LINK Context Analysis Uganda

Boosting Incomes through Improved Access to Banana and Orange-Fleshed Sweet Potato Plant Materials

GLOBAL KNOWLEDGE INITIATIVE

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Introduction to LINK: An Innovation Systems Approach to Development

It is difficult to overstate the significance of science, technology, and innovation (STI) for economic and social development. According to the Organization for Economic Cooperation and Development (OECD), "Continuous technological change and innovation are among the main determinants of productivity growth and as such are necessary conditions for the welfare of nations and regions" (2001). Low levels of scientific and technological development harm least developed countries, where the comparative cost of missing out on the benefits of STI is far higher than in the OECD, in profound ways (Farley et al, 2007). As the UNIDO (the United Nations Industrial Development Organization) Position Paper on Innovation Systems for Development states:

> *In the face of the opportunities presented by globalization, and the multiple challenges arising from poverty and resource scarcity, the ability to innovate relates not just to the ability to survive but the ability to thrive. Innovation lies at the heart of peoples', firms', sectors', and countries' ability to cope with change (Farley et al, 2007).*

For developing countries that do not possess the full gamut of knowledge and resources required to maximize the application of STI for development, collaborative innovation offers a path forward. Collaborative innovation is "the creation of a good, service, or process using the shared knowledge, resources, and capacity of partners who seek to solve challenges that are beyond the capability of an individual partner" (GKI 2012). The premier challenges of today—mitigating climate change, ensuring food security, generating income for millions of unemployed youth—are complex and multi-sectoral. Solving these problems demands that we create linkages across sectors and connect domains of knowledge—agronomy, biology, architecture, mechanical engineering, zoology—that previously existed in silos. Collaborative innovation networks bring diverse problem solvers together, aligning resources and partnerships toward shared goals.

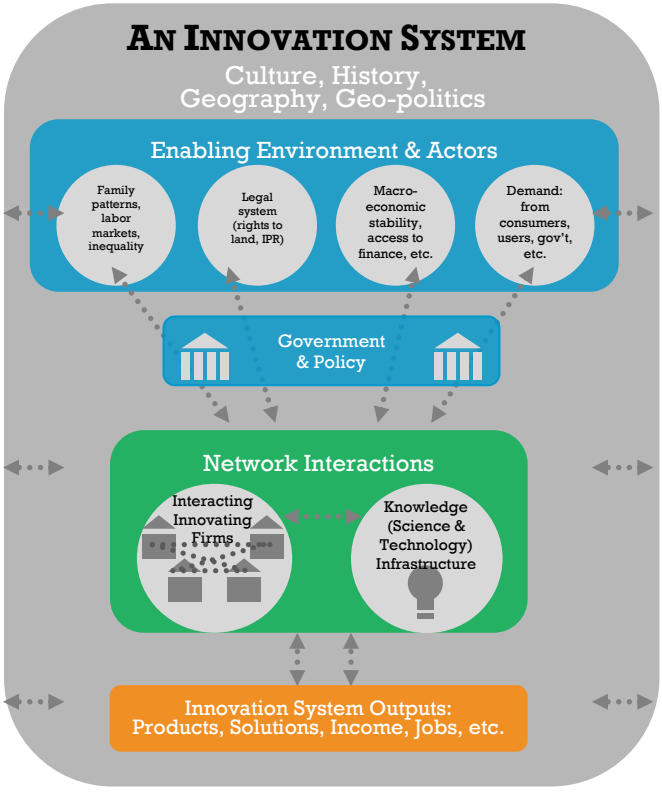


Figure 1: Global Knowledge Initiative, 2012

Under what conditions does collaboration drive effective problem solving? Productive, solutions-based collaborative innovation thrives in an innovation system characterized by dynamic linkages across sectors (public, private, civil society, informal), disciplines, and geographies. Indeed, the capacity to innovate depends not only on individual institutions' abilities to participate in innovation-based activities, but also on "the degree to which these institutions collaborate, partner, and link to generate, adapt, use, and diffuse innovations" (Farley et al, 2007). Taking an innovation systems approach allows problem solvers to consider the array of actors, functions, and interactions required

to achieve innovation that delivers meaningful outputs: solutions to development challenges, new jobs, and increased livelihoods. Figure 1 illustrates a simple innovation system and the numerous interactions that define it. As this report makes clear, solutions to challenges in Ugandan tissue culture systems—the focus of this report—will depend on the ability to work within the Ugandan innovation system's enabling environment, with myriad interconnected government and research actors, and in two distinct value chains: banana and orange-fleshed sweet potato (OFSP). US-based non-profit organization the Global Knowledge Initiative (GKI) has designed the LINK (Learning and Innovation Network for Knowledge and Solutions) program, described below, to take on complex challenges just as Uganda's tissue culture challenge.

LINK as a response to challenges requiring networked solutions

In 2011, GKI launched the LINK program in Africa to offer a new response to a persistent question in development: **How do those who need critical knowledge, technology, and other resources find and collaborate with those who have them?** LINK Africa, supported by the Carnegie Corporation of New York, builds purpose-driven networks around innovators in Eastern and Southern Africa working on challenges related to agriculture, climate change, and the environment. As described in the next section, the LINK Program moves from **locating** challenges, resources, and possible partners, to **enabling** the LINK team members to frame challenges and identify solutions through skill-building on collaborative innovation tools, and finally **connects** international problem-solving networks around shared challenges. The ultimate aim of LINK is **solving** challenges that matter, challenges that relate to science, technology and innovation, and challenges for which rendering solutions would improve the lives of thousands, if not millions, of people living at or near $2/day. In 2014, a team based at the biotech company BioCrops Uganda Ltd. won GKI's fourth round of the LINK Africa competition. Their work focuses on solving challenges in producing and distributing tissue culture planting material for banana and orange-fleshed sweet potato. Find a more detailed overview of their challenge and the process they have undertaken to date on page 7. As part of understanding the context of each LINK winner's challenge and identifying opportunities for solutions, GKI produces a Challenge Context Analysis—this document.

The LINK: Context Analysis as an Input to Solution Generation

This LINK Uganda Context Analysis fits into a larger initiative to forge, optimize, and sustain an international network aimed at solving challenges in propagating and distributing plant materials in rural Uganda. The goals of this Context Analysis are twofold: (1) to help the LINK Winner better understand the socio-economic and business context surrounding this challenge, and (2) to help newcomers to the budding LINK Uganda network quickly understand the features of the prevailing innovation system that bear on their collective efforts toward a solution. The rationale for this analysis is to establish a shared understanding of the contextual features—national, sectoral, institutional, and systemic—that affect solutions to the LINK Uganda challenge. In the following section, find an overview of the many related challenges that guide LINK Uganda.

To understand the challenges and opportunities that exist in developing and distributing improved plant material for banana and OFSP, it is essential to investigate the innovation system of Uganda—as noted above—but also to buttress this innovation systems analysis with analyses of the value chains for banana and OFSP in Uganda. Accordingly, this document combines a condensed treatment of the enabling environment for innovation on this challenge, the actors important to agriculture (and specifically tissue culture) development, as well as detail on how they interact, and what possible outcomes to this challenge might look like. These value chain analyses specifically are designed to provide a coherent picture of the strengths and weaknesses of banana and OFSP production.

Value Chain Analysis within an Agricultural Innovation System

Given the multiple, sometimes competing, variables at play in successfully growing an enterprise aimed at providing planting materials to low income Ugandan farmers, it is essential to clarify the strengths, weaknesses, linkages, and interactions between the actors relevant to developing and delivering these materials to the markets/users that need them. We use a value chain analysis to do this. A value chain is a representation of a vertically linked set of actors whose interdependent activities allow for the production and distribution of a given product or service, in this case banana and OFSP. Beyond listing the actors and roles involved in moving a product from production to consumption, though, value chain analysis examines the roles and interactions of actors along the value chain, assessing how the performance of each actor impacts the overall functioning of the value chain.

Value chain analysis consists of a few key features. First, value chain analysis provides a rich portrait of the activities and interactions that propel a product—agricultural or otherwise—toward consumption. This allows for informed decision making on the part of problem solvers about who is most important, who is most connected, and with whom partnerships should be forged. Second, this type of analysis helps to identify those steps that add value and those steps that represent weaknesses or inefficiencies in the value chain. Third, a value chain analysis aids in identifying the critical points at which added resources would produce the biggest impact for a pre-determined set of beneficiaries. Below, find an overview of what is included in this document.

Structure of the LINK Uganda Context Analysis

In guiding the LINK winning team and potential collaborators through the context for problem solving and innovation in Ugandan agriculture, this report focuses on five primary elements:

- **Challenge Overview** providing detail on the challenge identified by the LINK team, and the process GKI conducted with the LINK team to explore specific challenges to take on together. This section also includes overviews of tissue culture, the focal crops for this challenge (banana and OFSP), and the farmers who represent the beneficiaries of expanded access to clean planting materials.
- **Enabling Environment for Agribusiness** inclusive of macro-level issues such as the country's economic status, business climate, and the basic infrastructure available. Because of the LINK Uganda Winner's focus on building a business aimed at propagating and distributing plant material, the enabling environment for business is of key importance.
- **Enabling Environment Actors** that influence agricultural development from the government, research institutions, universities, donors, and other organizations.
- **Value Chains for Banana and OFSP** where actors within the agricultural, transport, and retail sectors—ranging from input suppliers to wholesalers to consumers—interact and produce outputs and outcomes.
- **Outputs and Outcomes: Case Studies** from comparable countries, and on comparable challenges. By observing how other initiatives have successfully propagated and disseminated seeds and other agricultural inputs, possible solutions to the tissue culture challenge in Uganda may emerge.

LINK Winner Dr. Geofrey Arinaitwe shares his passion with team: a TC banana plantlet produced in his lab. Photo: GKI

Overview of the Challenge

Challenge Overview

Food Security, Nutrition, and Economic Productivity in Uganda

Despite rapid economic growth over the past decade, Uganda faces severe challenges in feeding its citizens, and providing them with the building blocks needed to live healthy, productive lives. Even with rapid advances to its economy 63% of Ugandans live on less than $2 USD per day (PPP). In rural areas this number is likely even higher (World Bank 2015).

Key Facts and Figures:

- Families either food insecure or threatened by food insecurity: 27%
- Children under five suffering from malnutrition: 33%
- Children from farming families facing malnutrition: 40%
- Percent of Ugandans living on less than $2 USD (PPP) per day: 63%
- Percentage of the Ugandan labor force working in agriculture: 72%
- Percentage of rural Ugandans practicing subsistence farming: 80%

Sources (in order of use): Shively and Hao 2012; World Bank 2015; FAOSTAT 2015; Gollin & Rogerson 2010

While agricultural development programs have strengthened cash crops such as coffee and cotton, Uganda remains one of the "least well-nourished countries in the world," with 33% of Ugandan children under the age of five malnourished, and malnutrition accounting for 40% of child mortality (Chemonics 2008; Shively and Hao 2012; World Bank 2015; Bridge et al 2006). Beyond malnutrition itself, however, are two critical challenges, one that exacerbates this malnutrition, and another that underpins malnutrition: hidden hunger and agricultural productivity.

According to non-governmental organization (NGO) HarvestPlus, the burden of micronutrient (vitamin A, iron, zinc, and iodine, for example) deficiency is severe in Uganda. Across Africa, 32% of the under-five population are vitamin A deficient (HarvestPlus 2012). This "hidden hunger" "impairs the mental and physical development of children and adolescents and can result in lower IQ, stunting, or blindness, especially in children under five. Those suffering are at greater risk of disease and death (HarvestPlus 2012). Thus, beyond producing more food, Uganda must contend with the nutrients in that food, and how a lack of these nutrients can harm the health of its citizens.

One major cause of these food security and nutrition challenges is poverty within Uganda, which is especially intense for rural farmers, 80% of whom farm to subsist and are disconnected from markets (Gollin & Rogerson 2010). For the 66% of Ugandans who farm, life presents an onslaught of low commodities prices, lack of access to markets, difficulty in accessing agricultural inputs, and other challenges (World Bank 2015).

For rural, agricultural populations, the combined challenges of low incomes, food insecurity, and hidden hunger threaten both health and productivity. Crops such as banana—a widely consumed, marketable staple crop—and vitamin A-rich orange-fleshed sweet potato (OFSP), which has been introduced to provide increased nutrients to Ugandans, may hold the keys to breaking these cycles of poverty and malnourishment. However, a number of challenges hamper their ability to scale.

Challenges and opportunities in banana and OFSP

Historically, banana has been one of the most grown, eaten, and exported crops in Uganda: Ugandans eat more bananas per capita than any other country in the world (UBOS 2011). Beneficial for reducing malnutrition while boosting farmer income, banana production has

declined over the past 20 years due to disease and climatic challenges. The result: an 80% decrease in production that has triggered economic and food insecurity for the millions of Ugandans banana growers, banana consumers, and others active along the banana value chain (FAO 2011).

At present, Uganda exports little banana, and most banana that is produced is not sold: farmers consume 60% of their own cooking bananas (the main bananas grown) and sell only around 35% percent (UBOS 2010a). Challenges such as pests and diseases, inadequate access to input materials such as fertilizer and TC plantlets, and limited access to finance and markets for smallholder farmers constrain the ability of banana production to transform the lives of farmers.

With a history quite distinct from banana, orange-fleshed sweet potato (OFSP) also has great potential that, in some ways, has yet to be seized. HarvestPlus and its partners have promoted OFSP to improve nutrient availability since the early 2000s. OFSP has been exceptionally effective at improving health outcomes in Uganda – it became the primary vehicle for vitamin A for small children, and has significantly reduced vitamin A deficiency in women and children (HarvestPlus 2012). However, challenges of OFSP availability, farmer uptake, weak farmer organization, and low household use have prevented OFSP from effectively scaling across the country to date. Further, the lack of a strong private market for OFSP continues.

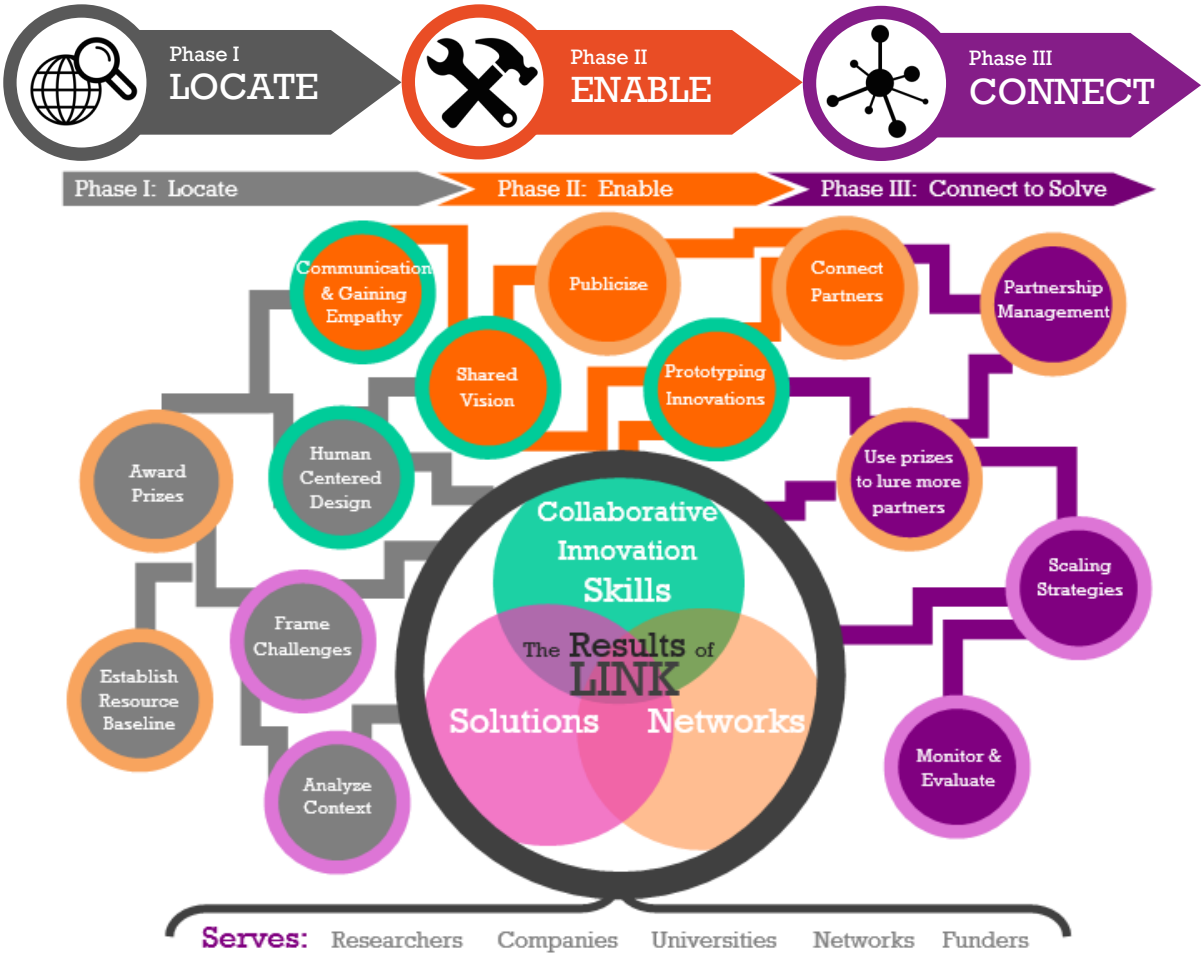
The promise and challenge of clean planting material

Against this backdrop, biotechnology innovations provide potential solutions. By propagating clean "tissue culture" (TC) planting material, it may be possible both to radically increase the availability of planting material for banana that is not affected by the diseases that have harmed the industry, and provide farmers with increased, steady supplies of biofortified OFSP that demonstrate its value both in terms of nutrients and as a marketable crop. Tissue culture is the process of cleaning flesh from vegetatively propagated crops such as bananas or sweet potatoes – thus ensuring the planting material is free of disease – and then multiplying shoots of this now-clean material (see page 14 for more information on the tissue culture process). This method allows farmers to start fresh with banana suckers and OFSP vines free of disease. Although TC technology has been used internationally for years, and has been implemented with some success in Kenya and other African countries, effectively scaling tissue culture in Uganda will require problem solving on challenges related to production, distribution, marketing, as well as substantial technological knowledge, sophisticated lab equipment, financing, and other resources. Additionally, building a robust OFSP value chain requires a network of actors committed to enhancing production and distribution channels.

Aside from their reliance on TC technology, banana and OFSP value chains are quite distinct. As noted, banana is a traditional staple crop, and although weakened by diseases, the banana value chain is robust in many ways. By contrast, the OFSP value chain remains largely supported by donors and NGOs, and does not demonstrate the same complexity and vibrancy as the banana value chain. Nonetheless, both crops have the ability to greatly benefit Ugandans through enhanced nutrition, improved food security, and increased economic productivity. See page 15 for overviews of both crops, and page 16 for a profile of the farmers who grow them.

As noted, in 2014, BioCrops Uganda Ltd. won the Global Knowledge Initiative's LINK competition. The following section overviews the LINK program, and details how the LINK winners have committed to solving challenges related to availing clean planting materials for banana and OFSP to Ugandan farmers.

GKI's LINK PROCESS



LOCATE

Goal: Identify challenges ripe for solutions as well as existing partners and resources that can be tapped to develop, refine, and implement solutions.

- **Identify and map challenges ripe for solutions** as submitted by teams poised to support solution generation in the defined challenge domain (food security, water, health, etc.). Through stakeholder workshops, GKI uses an array of innovation and design tools to frame and explore teams' challenges.
- **Analyze existing science, technology, and innovation resources** that can be applied to these challenges and partners already active in this space. Using proven analytic approaches to understanding innovation systems, GKI works with LINK teams to take stock of baseline resources available as well as those needed to address teams' challenges.

ENABLE

Goals: Support LINK teams as they create purpose-driven networks by helping to establish a shared vision; train network members in collaborative innovation skills to enhance impact.

- **Train Teams** of diverse stakeholders in essential collaborative innovation process skills, including: building and managing networks; prototyping; and scaling sustainable solutions.
- **Triage pieces of the challenge to potential solvers and test/refine solutions.** Tapping GKI's global network of experts, we alert high-potential solvers to selected challenges and sub-challenges. The triage process makes use of (1) GKI's distributed network of experts and partners, and (2) information & communication technologies to tap likely solvers wherever they are. Potential solutions are tested and refined to assure alignment with the shared vision for success.

CONNECT TO SOLVE

Goals: Organize distributed efforts through a collaborative innovation strategy for network members; evaluate progress; test, refine until achieve "success" as defined previously in the process.

- **Convene broad network for strategic design/action:** GKI's Collaboration Colloquia issue a call to action to additional experts carefully chosen to meet teams' needs. Such development "hackathons" source ideas and solutions in real-time from broad stakeholder communities.
- **Serve as network facilitator to maintain momentum as teams scale solutions to achieve long-term impact.** GKI provides backstopping, communications, and resource identification to teams as they move closer to solutions. Committed to supporting learning throughout LINK, GKI also catalogues users' insights to identify opportunities for refinement and enhanced impact.

