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TECHNOLOGY ADOPTION FOR IMPROVING AGRICULTURAL PRODUCTIVITY IN SUB- SAHARAN AFRICA

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ABSTRACT

Agricultural productivity in sub-Saharan Africa (SSA) continues to lag behind the rest of the world. Here, we briefly review the status of adoption of technologies that have potential to boost productivity – irrigation, mechanization, genetically-improved crops, and digital technologies. No more than 5-6 percent of SSA cropland is irrigated, despite the continent’s vast reserves of renewable and non-renewable water. Increasing irrigation may hold the greatest promise for increasing agricultural productivity and production in SSA. Recent trends suggest that small-scale “farmer-led” irrigation is on the rise in SSA. The lack of farm mechanization continues to challenge many SSA farmers. Recent innovations, including equipment-sharing schemes, are beginning to make a difference. Nevertheless, mechanization costs are still a barrier to most SSA farmers. The large majority of SSA farmers do not use improved seeds created through conventional breeding, hybridization, genetic modification, or gene editing – and thus are not able to take advantage of improvements in crop stress tolerance, adaptability, and other traits. Several African countries have or soon will revise standards to allow genetically-modified crops, a promising trend. Science-based policies and effective seed systems, both formal and informal, can give farmers to improved seeds. The number and use of agricultural digital applications in SSA is increasing rapidly, along with availability of internet and mobile devices. These hold promise for improving farmer information about weather, markets, pests, and more. There is no one solution to increasing agricultural productivity in SSA; this will require improved access to multiple inputs, supportive government policies, and well-functioning supply and value chains.

INTRODUCTION

After years of improvement, hunger is again on the rise in sub-Saharan Africa (SSA). Both the prevalence of undernourishment and number of undernourished individuals have increased since 2014. Now, twenty percent of individuals in SSA are undernourished, 347 million are moderately food-insecure, and 59 million children suffer from stunted growth.¹ In some regions, hunger and nutrition indicators are worse due to shocks such as drought, conflict, and pest infestations. In Eastern Africa, for example, 31 percent of individuals are undernourished.² The 2020 shocks of the desert locust invasion of East Africa and the economic and food security shocks due to COVID-19 may make an already serious situation dire. Furthermore, the United Nations projects that the population of SSA will double to 2.1 billion by 2050.³ For a continent that currently struggles to feed and nourish its population, it is imperative that agricultural production be increased.

Increases in agricultural production can arise through bringing new land into production, increasing application of key inputs such as fertilizer and crop protection products, expanding irrigation into new lands, and increasing total factor productivity (TFP) – the efficiency with which agricultural inputs are converted to outputs. In this brief essay, we will focus on how the adoption of appropriate agricultural technology – including irrigation, mechanization, genetically-improved crops, and digital technologies – will be crucial to create a food and nutrition-secure future for the people of SSA.

IRRIGATION

Expanding irrigation may hold the key for increasing agricultural production for the 38 percent of sub-Saharan Africa's population that live in arid and semi-arid regions.⁴ Currently, no more than 5–6 percent of Africa's cropland is irrigated, and this value has increased only slightly during recent years.⁵ This is despite the enormous potential to expand irrigation in Africa. With appropriate technology, it is estimated that an additional 96 million hectares in SSA can be irrigated by smallholders, potentially benefitting up to 369 million people.⁶ Such expansion would account for more than half of the currently cultivated land in SSA.⁷ According to a recent World Bank report, SSA has 1.4 billion cubic meters of renewable shallow groundwater, and non-renewable groundwater resources are estimated at 660,000 cubic kilometers.⁸ Because of ease of access, almost all farmer-led irrigation relies on renewable surface and groundwater sources.

Recent evidence suggests that irrigation in SSA may be more widely practiced than has been estimated, with smallholder farmers leading the way by utilizing a multitude of water sources such as shallow groundwater, streams, small impoundments, rainwater harvesting, and more. Farmer-led irrigation is driven by and for smallholder farmers.⁹ As much as 4.1 million hectares may be irrigated in Ethiopia through “farmer-led irrigation”, far higher than official statistics.¹⁰ More than 80 percent of irrigation in most SSA countries is small-scale farmer-led irrigation.¹¹ Creating supportive policies and an enabling environment to encourage irrigation expansion by smallholders could result in dramatic increases in agricultural production and productivity, and increased resilience to climate change.

