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A WORLD BANK STUDY


# Science, Technology, and Innovation in Uganda

RECOMMENDATIONS FOR POLICY AND ACTION

Sukhdeep Brar
Sara E. Farley
Robert Hawkins
Caroline S. Wagner

THE WORLD BANK

W O R L D   B A N K   S T U D Y

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# Acronyms and Abbreviations

| | |
|---|---|
| ICT | information and communication technology |
| IPR | intellectual property rights |
| NARS | National Agricultural Research System |
| NEPAD | New Partnership for Africa's Development |
| NGO | nongovernmental organization |
| OECD | Organisation for Economic Co-operation and Development |
| PMA | Plan for the Modernization of Agriculture |
| PSF | Private Sector Foundation |
| R&D | research and development |
| SMEs | Small, medium enterprises |
| STI | Science, Technology, and Innovation |
| TAF | Technology Acquisition Fund |
| THETA | Traditional and Modern Health Practitioners Together Against Aids and Other Diseases |
| THICK | technology, human resources, institutions and infrastructure, collaboration and communication, and knowledge base |
| UIRI | Uganda Industrial Research Institute |
| UNBS | Uganda National Bureau of Standards |
| UNCST | Uganda National Council of Science and Technology |
| UIRI | Uganda Industrial Research Institute |
| UNCTAD | United Nations Conference on Trade and Development |
| UNIDO | United Nations Industrial Development Organization |
| UOSPA | Uganda Oil Seed Producers and Processors Association |
| USAID | U.S. Agency for International Development |

# Acknowledgments

This report was written by Sara E. Farley of the Global Knowledge Initiative and Caroline S. Wagner of SRI International. The team was assisted by Kamau Bobb, Thiru Naidoo-Swettenham, Sheila O'Brien, Robin Skulrak, Peter Tindemans, and text editor Paul Holtz. The authors also benefited from extensive input, guidance, and suggestions from teams at the Uganda National Council of Science and Technology (UNCST) and the Uganda Industrial Research Institute (UIRI). In particular, UNCST's Peter Ndemere, Maxwell Otim, Julius Ecuru, and Ismail Barugahara and UIRI's Charles Kwesiga, Dick Kamugasha, Vincent Makoha, Moses Aheebwa, Abbas Nimanya, and Brenda Akuruchet offered substantial time over the years that the report evolved.

The report was conceived by the World Bank's Africa Region Senior Science and Technology Specialist, Michael Crawford, and the World Bank Institute's Senior Education Specialist, Robert Hawkins. Initially the two sought to analyze the role of science, technology, and innovation in industry across several East and Southern African countries. The team was lead and supported by Jee-Peng Tan, Advisor in the Bank's Africa Region, who helped craft the focus of the studies. The Bank-funded Uganda Millennium Science Initiative's original Task Team Leader, Michael Crawford, initiated the Uganda study and supported the report team in creating a useful methodology to gauge the role that science, technology, and innovation play in key sectors, particularly for small and medium-sized enterprises. He and Sector Manager Christopher Thomas were pivotal to the successful launch of the Uganda report.

Under the watch of Crawford and Hawkins, the team of authors constructed the methodology presented here and convened a pan-African validation exercise. Participants from across the continent convened in Maputo, Mozambique, in 2008 to validate the methodology, offer comments, and explore opportunities to use the studies in articulating national strategies and setting priorities. The report team is grateful to the many people who attended the regional workshop, which was sponsored by the Finnish Government, the World Bank Institute, and the Bank's Maputo office. In 2009 the World Bank and the Uganda National Council on Science and Technology convened the many Ugandan interviewees at a meeting generously hosted by Mukwano Industries. For those insights and validation, the report team extends its deepest thanks.

Sukhie Brar replaced Crawford as the Task Team Leader of the Millennium Science Initiative in 2009. Her dedication to finalizing the report ensured that its insights were widely shared and used to infuse the launch of a national strategy for science, technology, and innovation.