GKI's LINK PROCESS

Status of the LINK Uganda Team

LOCATE

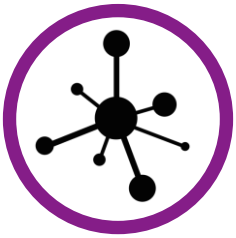
LOCATE: STEPS TAKEN

- Prior to a June 2014 kick-off meeting, GKI worked with BioCrops to develop a preliminary analysis of the socio-economic context of the biotechnology challenge that the BioCrops team seeks to solve.
- During the kick-off, BioCrops further explored the challenge they seek to solve. Using Challenge Mapping and other design tools, they clarified sub-challenges (i.e., smaller grain challenges within the broader tissue culture challenge) that they believe are important to solving their challenge.
- BioCrops studied these sub-challenges following the kick-off, specifically focusing on clarifying unknowns and assumptions associated with the sub-challenges.
- BioCrops and GKI conducted a resource analysis using an innovation systems-based methodology ("THICK methodology") to study the Technology, Human, Institutional and Financial, Collaboration- and Communication-, and Knowledge-based Resources available and needed to solve the challenge.
- Throughout the research process, BioCrops and GKI clarified the selected sub-challenges. Based on their research, the LINK team decided on four they would take on together. On the next page, find a Challenge Map illustrating how these sub-challenges relate to the LINK team's overarching challenge.

ENABLE

ENABLE: STEPS TAKEN AND UPCOMING

- During the June 2014 LINK kick-off in Uganda, GKI spent four days with the BioCrops team training on tools to clarify their challenges, come to a common understanding of goals among team members, identify areas for further fact-finding, and plan for how they might answer critical questions pertinent to their challenges.
- GKI analyzed learnings from the training, verifying a significant increase in knowledge of collaborative innovation-related skills as a function of the LINK training. GKI will continue measuring learning and retention following all trainings.
- In April 2015, GKI returned to Uganda to work with the BioCrops team. This training and facilitation focused on building skills for solution generation, honing solutions to the tissue culture challenge, and planning for the development of a problem solving network.



CONNECT TO SOLVE

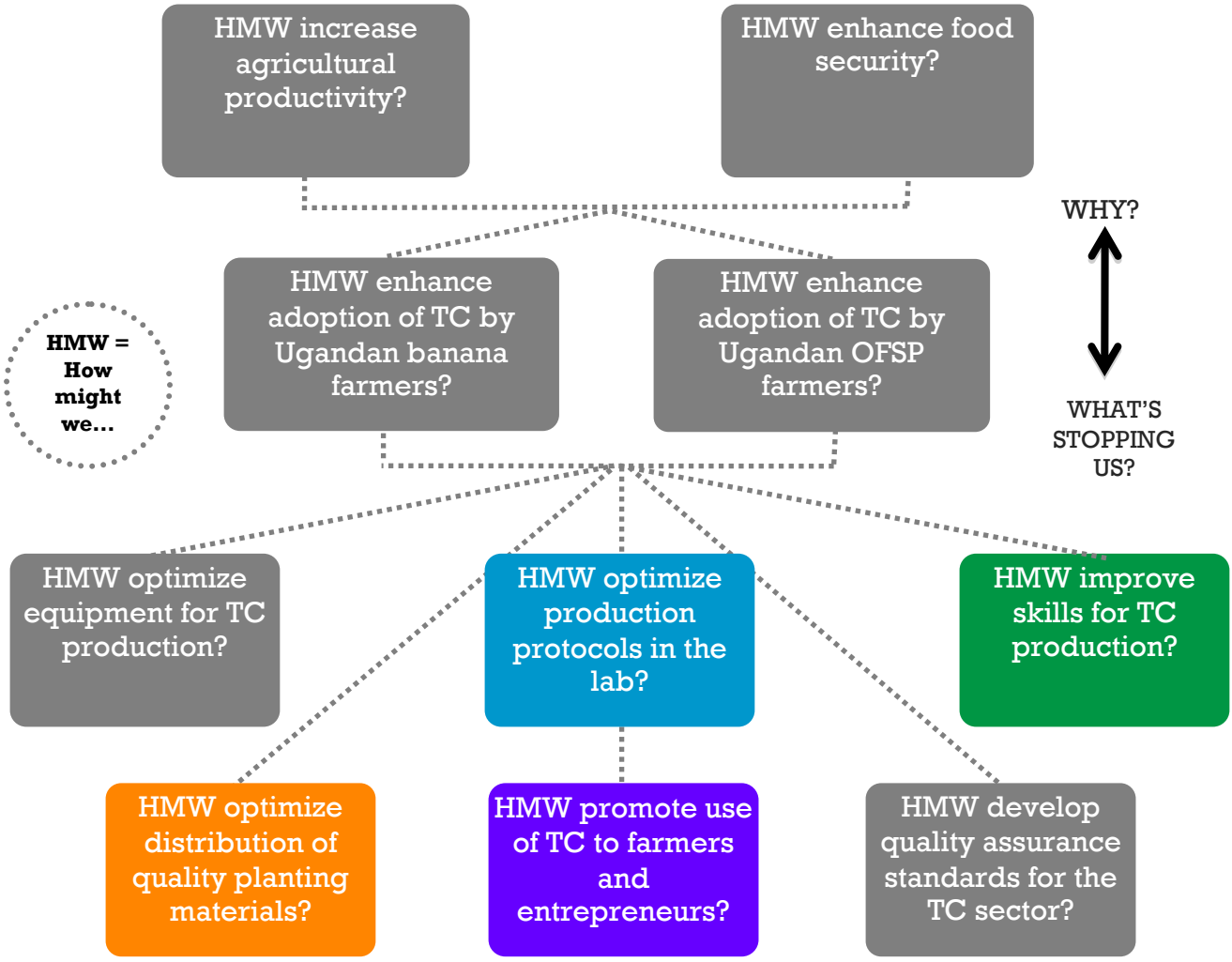
CONNECT TO SOLVE: STEPS TAKEN AND UPCOMING

- Based on analysis conducted on the sub-challenges BioCrops decided to take on, GKI analyzed hundreds of potential international experts to connect with the BioCrops team, with a specific emphasis on experts in biotechnology and agribusiness.
- GKI identified former Science and Technology Advisor to the US Secretary of State Dr. Nina Fedoroff and international agribusiness expert Mr. Rami Alsouqi as extremely high potential collaborators, and invited both to join the April 2015 visit to Uganda.
- During the April 2015 visit to Uganda, GKI (with Fedoroff and Alsouqi) worked with BioCrops to begin building their international problem solving network.
- During that same trip, GKI and BioCrops hosted a high-level meeting with potential partners and key influencers in Uganda to share the challenges tackled, questions they have asked and answered, and solutions that BioCrops needs their help to take on. The purpose of this meeting was to jump-start BioCrops' international problem solving network.

LINK Essential Challenge Map

Challenge Mapping is a tool that enables diverse groups to consider how they might solve a complex challenge. It offers users a structured method for breaking large, unwieldy challenges into smaller, actionable "sub-challenges." During GKI's work with the LINK team in April 2014—specifically part of the "Locate" phase described on the previous page—three Challenge Mapping sessions were conducted. Together, participants produced 129 distinct challenges and sub-challenges related to the broad tissue culture challenge posed by the LINK team. These sub-challenges represent starting points for further research, refinement, and action. Below find the "Essential" challenge map—those challenges and rationales voted by the LINK team as most essential for action. The map moves upward by asking "why do we want to solve a challenge?", and moves downward by asking "what's stopping us?" from solving challenges.

Challenge Statement: How might we (HMW) increase productivity and contribute to food security through enhanced adoption of tissue culture (TC) planting materials by Ugandan banana and orange-fleshed sweet potato (OFSP) farmers?



Above, in blue, green, orange, and purple, find the four focal sub-challenges upon which the LINK team chose to focus its efforts after problem framing. On the following pages, find overviews of each of these four sub-challenges that guide the LINK team.

Deeper Dive: Challenges and Opportunities on Select Sub-Challenges

How might we optimize production protocols in the laboratory?

Optimizing protocols for the production of tissue culture (TC) planting materials is essential because it can save energy, boost productivity, and ultimately lower tissue culture prices for nurseries and/or farmers. This has serious ramifications for the ability of Uganda to scale its banana and OFSP tissue culture industries, which have been stymied by high tissue culture prices. In studying the potential for innovation in this space, BioCrops researched a number of possible areas of action:

Efficient sterilization of tools and tissue culture materials: Producing tissue culture planting material requires sterilization of both equipment and planting material. Optimizing production protocols calls for developing methods to sterilize TC production tools (e.g., glassware) that increase efficiency while minimizing energy expenditure and maintaining high sterility standards. Possible means for sterilizing tools include using chemical sterilants or using radiation (microwaves or x-rays, for example). New chemical options may also be available to sterilize planting material itself.

Optimizing tissue culture multiplication rates and cycles: Beyond assessing sterilization options, the LINK team researched options for optimizing the shoot multiplication rate (i.e., how many TC shoots are multiplied at a time) and multiplication cycle (i.e., how many rounds of multiplication happen from the same original clean planting material) of TC production. The team found opportunities for optimization in both areas. Areas of optimization on the rate of multiplication may exist through using different combinations of chemicals in the multiplication process. In optimizing the multiplication cycle of banana and OFSP TC plants, BioCrops can experiment with increasing multiplication of the original planting material and, in doing so, test the threshold point up to which multiplication cycles can be increased before negative mutations become problematic.

How might we improve skills for tissue culture production?

Improving skills for tissue culture production is key for ensuring proper uptake of TC. Without training on the skills to meticulously handle tools and planting material, lab workers cannot properly sanitize the material, leading to inefficient production, low quality products, and high product costs. In studying this sub-challenge, BioCrops' has identified two overarching rationales for and pathways within skills development:

Proper training in best practices and safety measures: Comprehensive and continual training is important to ensure that laboratory staff are aware of new technologies as they become available and are able to properly use those technologies to efficiently clean and multiply tissue culture plantlets. This is especially the case as firms invest in new production protocols (as noted in the previous sub-challenge). Separate from the demands of production, workplace hazards can be serious in a laboratory that deals with harsh chemicals, electrical tools, sharp objects, etc. Training that incorporates safety standards can improve efficiency as well as worker safety. Solution pathways in developing key skills should improve performance and safety, and help organizations meet standards, thus improving the quality of products delivered to customers (ASCP 2013).

Retention of skilled workers: Beyond assuring safety and efficiency, for tissue culture-focused businesses to be successful, they must retain talent. Skilled, creative employees seek a work environment in which they have opportunities for growth and career development. If employees do not receive proper training, pay, and treatment, they will find a new employer to invest in their growth and development (ibid). Thus, sustainability for biotechnology firms requires investment in employees' health, skills, and happiness.

Deeper Dive: Challenges and Opportunities on Select Sub-Challenges

How might we optimize distribution of quality planting materials?

One of the main obstacles to selling clean planting materials in Uganda is safely transporting fragile plantlets to remote areas in a country that suffers from weak distribution networks, a lack of market information in rural areas, and poor market linkages. When researching methods to optimize distribution, the BioCrops and GKI teams found the following:

Optimizing distribution time and materials: To safely transport clean planting material from the laboratory to the farmer, there are a number of different distribution models TC producers can follow. It is possible to transport plantlets at varying stages of growth with different types of material. For instance, banana and OFSP plantlets can be transported at different levels of maturity. Presently, BioCrops ships banana plantlets once they have "hardened" in shadehouses. However, if they could safely be transported earlier, the smaller size and low weight could decrease transportation costs. Further research can clarify how this might be possible, and what resources and partners would be required.

Nursery incorporation in value chains: Nurseries are an essential link between TC producers and farmers, and currently function as the main distributors of banana plantlets and, with NGOs, one of the main distributors of OFSP vines. Therefore, it is crucial that nurseries are strategically located with proper access to water, credit, and transportation infrastructure (Dubois 2011). The nurseries should not only be in close proximity to the shade houses / greenhouses run by TC producers, but they must also be easily accessible for farmers, who often purchase planting material directly from those nurseries.

Infrastructure: When determining the best methods for scaling TC in Uganda, there are numerous geographic distribution options, but the quality of infrastructure can be a limiting factor in choosing distribution routes. The more developed Western districts of Uganda have higher population density, larger markets, and greater investment in infrastructure. However, recent donor-led infrastructure projects have increased and improved rural infrastructure across Uganda, which may enable opportunities for distribution beyond the Western districts (World Bank 2011).

How might we promote the use of tissue culture to farmers and entrepreneurs?

Though tissue culture methods have a great ability to remove disease contamination that leads to crop loss and spoilage, many farmers and entrepreneurs in Uganda either do not know about the technology or do not trust it based on negative experiences they have had in the past. Therefore, effectively marketing and training on the use of TC can increase farmer and business uptake, ultimately increasing production of banana and OSFP. BioCrops and GKI's research highlighted some broad potential approaches for promoting TC awareness and uptake:

Financing and training: Because the cost of TC plantlets is fairly high, farmers need access to affordable financing mechanisms. Access to credit and established market and distribution systems could serve as an incentive to uptake. Comprehensive training on proper use and handling can support successful, disease-free plant growth. Without proper extension services and training for TC plantlet management for both farmers and nursery operators, TC plantlets may be viewed not only as expensive, but sub-optimal in their results.

Participatory approaches: In terms of the method for sensitizing plantlet buyers to the benefits and use of TC, participatory approaches that take into account local environmental conditions, farming practices, on-farm demands, and the local social structure have been successful in the past. Additionally, research shows that a focus on gender mainstreaming and ensuring women realize the potential of TC technology can ensure higher adoption rates (Smale 2007). ICTs such as mobile phones can also be incorporated into sensitization campaigns. Studies have shown that ICT access influences the rate of adoption of TC (Mwombe n.d.).

Overview of key processes, crops, and actors

In this section, find overviews of some of the most important processes, crops, and actors related to this challenge. Directly below, find a profile of the tissue culture process. Following this overview two crop profiles are provided, one for banana and another for OFSP. Next, descriptions of three types of farmers are described in brief: subsistence farmers, farmer group members, and agribusiness owners. Each represents potential beneficiaries of solutions to this challenge. Although at present subsistence farmers likely would not be able to purchase TC, as the industry expands it may provide more farmers an avenue to move from subsistence to commercial farming.

Tissue Culture Overview

Farmers across Sub-Saharan Africa face challenges in producing crops that are disease-free, safe for consumption, and produce high yields. One technological process that can address these issues is called "tissue culture," (TC) a method of cleaning cultivars of vegetatively propagated plants in the laboratory and then multiplying that planting material such that the newly grown plantlets are free of all disease (AATF 2012). Vegetatively propagated plants, such as roots, tubers, bananas, and other plants, reproduce when parts of their flesh (roots, leaves, or stems, etc.) are removed and re-planted. Because diseases in this flesh will be transferred to new plants, TC is an important innovation—it can stop the transmission of plant diseases.

Beyond producing disease-free planting material, TC has a number of other benefits. In banana, for example, TC plantlets grow faster, have higher yields, are more uniform, and can be produced in bulk. All of these characteristics are beneficial to smallholder farmers because they can help those farmers move from subsistence agriculture to market-based, income generating agriculture (ibid.).

Producing TC planting material requires skilled lab technicians to ensure that each step of the process is completed under hygienic conditions such that the plantlets remain sanitized. Once properly cleaned and multiplied in the lab, the plantlets undergo a process of transition from the sterile conditions of TC flasks to the field conditions typical of farms (Lule et al 2013). This process takes place at a nursery, where nursery staff pot plantlets in sterilized soil before it is weaned in a shadehouse, which provides barriers to direct sunlight, but allows the fragile plants to grow and harden, preparing them for field conditions (ibid).

Transitioning from regular production to TC requires specific skill sets for farmers as well as nursery operators, extensionists, and others. For example, nursery operators must have the technical knowledge of sanitary handling practices as well as the business skills to market the TC plantlets to farmers. Meanwhile, farmers benefit from organizing into farmer-based organizations because the cost of TC plantlets is often prohibitive for individual smallholders.

Despite the challenges of uptake and of educating farmers about the benefits of TC, its adoption has gained traction in countries across East Africa, paving the way for biotechnology-fueled solutions to entrenched agricultural, nutrition, and food security challenges.

Focus on Food Crops

Banana

Banana is Uganda's most important crop in terms of food security, annual production, and income generation for farmers (FAO 2011a). Globally, Uganda is the second largest banana producer in the world after India, with more than 75 percent of Ugandan farmers engaged in banana production. Per capita, Ugandans consume 0.7 Kg of banana daily—the highest per capita banana consumption in the world (UBOS 2011; IITA 2009). The three main types of bananas on the Ugandan market include cooking banana (or matooke), dessert banana, and beer banana, with cooking banana the staple food crop of preference (UBOS 2010a). Producers are primarily independent smallholder farmers who operate on an average land holding of less than one hectare.

Despite being the second largest banana producing country in the world, Uganda ranked 40th in terms of the volume of banana exports (Global Post 2012). In fact, banana exports in Uganda drastically decreased from 3,025 tons in 1996 to 761 tons in 2011 (FAO 2011). Thus, while in previous decades international buyers made up a large proportion of Ugandan banana consumers, this is less the case today.

The onset of banana crop diseases in the early 2000s, along with erratic climate conditions, precipitated dramatic decreases in banana production. The 80 percent decline in banana production that occurred in the last decade and a half caused both an economic and food security challenge, as the majority of Ugandans are involved in agriculture (FAO 2011).

Thus, Uganda's banana sector currently represents a paradox: while characterized by stark challenges such as pests and diseases, the banana industry enjoys opportunities for growth and substantial support from government, university, and non-profit actors. With enhanced uptake of TC propagation methods, the industry has the ability to combat deadly diseases like banana bacterial wilt that have crippling effects on the country's economic and nutritional wellbeing.

Orange-fleshed Sweet Potato (OFSP)

Orange-fleshed Sweet Potato (OFSP) is a variety of bio-fortified sweet potato that is rich in vitamin A and which is being disseminated through a number of international development implementers in Uganda to improve nutrition. OFSP was first introduced in Uganda by the organization HarvestPlus in 2007. HarvestPlus selected Uganda for their OFSP breeding and dissemination pilot because other varieties of sweet potato are grown by over 44% of Ugandan farmers. Sweet potato is one of the country's major staple crops (USAID 2014). Moreover, consuming just 125 grams of OFSP provides the daily vitamin A requirement for young children, directly combatting stunting and other adverse effects of micronutrient deficiency. Since its introduction, OFSP has been adopted by over 55,000 Ugandan farming households with up to 237,000 households expected to be planting and eating OFSP by 2018 (Ibid).

Despite this positive trend, sweet potato production in Uganda suffers due to the sweet potato virus disease (SPVD) that is caused by both the sweet potato feathery mottle potyvirus (SPFMV) and a whitefly-transmitted sweet potato chlorotic stunt virus (Gasura 2009). This disease is widespread across the major Ugandan sweet potato growing regions and it can cause up to 98% yield loss (Ibid). Thus, tissue culture is an important means for propagating clean OFSP vines that are disease free and high yielding.

Because many Ugandans are used to consuming the less sweet, white-fleshed sweet potato and often do not like the taste of orange varieties, continued awareness and education about the nutritional benefits of OFSP consumption and the different means of cooking it will be critical to enhancing uptake across the country (GKI 2014). HarvestPlus has also noted the importance of building off of those OFSP adopters who grow it for their own consumption with help from NGOs and extensionists to a more market-driven approach, which would require wider adoption of, and potentially value addition to, OFSP (HarvestPlus 2012).

Focus on the Farmer

Subsistence farmers

Of the 80% of rural Ugandan households participating in subsistence agriculture—growing banana, maize, beans, and other staples to feed their families—most face challenges in accessing post-basic education, transportation, and electricity (NBER 2010). Though 81% of rural Ugandan children attend primary school, the quality of schooling is low, and few young people graduate secondary school (UNICEF 2015; UNESCO 2013). Transport poses a challenge in reaching markets, and 78% of subsistence farmers live more than two hours from the nearest market, which raises nearly insurmountable barriers to transitioning to market-oriented agriculture (FAO 2014). Although economic development programs have targeted subsistence farmers, and farmers have seen improvements in life expectancy and other basic indicators, the lack of mechanisms to move subsistence farmers from feeding their families to selling their crops poses a challenge both for farmers, and for Uganda's development (UNICEF 2015). Subsistence farmers, who make up the majority of Uganda's agricultural workforce (if not its agricultural GDP) are unlikely to purchase TC banana, though they may access TC banana or OFSP through NGOs or government extension workers (GKI 2014).