Extending irrigation can increase agricultural production and TFP by allowing crops to take advantage of increased additions of other inputs. Worldwide, 40 percent of agricultural production comes from the 20 percent of land that is irrigated.¹² Expanding irrigation in SSA can increase TFP and reduce the pressure to cultivate more land, which threatens biodiversity.¹³ However, there are many serious constraints to expanding farmer-led irrigation in SSA, including uncertain land tenure, poor infrastructure to support irrigation, inadequate farmer knowledge and lack of extension/advisory support, and limited awareness about irrigation technology.¹⁴ Investment in strengthening capacity of farmers and advisory services, increased availability of credit, improved infrastructure, more research and development, and supportive policies will be needed to overcome these obstacles.¹⁵ Women farmers often do not have equal access to water or irrigation technology compared to men; it will be crucial for gender equity that this is borne in mind in irrigation development.^{16,17}

Irrigation alone will not ensure food security for SSA. The higher yield potential with irrigation will not be realized unless farmers have access to other technologies, including genetically improved crops, fertilizers, crop protection products, and appropriate mechanization.¹⁸

MECHANIZATION

Sub-Saharan Africa has the least mechanized agricultural systems in the world. According to a 2019 report by the African Agricultural Technology Foundation (AATF), African farmers have only one-tenth the amount of mechanized tools per farm area than farmers in other developing regions, and access has grown at slower rates.¹⁹ This is understandable for an industry dominated by smallholder farming. However, several recent programs throughout SSA have shown that mechanization is a powerful and feasible tool for productivity growth for smallholder farmers.

Data from Uganda suggests that, despite the considerable barriers to acquiring the technology, access to tractors improves agricultural productivity for small-scale farmers much more than other inputs such as fertilizer.^{20,21} As yields in sub-Saharan Africa continue to hover around 56 percent of the international average, bringing the power of mechanization to smallholders is increasingly being considered as a powerful tool to sustainably increase productivity.²²

The Cassava Mechanization and Agro-processing Project (CAMAP), founded in 2012 by AATF, has expanded access to mechanization for smallholder farmers in Africa. The project allows farmers to buy into a collective revolving fund so that they each can afford the maintenance and mobilization of machines including tractors and trucks that increase productivity for cultivation and processing of crops.²³ By 2018, CAMAP had brought mechanization services to more than 6,000 operations in Zambia, Nigeria, and Uganda, and the project also formed a company called Agridrive Limited which is dedicated to expanding availability of mechanization services for farmers in Nigeria and Kenya.²⁴

CAMAP is one of several projects and companies that have been started by Africans in recent years to deliver financial and logistical access to productivity enhancing mechanical technologies for smallholders.²⁵ Internationally, major agri-business companies such as John Deere have also started projects to bring increased access to tractors to farmers in SSA. John Deere partners with the African company Hello Tractor to make 10,000 new tractors available to smallholders in Nigeria and Kenya. Farmers can affordably hire tractors for short term use, allowing them to make use of the productivity-enhancing technology without needing the significant capital investment of buying the machines outright.²⁶ However, there remain considerable challenges for wide access to mechanical tools for smallholders in Africa, and continued efforts from both public and private interests will be necessary if mechanization is to continue playing a role in closing the agricultural productivity gap between Africa and the rest of the world.

GENETICALLY-IMPROVED CROPS

Improved and genetically modified seeds represent some of the most widely used and broadly accepted technologies that have been proven to enhance yields and productivity for farmers of all scales. Genetic improvement may arise through conventional selection and breeding, biotechnology (GMOs), and recently by gene editing through CRISPR and similar technologies. The first Green Revolution proved more than fifty years ago the great potential of improved plant genetics for increasing agricultural production; by the year 2000, improved crop varieties introduced beginning in the 1960s had been planted on about 80 percent of cereal area in South and East Asia, resulting in a tripling of yields during the same period.²⁷ However, despite overwhelming evidence that improved crop genetics can improve productivity for smallholders in Africa, these technologies have yet to be widely adopted on the continent.²⁸

In 2018, the World Bank reported that Ugandan agricultural output grew by only 2 percent per annum during the past five years; this number was outpaced by population growth.²⁹ Malnutrition is widespread, with 29 percent of children below the age of 5 stunted. Meanwhile, only 30 percent of crops planted in Uganda are genetically improved.^{30,31} And Uganda is not alone. Use of genetically improved maize in many African countries represents just 20-30 percent of total acreage; and this fraction is much lower for most other local staple crops.³²

As the demands of increased population and the challenges of climate change mount, biotechnologies represent proven productivity enhancing solutions that various actors in Africa are beginning to turn to. One reason for the slow adoption of new seed technologies in SSA is the reliance on traditional seed systems, by which farmers pass on seeds to one another that never enter into a formal channel. Efforts are being made to incorporate partnerships

between farmers and the public and private sectors to develop formal seed systems by which farmers can have access to a wider and more reliable range of seeds.³³ However, even as new seed systems develop across SSA, the adoption of GMO technologies faces serious opposition from a number of sources.