This report's richness derives from hundreds of pages of transcripts captured through interviews conducted in the agriculture, health, energy, information and communication technology (ICT), transport, and logistics sectors. Extensive interviews with entrepreneurs, owners of small and medium-sized enterprises, government researchers, and decision makers in government and industry involved the following gracious thought leaders: Dr. Grace Nambatya, Harriet Musisi, Peter Otimodoch, Dr. Nantualya, Robert Kyukyu, B.W. Rwabwogo, Apollo Ntarirwa, Robert Okonja, Geoffrey Owen, Annick De Graeve, Kepher Kateu, Ben Manyindo, Ochaki Abuberkerer, Agi Konde, Robert Buusulwa, Susan Bingi, Nilesh Kanabar, Tony Gleason, Dr. Dorothy Bilaba, George Baguma, Fred Mutebi Kitaka, Godfrey Kibuuka, Imran Ahmen, David Bagenda, Jeremy Bassy Aguma, Badru Ntege, Hermant Mishra, and Patrick Masamba.

A large, diverse group of Ugandans provided the team with hundreds of hours of interviews. Undoubtedly, over the four years of the study, people beyond those listed here influenced its direction and quality. For all those not mentioned by name, the team is grateful for their generosity and commitment to ensuring that science, technology, and innovation are harnessed so that Uganda might realize its full potential.

The team looks forward, encouraged to see the move from policy to action that the government is taking on science, technology, and innovation. Our hope is that this report provides a foundation for all Ugandan stakeholders to stand on as these strides forward are made.

# Executive Summary

Between 2006 and 2010 the World Bank sought to unmask the role of science, technology, and innovation in Ugandan industry. This report presents insights from this research based on case studies of six sectors: agriculture, health, energy, information and communication technology (ICT), transport, and logistics. Based on more than 80 interviews cutting across Uganda's small and medium-sized enterprises, universities, and government entities, the report's findings are intended to offer the government and its partners in industry increased clarity about how better to harness science, technology, and innovation to propel the economy. Enabling implementation of the recent Uganda National Science, Technology, and Innovation Policy is a parallel goal of the report. The policy articulates the government's intent to foster research and development that builds the human capital that Uganda requires for a knowledge-based economy.

The case studies from which this report's recommendations are drawn depict a diverse range of experiences across industrial sectors in terms of generating, applying, and adapting science and technology to contribute to Uganda's development. Despite the relatively small size of the country's investments in science and technology, the past 20 years have seen considerable advances in building capacity in science and technology, developing related institutions and human resources, advancing collaboration and communication, and expanding the base of available knowledge. But given Uganda's limited investments in science and technology, policies should prioritize near-term investments that benefit key sectors. This report identifies those near-term investments as well as longer-term ones (three to five years in the future).

The analysis derives from a novel methodological framework adapted from a heuristic tool dubbed the National Innovation Systems framework. This new methodology focuses on the functions of a science and technology system that makes knowledge useable, summarized by the acronym THICK, which stands for **T**echnology, **H**uman resources, **I**nstitutions and Infrastructure, **C**ollaboration and Communication, and **K**nowledge base, each of which is needed to access, absorb, and retain technical knowledge. No doubt each of these functions needs attention in Uganda. These functions do not have to be built from scratch, however. Some critical sectors have sufficient capacity in one or more of the THICK dimensions to harness science and technology for growth. Broad recommendations emerged for each of these dimensions:

- *Technology*. In a joint effort between government and industry, craft science and technology investment strategies in areas with potential for near-term, high payoffs to multiple sectors. These sectors are computer science, civil and transportation engineering, environmental science related to soil management, ecology science related to specific ethnobotany applications, food science related to phytosanitary (food and water) assurance, and agricultural science related to export crops.
- *Human resources*. Train and certify paraprofessionals and technicians in functions that can bridge capabilities across sectors. For example, software engineers are needed in all sectors, particularly to customize computer-controlled machinery.