Organized Farmer Groups

In Uganda's agricultural sector, 16% of households are members of organized farming groups (FGs) that provide members with access to financial services, bulk-marketing, advocacy, and training (EPRC 2012). In 2007, a total of 39,684 FGs, including more organized co-ops, were registered with the National Agricultural Advisory Services (MFPED 2008). Through Area Cooperative Enterprises (ACEs) and Rural Producer Organizations (RPOs) farmers can bulk their produce to market it more effectively (IFPRI 2010). In 2007, more than 87% of formal co-op members sold over 80% of their marketed produce through their co-op (Ibid.). Over 90% of co-op members also reported changes in income due to their membership, with 92% of those whose income changed reporting an increase in income (Ibid.). Farmers have cited skills training, access to credit, access to planting materials, and opportunities for social interaction as other benefits of co-op participation (ILO 2008). Despite the apparent benefits of co-op membership, only 47% of registered co-ops in Uganda are considered "active," with most stagnating (Ibid.). As organized bodies, with access to more financing and training than individual farmers, FGs represent a promising destination for TC planting material.

Agri-business

Within Uganda's agricultural sector, those farmers producing goods for market as entrepreneurs (rather than through co-ops, or as informal smallholders) run small to medium-sized agribusinesses. The country has 400 registered commercial farms that employ a total of 28,000 individuals—a relatively small fraction of the millions of Ugandans who farm (NBER 2010). On average, these agribusinesses employ only 5 employees, and there is enormous variance between company size (Uganda Bureau of Statistics 2012). That only 20% of all agricultural producers own more than five acres of land, and an even smaller 7% own more than 10 acres, provides additional perspective on a context in which few individual farmers manage viable agribusinesses (Ibid.). While the main commodities of medium-sized businesses include soybeans and maize, large-scale commercial farmers produce mostly coffee—the country's main export commodity (FAO 2014). Of the total area of cropped land, however, only 8% is dedicated to export commodities, such as coffee, tea, and cotton, with subsistence farmers controlling much of Uganda's agricultural land (NBER 2010). Organized banana growing companies represent a strong potential market for TC planting materials, as well as other agricultural inputs such as pesticides and fertilizer.

Construction workers in the Kampala suburbs. Uganda's infrastructure poses a major barrier to agricultural value chain development. Photo: GKI

Enabling Environment for Agribusiness

In any location, a number of essential elements determine the enabling environment surrounding private research, development, marketing, distribution, and other business-related activities. Enablers for agricultural enterprises range from infrastructure, which allows transport of goods, to agricultural policies that prioritize sectors for development, to a country's regulatory system, which protects consumers and enforces standards. This section outlines the most relevant elements of the enabling environment for agricultural business development in Uganda. The section describes major features of the enabling environment affecting innovation, followed by a more detailed investigation into how these features affect agricultural innovation. Enabling environment components highlighted in this report include:

- **Infrastructure:** Separate sections highlight ground transportation; air travel and freight; trade logistics; energy and ICTs; and standards, testing, and metrology.
- **Policies supporting business and agriculture development:** This section includes commentary on national development and agricultural policies.
- **Business and Financing:** Descriptions of Uganda's ease of doing business, access to financing, and international trade are included here.
- **Research and Education:** This final section outlines Uganda's capacities for research and development of its human resources.

INFRASTRUCTURE

Despite rapid economic growth over the past decades, Uganda's poor infrastructure remains a serious impediment to its long term economic growth prospects, according to the United Nations Commission for Trade and Development's (UNCTAD) (World Bank 2011). While Uganda receives high scores relative to its neighbors in the World Bank Logistics Performance Index (LPI), poor infrastructure—in terms of unpaved roads, a decrepit rail system, regular power outages, and a poor ICT infrastructure—ultimately limits the efficiency and productivity of its budding private sector and industrial growth generally (World Bank 2014).

Ground Transportation

Ground transportation infrastructure remains underdeveloped throughout much of Uganda. The country possesses a weak rail system and relies heavily on its national road infrastructure for transportation. In the coming years, a regional overhaul of rail infrastructure has been planned by Kenya, Uganda, and Rwanda, though this will not be finalized until 2018. At present trucks are the most common type of vehicle for shipping (Agutamba 2014). Over 90% of goods transported throughout the country travel via road (The Republic of Uganda 2010). The vast majority—75%—of Uganda's roads are unpaved "district roads" (maintained at the district level). "National roads" make up just a fourth of the overall road network, but carry 80% of total road traffic (Global Times 2012). Of the 20,000 km of national roads in Uganda, only about 3,000 km have been paved, leaving substantial room for improving economic efficiency by upgrading roads (Uganda National Roads Authority 2009). Uganda's government has identified and budgeted for the enhancement of a number of priority roads deemed critical to the country's economic development, including an expressway between the capital Kampala and Entebbe international airport (Ibid). Improvements to Uganda's road system are essential: between 2000 and 2013, the number of cars in Uganda rose from 300,000 to over 1 million, without a corresponding improvement in infrastructure (Ogwang 2013; URSSI 2012).

Air Travel and Freight

While Uganda's ground transportation infrastructure has stagnated, its air transport capacity has grown impressively over the past few years, with the total number of passengers carried nearly tripling between 2009 and 2012 from 64,000 passengers to over 181,000 (World Bank 2014). The number of registered carrier departures increased 16-fold to 5,816 in the same period (Ibid.). Uganda is engaged in intense competition with its neighbors for regional airport supremacy, and recently began a $400 million modernization project of its largest airport, Entebbe International Airport. Kenya, Tanzania, and Rwanda have each invested in large airport expansion projects in recent years (Muchira 2013; Ssuuna 2013).

Uganda's Entebbe International Airport currently maintains a cold storage capacity of 230 metric tons, which is managed by Entebbe Handling Services (ENHAS) within the airport's cargo terminal. The terminal includes a total of four warehouses outfitted with digital weighing scales (World Food Programme 2014). These can be used to ship fresh and processed produce. In general, this capacity—along with cold storage capacity in other parts of the country—proves insufficient to cope with increasing trade volumes (Nabwiiso 2014).

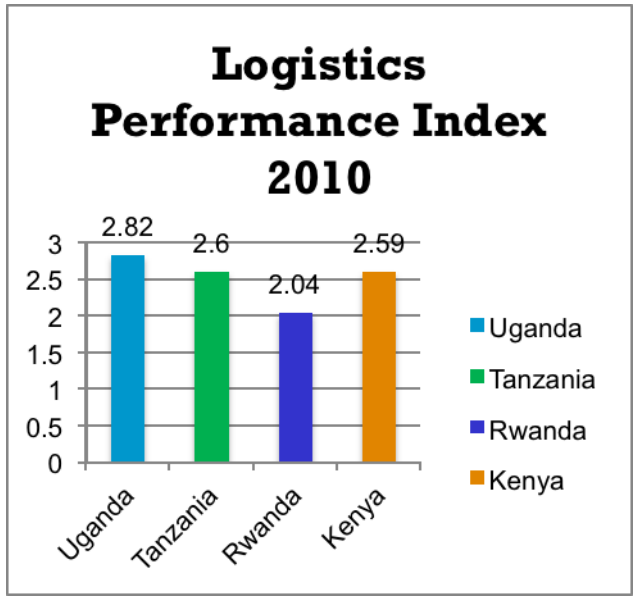


Fig. 2. Scores from the World Bank's 2010 Logistics Performance Index.

Trade Logistics

As a landlocked country, efficiency in logistics proves critical to unlocking trade potential. A tool for benchmarking logistical performance, the World Bank's Logistics Performance Index (LPI) consists of six indicators designed to help identify countries' challenges and opportunities with regard to trade logistics. The International LPI indicator scores derive from evaluations by trade partners (World Bank LPI 2014). With an overall LPI score of 2.82 out of 5 in 2010, Uganda outperformed all of its East African neighbors and performed above the Sub-Saharan average of 2.42 (Ibid.). Uganda performed particularly well in its "Timeliness" rating, which measures the timeliness of shipments' arrivals. With a "Timeliness" score of 3.52, a Uganda's performance is comparable to those of middle-income nations such as South Africa (3.57) and Colombia (3.52) (Ibid.). Uganda also scored well relative to its regional counterparts in "Customs" (2.84) and "International Shipments" (3.02). Despite scoring better than the Sub-Saharan average, Uganda's infrastructure scored only 2.35 out of 5, rendering "infrastructure" the country's weakest LPI component (Ibid.).

The World Bank's Enterprise survey uses a broader definition of transport than the LPI's shipping-specific logistics focus. Interestingly, only 16% of firms responding to the Enterprise Survey said that transport was a constraint to business in Uganda (World Bank Enterprise Survey 2013). That figure is low compared to the Sub-Saharan African average of 29.5%, Rwanda's average of 27.7% of businesses, or Tanzania's especially high average of 35.9%

(Ibid.). This perception of the adequacy of Uganda's transport, combined with the related LPI indicators, suggests that investments in logistical efficiency may be meeting with some success, despite other evidence of the weakness of the transport infrastructure itself.

Electricity and ICTs

Like many countries in Sub-Saharan Africa, intermittent power failures and insufficient provision of power levy significant economic costs on Ugandan businesses and society. According to the World Bank 2013 Enterprise Survey of Uganda, the country experiences an average of 6.3 power outages per month, compared with a Sub-Saharan average of 8.0 (World Bank Enterprise Survey 2014). However, on average Uganda's power outages last longer than those of their regional counterparts. The average power outage in Uganda lasts 7.1 hours, compared with a Sub-Saharan average of 5.0 hours, with the country's direct neighbors—Rwanda, Kenya, and Tanzania—averaging 2.7, 4.9 and 5.1 hours, respectively. As a result, businesses report losing approximately 6.6% of sales due to outages, compared to a Sub-Saharan average of 4.6% (Ibid.).

Uganda's growing economy contributes to upward pressure on electricity demand. While supply is growing as well, it is struggling to keep pace with demand. In July of 2012, power demand at peak hours was 443 MW, yet available supply was just 330 MW (Kasita 2012). While the completion of the Bujagali Falls Hydropower plant has increased electricity production capacity to 580MW, many of Uganda's production facilities regularly operate below capacity due to drought and technical difficulties, leading to regular blackouts (Ibid.; Musisi 2013).

In contrast to much of Uganda's infrastructure that has languished in disrepair, its information and communication technology (ICT) sector has grown immensely in recent years. In 2007, less than 3.7% of Ugandans had access to the Internet; by 2012, 14.7% were online (World Bank 2014). Similarly, between 2007 and 2012, the percentage of Ugandans using mobile phones jumped from 14% to 45% (Ibid.). The impressive double-digit growth in the ICT sector over the last few years stems largely from public investments in critical ICT infrastructure. Driven by demand for mobile technologies, ICT investments have remained high, with the roll out of mobile and broadband infrastructure, such as fiber optic cable, accounting for much of this high growth rate (Uganda Investment Authority 2014). Propelling this growth, the Ugandan government has begun implementing the final phase of a major infrastructure project called the National Data Transmission Backbone Infrastructure. This project aims to expand Uganda's broadband network and link it to submarine cables off of the Eastern coast of Africa, which will greatly increase internet speeds and reduce costs (Ibid.).

Standards, Testing, and Metrology

The Uganda National Bureau of Standards (UNBS) is the foremost agency dedicated to the provision of national standardization services. The Bureau's role focuses on the formulation and promotion of standards, as well as the enforcement of existing standards. UNBS is particularly active in the area of food security and food products, having developed standards pertaining to milk and milk products, fortified food products, and potable drinking water (UNBS 2015).

Despite the UNBS's standards development, quality-testing infrastructure in Uganda remains weak. To enforce standards, UNBS maintains a number of laboratories dedicated to the purposes of metrology and product testing. These include an internationally accredited

microbiology laboratory that tests fresh and processed food products for health and safety compliance, an accredited chemistry lab that carries out chemical analysis of edible and non-edible products, as well as an engineering lab to test building/manufacturing materials, an electrical lab that tests electrical products, and a petroleum lab that tests fuel content and quality (UNBS 2015). However, UNBS has faced challenges in effectively monitoring product quality and safety. A 2010 report by the Uganda Auditor General found that many consumer goods were not inspected, and far fewer warehouses were inspected than planned. They attributed these failures to an inability to control low quality goods coming into the country, a practice of focusing testing on those products whose testing was mandatory, and inadequate punishments for companies failing to meet standards, among other challenges. The Auditor General suggested steps including increasing monitoring of border crossings, better enforcing penalties, and hiring more inspectors, among others (UOAG 2010).

Infrastructure's Impact on Agricultural Development

In general, Uganda displays relatively effective logistics practices, despite limitations due to poor ground transportation infrastructure. Transportation infrastructure initiatives focus heavily on national roads connecting major economic centers as well as the international airport. Rural areas remain difficult to reach and relatively disconnected to transportation and electricity systems. Lack of access to electricity and regular power outages persist as significant limiting factors for economic activity, even as investments in a booming ICT sector promise growth.

The challenge of developing and distributing clean plant material to rural users depends, in part, on the strength of Uganda's infrastructure. Labs that produce clean planting material require consistent electricity; once seedlings have been propagated, transporters must move them through Kampala's crowded streets and into the countryside on rough dirt roads. On the plant material demand side, infrastructure also plays an essential role. Implicit in farmers' demand for clean plant material is their access to a viable market—local, national, or even international—for their crops. If that market is in an urban area, Uganda's road infrastructure again comes into play; if it is an international export market, then access to both air transit and cold chain storage are essential. Because of the weakness of Uganda's cold-chain storage system, this link in the banana export value chain is rendered weak. This, in turn, may lower demand for high quality plant materials. Thus, both on the plant material supply and demand side, infrastructure is critical to business success.

Policies Supporting Business and Agricultural Development

Development Policies

Uganda's development policies provide political and social guidance for initiatives across the economy—including those in agriculture. Uganda's Vision 2040 outlines the national government's goal to jumpstart the economy and transform Uganda into an upper-middle-income country within 30 years (National Planning Authority 2013). The plan highlights science, technology, engineering, and innovation (STEI) as the primary ingredients to spur national economic growth and international competitiveness, specifically focusing on biotechnology as a potential contributor to economic growth (Ibid).

Building upon Vision 2040, Uganda's National Council for Science and Technology (UNCST) led the design process for the National Science, Technology and Innovation Plan (NSTP), which addresses the science and technology pillar within Uganda's 2010 National Development Plan

(MFPED 2012). The NSTP focuses strongly on poverty eradication and transforming Uganda from an agrarian economy to an industrial and knowledge-based economy (Ibid). As part of its efforts to build a strong enabling environment for STI, the NSTP has put forth a legal and regulatory framework to govern biotechnology in Uganda. It has also created a support structure to bolster the proliferation of innovative technologies—such as those in agriculture—that promote economic development (MFPED 2012).

Agricultural Policies

As part of its focus on eradicating poverty—particularly in rural areas—Uganda's government crafted the Plan for Modernisation of Agriculture (PMA) to serve as a framework that provides an appropriate regulatory and policy environment for the implementation of programs aimed at modernizing its agricultural economy (Oxford Policy Management 2005). The PMA focuses on linking stakeholders from multiple sectors to improve the country's performance in agriculture and stabilize the local food supply (Ibid.). Key priorities of the policy include improved agricultural technology, improved agricultural extension services, agro-processing, agricultural education, and a number of other programmatic thrusts (Ibid.)

To accomplish its target of eradicating rural poverty, the government of Uganda identified biotechnology as a priority area to combat the high burden of pests and diseases on both food and cash crops (NARO n.d.). Many in Uganda's government recognize the potential of biotechnology as a strong tool for improving food security in Uganda, and Uganda stands as one of the only countries in East Africa with policies designed to develop and utilize biotechnology, and specifically genetically modified organisms (GMOs), for agricultural development (Ibid).

In 2008, UNCST designed the National Biotechnology and Biosafety Policy to protect the environment and ensure the safe use of biotechnology (MFPED 2008). This policy aligns closely with the national goals of eliminating poverty and improving healthcare, food security, and industrialization. To achieve these goals, the policy calls for strategic partnerships among national, regional, and international actors to foster synergistic linkages in the biotechnology space (Ibid). Through this policy and PMA, Uganda has developed a set of policy structures aimed at modernizing agriculture, and making the most of technological advances. This policy, however, has recently been under review, with some calling for specific biotechnology and biosafety laws to organize the Policy's implementation (Makerere University 2014).

Though many more relevant policies exist, the policies outlined here make clear the intention of the Ugandan government to invest in aggressive national and rural development plans. Part of this development involves leveraging technology to modernize agriculture. The government's prioritization of technologically and scientifically innovative solutions to agricultural challenges directly influences the potential success of efforts to provide biotechnology products such as planting materials to rural farmers. Though the level of implementation of these policies remains important, Uganda has developed a number of policies conducive to biotechnology initiatives.

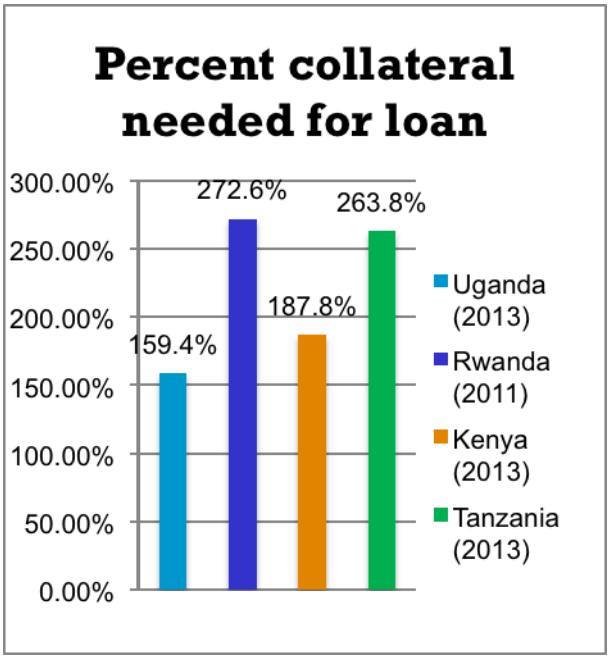


Fig. 3. Percent of collateral needed for a loan. For example, for a $100 USD loan, in Uganda you would need $159.40 in collateral. Source: World Bank Enterprise Survey, 2014.

Business and Financing

Ease of Doing Business

Uganda is one of the world's more difficult countries in which to operate a business, according to the World Bank's Doing Business Report. The Doing Business Report consists of indicators developed using both interviews and statutory data, such as number of forms needed to register a business, or number of days a government registration process requires (Doing Business 2014). In 2014, The Doing Business Report ranked Uganda 132 out of 189 countries, three spots below Kenya, but ahead of Burundi and Tanzania in terms of its composite score on the "Ease of Doing Business". One area in which Uganda performs particularly poorly within the context of Doing Business is in the difficulty of getting electricity, referring to the procedures, time, and cost required for a business to obtain a permanent connection to the electrical grid. In Uganda, this process takes an average of 132 days, or over four months. Uganda also performs poorly with regard to the difficulty of trading across borders—a particularly expensive, bureaucratic, and time-consuming process (Ibid.).

Accessing Financing

Gaining access to financing for businesses in Uganda proves quite difficult. According to The Doing Business Report, for example, on the "Getting Credit" indicator Uganda ranks 125 out of 189 countries, compared to Kenya at 111th place or Rwanda at a remarkable 10th place (Doing Business 2014). While the collateral required for businesses to take out loans in Uganda is lower than in its neighbors (see Fig. 3), at 159.4% of the amount of the loan it is still inaccessibly high to many (World Bank Enterprise Survey 2014). Consequently, only 9.8% of businesses in Uganda currently have loans, according to Enterprise Surveys. This rate compares to 35.9% of Kenyan businesses with loans and the 45% of Rwandan businesses that have them (2014). Of Ugandan businesses responding to the Enterprise Survey, 20.2% report that accessing financing is a challenge. By comparison, 35.1% of Rwandan businesses say that financing is a challenge (which throws some doubt on the 10th place Doing Business Score), while 16.8% of Kenyan businesses say the same (Ibid).

International Trade

Uganda's access to world markets, in terms of trade as a percentage of GDP, has increased rapidly; it nearly doubled over the last decade, from 36.6% in 2003 to 62% in 2012 (World Bank 2014). Kenya represents Uganda's most important trading partner, accounting for 8% of Uganda's exports and 11% of its imports, while also acting as a critical transportation hub for

Crop for Export	Exports as a percent of all merchandise exports
Coffee	20.33% of merchandise exports
Tea	3.56%
Raw sugar	3.47%
Raw tobacco	3.34%

Fig. 4. Uganda's top agricultural exports as a percentage of merchandise exports. Source: CEPII 2014.

goods entering and exiting the country (Ibid). Agriculture accounts for over half of Uganda's total exports, and 12% of its imports (WTO 2014). Coffee is Uganda's largest export, accounting for 20% of total exports. Other agricultural goods lag far behind in terms of percentage of exports, and Ugandan farmers produce the majority of food crops for domestic consumption. Overall trade volumes have risen significantly over the last few years, with exports to Middle Eastern countries such as Saudi Arabia and the United Arab Emirates growing by as much as 20% between 2009 and 2013 (Ibid). Imports have grown even faster, however, creating an increasing trade deficit. The reverse trend is true for agricultural products: the agricultural trade deficit of over $100 million in 2003 became a surplus of approximately $500 million in 2012, suggesting rising relative demand for Uganda's agricultural products in international markets (Ibid).

