small-scale and subsistence farmers in the 16 African countries under his responsibility of the virtues of using hybrid seeds in greenhouses.

D1. Opposition to GMOs

Hybrid seeds have been incredibly successful in both Malawi and Kenya, and genetically modified seeds have even greater potential to improve agriculture across Africa. However, only a small minority of African countries currently allow the use of genetically modified seeds despite the seeds' productivity gains and record of safety.[37]

African governments seem to be swayed by the lobbying of European governments, who dismiss the use of biotechnology under the precautionary principle whereby "any possible risk associated with the introduction of a new technology is avoided, until a full understanding of its impact on health and the environment is available."[38] Unfortunately for African farmers and consumers, European governments have exported this principle to Africa.[39] Sub-Saharan African countries that ban the use of GM seeds or the import of commercially produced GM crops substantially decrease the welfare of their citizens and unnecessarily perpetuate hunger throughout their countries.

D2. Credit

Accessing credit is a huge problem for smallholder farmers across Africa.[40] For example, in Malawi, most people cannot formally borrow any money, and can access only an average of $3 informally. Similarly, 38 percent of Kenyans are classified as "financially excluded" because they do not have access to financial services and products.[41] Without access to credit, smallholder farmers' ability to invest in their farms is incredibly limited, as an overwhelming portion of their incomes gets spent on food for themselves and their families. Little money remains to invest or to save.[42]

Without credit, farmers cannot take advantage of opportunities to improve the quality and quantity of their output. Credit enables farmers to buy more fertilizer, better seeds, or invest in capital improvements like irrigation or greenhouse technology.[43] When access to credit is constrained or is very expensive, these investments are not made, and farmers spend less on inputs.[44] When farmers own only a small piece of land, these differences matter a great deal, as their output is already limited by the size of their plot.

Equity Bank – Bringing banking to rural farmers

Equity Bank started operations in 1984 as Equity Building Society and was primarily concerned with providing mortgages to finance home construction. The bank, which operates across Kenya as a commercial bank, realized that there was a potential niche in Kenya's microfinance market and began to investigate ways to extend credit and bring banking services to Kenya's rural poor.

The bank uses an offroad vehicle with an attached automated teller machine (ATM) to make banking accessible to farmers in rural areas, reducing the opportunity and transaction costs of banking. Equity Bank has also entered into partnerships with the major commercial supermarkets, allowing customers to obtain "cash back" when using their debit cards to make a purchase.

Equity Bank makes opening and operating an account simple and educates rural farmers about the importance of having an account. For loan applications, the bank researches each customer's business practices and uses this information to determine the terms of the loan instead of stipulating an amount of income a client must have in order to qualify.

Equity Bank's appraisers try to ascertain the type of seed and fertilizer the farmer intends to use and encourage the farmer to use inputs from reputable companies. The bank also encourages farmers to make use of cellular communication technology to check the prices of produce in local markets.

To further meet small-scale farmers' needs, the bank also developed specialized loans that do not require interest payments for the first six months while the crop is growing. The farmer only begins to repay the principle, plus interest at a rate of 1 percent per month, once the crop is harvested. The six-month grace period allows farmers to make investments in their farm that do not need to have immediate effects.

Equity Bank intentionally targets the smallholder-farmer market. Esther Muiruri, General Manager of Marketing for Agri-Business, says, "People are talking about the next green revolution. We are hoping that [Equity Bank] can start it here in Kenya." She further notes, "Farmers are good risks. They are very loyal." She says her goal is to make Equity Bank the foremost provider of banking services to small-scale and subsistence farmers, and that "Equity Bank wants its customers to do well because then [Equity Bank] will also do well."[45]

Banks like this one help farmers in the short run by providing financing that can help fund investments that boost the farm's productivity. The banks hope that if the investments are effective, the farmers' incomes will increase and, ideally, they will begin to use more of the bank's services.

A variety of obstacles prevents farmers from accessing the formal financial system. Many rural farmers do not have a bank or financial institution nearby. When farmers can access banks, they often cannot receive loans because they do not have assets to post as collateral or because the assets they own are not accepted as collateral. When farmers are able to receive loans, they fear risking assets that are vital to their livelihoods, such as the land required as collateral. The banks may also fear loaning money to small-scale farmers because of the perceived risk.