Agronomists are needed in ethnobotany applications, phytosanitary testing, and agriculture for export. Certified professionals are also needed in welding and manufacturing.

- *Institutions and Infrastructure*. Focus on public support functions needed to ensure capabilities in areas underpinning competitiveness and productivity, including metrology, standards, testing, and quality assurance, and promote industry-specific infrastructure, such as broadband, that creates a robust and sustainable knowledge system at the national level and enables knowledge partnership and trade at the international level.
- *Collaboration and Communication*. Benefit multiple sectors simultaneously by leveraging opportunities to build knowledge across sectors—such as by focusing on knowledge exchange among industrial research centers, academic labs, and professional societies. Considerable indigenous knowledge exists in Uganda, but it remains largely isolated from the formal sector, which could benefit from it. Enhancing Uganda's collaboration and communication capacity requires creating initiatives and incentives for professional associations to meet with scientific researchers, engineers, and local businesspeople. Boosting the country's collaborative potential also requires clearly defining local, regional, and national Science, Technology, and Innovation (STI) challenges so that a more diverse group of knowledge partners—universities, firms, entrepreneurs, government, the informal and formal sectors—can understand how they may contribute to solving them.
- *Knowledge base*. Government should step up efforts to gather and publish the economic and technical data—such as the number of trained science and technology workers, import and export data, pricing information, and cost of capital—needed to track progress and plan business investments. Efforts should also be made to build the legal and regulatory framework needed for businesses to operate, including environmental regulations.

Implementing these recommendations require actions from at least three groups of stakeholders: government and public institutions (such as the National Council for Science and Technology), the private sector, and academia. The actions required of these stakeholders are presented in the final section of this report, on policy recommendations.

Among other findings, the report identifies fields of science and technology most likely to perpetuate Uganda's recent success as the country strives to achieve its development goals with the help of science and technology. The report recommends specific investments in science and technology that:

- Contribute to a number of critical sectors—such as agriculture, health, energy, ICT, and transport—reducing the need for one sector to make the investment.
- Strengthen all the sectors and industries studied for this report as well as others in the country.
- Draw on existing national STI competence and capacity.
- Leverage capacities in neighboring countries that can be tapped to increase local capacity.
- Help solve domestic development problems.

Fields that require investment, attention, and capacity building include the following:

- Computer science, particularly software writing and customization for domestic applications.

- Computer-aided design and numerically controlled machine tool management.
- Civil and transportation engineering, focusing on energy applications such as hydrology and grid management, and in transportation on road building and trucking logistics and on materials sciences for packaging and shipping.
- Environmental science and engineering, focusing on minimizing pollution, land and water use and planning, extraction methods, and sustainable forestry.
- Ecology science, focusing on ecosystem and water management, soil erosion, and hydration.
- Food science and nutrition, focusing on sustainable crop maintenance, food safety and security, phytosanitary measures, and packaging.
- Agricultural science and engineering, with a focus on biotechnology applications and safety, soil use, and productivity.

These fields can benefit the most from multidisciplinary and cross-sector research and investments led by coalitions of academic and business leaders. A national-level (perhaps presidential-level) initiative led by a "champion" of national stature is needed to energize research and development as well as production in these disciplines. This initiative should create incentives for collaborative research, information dissemination, and shared problem-solving. Success should be measured by the extent to which the needs of local businesses are met.

Detailed case studies for each of the six sectors explored in depth to produce this report appear in the annexes.

# This Report's Purpose

Reflecting an emerging global consensus, the government of Uganda identified science and technology as key means for advancing growth and reducing poverty. In 1990, through the statute creating the Uganda National Council for Science and Technology (UNCST), the government initiated the science, technology, and innovation policy making process. This process has been updated several times, most recently with the National Science, Technology, and Innovation Policy (August 2009, final). The policy articulates the government's commitment to fostering research and development in building the human capital that Uganda requires for a knowledge-based economy.