Business and Financing Impacts on Agricultural Development

In many ways, Uganda's business climate is similar to its neighbors. Uganda, Rwanda, Tanzania, and Kenya each enjoy brisk economic growth, bustling trade, and exhibit a mix of circumstances that are both favorable and challenging to business. In the case of Uganda, the process of getting a business loan appears comparable to most of its neighbors. However, for Ugandan entrepreneurs the experience of starting a formal sector business is expensive, arduous, and lengthy (Doing Business 2014).

Despite these challenges to entrepreneurship, however, Uganda's economy has grown briskly over the past few years, with average annual growth at 5.84% between 2009 and 2013 (World Bank 2014). With a boom in agricultural exports, entrepreneurs operating in the space of agricultural inputs—such as seeds and plant material—see the possibility of increased demand and ability to pay from producers, as farmers see demand and prices for their products rise.

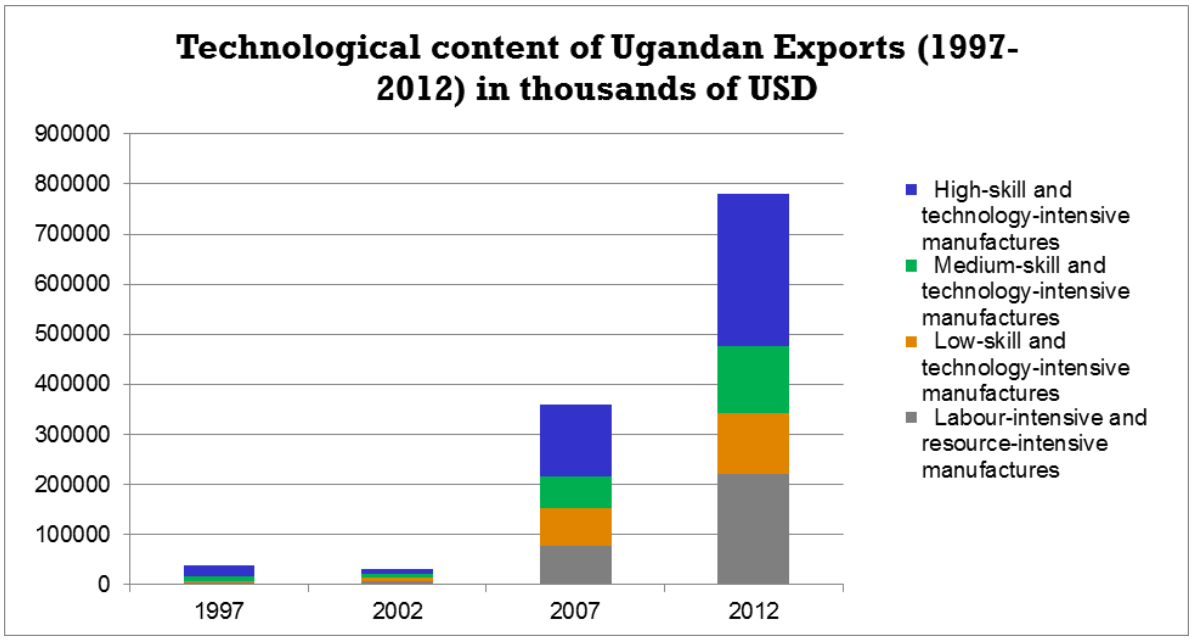


Fig. 5. Skill and technology intensiveness of Ugandan exports between 1997 and 2012. Source: UNCTADStat

Research and Education

Primary and Secondary Education

The pipeline of human resources with sufficient skills needed to build, manage, and grow companies is key to the success of a venture in Uganda that targets agricultural innovation. Moreover, the farmers' abilities to acquire the skills needed to boost productivity using improved planting materials also hinges on Uganda's capability to train its citizens.

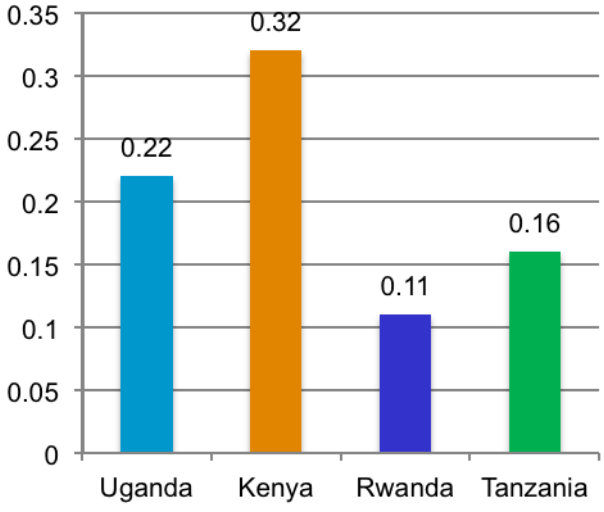


Fig. 6. Papers published in academic journals in 2013. Excludes conference proceedings. Publication data comes from Web of Knowledge; population data comes from the World Bank.

In terms of its educational performance metrics, Uganda has made strides toward achieving its Millennium Development Goal of universal primary education, but progress has been slow (MFPED 2013). While enrollment has increased and inequalities in terms of access have decreased, primary completion rates in 2010 were 54%, well below the 100% target for 2015 (Ibid.). Further, despite this progress in primary education, when data was last accurately collected for secondary enrollment ratios (in 2009), just 27.6% of secondary aged Ugandans were enrolled (UNESCO 2014).

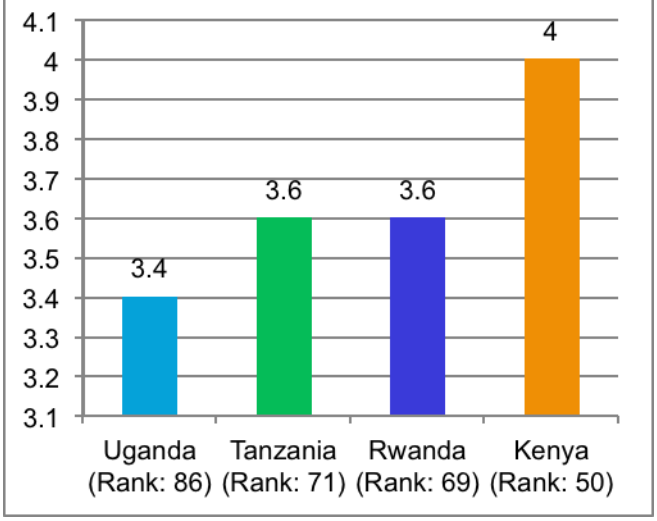


Fig. 7. According to WEF respondents, Uganda has lower quality research institutions than Rwanda, Tanzania, or Kenya. Source: WEF Global Competitiveness Report, 2013.

Tertiary Education and Research

In tertiary education and research, Uganda boasts a mixed record. Among the barriers to economic competitiveness noted by the World Economic Forum (WEF), a dearth of infrastructure, low levels of higher education and training, poor technological readiness, and a lack of innovation feature prominently. However, these represent challenges experienced across the region, and in terms of regional competitors, Uganda actually rates higher than both Kenya and Tanzania in tertiary enrollment rates, at 9.1% of tertiary aged population (UNESCO 2014).

However, Uganda's research institutions rank lower in quality than those of Kenya, Rwanda, and Tanzania based on WEF interviews. Uganda ranks 68th in university-industry collaboration in R&D. Although this ranking lags behind Kenya,

Rwanda, and Tanzania, this placement is impressive given Uganda's economic profile (all four countries are ranked relatively well). Similarly, WEF ranks Uganda's availability of scientists and engineers at 89th of 144 countries, well behind Kenya, but impressive for its income group. Overall, however, Uganda's Capacity for Innovation ranks at 102nd, below its neighboring competitors Kenya, Rwanda and Tanzania, ranked 46th, 55th and 71st respectively. This low performance bears on the development prospects of the country and establishes the context in which the LINK team undertakes the TC challenge.

Protecting and Promoting Innovation

Uganda intellectual property rights (IPR) legislation includes a number of separate IP laws that, together, govern IPR. An autonomous body—the Uganda Registration Services Bureau (URSB)—administers IPR laws and provides patent registration services, while also collecting and accounting for IP revenues. While Uganda's Ministry of Justice and Constitutional Affairs directly shapes URSB's governing policies, URSB defers patent application review to the African Regional Intellectual Property Organization (UNCTAD 2009).

According to stakeholder surveys, some Ugandans harbor concerns regarding the URSB's capacity to administer the relevant IPR laws. Stakeholders point to a lack of technical expertise in the bureau for reviewing technical patent applications as a reason for their trepidation (Ibid). According to some sources, infringement upon intellectual property laws in Uganda goes largely unpunished due to poor enforcement of existing laws (Kakooza 2010). Poor police training in IPR law, combined with the complexity of the legal procedures involved in bringing a case to court, represent further hindrances to enforcement (Ibid).

Research and Education Impacts on Agricultural Development

Overall, research and education present a mixed picture in Uganda. Uganda has seen rapid growth in primary and secondary education, essential to agricultural development and value addition. However, on the university level indicators provide a murkier picture. Although Uganda has made strides in university enrollment levels, it still lags in research capability and capacity to innovate more generally. Insofar as cleaning and propagating plant material is a knowledge intensive task, Uganda's education levels matter. However, the quality and specificity of technical training are more critical to this challenge than widespread access to such training. In this measure, it remains unclear whether Uganda's human resource base can support expansion of biotechnology-based efforts.

In terms of research capabilities, although WEF rates Uganda below its neighbors in a number of indicators, all four countries compared in this section (Uganda, Rwanda, Tanzania, Kenya) score high for their income levels on these education indicators. This is an excellent finding: if East African countries can partner on regionally important issues such as fighting plant diseases or developing biotechnology systems, this will make each countries' efforts more successful.

Makerere University's Administration Building. One of Uganda's most influential universities, Makerere conducts research and trains students on agronomics, biotechnology, and other areas of study relevant to the LINK Challenge. Photo: GKI

Key Actors in the Enabling Environment for Agri-business

Key Actors in the Enabling Environment for Agri-Business

Beyond a broad portrait of the enabling environment for agri-business in Uganda, key to understanding potential agricultural development are those institutions and actors that impact the performance of this sector, and specifically those that affect banana and OFSP value chains. To fill this gap, the following section describes some of the central actors that shape the enabling environment for agri-business in Uganda, including a strategic selection of government institutions, civil society organizations, international partners, and universities. Some of these actors provide critical support to the small-scale farmers who dominate this industry. Others briefly profiled in this section take steps to enable efficiency gains along agricultural value chains. Actors described are profiled within the following categories.

Government

A number of Uganda's government actors engaged in agriculture broadly and in biotechnology specifically influence the LINK Uganda TC Challenge. While the Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF) coordinates agricultural interventions on a national level, implementing and research agencies such as the National Agricultural Advisory Services (NAADS) and the National Agricultural Research Organisation (NARO) undertake much of the research and extension activities integral to the LINK Uganda challenge. NAADS advises farmers on how to effectively transition from subsistence farming to commercialized agriculture, which is key to promoting demand for clean plant materials, while NARO currently represents the chief source of sweet potato and banana tissue culture planting materials and resources integral to this challenge. The Uganda National Council for Science and Technology (UNCST), and the Ministry of Finance Planning and Economic Development (MFPED), also profiled in this section, represent critical stakeholders in propelling agricultural biotechnology and STI more broadly as enablers of national development. UNCST has proved itself instrumental in developing biotechnology policies. Beyond its engagement in biotechnology, MFPED acts as a partner in the Presidential Initiative on Banana Industrial Development (PIBID), which aims to boost Uganda's banana exports.

Civil Society

Civil society organizations address critical challenges in Ugandan agriculture such as providing agricultural extension services, creating linkages among agricultural actors, enhancing the business acumen of agricultural input dealers, improving farmer access to credit, advocating for policies enabling farmers to access the benefits of modern biotechnology, and numerous other services. Civil society organizations profiled in this analysis include the Uganda Biotechnology and Biosafety Consortium (UBBC), Volunteer Efforts for Development Concern (VEDCO), CHAIN Uganda, and the Uganda National Agro-Input Dealers Associations (UNADA). Particularly important as input suppliers, advocates, and as aggregators of producers, these entities are poised to enhance the integration of value chains for banana, OFSP, and other crops.

International Partners

International partners buttress the work of both government and civil society organizations. The international partners profiled in this analysis offer a range of functions to optimize the performance of Uganda's agricultural sector. For example, in some instances international partners provide small-scale farmer groups with entrepreneurial skills to boost income

generation from matooke bananas. In others, they raise awareness of the nutritional benefits of OFSP, train farmers on environmentally sustainable practices, and leverage their political and financial capital to boost further agricultural development, among many other roles. These organizations and initiatives include TechnoServe and organizations within the Consultative Group for International Agricultural Research (CGIAR) like HarvestPlus, the International Center for Tropical Agriculture (CIAT), and the International Potato Center (CIP).

Although international partners profiled in this document largely include implementing organizations and research groups, much of the funding they use to conduct their work comes from international donor organizations. Below, find an overview of the donor organizations contributing the most to agricultural development (both through grants and loans). While the actions of local organizations and initiatives propel development in plant material availability, much of the funding for such initiatives comes from these and other international donor organizations.

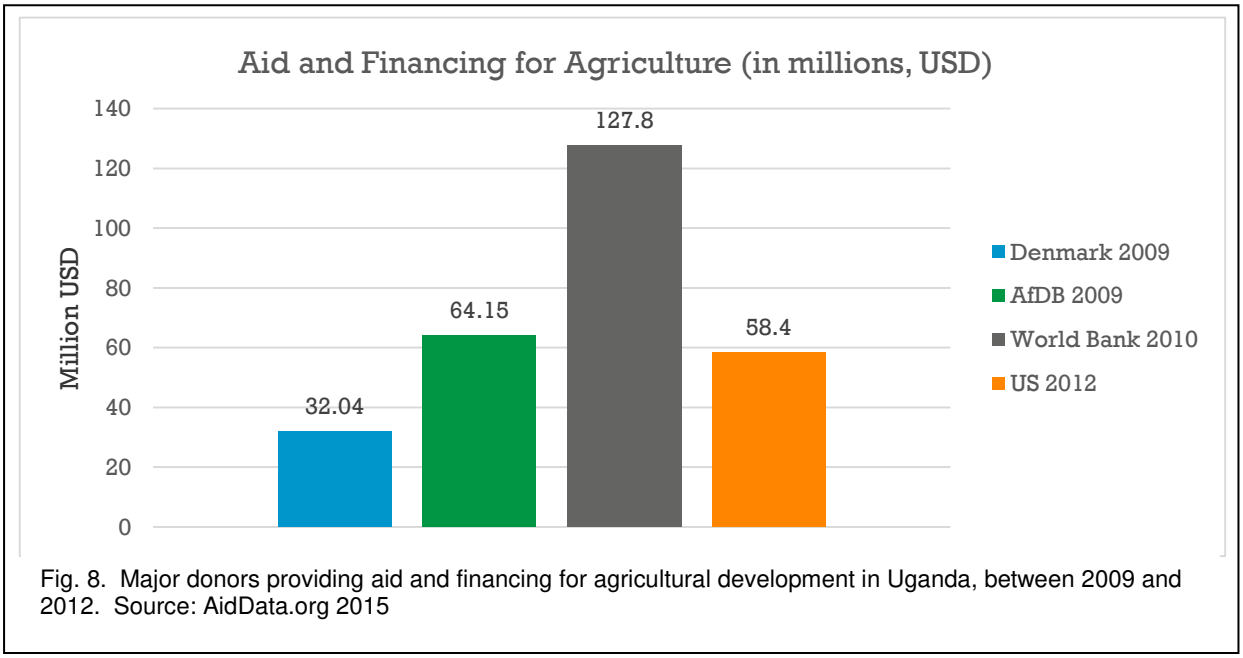


Fig. 8. Major donors providing aid and financing for agricultural development in Uganda, between 2009 and 2012. Source: AidData.org 2015

Universities

The final group of actors described in this section includes higher learning institutions with experience and activities in the agricultural sector related to the LINK Uganda TC Challenge. Makerere University has emerged as Uganda's leading tertiary institution involved in agricultural research, and as Uganda's most influential and active university, it merits specific focus. Makerere University's varied research initiatives and robust degree programs and trainings related to agricultural development and biotechnology make it a singular institution in Uganda, and indeed in East Africa. However, Mbarara University of Science and Technology, Kyambogo University, and Gulu University—also profiled in this section—offer high quality programs on pertinent agricultural issues affecting OFSP and banana production in Uganda as well.

GOVERNMENT

National Agricultural Research Organisation (NARO)	A public, semi-autonomous institute, the National Agricultural Research Organisation (NARO) endeavors to study Uganda's most pressing agricultural challenges (NARO 2014). NARO studies a broad range of crops, including banana, with its focus on analysis of profitable and sustainable technologies, including TC technology. NARO is one of the primary sources of banana TC planting materials in Uganda, and has expertise in generating large volumes of TC plantlets. NARO's Kawanda Laboratories work closely with the LINK team, providing them with planting material and technical assistance (Ibid; GKI 2014).
National Agricultural Advisory Services (NAADS)	The National Agricultural Advisory Services (NAADS) operates under MAAIF and aims to hasten the transition of Ugandan farmers from subsistence to commercial agriculture through provision of extension services (NAADS n.d.). Advancing the efficiency of agro-input dealers is a core component of NAADS' strategy (Ibid). Efficient distribution and affordability of planting materials remain challenges in Uganda. NAADS seeks to address these issues by increasing market linkages between farmers and agro-input dealers. As the agricultural sector commercializes, suppliers of TC planting materials will play a large role, since these planting materials ease mass production. NAADS already distributes banana and OFSP, and will likely continue to play a leading role in these efforts (GKI 2014).
Uganda National Council for Science and Technology (UNCST)	The Uganda National Council for Science and Technology (UNCST) is an agency housed under the Ministry of Finance, Planning and Economic Development (UNCST 2014). A key biotechnology actor, UNCST has the primary mandate of promoting and integrating science and technology in Uganda's economic development. In 2008, UNCST designed a national biotechnology and biosafety policy, which positioned Uganda to begin biotechnology commercialization. However, there has since been a public call for review, as the policy was deemed not to have adequately addressed biosafety concerns when handling infectious agents. UNCST works with the Uganda Academy of Sciences to address this issue (Ibid).
Ministry of Finance, Planning, and Economic Development (MFPED)	The Ministry of Finance, Planning, and Economic Development (MFPED) works to stimulate economic growth by managing Uganda's finances and economic policies (MFPED n.d.). After the release of the national biotechnology and biosafety policy, MFPED collaborated with UNCST to draft biosecurity legislation to govern the safe implementation of biotechnology (Makerere University 2014). MFPED also works as a partner in the Presidential Initiative on Banana Industrial Development, which seeks to empower rural communities by boosting value added banana products for export, partly through increasing access to advanced processing techniques (PIBID 2013).

Civil Society

Uganda Biotechnology and Biosafety Consortium (UBBC)	An alliance of actors from a wide variety of sectors, including policymakers, scientists, private sector leaders, and government officers, the Uganda Biotechnology and Biosafety Consortium (UBBC) aims to garner support for the development and implementation of biosafety legislation in Uganda (UBBD 2013). Specifically, it seeks to promote and advance the use of biotechnology in agriculture to improve Ugandan livelihoods (Ibid). UBBC has developed a relationship with UNCST to facilitate dialogue and enable the sharing of ideas between Ugandan biotechnology actors (Ibid).
Volunteer Efforts for Development Concerns (VEDCO)	Volunteer Efforts for Development Concerns (VEDCO) is a non-profit agricultural organization that aims to empower Ugandan small and medium holder farmers through five focus areas: food and nutrition security, agricultural trade development, communication and advocacy, community energy access, and organizational development (VEDCO n.d.). VEDCO works with partners such as IITA to implement training programs for banana farmers and nursery operators on cultivating TC bananas. They also help certify banana farmer groups so they can access savings and credit schemes (Lule et al 2013; Dubois, 2011). In partnership with HarvestPlus, VEDCO also conducts practical trainings to educate communities on the importance and benefits of OFSP in Uganda (HarvestPlus 2012).
CHAIN Uganda	CHAIN (Coalition for Health Agriculture and Income Networks) Uganda is a CBO that was established in 2008 with the goal of improving the incomes and livelihoods of farming communities (CHAIN Uganda 2014). A large focus of CHAIN's work is catalyzing the transition from subsistence to commercial farming, which is supported by their TC project. Specifically, this project aims to boost smallholder access to clean OFSP vines (Lerner 2014). It does so by offering technical (and sometimes financial) support to nursery operators and farmers so they can properly handle the clean planting material obtained from BioCrops, and let those plantlets grow in a disease-free greenhouse environment. CHAIN partners with USAID and HarvestPlus on this project (Ibid).
Uganda National Agro-Input Dealers Associations (UNADA)	The Uganda National Agro-Input Dealers Association (UNADA) represents all Ugandan agricultural input suppliers and has the primary objective of creating an environment conducive to affordable and sustainable agricultural business (UNADA 2014). To fulfill this mission, UNADA performs various functions, including acting as a negotiating body, offering advisory services to members (agricultural input dealers), and advocating for the modernization of agriculture through improved agricultural inputs in Uganda (Ibid). UNADA works with seed/planting material dealers on the above functions, and helps with marketing (AGRA 2010).