D3. Infrastructure

Market access is another major problem for smallholder farmers. Even if they can increase their production using new technology, farmers may have difficulty selling their products because they cannot get them to a market. Markets may be far away, and the roads between farmers and markets are often poor. Without access to markets – without people to buy what they are producing – farmers have little incentive to increase their production for commercial use, particularly when faced with significant costs. Poor infrastructure across Africa affects not only domestic markets, but affects trade between African nations as well.[46]

Increasing market access can incentivize greater food production over the short and medium term as capital investments in farming increase.[47] Unfortunately, in much of Africa significant capital investments are not being made, particularly on smallholder farms.

Peter Randa and Gilbert Kibiti

High transportation costs also make it harder for farmers to acquire new technology. When it is difficult and expensive to travel, the costs of acquiring new technology can be prohibitive.

D4. Education and overcoming cultural barriers

For new technology to be used, farmers must be informed and educated about it. However, many of the same obstacles that make market access difficult for farmers are also barriers to educating farmers. As smallholder farmers are often in areas that are hard to access and far from major centers, spreading knowledge to them can be costly and time consuming. For example, though companies like Monsanto have success in using demonstration plots to show off new crops, they have great difficulty covering large areas of land with poor roads.

Certain cultural traditions and habits also present obstacles to education and the spread of new technology. In Kenya, when Monsanto or other companies host field days to demonstrate new crops or techniques, an overwhelming majority of the attendees are men. However, as is typical across Africa, the men are not the members of their households responsible for much of the farming – their wives are. Because cultural traditions place men in the role of decision-maker, the women who do much of the farming do not get the information they need to improve their families' farms.

In Malawi, culture also plays a role in poorly informing

Gilbert Kibiti and the role of retail stores in spreading agricultural technology throughout Kenya

Gilbert Kibiti is the managing director of Farmers Centre in the Meru district of Kenya, the largest distributor of agricultural products in the Mount Kenya region. Its trucks regularly deliver seed, fertilizer, chemicals, spraying equipment, and other agricultural supplies to various retail stores within a 40 mile radius of Meru. Farmers Centre also plays a critical role in disseminating new technologies and methods to farmers.

In addition to the agricultural inputs that retail establishments like Farmers Centre sell, they provide advice and information to farmers. The staff members at the retail outlet know the best farming practices; the majority of Kibiti's's employees studied horticulture at a tertiary institution. Most farmers come to Farmers Centre seeking information about the appropriate seed to overcome diseases that are prevalent in their particular areas or simply to garner general advice on a range of agricultural issues. As part of his combined educational and marketing efforts, Kibiti organized a demonstration of a tomato tunnel with Peter Randa that was attended by more than 1,000 people.

According to Kibiti, "The farmers in the Mount Kenya region are more progressive and prepared to try new technology as it becomes available."[48] About 70 percent of Kibiti's maize seed customers buy hybrid seed, while 75 percent buy hybrid vegetable seeds, especially cabbage seed.

Farmers Centre also acts as a small microfinance institution that offers credit to farmers that have demonstrated that they are good risks. Kibiti determines the farmers' ability to repay loans by visiting farmers on their farms. If he sees that a farmer is "serious about farming," he will provide credit. In Kibiti's experience, the majority of these farmers honor their commitments.[49]

By educating farmers about new technology, Farmers Centre and other stores are able to increase their sales in addition to helping farmers increase their productivity. Because a store that provides informational services as well as goods will attract more customers than one that provides goods alone, Farmers Centre has a clear incentive to provide education. Perhaps the best hope for education around new technologies comes from stores like this one.

Peter Randa in the Farmer's Centre

agricultural techniques. In maize fields across Malawi, seeds are planted in small ridges that run in rows across the field. Because the ridges need to be re-formed each season, oriented in the opposite direction, they increase the time farmers must spend when it comes to replanting. However, with modern seeds, the ridges are completely unnecessary. Despite the efforts of agricultural extension officers from Monsanto, Malawian farmers are holding on to this method that the British initially brought to the country.

D5. Trade barriers

The taxes on seed trays are one of the major obstacles Longonot Farms faces in producing affordable seedlings. The government of Kenya, despite many petitions, continues to charge a duty on the import of the trays, raising the costs of production for Longonot, and, therefore, the purchase price for consumers. Duties like this one, as well as regional and developed world barriers to trade (described below) all increase the costs of farming for African smallholders.