The government has taken steps to achieve this goal. Efforts have been made to coordinate with other government policy statements, particularly the Poverty Eradication Action Plan and the Plan for the Modernization of Agriculture. Uganda participates in the Millennium Science Initiative, which funds innovative research and science and technology training in the country. As these policy actions bear fruit, the next steps in building science and technology capacity require applying science and technology to specific sectors to address key development challenges. Among its findings, this report identifies the fields of science and technology most likely to sustain the recent successes in Uganda as it pursues its development goals.

This report is designed to inform policy makers and donors of targeted ways to realize the government's strategy in six strategic sectors: agriculture, health, energy, information and communication technology (ICT), transport, and logistics. The report aims to help answer questions about investments in science, technology, and innovation for development, in product development, and in the legal and regulatory framework needed to achieve policy goals. The recommendations are derived from a series of case studies conducted in Uganda over several months.

The six sectors were chosen based on their relevance to national development needs, the availability of data, and the presence of companies that could be contacted for interviews. The choices were made in consultation with World Bank and country representatives to ensure that the selected sectors include those that can benefit significantly from better science and technology infrastructure and capacity. The choices were further influenced by government priorities, including food processing technology, water and environmental technology, mineral processing, renewable energy, ethnobotany, and construction technology (particularly for housing and roads).

Interview subjects were chosen based on their depth of knowledge of the scientific or technical aspects of the case study subject. Efforts were made to interview people within industry or professional associations. Priority was given to firms owned and operated by local businesspeople. Foreign direct investors were also interviewed if their input would increase understanding of sector dynamics.

The report's findings originated from four questions posed by Ugandan stakeholders:

- To what extent do science and technology contribute to the most critical sectors in Uganda?

- To what extent can science and technology improve products and processes in these sectors, and what are the most important science and technology fields for industrial growth?
- To what extent are these fields available in Uganda and need strengthening?
- How can Uganda prioritize and price the investments needed to build the science, technology, and innovation capacity needed for key sectors?

These questions guided the creation of a protocol and questionnaire that were used to interview companies, researchers, and policy makers and to compile case studies based on the information collected. These questions guided the development of the conceptual framework and analytical methodology, described in the next sections.

## Conceptual Framework: Analyzing the Knowledge Infrastructure

Science and technology—along with land, labor, and capital—are key contributors to innovation and productivity (Freeman 2000). The United Nations Millennium Development Task Force on Science, Technology, and Innovation encouraged developing countries to develop strategies that use science and technology for growth. The United Nations Conference on Trade and Development makes a similar recommendation and points out that the central issue is not acquiring the capability to invest in products and processes, but learning to master the knowledge that increases efficiency and raises productivity (UNCTAD 2007). A World Bank study pointed out that "technological learning takes place when engines of diffusion spread knowledge to producers" (Chandra and Kolivalli 2002).

Knowledge is universally acknowledged as being crucial to economic growth, though economists differ on whether institutions or technology are more influential for per capita income growth. But most agree that technology grows from a knowledge base that first encourages mastery of capabilities and then moves to a more complex, evolutionary process of "technology deepening." This growth process involves increasing the complexity of production processes and the value added to and differentiation of resulting products.

This vision of technology adoption and diffusion requires strategic investments in science and technology capacity. Other elements of a knowledge system beyond science and technology—such as professional societies and industry associations, university outreach, government extension services, and funding programs—are also critical to knowledge diffusion. In fact, within a knowledge system, science and technology have features closer to a catalyst than to an input or output. They can energize a system under development, but neither science nor technology "cause" development or create innovation on their own.

Like any catalyst, science and technology need to be calibrated to the functioning of the system. In the case of economic systems, this means that policy must be carefully crafted to ensure timely and appropriate science and technology inputs, interventions, and outputs. Moreover, a critical mass of people trained in science and technology who collaborate and communicate with entrepreneurs, financers, opinion shapers, and policy makers are needed to serve as the agents of change through which science and technology can influence production processes or innovation.