INTERNATIONAL PARTNERS

HarvestPlus	HarvestPlus works across disciplines internationally to eliminate malnutrition and "hidden hunger" caused by vitamin and mineral deficiencies by developing nutrient rich seeds (HarvestPlus 2012). An NGO coordinated by CIAT and IFPRI, it targets highly nutritious crops, including OFSP (Ibid). Through the Reach End Users project, HarvestPlus distributed vitamin A-rich OFSP to over 24,000 households in both Mozambique and Uganda (HarvestPlus 2012b). HarvestPlus works closely with BioCrops Ltd. and other local organizations to source OFSP plant material for farmers (GKI 2015).
International Center for Tropical Agriculture (CIAT)	A member of CGIAR, the International Center for Tropical Agriculture (CIAT) conducts research aimed at improving smallholder farmers' ability to engage in environmentally sustainable, profitable, and resilient production techniques (CIAT 2014). Among CIAT's noteworthy projects in Uganda are a research effort focusing on the agricultural profitability and technical efficiency of potatoes, the harnessing of nitrogen to increase the nutrition available in Uganda's often-poor quality soil, and the breeding of banana varieties (Ibid; CIAT 2012). CIAT partners with the International Food Policy Research Institute (IFPRI) to co-organize HarvestPlus.
TechnoServe	US-based non-profit TechnoServe focuses on business and entrepreneurship solutions that can support economic development and poverty reduction (TechnoServe 2014a). Starting in 2009, TechnoServe launched a project to improve the matooke banana industry in southwestern Uganda (Ibid). In collaboration with the Alliance for a Green Revolution in Africa, it connected with 26,000 farmers and provided training on best practices and business skills (TechnoServe 2014b). With TechnoServe's help, farmers generated $22 million in matooke banana sales over three years (Ibid).
International Potato Center (CIP)	A CGIAR affiliate, the International Potato Center (CIP) focuses on improving food security in low-income populations by using root and tuber farming and indigenous food systems (CIP n.d.). While CIP has worked with HarvestPlus and through other initiatives on OFSP in Uganda, it has also developed unique models for OFSP development elsewhere. The CIP Reaching Agents for Change (RAC) project promotes investment in OFSP to mitigate the prevalence of vitamin A in Tanzania, Mozambique, and Nigeria (CIP 2013). Whereas HarvestPlus' work largely focuses on providing farmers with input materials for OFSP development, RAC leverages the resources and reach of policymakers, donors, and experts to promote the production and consumption of OFSP (Ibid).

UNIVERSITIES

Spotlight on Makerere University

Makerere University, in Kampala, is the largest university in Uganda, and acts as the primary public institutional partner of the government-run National Agricultural Biotechnology Centre (NABC) at the National Agricultural Research Laboratories (NARL) (NARO n.d.). NABC operates as the focal point for biotechnology research in Uganda and coordinates various institutional laboratory nodes in tertiary institutions across the country, including substantial agricultural research at Makerere University (Ibid). Makerere University hosts three main colleges that focus on agricultural and biotechnology research.

College of Natural Sciences (CoNAS). The College of Natural Sciences includes two schools, one of which is the relatively new School of Biological Sciences, founded in 2011 (MU 2014). CoNAS forges partnerships with key government institutions in the agricultural sector such as NARO, NARL, and UNCST. To better understand and mitigate the effects of sweet potato mild mottle virus, which severely threatens sweet potato production in East Africa, CoNAS provides scholarships to support graduate students who conduct research in this area. CoNAS researchers Arthur Tugume and Settumba Mukasa represent two of Uganda's most prominent published scholars on sweet potato; both have studied OFSP, as well as other varieties (Thomson Reuters 2014).

College of Agricultural and Environmental Sciences (CAES). CAES includes three schools: Agricultural Sciences; Forestry, Environmental and Geographical Sciences; and Food Technology, Nutrition, and Bio-Engineering. CAES continues to play a major role in agricultural and biotechnology research. The School of Agricultural Sciences hosts biotechnology laboratories and has designed methods to produce banana tissue culture , increasing the yield of vegetatively propagated plants such as cassava, sweet potato, and banana by 40 percent (CAES 2014). The Agricultural Research Institute, Kabanyolo, hosted by CAES, acts as a primary liaison for the National Agriculture Research System, with a focus on biotechnology and animal science (MUARIK n.d.). The institute provides an array of resources for research in these areas, such as laboratories, libraries, computers, farm machinery, and a gene bank.

College of Veterinary Medicine, Animal Resources, and Bio-security (CoVAB). Of the two schools included in this college, the School of Bio-security, Biotechnical and Laboratory Sciences has a strong emphasis on promoting the use of biotechnology to decrease the disease-burden of key crops in the Ugandan agricultural sector (CoVAB 2014). To achieve these goals, CoVAB has set the objective of pinpointing, securing, and improving biomolecular resources, bio laboratory sciences, and skill-building in biotechnology (Ibid.)

UNIVERSITIES, CONT.

While Makerere University is Uganda's main public, tertiary educational institution engaged in agricultural research, a number of other universities in Uganda offer training and programs in agriculture and biotechnology.

- **Mbarara University of Science and Technology** collaborates with IFPRI and CIP to deliver OFSP varieties to farmers located in Uganda's main sweet potato producing districts (IFPRI et al 2013). This project contracted BioCrops Ltd. to clean and multiply OFSP tissue culture vines (Ibid).
- **Kyambogo University** works on challenges in food management and food safety and security through programs in the Department of Food Processing Technology in the Faculty of Science (KYU, n.d). Kyambogo helped form Afri Banana Products Ltd. (ABP) in 2008, a consortium agribusiness incubator that supports and promotes business in the banana value chain. Among other priorities, ABP supports production of tissue culture seedlings (ABP, n.d). Kyambogo University, which focuses on promoting technical skills, has produced many of the employees hired by BioCrops Ltd. and others in the TC sector (GKI 2014).
- **Gulu University's** position as a beneficiary of the UNCST funded Millennium Science Initiative (MSI) and its partnership with the BecA-ILRI Hub helped create the new Bachelor's of Science in Bio Systems Engineering in 2008 (UNCST, n.d). Gulu constructed a new, modern biosciences laboratory in early 2014. Guided by BecA-ILRI expertise, this lab will support Gulu's Plant Sciences Faculty (BecA, 2014).

Beyond the institutions profiled here, and additional actors within government, civil society, international partners, and academia, an entire ecosystem of small businesses and associations compose Uganda's banana and OFSP value chains. These input suppliers, TC producers, traders, farmers, retailers, and others ensure that planting material arrives where producers need it, that crops move from farm to warehouse, and that village markets have produce to sustain Ugandan families. The subsequent section, starting on page 35, profiles these actors and their interactions within Uganda's banana and OFSP value chains.

Bananas for sale outside of Kampala. Photo: GKI

Interactions: A focus on Value Chains

For banana and OFSP

Thus far, this report has explored the contributions of a diverse range of actors in the Ugandan banana and OFSP/sweet potato industries. While actors represent an important aspect of the broader innovation system, *how they interact* to identify challenges and collectively seize opportunities for efficiency gains constitutes an even more important consideration. The following value chain analyses are designed to assess the current state of interactions among relevant actors pertinent to the banana and OFSP sectors. These actors include TC producers, traders, farmers, processors, retailers, and others – finally ending with consumers of banana and OFSP products.

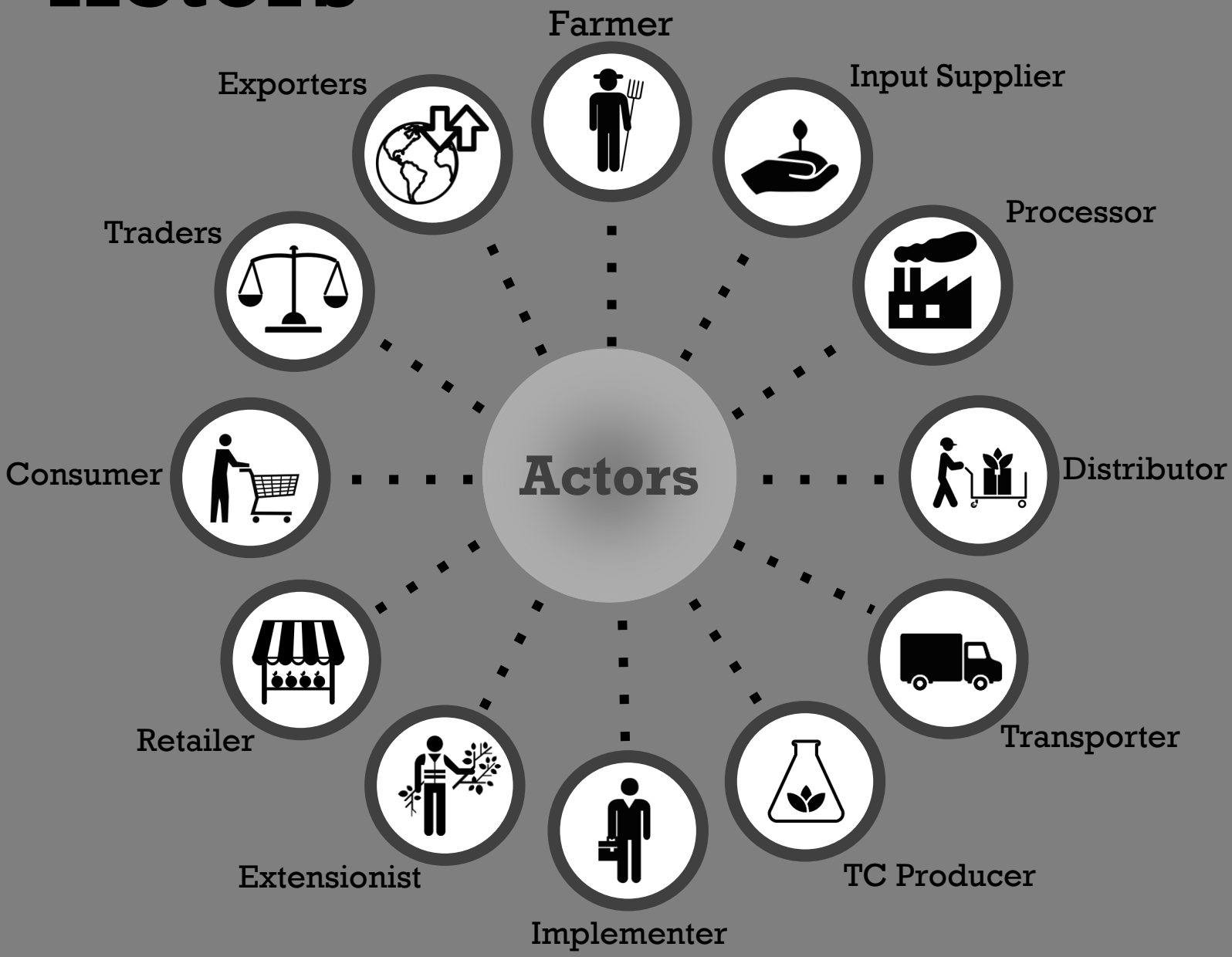
Presented separately within this section, these chains are distinct in their makeup and functions. In the case of the banana value chain, Uganda faces the complex challenge of re-launching a formerly vibrant industry for both local and international markets. The onset of banana crop diseases in the early 2000s, along with erratic climate conditions, precipitated dramatic decreases in banana production. The 80 percent decline in banana production that occurred in the last decade and a half caused both an economic and food security challenge, as the majority of Ugandans are involved in agriculture (FAO 2011). The full value chain for tissue culture bananas – spanning from the input suppliers who sell chemicals to TC producers, all the way to the consumers — is included within this section of the LINK Analysis, supported by profiles of the key actors within it. Information used to construct the first several steps of this value chain (steps 1 through 5) comes from interviews with the BioCrops team. Additional sources furnished the information used for subsequent steps as well as for some of the key actors profiled.

The sweet potato value chain in Uganda, by comparison, is newer, and less organized than the banana value chain. It is also largely supported by the Ugandan government and NGOs such as HarvestPlus, as this section's depiction of the OFSP value chain reveals. The overview of the OFSP value chain offered includes those steps of the value chain by which TC OFSP vines are transferred from the lab to farmers in Uganda. However, the information necessary to describe these steps was scant and emerged primarily from interviews with BioCrops. Because a large proportion of OFSP is consumed on farm in Uganda, and because less information is available on the small part of OFSP production that is sold, fewer steps are profiled in the Uganda OFSP value chain. To supplement this incomplete value chain, and to provide another example of how the value chain might be organized, a full value chain for OFSP in Tanzania follows, produced from analysis conducted by the Institute for Development Studies (Temu et al 2014). Further, because of the somewhat nascent nature of the private OFSP market in Uganda, in-depth profiles of actors are not included for the OFSP value chain.

On the next page, find visualizations and descriptions of the actors that factor into all three value chains – Uganda banana, Uganda OFSP, and Tanzania OFSP followed by the final section of this report, which focuses on case studies of innovative seed system outcomes.

Agricultural Value Chain

Actors



The majority of Ugandan families farm for their income. Farmers grow and either sell or feed their families with banana and OFSP, as well as other crops.

Input suppliers sell inputs needed for TC production (chemicals, equipment); while others supply nurseries and farmers with fertilizers, pesticides, seeds, and other inputs.

Processors take raw banana and OFSP and add value, producing products that can be sold at a higher price.

Distributors, often nurseries, get TC planting material to farmers. They grow needed plants, while also receiving shipments of TC from traders and others.

Transporters are often independent drivers, though some work for government/NGOs, who move TC plantlets, as well as harvested crops, between actors in the value chain.

Implementers are NGOs or contractors that work across the entire value chain, from placing orders for TC, to picking up TC, to contracting with nurseries, to finally delivering TC to farmers.

Extensionists are government workers who advise farmers on production techniques (such as growing TC plantlets). They also help transport and distribute TC plantlets to farmers.

Retailers include informal markets and supermarkets. These buy fresh and processed banana and OFSP and sell to consumers.

Consumers eat banana and OFSP that they grow, and also purchase fresh or processed banana and OFSP from retailers.

Traders buy and sell TC plantlets and harvested crops. These "middlemen" buy farmers' crops and either transport them or pay for their transport to retailers or processors.

Though little banana and OFSP is exported in Uganda, a few groups ship these crops to neighboring countries and to overseas consumers.

TC producers produce and multiply clean banana and OFSP tissue culture in labs.

Challenges and Opportunities in the Banana Value Chain

Characterized by stark challenges such as pests and diseases, the banana industry poses a number of exciting opportunities for growth and substantial support from government, university, and non-profit actors. Despite opportunities for value addition and marketing of bananas, banana's exploitation as a commercial crop is still largely under-developed. Uganda's recent census indicates that Ugandan farmers primarily grow banana for subsistence. This is particularly true of the cooking banana: farmers consume 59.8 percent of the cooking bananas they grow and sell just 34.6 percent (UBOS 2010a).

Some of the most acute challenges confronting this value chain include:

- Pests and diseases that significantly decrease crop production
- Inadequate access to quality input materials such as fertilizer and tissue culture plantlets
- Limited access to finance and markets for smallholder farmers, who represent the majority of Ugandan banana producers

Despite challenges along the value chain, a high level of government and donor investment in the banana market renders a number of opportunities.

- The Presidential Initiative for Banana Industrial Development (PIBID), a project that President Museveni launched in 2005, successfully increased local capacity for banana processing, the results of which included advances in terms of extended shelf life of bananas and production of such processed products as banana flour. The production of flour eases the bulking process and positions small-scale farmers in rural areas for export opportunities (PIBID 2013).
- Development of farmer groups has the potential to enable smallholders to seize large contracts with formal retailers. Scaling up the practice of farmer organization is key to improving the competitiveness and income potential of rural farmers.
- Decentralization of tissue culture laboratories to banana producing districts, coupled with strong extension services, can increase access to quality planting materials and could enhance the volume of bananas that farmers are able to produce each harvest.

The following section provides an overview of the Ugandan banana value chain, beginning with a visualization of the value chain itself, offered on the next page. Profiles of a number of key actors in the banana value chain follow, starting on page 40.

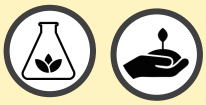
Uganda TC Banana

Value Chain

Uganda's tissue culture banana value chain includes nine steps. Below find a visualization and descriptions of these steps, as well as icons indicating the actors implicated in each step.

1 **Purchase TC production inputs from suppliers:**

TC Producers purchase inputs, such as chemicals and equipment, from private companies and government labs. Depending on the chemical or piece of equipment, suppliers may be based in Uganda, or in another part of the world.



2 **Produce TC banana plantlets:**

TC Producers clean and multiply banana planting material. They raise the fledgling plantlets first in a laboratory, then in a humid greenhouse, and then in a shadehouse where the plantlets "harden" before being transported.

3 **Offload to intermediary for delivery:**

Traders, distributors (generally nurseries), and extensionists pick up banana plantlets from the TC producer, and deliver them either to farmer groups or to nurseries.

4 **Grow and propagate planting materials:**

At nurseries, nursery operators continue growing the plantlets. A small number of more sophisticated nurseries also have the ability to harden early-stage plantlets.

5 **Sell to farmers:**

Directly, or through traders or government extensionists, distributors sell banana plantlets to farmers and farmer groups. Distributors often sell needed inputs, such as fertilizer and pesticides to farmers and farmers groups too.

6 **Farmers grow and sell crops:**

Farmers grow TC bananas, selling some to traders or directly to retailers, and eating others. Transporters pick up bananas from the farm, or farmers bulk bananas in a central location for pick up. Bananas are then transported to processors or market.

7 **Traders sell to retailers, processors, and exporters:**

After purchasing bananas from farmers, traders transport bananas to urban areas, where they sell bananas to retailers, processors, and (in some cases) exporters. The majority of these bananas are sold fresh. Processors sell value-added products to retailers or exporters.

8 **Retailers sell to consumers:**

Consumers purchase bananas from markets and supermarkets, in fresh or processed form. Many Ugandans also consume bananas that they grow on their own land, either fresh, as mashed matooke, or in the form of banana beer.

Tissue Culture Producers

Although input suppliers active in the banana value chain include purveyors of products as various as banana suckers, fertilizers, pesticides, and farming tools such as hoes, axes, and pangas, this analysis focuses on tissue culture producers. Although a private tissue culture production industry for banana has sprung up in Uganda, government-run tissue culture laboratories, such as the Kawanda Agricultural Research Institute (KARI) remain the primary suppliers of tissue culture planting materials and are concentrated in Kampala. Private banana TC producers remain small in size, and have had challenges in meeting demand, controlling quality, and keeping prices low enough that farmer groups can afford TC plantlets. While some TC planting material suppliers have developed centers in banana-producing regions to multiply plantlets, most distribute more mature plantlets to rural nurseries away from Kampala. Kampala-based TC suppliers such as BioCrops and Agro Genetic Technologies Laboratories (AGT) work with traders to distribute their products to farmers, which adds distribution costs to this process. However, because the need for banana TC exceeds the supply, ample opportunity exists for new entrepreneurs to enter this market.

Tissue Culture Producers: Roles, Interactions, Challenges, and Opportunities

Roles and Interactions

- Produce TC plantlets and other input materials
- Train producers and community organizations to effectively use input materials

Challenges

- High cost and variable quality of tissue culture

Opportunities

- Improve producer access to input materials by establishing distribution centers closer to farming communities
- Decrease product distribution costs by decentralizing distribution centers

Example: Agro Genetic Technologies Laboratories Ltd. (AGT)

Based in Kampala, Agro Genetic Technologies Laboratories Ltd. was the first private supplier of tissue culture planting materials in Uganda, and continues to supply planting materials both locally and across East and Central Africa (AGT 2010). Supported by partnerships with Makerere University, non-profit organizations, and government institutions, AGT's production capacity has grown from 1 million tissue culture plantlets per year to 10 million plantlets per year since its founding in 2002, with banana accounting for 50 percent of their production line (AGT 2010; World Bank 2002). This company enjoys first mover benefits, including holding the majority market share in developing and disseminating agro-biotechnology research and products (AGT 2010). AGT designed its business model to maximize interactions and knowledge transfer with farmers in banana producing districts such as Wakiso, Mukono, and Masaka, among others. For example, while AGT maintains its laboratories in Kampala, the company strategically located 27 banana nurseries and demonstration gardens in a number of Uganda's banana producing districts (Ibid). At these demonstration gardens, AGT staff members deliver agricultural advisory services, train farmers on modern agronomic practices, and provide tools to maximize the potential yield from using tissue culture banana plantlets (World Bank 2002).