D5a. Regional barriers to accessing markets

While accessing local markets can be difficult for smallholder farmers, barriers to trade between African countries present an additional obstacle, adding to problems created by poor infrastructure.[50] High tariff rates on agricultural products drive up the price of imported goods, and export taxes raise the cost of exporting. Barriers to trade raise the price of Longonot Farm's seedling trays beyond what smallholders can afford, reducing accessibility to the technology and undermining agricultural productivity and food security.

Delays in moving products across borders created by inefficient trade procedures also raise transaction costs for farmers and exporters and limit regional market access. As the World Bank recently noted, the costs associated with exporting products are particularly high in Africa:

> *[I]n many countries trading across borders is more difficult than it need be… . Much is lost from delays in trading. The longest are in Africa. Each additional day that an export product is delayed reduces exports by more than 1%. For time-sensitive agricultural products, reducing delays by 10% increased exports by more than 30%.*[51]

It takes an average of 35 days to export a product in SSA, compared to 10 in high-income developed countries, 22 in Latin America, and 25 in the Middle East and North Africa.[52] These delays can also contribute to higher prices for capital investments like irrigation pipes.

E. Policy solutions for African governments

While a number of long-term, systemic problems plague agriculture in Africa, such as land-tenure issues and a lack of educational opportunities, there are a number of policies that can be implemented in the short term to supplement the spread of technology and increase food production and food security while adding to economic growth. The policies suggested next are of this nature.

E1. Genetically modified organisms

African governments need to adopt food safety and environmental policies that differ from those of European countries. Clearly the demand for increased food production is greater in Africa than in Europe, and GM seeds represent the best way to meet these demands. Africa's poor have much to gain from the adoption of GM crop varieties, and their governments should allow their use.[53]

Genetically modified organisms (GMOs) have the ability to improve productivity fairly rapidly because they can be put to use almost immediately by farmers, once approved by regulators. African countries that lack the necessary research and development capacity and programs to develop GM seeds locally can use technologies researched in developed countries.

Similarly, to lower the cost of regulating GM crops, African governments can piggyback off of policies that exist in other countries in Africa. Lacking institutions of their own and facing high costs to build such institutions, African governments should consider outsourcing their monitoring of GM seeds. These governments could consider GM seeds that are approved for use in other African countries, such as South Africa, as safe for use within their countries.

E2. Credit

Ultimately, Africa needs an improved land tenure environment – improved institutions for the ownership and use of land. However, in the short term, credit can be provided in a variety of other ways.

While farmers may not be able or willing to use their land as collateral, there are other models of financing that may help farmers to access credit. Savings groups, operating formally or informally, help farmers to pool their limited funds and make capital purchases for their farms. Microfinance operations are another avenue farmers have to access credit. Farmers can also gain access to credit through their supply chains. Storeowners like Gilbert Kibiti (see box, page 11) grant credit to farmers that prove to be reliable. In turn, larger suppliers, like Monsanto, offer credit to their retailers.

Using moveable property as collateral is another way farmers may access credit to invest in technology. If farmers do not own their land or are unwilling to risk losing it by putting it up as collateral, banks and other providers of credit should be willing to accept other property, such as farm animals or household items, in lieu of land. In doing so, farmers become more integrated with the formal financial markets while also gaining credit, and banks' risks are mitigated.[54]

When banks have the freedom to innovate and to operate flexibly in the way they serve the smallholder market, they can be successful, as in the case of Equity Bank in Kenya (see box, page 10). In places where there is access to credit, there is a high demand for a variety of

financial services to fill different needs, as long as the cost is affordable.[55] Equity Bank's success in financing smallholders demonstrates that targeting this group can be a successful venture. Other banks should be able to follow suit.

E3. Infrastructure

In order to access markets, farmers need roads.[56] This key piece of infrastructure is lacking or of low quality across much of Africa. Where roads do exist, the government agencies responsible for maintaining and building them have done little to preserve their investments.[57] For smallholder farmers, who often live in remote areas, poor-quality roads, or no roads at all, severely limit the ability to get goods to markets on a regular basis and disincentivize increased production due to the high cost of transporting goods.[58] To lower these costs and increase food availability, the infrastructure that connects farmers to markets needs to be improved.[59]

The desperate state of roads and other infrastructure across Africa should lead governments to consider all options for improvement. Government policies could create room for entrepreneurs to tackle these problems. Given the right incentives, the private sector may see an opportunity to profit from making improvements in infrastructure.[60]

E4. Provision of Technology

The seed coupon program in Malawi successfully spreads improved seed technology by providing better inputs to farmers. The United Kingdom's Department for International Development (DFID) funds a program providing farmers with coupons for the subsidized purchase of maize seed.