The knowledge provided by researchers, innovators, scientists, and engineers relies on complementary functions provided by actors and institutions not engaged in science and technology. These other elements of the knowledge system include the financial system, an educated and skilled workforce, markets, and firms. Indeed, each function is usually the subject of its own dedicated ministry, and (except for science and technology) this is the case in Uganda as well. Pulling these ministries in the same direction to support innovation can be challenging because each has its own mission.

Focusing policy on specific cross-cutting goals or initiatives (such as alternative energy production), though challenging, may provide a focal point for coordination. But without considered balance among the functions listed, excess development of one part of the system over another can distort the knowledge system. For example, providing too many skilled workers to a system that does not have enough firms to absorb them can create imbalances in the system and disrupt growth. Thus the case studies presented in this report focus less on the roles of ministries and more on the functions and policies that are essential to the knowledge system to find ways to grow the system as a whole, rather than one single part.

Rapid change in the global economic system has implications for Uganda and for this report. On the one hand, the global economic system offers enhanced opportunities to access knowledge and new markets created by globalizing forces. A more open system at the global level offers new opportunities for local firms, researchers, universities, entrepreneurs, and civil society to access knowledge for development. On the other hand, rapid change means that developing countries cannot borrow road maps from countries that followed a similar path in the 20th century—rapid developers such as the Republic of Korea—because many of the conditions that existed then no longer do. Today's developing countries must craft flexible policy and strategic plans responsive to their own needs. This requires strengthening the functions of the knowledge-led system, as discussed in the next section.

## Analytical Methodology: The THICK Concept of Development in the National Innovation System

Many policy makers are familiar with the National Innovation System (NIS) framework. The New Partnership for Africa's Development (NEPAD) has defined the framework as a set of institutions, organizations, and policies that interact in the pursuit of common social and economic goals and that use the introduction of innovations as the key promoter of change (Paterson, Adam, and Mullin 2003). In the private sector—the focus of this report—the NIS framework can be further delineated to have specific functions and features:

- ***T****echnology*—the tools and the knowledge to use them (which incorporates scientific knowledge).
- ***H****uman resources*—the trained people who can put science and technology to work for industrial production.
- ***I****nstitutions and Infrastructure*—whether in a fixed place or as a networked composite of organizations or functions that provide the structure and collective knowledge needed to innovate.
- ***C****ollaboration and Communication*—connections among the parts of the system that diffuse knowledge and enable learning.
- ***K****nowledge base*—the information embedded in research and indigenous knowledge, written guidelines and procedural documents, regulatory and legislative code, and intellectual property that add value and enable trade.

This THICK framework tracks closely the framework used by the InterAcademy Council (the international consortium of academies of science) in its report on science and technology for development, which identifies the basic functions and capacities needed to use science and technology for industry-led economic development (InterAcademy Council 2005).

The decision to forge a new framework from the NIS arose from three observations. First, with its emphasis on functions and features, the THICK framework is more conducive than its predecessor in conducting firm-level interviews and maintaining a human-centered approach. THICK was designed to distill science and technology capacities from the national level to the firm or institution level. By contrast, the NIS framework was devised two decades ago to describe the innovative activities of highly developed, technology oriented members of the Organisation for Economic Co-operation and Development (OECD), specifically Germany and Japan. Without alteration, its fit is less precise when applied to the developing country context.

Second, the NIS framework assumes the presence of highly innovative, interacting, dynamic firms at the core of the system—an assumption that does not hold in many developing countries, where the private sector is dwarfed by the informal sector and the public sector is the dominant actor in research and development. THICK takes account of a much wider range of actors and can accommodate systems in which other actors—informal sector, small, medium enterprises (SMEs), academia, public sector—take center stage.