Distributors

Once banana cultivars have been cleaned and successfully multiplied into numerous plantlets, the plantlets must be transported to distribution centers, or nurseries, for weaning and/or hardening before they are sold to traders and/or farmers. Farmers often get their plantlets from nurseries rather than directly from the TC producer because plantlets are easier to grow and properly handle once they are more fully formed and less delicate (IITA 2013). In some cases, distributors have the capacity to wean and harden banana plantlets (these are the steps required for plantlets to be viable in normal soil). Often, however, distributors will receive TC plantlets after they have been weaned or hardened (GKI 2014). For those nurseries that take bananas through the hardening stage, they begin to expose weaned plantlets to the natural environment in shadehouses for approximately one month, thus preparing them for normal field conditions (IIATA 2013). Once the plantlets are in the shadehouse, nursery operators must water them daily, maintaining specific temperatures, and a high standard of hygiene. Distributors market their TC plantlets to traders and farmers, though some nurseries contract with NAADS extensionists, providing them with banana plantlets. To facilitate farmer groups and others in purchasing TC, some nurseries provide discounts or free transport for large/bulk purchases; this has been shown to increase sales (Ibid.).

Distributors: Roles, Interactions, Challenges, and Opportunities

Roles and Interactions

- Purchase tissue culture (either pre-weaned, weaned, or hardened) from laboratory
- Pre-weaned: Sterilize soil and place potted plantlets in humidity chamber
- Weaned: Place plantlets in shadehouse for hardening
- Market TC plantlets
- Sell plantlets to farmers, extensionists, and/or traders

Challenges

- Plantlets can be infected with pests and diseases if soil is not properly sterilized
- Lack of marketing and awareness about TC
- Poor nursery operator knowledge of proper TC growing/handling practices
- TC prices are too high for most farmers

Opportunities

- Meetings facilitated by NGOs or extension officers can help train nursery operators and link operators to plant buyers

Example: Trinity Organic Projects Initiative

Florence Sanyu is a Ugandan farmer who focused on using mushroom farming as a means of income diversification for herself and other women farmers in the area. After becoming frustrated with the high cost of equipment, such as autoclaves, Florence learned of Agro-Genetic Technologies' (AGT) work producing tissue culture banana plantlets. Shifting her focus, she realized that TC would be a good opportunity for the farmers in the Ankole region of Uganda to obtain clean planting material for disease-free matooke (cooking) bananas. Thus, Florence made a deal with AGT and opened a nursery worth 6 million Ugandan shillings (approximately $2,000 USD in 2015). Trinity Organic Projects Initiative has sold over 20,000 banana plantlets to farmers and has also set up a demonstration garden (Daily Monitor 2011).

Farmers

Banana is Uganda's most important crop in terms of food security, annual production, and farmer income generation (FAO 2011). Globally, Uganda is the second largest banana producer in the world after India, with more than 75 percent of Ugandan farmers engaged in banana production. The three main types of bananas on the Ugandan market include cooking banana (or matooke), dessert banana, and beer banana, with cooking banana the staple food crop of preference (UBOS 2010). Producers are primarily independent smallholder farmers who operate on an average land holding of less than one hectare (for cooking banana less than half a hectare). Many producers have received primary school level education, though most have not completed secondary school (UBOS 2010b). Sourcing input materials mostly from extension centers and local nurseries, the average Ugandan banana farmer grows 12 different banana cultivars (Trias 2012). Given the highly perishable nature of banana—spoilage occurs after a few days for dessert bananas and after two weeks for cooking bananas—good post harvest handling and storage options are of chief importance (UNIDO 2004). Other common challenges faced by banana producers include combating pests and diseases, such as black sigatoka and banana bacterial wilt disease, and maintaining soil fertility given the crop's high nutrient extraction rates (FAO 2011).

Farmers: Roles, Interactions, Challenges, and Opportunities

Roles and Interactions

- Purchase input material from input suppliers
- Produce bananas
- Identify traders and sell produce to them for bulking and transport
- Identify retailers and wholesalers and sell produce directly to them

Challenges

- Small-scale farmers priced out of TC planting materials
- High pest and crop disease burden
- Limited access to processing equipment

Opportunities

- Adoption of TC and other technologies
- Producer associations forge market linkages
- Producer-to-producer knowledge sharing
- Bulking with other producers to service large-scale retailers

Example: Mbarara District Farmers Association (MBDIFA)

Established in 1994, the Mbarara District Farmers Association (MBDIFA) operates in the leading banana producing district of Mbarara. With a membership of approximately 19,000 farmers, MBDIFA represents the largest farmers' organization in the region (MBDIFA 2010). MBDIFA's mission is to improve the livelihoods of local farmers (Ibid). The Uganda National Farmers' Federation (UNFFE) created MBDIFA as a branch of the umbrella organization to offer capacity building, advisory services, and advocacy for Mbarara-based farmer needs. This action manifested due to UNFFE dissatisfaction with governmental support to farmers in Mbarara (Ibid). In 2010, MBDIFA began building an Agro-Input Shop to increase access to quality input materials and share knowledge on best practices for using agricultural inputs (BidNetwork 2010). MBDIFA also helps implement projects on post-harvest handling and marketing of perishable agricultural products, with the aim of increasing access to advanced agricultural technology among banana producers (MTA n.d.).

Traders

Banana traders take on a number of roles, including negotiating prices with and purchasing bananas from farmers, sorting and grading crops, aggregating and packaging bananas, and transporting them to processors or retailers. Traders also often transport processed bananas from processors to market. At the "bulking" stage, traders collect bananas from farmers and then transfer them to collection centers where workers sort, grade, and package bananas before distributing them to markets (NARO 2010). After bulking, traders take goods to processors, retailers, or—in limited cases—prepare them for export. The transport system for banana includes a mix of informal independent traders and transporters employed directly by large firms (e.g., supermarkets). Informal actors—the majority of traders—include brokers who contract with retailers or who independently collect goods and then seek out opportunities to sell them to retailers (Ibid). Given the perishable nature of banana, farmers must quickly distribute bananas for sale (Ibid). Traders serve the function of connecting farmers to large formal and informal markets that might not be accessible otherwise – they also often play the role of wholesaler, which is not a well-developed function in banana (Ibid). According to NARO, 72 percent of producers sell their produce through traders (Ibid). Farmers selling crops to traders face challenges in capturing much of the market price; individual farmers collect only 20 percent of the consumer market price, while traders capture 35 percent of the market price (Ibid). Indicative of the benefits of collective bargaining for smallholders, farmers selling in informal groups gain 44 percent of the wholesalers' price, while those organized in collective marketing groups capture 67 percent of this price (Ibid).

Traders: Roles, Interactions, Challenges, and Opportunities

Roles and Interactions

- Collect produce from farmers
- Sort and grade produce
- Transport produce to rural or urban warehouses, processors, retailers, and wholesalers

Challenges

- Traders have negotiating power over smallholders

Opportunities

- Traders help farmers access otherwise inaccessible markets
- Traders can transfer knowledge about pricing/consumer demand to farmers

Example: Jay Fortune

The trader Jay Fortune exports handpicked fresh fruits and vegetables, including matooke cooking banana and dessert "apple bananas" from Ugandan farms (Jay Fortune 2014). Being a formalized entity, Jay Fortune stands apart from most informal traders. Yet, the company's experience provides a perspective on trading as part of an integrated set of bulking, trading, and export services integral to the value chain. Jay Fortune contracts farmers to supply the quantities and types of crops that best suit the needs and timeline of their customers (Ibid). Jay Fortune manages all stages of the banana distribution process. Upon collecting and sorting fresh produce from local farms, Jay Fortune transports the crops in refrigerated trucks (or "reefer trucks") to safeguard freshness and quality (Ibid). Once delivered to pack houses, workers package bananas in lined loose boxes (Ibid). Jay Fortune then transfers bananas to refrigerated rooms until they are transported for final delivery to processors or retail markets (Ibid).

Processors

Processing increases the value of bananas, enables the efficient transport of bulk bananas, reduces post harvest losses, and increases the shelf life of bananas (EAA n.d.). However, Uganda's banana industry lacks significant processing capacity. Smallholder farmers lack the resources to access quality processing equipment either as individuals or in groups. Industrial processing also remains underdeveloped due to expensive startup costs, lack of local know-how, and the high perishability of banana (Trias 2012). With 58.9 percent of cooking bananas and 39.6 percent of dessert bananas grown for household consumption, Ugandan farmers consume a large proportion of the bananas produced nationally—cooked or raw—rather than selling them (UBOS 2010b). When they are sold, farmers typically sell cooking bananas as a fresh product to local traders without value addition (New Agriculturalist 2009). Insufficient processing capacity hampers value chain development in a number of ways: it keeps farmers from capturing the higher market price that processed bananas can command; it also restricts consumers' ability to capture the nutritional benefits of bananas beyond their short shelf-life. Despite the limited processing capacity available in Uganda, some formal processors transform bananas into a variety of products, such as beverages (banana beer, juice, gin), desserts (cakes, crisps, bread, chips), fried products, banana paper, and organic products for export such as Tooke flour (FAO 2011).

Processors: Roles, Interactions, Challenges, and Opportunities

Roles and Interactions

- Contract traders to supply bananas
- Deliver banana value-addition services for retailers, and wholesalers
- Provide packaging services

Challenges

- Low processing capacity
- High costs of processing equipment

Opportunities

- Develop collection and bulking capacity in-house to capture higher percent of market price
- Develop relationships with farmer organizations to source large volumes of banana

Example: Presidential Initiative on Banana Industrial Development (PIBID)

Initiated in 2005, the Ugandan Presidential Initiative on Banana Industrial Development (PIBID) serves as a government-run rural incubator aimed at improving farmer access to advanced processing technologies and value addition enterprises (PIBID 2013). Boosting household income and banana exports serves as the ultimate goal of PIBID (Ibid.). The Bushenyi District Technology Incubator Center, a center with a processing capacity of five tons of banana per day, houses PIBID's banana processing and research activities (PIBID n.d.). The architects of PIBID believe these resources will enable rural matooke banana farmers to rapidly access profitable local, regional, and international markets by selling banana products such as flour, bread, and desserts (Ibid). PIBID aims to substitute over 25 percent of wheat in the bakery industry with banana flour (Ibid). To achieve these goals, PIBID offers services such as access to high quality processing equipment for banana value addition, quality assurance systems, and commercialization (Ibid). PIBID also operates community processing centers with food driers and skill development programs in value addition (Ibid).

Retailers

Like many banana value chain actors, retailers include those that participate in the formal sector and those who work in the informal sector. Retailers in the informal market include street-side vendors and rural village markets (NARO 2010). Farmers may act as retailers, selling their own products in local markets, or they may sell their produce to street-side vendors or traders, who then sell their products at a local market. Because more agricultural households are close in proximity to informal retailers, they represent the more readily accessible retail option and benefit from high access to bananas (UBOS 2011). These informal retailers may also have an advantage in negotiating sales prices, especially when dealing with farmers without the processing capacity to extend banana shelf life. Because formal retailers often concentrate in major cities, rural farmers find it challenging to gain market access to them (Ibid). Furthermore, formal retailers often have strict contractual agreements with suppliers that stock their stores, which makes securing this type of business more difficult. Thus, large-scale farmers and farmer producing groups find themselves better positioned to sustain business relationships with formal retailers, as they can more readily supply high volumes to meet business requirements.

Retailers: Roles, Interactions, Challenges, and Opportunities

Roles and Interactions

- Identify qualified and certified farmers to assume a supplier role
- Purchase products and traders
- Enforce quality assurance measures
- Stock stores based on consumer demand
- Sell products to consumers

Challenges

- Sourcing sufficient quantities of marketable processed material

Opportunities

- Develop relationships with farmer based organizations to offer training and advisory services on safety regulations and quality standards
- Purchase directly from farmer groups

Example: Shoprite Holdings Ltd.

Shoprite Holdings Ltd. is a South African retailer with three locations in Uganda, the first of which opened in 2000. With 361 stores in the region, it represents sub-Saharan Africa's largest retailer (Shoprite 2014). Shoprite caters to middle-income consumers, with the goal of offering affordable prices for grocery items and durable products (Shoprite 2013b). In Uganda, Shoprite contracts with suppliers—specifically small-scale local suppliers—to stock its stores with produce such as bananas (Ibid). Shoprite manages its solicitations through an online supplier portal, which forecasts stock needs, and has programs that provide support for small-scale produce suppliers to successfully comply with requirements (Shoprite Holdings Ltd 2013). Support for small-scale suppliers often takes the form of advisory programs on how to meet procurement, quality, and packaging standards as well as routine Shoprite visits to supplier locations (Shoprite 2013b).

Consumers

Ugandan banana consumers exhibit the highest per capita cooking banana consumption in the world, at 0.7kg daily consumption per person (IITA 2009). The latest Ugandan census data conducted in 2009 revealed that 34.6 percent of cooking banana is sold, 59.8 percent is consumed as household subsistence, and 0.6 is stored (UBOS 2010). While beer banana production is significantly lower than cooking banana production, farmers sell a higher proportion of beer bananas—77.8 percent, with only 11.8 percent consumed on-farm (UBOS 2010). Although consumers represent the final actors along the banana value chain, in many cases the value chain is quite short. Consumers are often themselves producers, relying upon their produce for household subsistence (Ibid.). Consumption also occurs at the level of purchase from informal and formal retailers who offer both processed and unprocessed banana products, such as street-side vendors, supermarkets, and restaurants. Despite being the second largest banana producing country in the world, Uganda ranked 40th in terms of the volume of banana exports (Global Post 2012). In fact, banana exports in Uganda drastically decreased from 3,025 tons in 1996 to 761 tons in 2011 (FAO 2011). Thus, while in previous decades international buyers made up a large proportion of Ugandan banana consumers, this is less the case today, exposing an attractive opportunity to win back international consumers.

Consumers: Roles, Interactions, Challenges, and Opportunities

Roles and Interactions

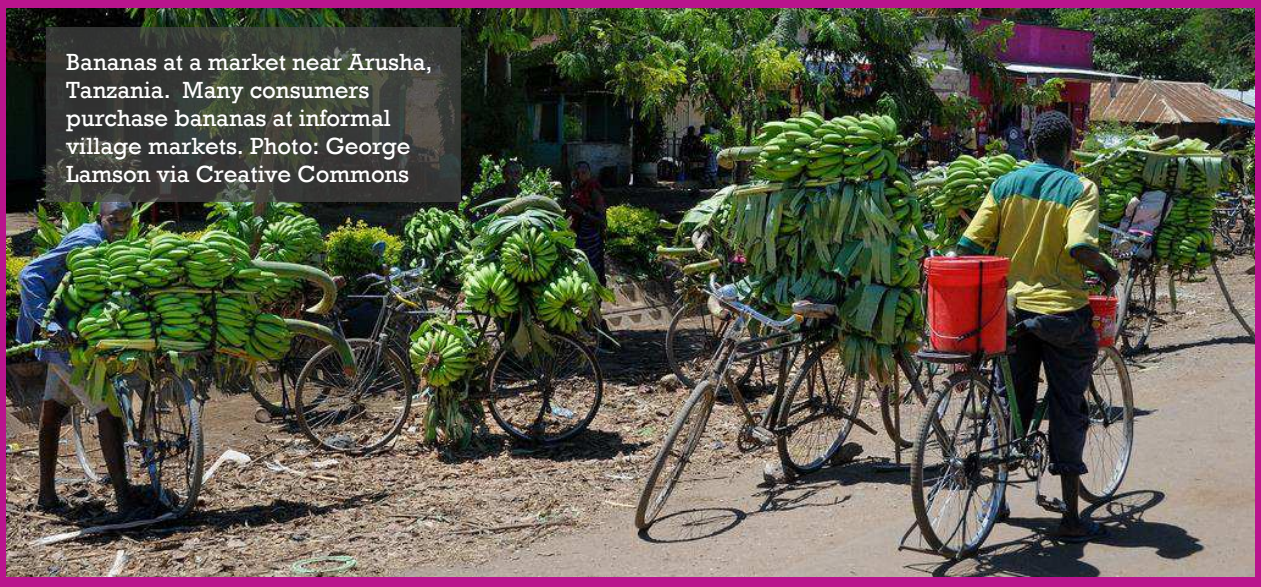
- Consume bananas produced on-farm
- Purchase raw and processed products from both formal and informal retailers

Challenges

- Significant income constraints, as most Ugandans live on less than $2 USD per day

Opportunities

- Current banana consumption levels suggest that with urbanization, Ugandans may buy more processed banana products
- Expand export of bananas



Bananas at a market near Arusha, Tanzania. Many consumers purchase bananas at informal village markets. Photo: George Lamson via Creative Commons

Uganda's OFSP value chain differs hugely from that of banana: farmers themselves consume 76% of Uganda's sweet potatoes (across varieties), resulting in limited value chain activity occurring beyond the farm-gate (UBOS 2010b). Of the OFSP going to market, most sells at informal markets rather than formal businesses. However, OFSP has also received attention as a way to reduce malnutrition and "hidden hunger," eliciting both government and donor support. Thus, it represents a contrasting value chain to banana: while banana experiences tremendous consumer demand, OFSP elicits weak demand from farmers and consumers, despite available planting material and evidence of health effects. Concerted market development initiatives aim to grow its prominence. Ultimately, if processors and others can attract consumers to eat OFSP, and if government and NGOs can effectively convince uptake through information sharing about OFSP's health benefits, value chain development will occur.

Challenges and opportunities in the sweet potato value chain

Uganda's OFSP value chain is still underdeveloped, especially when compared to banana, coffee, and other staple and cash crops. Uganda's OFSP value chain faces a number of challenges:

- Many Ugandans consider sweet potato a "poor man's food," and little marketing of or value addition in sweet potato occurs (SPK 2012; CIP 2009).
- Few farmers organize into associations or cooperatives focused on producing OFSP.
- Consequently, those farmers who do sell in the formal market have little ability to bulk products, and as a result, exert scant leverage with transporters.
- Though its availability and use have increased, OFSP is still not the primary or most valued sweet potato variety in Uganda (UBOS 2010b).

The fact that Ugandans eat large amounts of sweet potato—with the average farmer already growing multiple varieties—represents a positive sign for OFSP value chain development (EPAR 2013; Mmasa and Msuya 2012). Other opportunities include:

- Farmers can organize into associations or cooperatives, advocate for better prices, and take on roles traditionally played by traders to increase the income earned from this crop.
- Farmers and consumers who have had positive experiences with OFSP may develop a private sector-led industry, transitioning from what is currently largely a donor and government-supported sector. There exist great opportunities in value addition in OFSP, further providing avenues for private sector uptake and investment.

On the following page, find a visualization of the steps of the value chain that get TC OFSP vines from the lab to farmers—information gleaned through interviews with BioCrops. Because a large proportion of OFSP is consumed on farm, and because less information is available on the small part of OFSP production that is sold, fewer steps are profiled in the Uganda OFSP value chain as compared to that for banana. To supplement this incomplete value chain, and to provide an example of how such a value chain might be organized in the future, a full value chain for Tanzanian OFSP follows. Because of the nascent nature of the private OFSP market in Uganda, in-depth profiles of actors in OFSP are not included.

Uganda Orange-Fleshed Sweet Potato

Value Chain

The value chain that produces tissue culture for OFSP and delivers it to farmers - the value chain in which BioCrops works - includes five steps. A visualization and descriptions of these steps follows. Icons indicate the actors implicated in each step.

1

Purchase TC production inputs from suppliers:

TC Producers purchase inputs, such as chemicals and equipment, from private companies and government labs. Depending on the chemical or piece of equipment, these entities may be based in Uganda, or in another part of the world.

2

Multiply clean OFSP vines:

TC OFSP Producers clean and multiply biofortified OFSP vines. Vines are hardier than banana plantlets, but are also initially raised in hygienic, protected conditions before sale.

3

Transport vines to nurseries:

Extensionists and implementers either hire trucks or drive their own to pick up OFSP vines from the TC producer and deliver these vines to nurseries for further propagation.

4

Multiply vines at nurseries:

At nurseries, distributors continue to multiply vines. These vines are then picked up by various organizations, as well as some farmer groups.

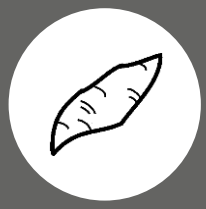
5

Deliver vines to farmers:

Government extensionists and implementers work with distributors and transporters to deliver planting materials to farmer groups. Often these vines are provided free, or at highly subsidized prices. Farmers then produce OFSP, largely for home consumption.

Tanzania OFSP

Value Chain



Building off of an analysis by Institute for Development Studies, Tanzania's TC OFSP value chain includes six broad steps (Temu et al 2014). Below find a visualization and descriptions of these steps, as well as icons indicating the actors implicated

1 **Purchase TC production inputs from suppliers:**

TC Producers purchase inputs, such as chemicals and equipment, from private companies and government labs. Development organizations are key to initiating this process.

2 **Produce TC OFSP plantlets:**

TC Producers eliminate OFSP viruses by cleaning and multiplying OFSP vines. After cleaning the planting material, producers pot the material in a sterilized medium and grow it in a greenhouse under extremely hygienic conditions.

3 **Sell clean OFSP vines to farmers:**

Despite the fact that OFSP uptake is still emerging and adoption is slow, farmers purchase and grow OFSP vines, usually facilitated by NGOs with a nutrition focus. Mainly smallholder farmers, these actors are also the primary consumers of OFSP.