The continued widespread use of nontariff trade barriers on GMO crop imports to the European Union has been a central issue to blocking genetic crop technologies in Africa, as African farmers are forced to refrain from using genetically-modified seeds in order to access the vast markets in Europe.³⁴ Major influence is also wielded by developed countries that have tied development aid packages to anti-GMO policies, and from international activist non-governmental organizations such as Greenpeace and Via Campesina that spread anti-GMO sentiment and often disinformation about the technologies.^{35,36} A 2016 study estimated that under the current restrictive regime of anti-GMO policies, low- and middle-income countries globally could be forgoing as much as US \$1.5 trillion in economic benefits through 2050.³⁷

In 2019, Nigeria became one of the first African nations to approve the commercial use of GMO technology in a food crop; and similar actions are under development in Ghana, Kenya, Tanzania, Ethiopia, Mozambique, Uganda, and Malawi.³⁸ Projects such as the African Center for Crop Improvement (ACCI) which, through support from the Rockefeller Foundation and the Alliance for a Green Revolution in Africa (AGRA), have educated and trained more than 100 plant breeders from throughout Africa at a PhD level.³⁹ ACCI is a project launched by Africans to expand the availability and use of improved seed technologies that can be tailored to local needs.

Throughout much of Asia, availability of genetically-improved seeds has played a critical role in increasing agricultural productivity. In SSA, supportive government policies, including science-based regulations governing genetic technologies, are necessary so that farmers can access improved seeds. Recent trends are encouraging, with several SSA countries allowing or considering sales of genetically-modified seeds. Private-sector solutions will be needed to ensure availability and affordability of improved seeds for farmers.

DIGITAL TECHNOLOGIES

In 2018 the number of SIM connections in sub-Saharan Africa reached 747 million, representing a 74 percent penetration rate, and it is projected that by 2025 that number will reach 1.04 billion.⁴⁰ The role that digitalization can play in fostering economic development in developing countries is documented in numerous studies; and digital technologies have recently reached the agricultural sector in SSA.⁴¹

According to the Technical Centre for Agricultural and Rural Cooperation (CTA), various digital technologies for agriculture have registered more than 33 million smallholder farmers across Africa, (representing up to “13 [percent] of all SSA smallholders and pastoralists... depending on assumptions used to calculate penetration.”).⁴² The report found that there are at least 390 distinct digital agricultural tools, or ‘solutions’ currently active in Africa, 60 percent of which were launched in the last three years.⁴³

These ‘solutions’ include mobile-accessible apps and tools that increase access to updated market price data, financial services, weather forecasts, pest outbreaks, and more. Weather is increasingly erratic, however many farmers in Africa can only rely on outdated weather stations and traditional knowledge about weather.⁴⁴ New tools can now bring accurate and modern forecasting directly to smallholders via SMS or other messaging services in local languages for just a few US \$ cents a day.⁴⁵ Other evidence shows that digital tools already rolled out in Kenya have succeeded in significantly facilitating much needed extension services, and that smallholder farmers who gained digital access to market information systems experienced higher labor and land productivity, among other benefits.⁴⁶

One successful example is Twiga Foods, a company started in 2014 to connect small farmers in Kenya with small and medium sized vendors in cities.⁴⁷ By using blockchain technology and cutting out the need for intermediary wholesale markets, Twiga has been able to offer higher prices and a guaranteed market to more than 17,000 producers in Kenya as of 2019.⁴⁸

To date, technologies like these have been concentrated in East Africa and nearly two-thirds of farmers using digital tools are in East African nations such as Kenya.⁴⁹ However, CTA reports that digital tools for agriculture are present in at least 43 out of 49 sub-Saharan African countries and their prevalence increases each year. Increasing

the access to internet and mobile devices, and increasing digital literacy will be critical to expanding engagement with these productivity-enhancing tools.⁵⁰ Despite the potential benefits of the use of digital technologies in agriculture, their use could exacerbate existing gender disparities. At least 40-50 percent of smallholder farmers in SSA are women, but women represent only 25 percent of registered users of digital agricultural solutions. Increasing women's access to digital technologies must be considered of paramount importance for increasing agricultural productivity.

ENDNOTES

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