Finally, the NIS model was not crafted as a normative tool, but rather a heuristic one. This report sought to present a framework conducive to generating recommendations for funding priorities and implementation of national science and technology policy. Both needs are beyond the capacity of the NIS model. Compared with emerging economies such as Brazil and Mexico, where an NIS framework can be meaningfully used, Uganda's innovation system is still too fragmented for a NIS framework to be aptly applied. The goal here is to help Ugandans infuse knowledge into their economy to the extent possible, given its current resources, and to identify ways to move toward a knowledge-based economy one step at a time.

The World Bank Institute has defined a knowledge-based economy as consisting of the following:

- An economic and institutional regime that provides incentives for the efficient use of existing knowledge and the creation of new knowledge and entrepreneurship.
- An educated and skilled populace that can create and use knowledge.
- A dynamic information infrastructure that can facilitate effective communication, dissemination, and processing of information.
- An effective innovation system comprising a network of firms, research centers, universities, consultants, and other organizations that can tap into the growing stock of global knowledge, assimilate and adapt it to local needs, and create new knowledge and technology (Dahlman and Aubert 2001).

This is a reasonable set of goals for most economies, and this definition helped guide this report. But with this description as a yardstick, Uganda is still en route to building its national innovation system and becoming a knowledge-led economy.

The choice of the THICK methodology was further guided by an UNCTAD (2007) report on the least developed countries that states:

> Processes of technological change in rich countries, where firms are innovating by pushing the knowledge frontier further, are fundamentally different from such processes in developing countries, where innovation primarily takes place through enterprises learning to master, adapt and improve technologies that already exist in more technologically advanced countries.

As experts said at a 2007 workshop in Maputo, Mozambique, convened to bring together stakeholders for consultation during the preparation of this report: "Within the African context it is important not to lose perspective and to always fully engage with rural communities, particularly with regard to initiatives centered on indigenous knowledge. The approach must always be innovation by the community for the community" (WBI 2008).

With the THICK framework to guide the report's inquiries, the authors sought data in each sector about relevant functions or capacities. Interviews were conducted with people who were either in the private sector or familiar enough with it to determine the extent to which these resources are available and used. Public servants and private sector groups were asked about the functions and capacities existing in Uganda as well as those that need to be strengthened. This methodology provided insight into where a sector was weak, adequate, or strong, which led to recommendations for investments on science and technology.

This report occurred in three parts. First, the authors reviewed the existing literature and data on science and technology investments in Uganda for the six sectors of focus (agriculture, health, energy, ICT, transport, and logistics). Second, interviews were conducted with knowledgeable businesspeople, scientists, engineers, and academics. Finally, a series of workshops with government, academic, and other experts convened to validate findings and explore potential recommendations.

The sectors were chosen based on their importance to the economy. In each case, an effort was made to understand science and technology in the sector, assess the knowledge available to the sector from local sources, examine lines of communication between scientific or technical centers and industry, and identify the limits placed on industry by scarce or absent functions and capabilities. (The annex contains a case study protocol.)

Every resource or feature of the knowledge system listed in table 1 is part of an infrastructure available to an economy that enables the creation, absorption, or retention of knowledge. These resources are generally non-market functions provided through intermediary organizations. Facilities such as a metrology lab provide essential functions, but a proximate location is not always required; many services can be provided at a distance. Intangible assets—such as laws and regulations—can be put in place but, at times, cannot be implemented because of weak governance. Some key functions, such as technical skills, are embodied in people.

Among these resources, some are relatively easy to quantify (such as numbers of labs or professional societies) and some—though universally acknowledged as important—are nearly impossible to measure (such as indigenous knowledge). In conducting the interviews for this report, focus was placed on identifying whether a resource was available, where it was located, and how it could be accessed. When it was not possible to collect such data, people were asked about the availability of a feature or resource. Both approaches are reflected in the analysis.