If developed countries are going to continue to subsidize their agricultural production, developing nations may have no choice but to do the same. Because farmers in developing countries are in much more desperate need of support, subsidies there may be much more effective. Though agricultural subsidies anywhere are a less-than-ideal policy solution, the program in Malawi is an example of a program that attempts to develop markets and that is implemented at a relatively low cost. In these ways, it may be an example for agricultural support, if agricultural support must take place.

Beyond encouraging the use of hybrid seeds, the Malawian program aids the development of the agricultural input markets and commercial distribution systems. OPV seeds became available commercially because the government-issued coupons made producing OPVs a profitable option for seed companies. Before the implementation of the coupon program, NGOs gave away OPV seeds in such quantity that the seed companies did not think there was a market for them. After they saw the success of the coupon program, the seed companies began selling OPV seeds in addition to hybrids, though at a lower price.

Malawi's agricultural markets are also strengthened by the program's use of private stores to provide seeds to farmers. Using private markets instead of government provision develops commercial systems while reducing the cost of administering the program. In contrast, a similar government-run fertilizer subsidy program relies on government purchasing to provide the fertilizer and on parastatals (government owned companies) to supply fertilizer to farmers. The fertilizer program faces issues of both excess and shortage because different areas receive different, and not always correct, shipments of fertilizer.[61]

At approximately six million U.S. dollars, the cost of the seed subsidy program is rather low, and borne by the DFID.[62] The minor cost and relatively market-friendly nature of the program may be a model for foreign expenditure in the future.

However, the program is not without its faults. As a subsidy program with an exogenous source, farmers could suffer if the UK stops funding the program. The subsidy is designed to encourage farmers to increase their incomes while saving money, but this may not be occurring. The program constrains certain market activity: coupons cannot be exchanged for seeds that are not produced within Malawi, and seed producers are limited in the amount they can charge in addition to the coupon. The former constraint may prevent cheaper or better seeds from entering the market, while the latter may discourage some companies from offering their

seeds for sale in Malawi. To improve the program, the government of Malawi should allow coupons to be redeemed for all kinds of seeds, regardless of where they are produced. The seed companies should also be allowed to charge whatever price they wish in addition to the coupon in order to encourage seed companies to bring better goods to market, decrease the risk faced by seed companies, and give the coupon a specific monetary value.

Within Malawi, the means by which the seeds are distributed is the most controversial element of the seed coupon program. Village chiefs and Ministry of Agriculture personnel have both been in charge of distributing the coupons, and there have been complaints about both. Accusations have been made that the seed coupon and fertilizer distribution programs are being used as political tools, with coupons being funneled to certain areas over others.[63] Even the printing of vouchers has been problematic: in the first year an unlimited number of vouchers were printed, costing the government more than it had budgeted and possibly leading to an accumulation of vouchers in the hands of people who did not need them. In the second year, the vouchers were printed too late, preventing farmers from using fertilizer at the correct time in the planting process.

Though implementation of the coupon program has been far from flawless, elements of its design may inform a model for agricultural foreign aid, if that aid is to be given. The program encourages market provision of the goods and creates market incentives, leading to the creation of new products. The low overall cost of the program suggests that change can take place without significant financial investment.

E5. Remove Barriers to Trade

African and developed countries should reconsider these duties, tariffs, and supports in order to achieve better health and economic outcomes for farmers and the citizens who rely on them.

E5a. Regional Barriers

Many SSA countries tax exports. Much progress has been made in this area, as the taxation of agricultural exports has fallen from an average of 46 percent in the 1980s to 19 percent in the mid-2000s.[64] Nonetheless, continuing policies of taxing agricultural products mean farmers face high costs in transporting any surplus they grow to foreign markets.[65] While the trend in lowering export taxes is a promising start, lowering these rates further would reduce transaction costs for farmers, making their products more competitive in external markets.