4 **Traders sell to retailers, processors, and exporters:**

After purchasing OFSP from farmers, traders transport OFSP to retailers, processors, and (in some cases) exporters. A handful of agents export OFSP to the Middle East; however, volumes of exported OFSP remain small.

5 **Processors purchase OFSP and process it into various food products:**

The majority OFSP is consumed with little or no processing. The commercial processing that exists is usually small-scale and sponsored by development projects. Processed goods include flour, chips, and other products.

6 **Retailers sell to consumers:**

Consumers purchase OFSP from markets in fresh or processed form; however, most OFSP consumers eat OFSP they produced on their farms. When supplies are available, OFSP are sold in urban food kiosks. Processed OFSP goods are available in a handful of urban supermarkets, but for high prices.

Rami Alsouqi (far left) and Dr. Nina Fedoroff (middle left) discuss banana hardening methods with BioCrops' Dr. David Talengera (middle right) and Dr. Geofrey Arinaitwe (far right). Photo: GKI

Outputs and Outcomes: Case Studies of Successful Seed Distribution Systems

Outputs and Outcomes: Case Studies of Successful Seed Systems

It is difficult to predict what a successful plant material production and distribution system in rural Uganda would look like without first unpacking all of the challenges and sub-challenges that constrain it. Even as the LINK team works on problem framing, much can be learned by exploring successful seed distribution systems in other contexts. This section provides three case studies intended to inspire innovative solutions to the TC Challenge. First, One Acre Fund's combined approach that offers input financing, distribution, and training in Rwanda, Kenya, and Burundi is presented. Next, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and SeedCo efforts in Zimbabwe follow. Finally, Africa Harvest Biotech Foundation International's effort to scale tissue culture bananas in Kenya illustrates an integrated set of innovative solutions that boosted farmer incomes by as much as 400%.

As the value chain analyses in the previous section illuminate, two of the major constraints to Ugandan farmers improving their incomes are (1) the challenge of accessing inputs, and (2) the difficulty smallholders face in marketing produce to urban consumers. By presenting case studies of groups that successfully provide plant material and other inputs to farmers—and combine this service with capacity building, marketing, and organizational support—this section endeavors to inspire ideas on how such a system might work for banana and OFSP in Uganda.

Although these case studies contain similarities, the actors within them used distinct mechanisms that allowed each to be successful. The table below highlights the unique mechanisms used in each intervention. The following pages offer brief case studies.

Mechanisms used in seed distribution case studies			
	One Acre Fund (OAF)	**ICRISAT/SeedCo**	**Africa Harvest**
Financing for inputs	OAF finances inputs, with a small down payment and the rest collected at harvest	SeedCo initially provided farmers credit to purchase small seed packets—they phased this out, but demand for seeds remained strong	Africa Harvest worked with micro-finance organizations to avail financing for plant materials
Distribution mechanisms	OAF operates offices within walking distance of farmers for easy access and monitoring	ICRISAT distributed seeds through SeedCo, which had a strong network in rural Zimbabwe	*
Small input bundles	Though not as small as SeedCo's seed packets, OAF designs input bundles for small scale farmers	SeedCo developed seed packets much smaller than the normal 25 Kg volume	*
Help in organizing farmer groups	OAF assists farmers in organizing. It also assists groups with marketing	*	Africa harvest organized and trained farmer groups, it also provided marketing assistance
Capacity building efforts	OAF uses a training of trainers model to empower farmers to train each other	*	Africa Harvest used farmer field schools to train farmers on TC bananas; trained lab technicians at Kenyan institutions to produce TC
Collaboration with in-country actors	*	ICRISAT implemented this project through close coordination with SeedCo	Africa Harvest worked with a large number of private, government, and NGO actors to implement the project
Build systems for TC production	*	*	Worked with Kenyan public institutions and universities to create sources for TC
Crop insurance	OAF often provides crop insurance with their bundles	SeedCo no longer purchases unsold crops to mitigate risk, though it had previously	*

* Not a major element of intervention

Outcomes

Case studies of effective seed and plant material distribution systems

Challenge: Farmers cannot access or afford up-front costs of improved seeds

Bundled seeds and services for productivity

Country: Kenya, Rwanda, Burundi
Crop: Various
Implementing organization: One Acre Fund

Increased farm productivity makes the difference between poverty and prosperity for many smallholder farmers in East Africa. Recognizing the leaps in productivity possible with just a few inputs, One Acre Fund (OAF) has worked since 2006 to help African farmers access quality seeds and other inputs to improve productivity and support their families by providing input financing, distribution, and training within walking distance to the farmers they serve (Binns 2011).

In Kenya, Rwanda, Burundi, and Tanzania, OAF offers "bundles" of seed, fertilizer, training, and market access to smallholder farmers (OAF n.d.). OAF provides these packages through asset-based loans with a flexible repayment schedule (Dare and Hanson 2014). Worth about $80 USD each, the loans of improved (and at times traditional) seed and fertilizer are less intimidating for farmers than other options. Farmers repay approximately 10% of the value of their loan before receiving their seed and fertilizer. The remainder of the value of the loan can be repaid as suits the farmer up to a deadline set just after harvest (Ibid.).

Asset-based lending paired with training also lowers the risk borne by lenders because they know exactly what investment they are making and that the inputs will be used properly (Ibid.). OAF establishes a pyramid system of training networks: one local field officer manages a group of 200-250 farmers; 10 of these farmer groups report to a field manager (ODI 2013). The success of the model rests in its reliance on training farmers to produce crops more effectively—some farmers report tripling their yield—with technologies and inputs that are familiar (Ibid.). To help farmers get the most out of their loans, OAF helps them market their output and connect with buyers. In many cases, OAF reports, farmer incomes double after joining their program.

OAF's experience has not been all rosy. When OAF tried to implement this program in Uganda, it faced serious challenges. Because, on average, farmers in Uganda have more land than smallholders in Rwanda, Kenya, or Burundi, they had less of an incentive to improve their agronomic practices; rather, they preferred to just plant on more land (Binns 2011). They have since chosen to focus their efforts where there is clearer demand.

Challenge: Lack of evidence on producer demand hampers improved seed uptake by private sector

Small seed packets for big agricultural outputs

Country: Zimbabwe
Crop: Sorghum, millet, others
Implementing organization: ICRISAT & SeedCo

In the first years of the 21st century, commercial seed companies in southern Africa avoided investing in rural seed sales networks because they perceived a lack of demand for Open Pollenated Varieties (OPV) (as opposed to hybrid or heirloom, etc.) of seed for staple crops from both smallholder farmers and rural retailers (Monyo, Rohrbach & Mgonja 2004). At the same time, farmers cited lack of access to OPVs as their main reason for not adopting them. How could smallholder farmers and commercial seed companies find a win-win solution on improved seed? The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the Seed Company of Zimbabwe (SeedCo), a wholesale seed producer, partnered to pilot a model to do just that. Their method: selling seeds in small packages through rural retailers (Ibid.).

Key elements of success for this model included capitalizing upon existing agricultural networks and packaging improved seed in volumes suitable to smallholder farmers. ICRISAT developed OPV staple crop seeds and distributed them through SeedCo, a seed producer with an established retail network in rural Zimbabwe for hybrid maize (World Bank n.d.). SeedCo distributed OPV seed for sorghum, pearl millet, groundnut, and sunflower to 14 credit-worthy rural retailers in small quantities (Ibid.). Rather than packaging the improved seed in the standard 25 kg bags that smallholders could not afford, retailers would sell packets in much smaller volumes, ranging from 0.5 to 5 kg (Monyo, Rohrback, and Mgonja 2004).

In the first year, SeedCo sold seeds to retailers on credit and minimized retailer risk by promising to buy back any unsold stock. In return, retailers limited their markup to a maximum of 2.5%, while still including the full cost of packaging in the price (World Bank n.d.). Farmers appreciated these size options and became a reliable market for the seeds, with 55% of small seed packets in rural shops selling (Ibid.). Farmers were willing to purchase the small seed packets without subsidy. Program organizers wisely chose to locate points of sale in drought-prone areas, where demand for improved seed would be highest (Monyo, Rohrback, and Mgonja 2004).

In subsequent years, SeedCo removed the credit component, but participation by rural retailers continued without customer decline (World Bank n.d.). Program organizers did not run any extra marketing campaigns to raise awareness of availability of new seeds; instead, word of mouth and presence in local shops attracted new consumers (Ibid.). Farmers, satisfied with the price and availability, even requested that the small packaging size be extended to seed for other crops, including maize (Ibid.).

Challenge: Farmers need access to tissue culture, and help growing and marketing crops from TC plantlets

A Value Chain Approach to Kenyan Tissue Culture Banana

Country: Kenya
Crop: Banana
Implementing organization: Africa Harvest Biotech Foundation International

In East Africa, banana farmers face challenges ranging from plant disease and infestation, to poor plant husbandry practices and insufficient links to markets (Acharya & Mackey 2008). With many farmers perceiving banana as a subsistence crop, in the 1990s few banana research projects existed and policy designed to support banana farming was scant (Wambugu 2004). While TC banana has the potential to stem the spread of disease and increase productivity, when first introduced in East Africa TC failed to meet smallholders' needs; thus, no immediate market was established (Ibid). The Tissue Culture Banana Project commenced in Kenya in the 1990s to help boost access and extend the benefit from TC banana, and in 2003 Africa Harvest Biotech Foundation International stepped in to scale the project, addressing the bottlenecks to marketing TC bananas through a "whole value chain" approach (Ibid; Acharya & Mackey 2008).

TC banana cultivation means more than simply using a different plantlet from traditional bananas. TC bananas mature faster and have greater yields, but also require more inputs (Acharya and Mackey 2008). To scale TC banana cultivation in Kenya, Africa Harvest identified and addressed challenges at critical phases in the TC banana farming value chain: (1) awareness; (2) seedling availability and affordability; (3) growing and orchard management; (4) post-harvest handing; and (5) marketing and consumer acceptance (Ibid.). In these efforts, they involved actors from the breadth of the value chain: farmers; marketing companies; growers associations; private laboratories and public institutions like Kenya Agricultural and Livestock Research Organization (KALRO, formerly KARI); micro-credit institutions; and entrepreneurs and investors (Ibid). Each of these actors played important roles in creating linkages and strengthening the value chain for TC banana.

Before distributing TC to farmers, Africa Harvest needed to develop systems to effectively clean and multiply TC planting material, and build the skills needed in Kenya to make this effort sustainable. To meet these dual goals, Africa Harvest worked with KALRO and local universities to build TC production capacity. They did this through training at labs and nurseries, and developing procurement systems with local institutions (Ibid).

To develop awareness and skills for growing TC bananas, and handling them post-harvest, farmers received training through farmer field schools (Acharya and Mackey 2008). Africa Harvest built marketing awareness through exchange visits and developed packaging that detailed guidelines for producing bananas and possible uses of TC bananas (Ibid). While making plantlets affordable was a challenge for Africa Harvest, they succeeded in reducing costs by developing "hardening" nurseries that minimized the costs of distribution. Simultaneously, they secured partnerships with micro-finance institutions to increase farmers' access to credit for purchase of TC banana plantlets (Ibid). Africa Harvest also focused on marketing by linking farmers in groups and connecting them with marketers (Ibid.). As a result, between 2003 and 2007 banana yields increased 250% and farmer incomes increased up to 400% (Kinyua 2008).

This model yielded a full system for TC bananas that incentivized participation among all actors in the value chain from entrepreneurs and private seed companies, to farmers, government, and consumers.

Annex I: References

ACDI/VOCA. 2014. "Potato Farmers Fight Poverty in Uganda." Retrieved from: http://www.acdivoca.org/site/ID/ugandapotatofarmers

Acharya, S. and M. Mackey. 2008. *Socio-economic Impact Assessment of the Tissue Culture Banana Industry in Kenya*. AfricaHarvest: Nairobi.

African Agricultural Technology Foundation (AATF). 2012. "Increasing banana yields by using tissue culture method." Retrieved from: http://banana.aatf-africa.org/news/media/increasing-banana-yields-using-tissue-culture-method.

Afrosoko. 2012. Afrosoko Website. Retrieved from: http://afrosokolink.org/about-us.html

Agro Genetic Technologies Ltd (AGT). 2010. AGT Website. Retrieved from: http://www.agtafrica.com/Laboratories/LabObjectives.aspx

Agutamba, K. 2014. 2015: "The Test that Awaits Northern Corridor Projects." *The New Times*. Retrieved from: http://www.newtimes.co.rw/section/article/2014-12-24/184352/

AidData. 2015. *Aid Allocation Distribution*. Retrieved from: http://aiddata.org.

AllAfrica. 2008. "Uganda: Kibuzi Bananas follow Citizens to London." All Africa Website. Retrieved from: http://allafrica.com/stories/200811180569.html

Alliance for a Green Revolution in Africa (AGRA). 2010. *Mid-Term Review of the Program for Africa's Seed Systems*. AGRA: Nairobi.

ASCP. 2013. "Building a laboratory workforce to meet the future." Retrieved from: http://www.ascp.org/pdf/advocacy/ascp-task-force-on-lab-pros.pdf

Bagamba and Ilukor. N.d. Sweet Potato and Potato Production Systems in Uganda. PPT Presentation.

BidNetwork. 2010. "MBADIFA Agro-Input Shop Business Plan." BidNetwork Website. Retrieved from: http://www.bidnetwork.org/en/plan/180803

Binns, C. 2011. "One Acre at a Time." *Stanford Social Innovation Review*. Retrieved from: http://www.ssireview.org/articles/entry/one_acre_at_a_time

BioFresh Ltd. 2014. BioFresh Ltd Website. Retrieved from: http://www.biofreshltd.com/about-us

Bonabana-Wabbi, J., Ayo, S., Mugonola, B., Taylor, D., Kirinya, J., and M. Tenywa. 2013. "The performance of potato markets in South Western Uganda". *Journal of Development and Agricultural Economics*. Vol. 5(6), pp. 225-235.

Brar, S., Farley, S., Hawkins, R., and C. Wagner. 2011. *Science, Technology and Innovation in Uganda.* The World Bank: Washington, DC.

Bridge, A., Kipp, W., Raine, K., Konde-Lule, J. 2006. *Nutritional status and food consumption patterns of young children living in western Uganda.* East African Medical Journal 83(11): 619-625.

CEPII. 2014. *CEPII Database.* Retrieved from: http://www.cepii.fr/CEPII/en/bdd_modele/bdd.asp

Chemonics International Inc. 2008. *Moving from Subsistence to Commercial Farming in Uganda: Agricultural Productivity Enhancement Program Final Report*. USAID: Washington, DC.

Commercial Tissue in Uganda. 2012. Retrieved from: http://www.slideshare.net/b4fa/commercial-tissue-culture-in-uganda-november-2012

Consultative Group for International Agriculture (CGIAR). 2012. "BREAD: Fast Breeding for Slow Cycling Crops: Double Haploids in Cassava and Banana/Plantain." *CGIAR Ongoing Research.* Retrieved from: http://ongoing-research.cgiar.org/factsheets/breadfast-breeding-slow-cycling-crops-double-haploids-cassava-bananaplantain/

Dare, L. and S. Hanson. "Asset-Based Financing and Flexible Repayment Schedules to Better Serve Africa's Smallholder Farmers". *Center for Financial Inclusion Blog*. Retrieved from: http://cfi-blog.org/2014/03/31/asset-based-financing-and-flexible-repayment-schedules to-better-serve-africas-smallholder-farmers/

Dubois, T. 2011. "Towards a healthy banana TC industry." Retrieved from: http://r4dreview.org/2011/04/towards-a-healthy-banana-tc-industry/

East Africa Agribusiness (EAA). N.d. "Uganda Starts Banana Processing and Exporting." EAA Website. Retrieved from: http://ea-agribusiness.co.ug/uganda-starts-banana-processing-and-exporting/

Evans School of Policy Analysis and Research (EPAR). 2013. EPAR Brief No. 217: Sweet Potato Value Chain in Uganda. Retrieved from: http://evans.washington.edu/files/EPAR_UW_Request_217_Uganda_Sweet_Potatoes_Final[1].pdf

United Nations Food and Agricultural Organization (FAO). 2015. FAOSTAT Database. Retrieved from: http://faostat.fao.org/site/342/default.aspx

United Nations Food and Agricultural Organization (FAO). 2011a. Intergovernmental Group on Bananas and Tropical Fruits: Economic Significance of Banana Varieties Other Than Cavendish – Uganda Case Study. Retrieved from: http://www.fao.org/docrep/meeting/022/ma801e.pdf

United Nations Food and Agricultural Organization (FAO). 2011b. FAOSTAT Database. Retrieved from: http://faostat.fao.org/site/342/default.aspx

Foodnet. 2005. Kampala Traders. Foodnet Website. Retrieved from: http://www.foodnet.cgiar.org/market/Uganda/Prices/ugandatraders.htm

Global Knowledge Initiative (GKI). 2014. Interviews with BioCrops Uganda Ltd. Conducted by GKI in Kampala, Uganda, June 2014. GKI: Washington, DC.

Global Post. 2012. "Uganda Goes Bananas." Global Post Website. Retrieved from: http://www.globalpost.com/dispatch/news/regions/africa/120419/uganda-goes-bananas

Global Times. 2012. "China Boosts Uganda's Road Construction, Unlocking Economic Potential." Global Times. September 25, 2012. Retrieved from: http://www.globaltimes.cn/content/735173.shtml

Gollin, D. and R. Rogerson. 2010. "Agriculture, Roads, and Economic Development in Uganda." *National Bureau of Economic Research*. NBER WORKING PAPER 15863.

HarvestPlus. 2012. *Uganda Country Report.* Retrieved from: http://r4d.dfid.gov.uk/PDF/Outputs/Misc_Crop/Uganda-country-report_web.pdf

HarvestPlus. 2012. *Disseminating Orange-Fleshed Sweet Potato: Findings from a HarvestPlus Project in Mozambique and Uganda*. HarvestPlus: Washington, D.C.

Institute for Marketecology Uganda (IMO). 2014. IMO Official Website. Retrieved from: http://www.imo.ch/logicio/pmws/indexDOM.php?client_id=imo&page_id=ug

International Atomic Energy Agency. 2004. "Low cost options for tissue culture technology in developing countries." Retrieved from: http://mvgs.iaea.org/pdf/TECDOC1384.pdf

International Food Policy Research Institute (IFPRI.) 2010. *Impact of Farmer Field Schools on Agricultural Productivity and Poverty in East Africa*. Retrieved from: http://www.ifpri.org/sites/default/files/publications/ifpridp00992.pdf

International Institute of Tropical Agriculture (IITA). 2013. "A training course for banana farmers interested in growing tissue culture bananas." Retrieved from: http://www.iita.org/c/document_library/get_file?uuid=961e89b0-1827-43f5-bc8c-3f3fdf04ec10&groupId=25357

IITA. 2010. Banana Value Chains in Central Africa: Constraints and Opportunities. Retrieved from: http://ageconsearch.umn.edu/bitstream/96169/2/114.%20 Banana%20value%20chains 20in%20Central%20Africa.pdf

International Institute of Tropical Agriculture (IITA). 2009. IITA Website. Retrieved from: http://www.iita.org/banana-and-plantain

International Potato Center (CIP). 2009. Challenge Theme Paper No.4 : Sweet Potato Value Chains. Retrieved from: http://sweetpotatoknowledge.org/adding-value/value-chain-approach-to-sp/CH4%20CHALLENGE%20THEME4% 20VALUE%20CHAINS.pdf

CIP. 2008. Facilitating Pro-Poor Market Chain Innovation. Retrieved from: file:///Users/latoyamcdonald/Downloads/004287%20(1).pdf

International Service for the Acquisition of Agri-biotech Applications (ISAAA). 2014. "Pocket K No. 14: Tissue Culture Technology." Retrieved from: http://www.isaaa.org/resources/publications/pocketk/14/default.asp

ISSUU. 2014. Agribusiness Directory. Retrieved from: http://issuu.com/agribusiness/docs/agribusiness_directory_uganda_2014

Jay Fortune. 2014. Jay Fortune Website. Retrieved from: http://www.jayfortune.com/english/index.php/packaging

Kahangi, E. 2010. "The Potential of Tissue Culture Banana (Musa spp) Technology in Africa and the Anticipated Limitations and Constraints." Retrieved from: http://www.banana2008.com/cms/details/acta/879_28.pdf

Kakooza, A. 2010. *The Enforcement of Intellectual Property Rights in Uganda: The Complexities and Realities*. University of Warwick, UK.

Karembu, M. 2007. "Enhancing the Diffusion of Tissue Culture Bananas to Small-Scale Farmers in Kenya." Retrieved from: http://www.isaaa.org/kc/cropbiotechupdate/documents/TC_Banana_Policy_Brief.pdf

Kasita, I.. 2012. "Demand for Electricity Up." New Vision. Retrieved from: http://www.newvision.co.ug/news/634884-Demand-for-electricity-up.html

Kinyua, H. 2008. Transformed Banana Value Chain—TechnoServe. Retrieved from: http://www.banana2008.com/cms/posters/kinyua.pdf

Lerner, E. 2014. "Eric Lerner THICK Interview". Conducted by GKI. Global Knowledge Initiative: Washington, DC.