Reducing trade barriers between African nations could expand markets for smallholders. In some countries, areas with good agricultural potential are closer to markets in neighboring countries than to large domestic markets, making trade across borders a better option, but only if costs are not raised by tariffs or export taxes. Further, if one country experiences a drought or other crisis that limits food supplies, lower tariff barriers would allow producers in other countries to more easily meet the affected country's food needs.[66]

F. Conclusion

Technologies such as hybrid and genetically modified seeds, greenhouses, irrigation, and plug seedlings that have been available for many years in developed countries are finally becoming available to small and subsistence farmers in developing countries. This study, as well as another *Enterprise Africa!* study, *Seeds of Hope,* demonstrates that these technologies help to increase food security and make life more prosperous for many farmers, including resource-poor rural farmers.[67]

Farmers seeking better lives for themselves and their families need ways to grow more food, in order to be more food secure and have excess to sell. When farmers are able to take a surplus crop to market, they are provided an income and others are made more food.

Market incentives drive technological change around the world, and agriculture in Africa is no different. Companies that produce and sell seeds contribute by providing technical assistance with growing problems, which adds value to their products. Banks that provide credit to farmers help them be more productive; when the farmers advance financially, they will use more financial services.

Though all the problems surrounding African agriculture cannot be solved in the short term, technology can help make immediate improvements in agricultural productivity and standard of living.

Notes

1. According to the World Food Programme, the factors contributing to global food price increases include rising oil and energy costs; growing competition between biofuels and food; growing demand from burgeoning economies in the developing world; and increased climate and weather-related events destroying crops and reducing food supplies. See World Food Programme, "What high food prices mean for WFP," May 26, 2008, http://www.wfp.org/english/?ModuleID=137&Key=2797.
2. Agustín Carstens, "Development Committee Press Briefing" (Washington, DC: International Monetary Fund, April 13, 2008), http://www.imf.org/external/np/tr/2008/tr080413.htm.
3. The World Bank, *World Development Report 2008: Agriculture for Development* (Washington, DC: The World Bank, 2007), http://siteresources.worldbank.org/INTWDR2008/Resources/WDR_00_book.pdf.
4. Ibid.
5. African Green Revolution, "Impact on Society – and Poverty reduction," Yara International, http://www.africangreenrevolution.com/en/african_agriculture/impact/index.html.
6. Mylène Kherallah et al., *The Road Half Traveled: Agricultural Market Reform in Sub-Saharan Africa* (Washington, DC: International Food Policy Research Institute, 2000), 14, http://www.ifpri.org/pubs/ib/ib2.pdf.
7. See U.S. Government Accountability Office (GAO), *International Food Security: Insufficient Efforts by Host Governments and Donors Threaten Progress to Halve Hunger in Sub-Saharan Africa by 2015*, GAO-08–680 (Washington, DC: May 2008), 19–20, http://www.gao.gov/new.items/d08680.pdf.
8. See Kherallah et al., *The Road Half Traveled*, 5.
9. Robert H. Bates, *Markets and States in Tropical Africa: The Political Basis of Agricultural Policies* (Berkeley, CA: University of California Press, 1981), 13, 18.Markets and States in Tropical Africa, Bates, 13
10. Thomas S. Jayne et al., "False Promise or False Premise? The Experience of Food and Input Market Reform in Eastern and Southern Africa," *World Development* 30, no. 11 (2002): 1981; Kherallah et al., *The Road Half Traveled*, 9.
11. See Robert Paarlberg, *Starved for Science: How Biotechnology is Being Kept Out of Africa* (Cambridge, MA: Harvard University Press, 2008), 94.
12. See Paarlberg, *Starved for Science*, 81.
13. The World Bank, *Agricultural Development at a Glance* (Washington, DC: The World Bank, 2003), http://siteresources.worldbank.org/ESSDNETWORK/64158610–1111583197441/20488135/AgriculturalDevelopmentAtAGlance.pdf.
14. African Green Revolution, "Productivity," Yara International, http://www.africangreenrevolution.com/en/african_agriculture/productivity/index.html.
15. Central Intelligence Agency, *The World Factbook – Malawi*, https://www.cia.gov/library/publications/the-world-factbook/geos/mi.html and Central Intelligence Agency, *The World Factbook – Kenya*, https://www.cia.gov/library/publications/the-world-factbook/geos/ke.html
16. International Comparison Program, *Table of Results*, The World Bank, http://siteresources.worldbank.org/ICPINT/Resources/icp-final-tables.pdf.
17. A hybrid is the product (first generation progeny) of a cross between two unrelated (genetically dissimilar) parents, one designated female and the other male. Seed is produced by controlled cross-pollination.
18. Benabe Sanchez (economist, DFID-Malawi), interview with the authors, June 6, 2008, Lilongwe, Malawi.
19. Agricultural Research Council, "Plant Breeding and Biotechnology," http://www.arc.agric.za/home.asp?pid=636#hybrids.
20. Sanchez, interview.
21. International Service for the Acquisition of Agri-Biotech Applications (ISAAA), "Global Status of Commercialized Biotech/GM Crops: 2007" (ISAAA Brief 37–2007: Executive Summary), http://www.isaaa.org/resources/publications/briefs/37/executivesummary/default.html.
22. This may be changing. Kenya recently became the fourth African country to approve the use of genetically