Lule, M.., Dubois, T., and D. Coyne. 2013. "Trainer's manual: a training course for banana farmers interested in growing tissue culture bananas." IITA. Retrieved at: http://www.iita.org/c/document_library/get_file?uuid=961e89b0-1827-43f5-bc8c-3f3fdf04ec10&groupId=25357.

Makerere University. 2014. "Biotechnology and Biosafety Law Process in Ugand *College of Natural Sciences*. Retrieved from: http://cns.mak.ac.ug/biotechnology- and biosafety-law-process-uganda

Majestic Directories (MD). 2014. "Mashamba Brand Company Profile." Retrieved from: http://www.majestysdirectory.com/mashambaicemark-africa/

Maendeleo Agricultural Technology Fund (MATF). N.D. "Postharvest Handling and Marketing of Perishable Agricultural Products Project with MBDIFA." Retrieved from: http://api.ning.com/files/OS21uYIJMcVFCuaEUxXquYg46hIYyRnYDVpb6HClu25a9g9okNQ9vZWCAF5V7oSR-GRIbsb3d*OH6GclAEBKJx0OykeQK7JE/MBADIFAprojectbrief.pdf

Mbarara Disctrict Farmer's Association (MBDIFA) 2010. MBDIFA Website. Retrieved from: http://www.mbadifa.org/progservices.php

Mmasa and Msuya. 2012. "Mapping of the Sweet Potato Value Chain Linkages Between Actors, Processes, and Activities in the Value Chain: A Case of "Michembe" and "Matbolwa" Products." Retrieved from: www.ccsenet.org/journal/index.php/sar/article/download/14578/9941

Moghaddam, S., Hawa J., Maheran, A., Rusli, I., Asma, B., and E. Philip. 2011. "Optimization of an efficient semi-solid culture protocol for sterilization and plant regeneration of Centella asiatica (L.) as a medicinal herb." *Molecules* 16, no. 11: 8981-8991.

Monyo, E. Rohrbach, D, and M Mgonja. 2004. "New partnerships to strengthen seed systems in Southern Africa: Innovative community/commercial seed supply models." From *Successful Community Based Seed Production Strategies*, Eds. Sentimela, P., Monyo, E., and M. Banziger. CIMMYT: Mexico City.

Muchira, J. 2013. "Uganda Announces $400m plan to Modernise Entebbe Airport." Engineering News. Retrieved from: http://www.engineeringnews.co.za/article/uganda-announces-400m-plan-to-modernise-entebbe-airport-2013-07-26

Musisi, F. "Energy Demand Increases as Uganda Faces Load Shedding." Daily Monitor, December 17, 2013. Retreived from: http://www.monitor.co.ug/Business/Prosper/Energy-demand-increases-as-Uganda-faces-load-shedding/-/688616/2114116/-/kdetd8/-/index.html

Mwombe, S. N.d. “Evaluation of Information and Communication Technology Utilization By Smallholder Banana Farmers in Gatanga District, Kenya.” Retrieved from: file:///Users/Home/Downloads/Department_of_Agricultural_Economics_-_EVALUATION_OF_INFORMATION_AND_COMMUNICATION_TECHNOLOGY_UTILIZATION_BY_SMALL_HOLDER_BANANA_FARMERS_IN_GATANGA_DISTRICT_KENYA_-_2012-06-25.pdf

Nabwiiso, S. 2014. “Not Enough Cold Storage in Uganda.” The East African Business Week. Retrieved from: http://www.busiweek.com/index1.php?Ctp=2&pI=588&pLv=3&srI=68&spI=107&cI=10

Namanda, Sam, Richard Gibson, and Kirimi Sindi. 2011. “Sweet Potato Seed Systems in Uganda, Tanzania, and Rwanda.” Journal of Sustainable Agriculture, Vol. 35, No. 8, pp. 870-884. Retrieved from: http://sweetpotatoknowledge.org/seedsystem/Sweetpotato%20Seed%20Systems%20in%20Uganda%20Tanzania%20and%20Rwanda.pdf

National Agricultural Research Organization (NARO). 2014. NARO Website. Retrieved from: http://www.naro.go.ug/

National Agricultural Research Organization (NARO.) 2010. The Extent and Causes of Banana (Musa spp.) Market Distortions in Uganda. Retrieved from: http://www.banana2008.com/cms/details/acta/879_12.pdf

National Agricultural Research Organization (NARO.) 2005. NARO Website. Retrieved from: http://www.naro.go.ug/Institute/Namulonge/

National Resources Institute (NIR). 2005. Promotion of Sustainable Sweet Potato Production and Post-Harvest Management through Farmer Field Schools in East Africa. Retrieved from: http://r4d.dfid.gov.uk/PDF/Outputs/CropProtection/R8167_FTR.pdf

Niedz, R. 1998. "Using isothiazolone biocides to control microbial and fungal contaminants in plant tissue cultures." *HortTechnology* 8, no. 4: 598-601.

New Agriculturalist. 2009. “A New Take on Matooke.” Retrieved from: http://www.new-ag.info/en/focus/focusItem.php?a=669

Nsubuga, E. 2012. "Agro-Genetic Technologies, Ltd: Commercial Tissue Culture in Uganda." Retrieved from: http://www.slideshare.net/b4fa/commercial-tissue-culture-in-uganda-november-2012.

Ogwang, J. 2013. “Uganda: Traffic Jams - Uganda's New Health, Economic, Environmental Disaster”. *The New Vision*. Retrieved from: http://allafrica.com/stories/201302261381.html

One Acre Fund (OAF). N.d. *Program Model*. Retrieved from: http://www.oneacrefund.org/our-approach/program-model/

Overseas Development Institute (ODI). 2013. *Leaping and Learning: Linking Smallholders to Markets*. Retrieved from: http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8401.pdf

Otushabire, T. 2011. "Using genetic technology to produce more matooke." *Daily Monitor*. Retrieved from: http://www.monitor.co.ug/Magazines/Farming/-/689860/1168524/-/item/0/-/sj3oc3/-/index.html.

Oxford Policy Management. 2005. *Evaluation of the Plan for the Modernisation of Agriculture, Uganda.* Oxford Policy Management: Oxford.

Presidential Initiative for Banana Industrial Development (PIBID). 2013. PIBID Website. Retrieved: http://www.pibid.org/index.php/about-us/who-we-are

PIBID. N.d. Models of Knowledge-Based Transfer—the Case of the Presidential Initiative on Banana Industrial Development (PIBID). Retrieved from: http://www.eastsym.org/documents/P2_Muranga_ModelsOfKnowledge.pdf

Ravinvest. 2006. "From Farmer Field School to Association: The Story of Abuket Sweet Potato Association." Retrieved from: http://www.ravinvest.biz/downloads/Stories/StoryEkinyuSPotato.pdf

Shively, G. and J. Hao. 2012. *A Review of Agriculture, Food Security, and Human Nutrition Issues in Uganda.* Purdue University Department of Agricultural Economics. Retrieved from: http://www.agecon.purdue.edu/staff/shively/Uganda_review.pdf

Shoprite. 2014. Shoprite Website. Retrieved from: http://www.shoprite.co.za/Pages/Uganda.aspx

Shoprite. 2013. Shoprite Sustainability Report 2013. Retrieved from: http://www.shopriteholdings.co.za/Sustainability/Sustainability/Documents/SUSTAINABILITY_REPORT_30Sept2013.pdf'

Shoprite. 2013b. Shoprite Integrated Report 2013. Retrieved from: http://www.shopriteholdings.co.za/InvestorCentre/Documents/2013/Shoprite_2013_Integrated_Report.pdf

Smale, M. and Wilburforce, T. 2007. "An Economic Assessment of Banana Genetic Improvement and Innovation in the Lake Victoria Region of Uganda and Tanzania." IFPRI: Washington, DC. Retrieved from: http://www.ifpri.org/sites/default/files/publications/ab155.pdf

Soroti Sweet Potato Producers and Processors Association (SOSPPA). 2007. "Starting a Warehouse Receipt System for Kyere, Uganda." Retrieved from: http://www.ravinvest.biz/downloads/Stories/StoryZeblonSorotiWRS.pd

Ssuuna, I. 2013. "New Rwanda airport ready for take-off." The East African. Retrieved from: http://www.theeastafrican.co.ke/business/New-Rwanda-airport-ready-for-take-off/-/2560/1747438/-/oqexn5z/-/index.html

Sweet Potato Knowledge (SPK). 2012. DONATA Enhanced Uptake and Adoption of Orange-Fleshed Sweet Potato (OFSP) Technologies in Ethiopia, Kenya, Rwanda, Tanzania, and Uganda. Retrieved from: http://sweetpotatoknowledge.org/projects-initiatives/sweetpotato-for-profit-and-health-initiative-sphi/sphi-flyers/11SPHIFLYER_DONATA_201208.pdf

SPK. 2007. Training Manual on Marketing and Product Development for Extension Workers. Retrieved from: http://sweetpotatoknowledge.org/use-consumption/nutritional-information/training-material-from-harvestplus/training-material-from-harvestplus/harvestplus-mpd-training-manual-for-extensionists.pdf

Temu, A., Waized, B., Ndyetabula, D., Robinson, E., Humphrey, J., and S. Henson. 2014. "Mapping Value Chains for Nutrient-Dense Foods in Tanzania." *Institute of Development Studies*. Retrieved from:http://opendocs.ids.ac.uk/opendocs/bitstream/handle/123456789/4025/ER76%20Mapping%20Value%20Chains%20for%

Thomson Reuters. 2014. *Web of Science.* Retrieved from: http://wokinfo.com/

Trias. 2014. Trias Website. Retrieved from: http://www.triasngo.org/about-trias/

Trias. 2012. “Sub-sector Study on Matooke Banana in Uganda.” Retrieved from: http://api.ning.com/files/*4tKBBKl2VgfkPTUA8DuPv9i3n9LsIR5fuSBZbUYJAcyEkkJtUYv6Sj-Ura6lIEEWSAaqxDSP2N4xUxBN7gafib41t4Djrt/FinalvaluechainreportonBananaMatookeHighlandcooki.pdf

Uganda Bureau of Statistics (UBOS). 2011. Uganda Census of Agriculture 2008/2009 At A Glance. Retrieved from: http://www.ubos.org/onlinefiles/uploads/ubos/pdf%20documents/UCAGlance.pdf

UBOS. 2010. Volume III: Agricultural Household and Holding Characteristics Report. Retrieved from: http://www.ubos.org/onlinefiles/uploads/ubos/pdf%20 documents/UCAholding.pdf

UBOS. 2010b. Uganda Census of Agriculture 2008/2009: Volume IV Crop Area and Crop Production Report. Retrieved from: http://www.ubos.org/onlinefiles/uploads/ubos/pdf%20documents/UCACrop.pdf

Uganda Investment Authority. 2013. *ICT Sector Profile*. Retrieved from: http://ugandainvest.go.ug/index.php/usp/doc_details/160-icd-corprate-brochure

Uganda Ministry of Finance, Planning and Economic Development (MFPED). 2012. *National Science, Technology and Innovation Plan*. Government of Uganda: Kampala.

MFPED. 2008.*National Biotechnology and Biosafety Policy.* Government of Uganda: Kampala Retrieved from: http://scifode-foundation.org/attachments/article/16/National %20 Biotech%20Policy%20-%20Approved%20by%20Cabinet%20on%202%20April%202008.pdf

MFPED. 2013. Millennium Development Goals Report for Uganda 2013. Government of Uganda: Kampala. Retrieved from: http://www.us.undp.org/content/dam/uganda/docs/UNDPUg-2013MDGProgress%20Report-Oct%202013.pdf

Uganda National Bureau of Standards. 2015. *Product Testing*. Retrieved from: http://www.unbs.go.ug/#

Uganda National Roads Authority (UNRA). *National Roads Development Plan 2009/2010.* Retrieved from: http://www.unra.go.ug/intranet/forms/UNRA%20Business%20Plan%20book.pdf

Uganda Office of the Auditor General (UOAG). 2010. *Value for Money Audit Report on Regulation and Enforcement of Standards by Uganda National Bureau of Standards.* UOAG: Kampala. Retrieved from: http://www.oag.go.ug/uploaded_files/1273678678UNBS-Report.pdf

Uganda Planning Authority. 2013. Uganda Vision 2040. Retrieved from: http://npa.ug/uganda-vision-2040/

Uganda Road Sector Support Initiative (URSSI). 2012. “Road Safety.” URSSI. Retrieved from: http://www.ugandaroadsector.org/RoadSafety.php.

Uchumi Supermarkets. 2014. Official Website. Retrieved from: http://uchumicorporate.co.ke/uganda/about-us

United Nations. 2014. UN *Comtrade Database.* Retrieved from: http://comtrade.un.org/

United Nations Conference on Trade and Development (UNCTAD). 2012. “Infocomm Commodity Profile – Sweet Potato.” Retrieved from:http://www.unctad.info/en/Infocomm/ AACP-Products/COMMODITY-PROFILE---Sweet-potato/

UNCTAD. 2009. *Development Dimensions of Intellectual Property in Uganda: Transfer of Technology, Access to Medicines and Textbooks*. Retrieved from: http://unctad.org/en/Docs/diaepcb200913_en.pdf

UNCTAD. 2014. *UNCTADStat*. Retrieved from: http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx

United Nations Educational, Scientific and Cultural Organisation (UNESCO). 2014. Uganda Institute of Statistics.Stat. Retrieved from: http://data.uis.unesco.org/

United Nations Industrial Development Organization (UNIDO). 2004. Small Scale Fruit and Vegetable Processing and Products. Retrieved from: http://www.unido.org/fileadmin/import/32382_fruitsDec21.2.pdf

UNIDO. 2007. *Uganda Integrated Industrial Policy for Sustainable Development and Competitiveness.* Retrieved from: http://www.unido.org/fileadmin/user_media/Publications/Pub_free/Uganda_integrated_industrial_policy_for_sustainable_industrial_development_and_competitiveness.pdf

USAID. 2013. "The Fresh Fruits and Vegetable Markets of East Africa." Retrieved from: http://www.competeafrica.org/Files/FFV_Markets_of_East_Africa_final_approved_and_compressed_July_17_2013.pdf

USAID. N.d. "Orange-fleshed Sweet Potato: Improving lives in Uganda." Retrieved from: http://www.usaid.gov/results-data/success-stories/orange-fleshed-sweet-potatoes-improving-lives-uganda

USAID. N.d. " Potato Farmers Fight Poverty in Uganda". Retrieved from: http://egateg.usaid.gov/sites/default/files/Potato%20Farmers%20Fight%20Poverty%20%20Uganda.pdf

World Bank. 2014. Databank. Retrieved from: http://data.worldbank.org/country/uganda

World Bank. 2014. Doing Business Report. The World Bank. Retrieved from: http://www.doingbusiness.org

World Bank. 2014. World Enterprise Surveys. The World Bank. Retrieved from: http://www.enterprisesurveys.org

World Bank. 2014. Logistics Performance Index. The World Bank. Retrieved from: http://www.lpi.worldbank.org

World Bank. 2011. "Uganda: Agriculture for Inclusive Growth in Uganda." Retrieved from: http://siteresources.worldbank.org/INTDEBTDEPT/Resources/468980-1316457581843/CaseStudy_Uganda_02.pdf

World Bank. N.d. SeedCo-ICRISAT Experience with Testing Small Packs of Improved Varieties. Retrieved from: http://www.worldbank.org/html/extdr/fertilizeruse/documentspdf/SeedCo_ICRISAT_SmallPack_Policy.pdf

World Economic Forum (WEF). 2014. *Global Competitiveness Report*. Retrieved from: http://www.weforum.org/issues/global-competitiveness

World Food Programme. 2014. *Digital Logistics Capacity Assessment.* Retrieved from: http://dlca.logcluster.org/display/public/DLCA/LCA+Homepage

World Trade Organization. 2013. *Uganda Trade Profile.* Retrieved from: http://www.wto.org/english/res_e/booksp_e/trade_profiles13_e.pdf

Annex II: About the Global Knowledge Initiative

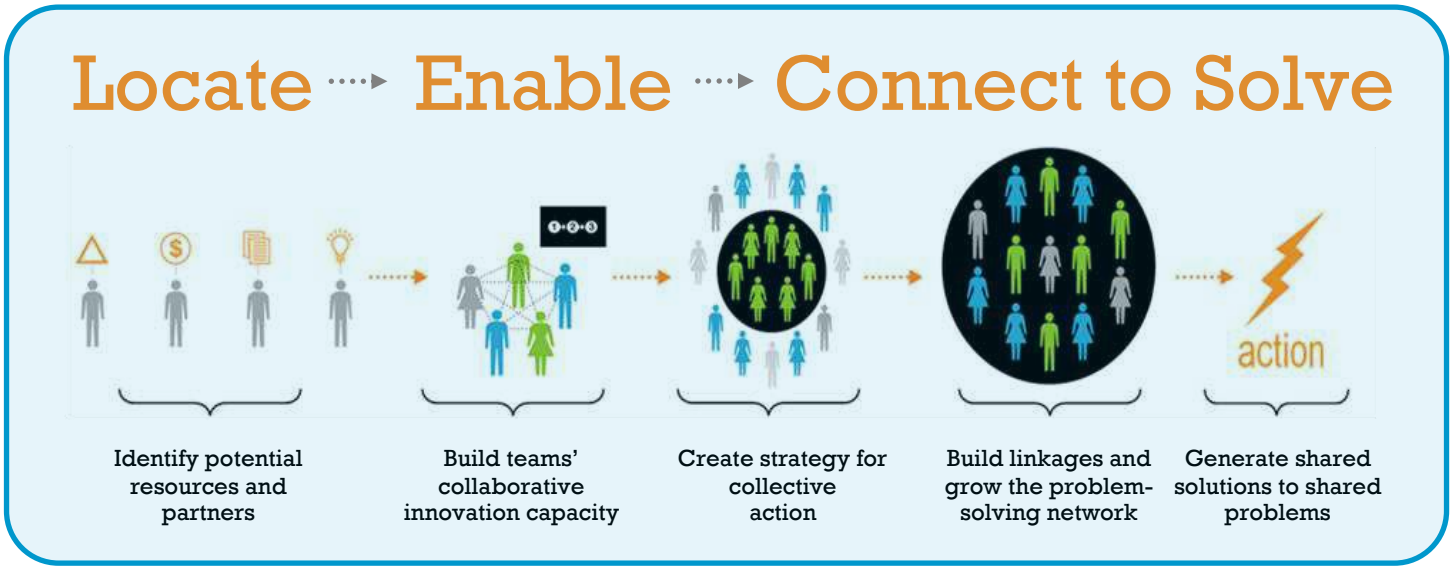
The Global Knowledge Initiative's mission is to forge, optimize, and sustain knowledge partnerships between the people and institutions of higher education and research.

We catalyze purpose-driven networks to solve shared challenges in science, technology, and innovation.

How We Work

The premier challenges of today — saving the lives of women and children at birth, reducing waste and spoilage in the food chain, minimizing water insecurity in arid and semi-arid landscapes — are complex and multi-sectoral. Solving these and other problems demands that we create bold new ways of organizing people and resources that cut across traditional sectoral, disciplinary, and geographic divides. Collaborative innovation networks offer a way to align resources and partnerships toward shared goals. Building and supporting such networks represents a cornerstone of our work.

Guided by the challenges offered by our partners, we help researchers, entrepreneurs, and others **locate** resources critical for problem solving; **enable** effective collaboration by building skills and designing shared agendas; and **connect** resources and partners into durable networks; all to **solve** explicit development challenges pertinent to science, technology, and innovation. These four steps — **Locate**, **Enable**, **Connect to Solve** — underpin our systematic approach to building and optimizing solution-driven networks.



How We Got Started

The Global Knowledge Initiative (GKI) originated from the 2008 Higher Education Summit for Global Development convened by the US Secretaries of State and Education and the Administrator of the US Agency for International Development. Attended by more than 200 university presidents, heads of technology firms, and philanthropists, the Summit identified the need for a "clearinghouse for resources and information to help build knowledge partnerships that can tackle development challenges." Chief Operating Officer Sara Farley together with Chairman Sam Pitroda and Advisory Board Co-Chair Nina Fedoroff established the Global Knowledge Initiative as a response to this call.

How We Choose Challenges to Solve

Not every challenge facing the world today can be addressed through science, technology, and innovation, yet many can. To maintain a clear focus, we address challenges that align with these criteria:

- The challenge constitutes a **shared concern** for developing and developed country partners.
- The challenge relates to **science, technology, and innovation.**
- Solving the challenge will **improve the lives of thousands, if not millions.**
- The challenge is germane to the lives of those **people living on less than $2 per day.**
- Solving the challenge **deepens capacity** for science and engineering training, research, and innovation.
- A pre-identified **community of implementers** commits to implementing the solution within 3 years.

We are currently demonstrating impact through initiatives in East and Southern Africa, South and Southeast Asia, and the United States. Our global network of partners supports activities in these focal geographies and other places around the world. We look forward to expanding our reach and impact in the coming years.

GLOBAL KNOWLEDGE INITIATIVE

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