modified crops (joining South Africa, Burkina Faso and Egypt). See Hanibal Goitom, "Kenya: Agriculture – Law on Use of Genetically Modified Crops," *Library of Congress Global Legal Monitor*, February 27, 2009, http://www.loc.gov/lawweb/servlet/lloc_news?disp3_1034_text.

23. Sweden Abroad, "Kenya," Embassy of Sweden, http://www.swedenabroad.com/Page____32872.aspx. See "Kenya," *The World Factbook*, (Washington, DC: Central Intelligence A

24. ency, 2009), https://www.cia.gov/library/publications/the-world-factbook/geos/ke.html. Ibid.

25. Ibid.

26. Paul Donde (farm manager, Longonot Farm), in discussion with the author, June 11, 2008, Naivasha, Kenya.

27. The World Bank, *World Development Report 2008*.

28. Ibid.

29. Commission for Africa, *Our Common Interest: Report of the Commission for Africa* (March 2005), http://213.225.140.43/english/report/thereport/english/11–03–05_cr_report.pdf.

30. The World Bank, *World Development Report 2008*.

31. Teresa Mellish (Volunteer, Farmers Helping Farmers), personal correspondence with the author, June 10, 2008.

32. For a history of greenhouses, see The Sun Country Greenhouse Company, "The History of Greenhouses," http://www.hobby-greenhouse.com/history_of_greenhouses.htm.

33. Peter Randa (scientist, Semenis division, Monsanto Company), interview with the authors, June 12, 2008, Nairobi, Kenya.

34. Each hybrid tomato plant in a greenhouse will produce approximately 20 kg of fruit whereas each OPV plant in the field will produce approximately 1.5 kg of fruit.

35. Randa, interview.

36. Randa, interview.

37. The Food Safety Department of the World Health Organization states, "GM foods currently traded on the international market have passed risk assessments in several countries and are not likely, nor have been shown, to present risks for human health." See Department of Food Safety, Zoonoses and Foodborne Diseases, World Health Organization, *Modern Food Biotechnology, Human Health and Development: An Evidence-Based Study* (Geneva: World Health Organization, 2005), http://www.who.int/foodsafety/publications/biotech/biotech_en.pdf.

38. Food and Agriculture Organizatoin of the United Nations, *FAO Glossary of Biotechnology for Food and Agriculture,* "Precautionary Principle," http://www.fao.org/biotech/index_glossary.asp.

39. See Paarlberg, *Starved for Science*, 121.

40. Manohar Sharma and Manfred Zeller, *Rural Finance and Poverty Alleviation* (Washington, DC: International Food Policy Research Institute, June 1998), http://www.ifpri.org/pubs/fpr/fpr25.pdf.

41. Ibid, 13. According to a survey on access to financial services in Kenya, conducted by *FinAccess,* only 19 percent of Kenyans have access to formal financial services through commercial banks and Postbank. See Njuguna Ngung'u, *Official Opening of the Kenya Microfinance Workshop* (keynote address, Kenya Microfinance Workshop, Strathmore University, Nairobi, November 23–24, 2007), http://www.centralbank.go.ke/downloads/gov_speeches/microfinance231107.pdf. An additional 8 percent of Kenyans are served by savings and credit cooperative societies (SACCOS) and micro finance institutions (MFIs), while 35 percent depend primarily on informal financial services such as rotating savings and credit associations (ROSCAs) and accumulating savings and credit associations (ASCAs). Therefore, approximately 62 percent of the Kenyan population is "financially included," meaning that they have access to financial services and products either from formal, semi-formal, or informal financial service providers. Financial Access Partnership, *Results of a national survey on access to financial services in Kenya 2007* (brochure, Kenya: FSD Kenya, 2007), http://www.fsdkenya.org/finaccess/documents/07_01_18_FinAccess_Results_summary.pdf.

42. Sharma and Zeller, *Rural Finance and Poverty Alleviation*, 8.

43. Joachim Von Braun et al., "Achieving Long Term Food Security in Southern Africa: International Perspectives, Investment Strategies and Lessons" (Southern Africa Regional Conference on Agricultural Recovery, Trade and Long-term Food Security, Botswana, Gaborone,

March 26–27, 2003): 4; Sharma and Zeller, *Rural Finance and Poverty Alleviation*, 7.

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45. Esther Muiruri (General Manager of Marketing, Agri-Business, Equity Bank), interview by *Enterprise Africa!*, June 13, 2008.

46. The World Bank, *World Development Report 2008*, 119–20 and 125–26. For a discussion of the impact of poor infrastructure on smallholder farmers in one SSA country, Rwanda, see Ndiame Diop, Paul Brenton, and Yakup Asarkaya, "Trade Costs, Export Development and Poverty in Rwanda" (Policy Research Working Paper no. 3794, World Bank, 2005).

47. See Michael Roth and Dwight Haase, "Land Tenure Security and Agricultural Performance in Southern Africa" (Working Paper, Madison, WI: Broadening Access and Strengthening Input Market Systems, June 1998), 15, http://pdf.usaid.gov/pdf_docs/PNACL422.pdf.

48. Gilbert Kibiti (owner, Farmers Centre), interview with the authors, June 10, 2008, Meru, Kenya.

49. Ibid.

50. The World Bank, *World Development Report 2008*, 119–120 and 125–26. For a discussion of the impact of poor infrastructure on smallholder farmers in one SSA country, Rwanda, see also Diop, Brenton, and Asarkaya, "Trade Costs."

51. The World Bank, *Doing Business 2008: Comparing Regulation in 178 Economies* (Washington, DC: The World Bank, 2007), 44–45.

52. Ibid., 45.

53. Kym Anderson, "Implications of Genetically Modified Food Technology Policies for Sub-Saharan Africa, African Development and Poverty Reduction: The Macro-Micro Linkage" (Forum paper, 2004).

54. Report of the UN Commission on the Legal Empowerment of the Poor, Chapter 2: *Empowering the Poor Through Property Rights* (United Nations, 2008), 71.

55. According to Sharma and Zeller, "Poor households … place special value on reliable and continued access to different types of financial services, available at reasonable cost and catering to their specific needs." See Sharma and Zeller, *Rural Finance and Poverty Alleviation*, 7.

56. See Von Braun et al., "Food Security in Southern Africa," 6.

57. Ian G. Heggie, "Management and Financing of Roads: An Agenda for Reform" (technical paper no. 275, Africa Technical Department Series, The World Bank, Washington, DC, 1994), http://www.worldbank.org/afr/findings/english/find32.htm.

58. See Von Braun et al., "Food Security in Southern Africa," 6.

59. Joachim von Braun, J. Msuya, and S. Wolf, "On the 'How To' Agricultural Growth Promotion and Improved Food Security: Implications for Southern Africa in a Regional and International Context," *Agrekon South Africa* 38 (1999): 6.

60. Britain's economic growth during its industrial revolution is attributed in part to its private roads and canals that were "responsive to need … and profitable to users." See David S. Landes, *The Wealth and Poverty of Nations: Why Some Are So Rich and Some So Poor* (New York: W.W. Norton and Company, 1998), 215.

61. Sanchez, interview.

62. Ibid.

63. Misheck Nyirenda (Monsanto-Malawi), interview with the authors, June 6, 2008, Lilongwe, Malawi.

64. The World Bank, *World Development Report 2008*, 99–100.

65. For an interesting discussion of the role that ethnic identity does and does not play in the setting of agricultural tax rates in sub-Saharan Africa, see Kimuli Kasara, "Tax Me If You Can: Ethnic Geography, Democracy and the Taxation of Agriculture in Africa," *American Political Science Review* 101, no. 1 (2007): 159–172. See GAO, *International Food Security,* 23.

66. See GAO, *International Food Security,* 23.

67. Available at enterpriseafrica.org

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International Policy Network
Rooms 200–205
Temple Chambers
3–7 Temple Avenue
London EC4Y 0HP

Tel: +44 20 3393 8410
Fax: +44 20 3393 8411

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