**Table 1. Components of the THICK Methodology Used to Study Key Sectors in Uganda**

| | Resource to support innovation | Function required for successful implementation |
|---|---|---|
| T | Technology Resources | Technology in use and locally available |
| | | Technology transfer opportunities |
| | | Infrastructure supporting the sectors |
| H | Human Resources | Number of scientists and technical workers |
| | | Number of engineers |
| | | Technical training opportunities |
| | | Numbers of tertiary-level students studying S&T subject |
| | | Management training |
| | | Entrepreneurship training |
| I | Institutional Resources | Ministries focused on science and technology issues |
| | | Standards-setting bodies |
| | | Metrology testing centers |
| | | Educational and training organizations |
| | | Research institutions |
| | | Donor institutions |
| | | Incubators and/or science parks |
| | | Producer associations |
| | | Financial institutions/risk capital |
| C | Collaboration/Communication Resources | Professional societies |
| | | Extention services |
| | | Conferences and demonstration opportunities |
| | | Access to ICTs |
| | | On-line technical resources |
| K | Knowledge Resources | Technical data and reports |
| | | Research funds |
| | | Technical development funds |
| | | Regulations |
| | | Laws |
| | | Indigenous knowledge |

*Source*: Compiled by authors.

The THICK methodology facilitates analysis across sectors (government, private, academic) and examines the economy in a unique way. It complements the value chain approach, which postulates that products emerge from interlocking production capacities in the private sector. The value chain identifies the range of activities required to bring a product or service from conception through production to delivery to the consumer. The THICK methodology crosses lines between the public, private, and academic sectors to identify the core capabilities that industry needs to use science and technology to apply technical knowledge.

Science and technology research and development do not contribute directly to the value chain; they are exogenous unless the product or service is science or technology (such as in biotechnology). Still, knowledge gained from science and technology can increase the efficiency of design, production, product delivery, and communications along the chain. The research, conducted in labs often geographically distant from the point of application, improves production efficiencies. It is usually conducted and applied early in the process, during the design and planning stages, or during the development of the production process.

This report sought to identify the existence or lack of resources available to Ugandan industry, no matter who provided them and even if they came from outside the country. Similarly, recommendations are offered for the system as a whole, leaving the various stakeholders to decide which institutions should provide resources or services.

CHAPTER 1

# Science, Technology, and Innovation Strategies and Actors in Uganda

Since 2000 Uganda has been one of Sub-Saharan Africa's fastest-growing economies, with growth averaging 7.8 percent a year. Still, per capita income is just $370. Though the country has made steady progress in recovering from the economic breakdown of the 1970s, social and economic indicators show that much remains to be done. Life expectancy at birth is about 50 years old, and the 3.3 percent annual population growth rate is among the highest in the world—posing serious development challenges. Uganda also has the world's youngest population, with children under 15 making up more than half the population. It also has the world's highest dependency ratio, with 1.12 dependents per worker, compared with 0.84 in Kenya, 0.85 in Tanzania, and 0.87 for Sub-Saharan Africa as a whole (World Bank 2009).

Uganda's science and technology plan is designed to strengthen and interconnect the various elements of its economy to achieve development goals. The National Science, Technology, and Innovation Plan, issued by the Uganda National Council for Science and Technology (UNCST), presents a development vision related to specific social needs. The government's strategy is to develop ideas about how to use science and technology to serve these needs.

Ugandan policy makers see these opportunities being played out in the near term through research in agriculture, agroprocessing, industry, infrastructure, energy, minerals, information and communication technology (ICT), biotechnology, and investments in natural resource extraction (particularly oil and natural gas). The plan's implementation phase includes expanding training and education to several parts of the country through the work of various ministries. Furthermore, as part of the World Bank's Millennium Science Initiative Project, the Ugandan government seeks to advance basic science and to link this effort more closely to technology. This is being done through a series of research projects being funded in Uganda that will benefit different parts of the country's knowledge system.

## Research Actors

Uganda has had two decades of success in building capacity in science and technology. The UNCST has been coordinating policy aimed at shortening the cycle of technology mastery and knowledge and at deepening technology. This has been done by finding ways to infuse knowledge into existing industries—an approach widely considered effective by groups that analyze development. Unlike many African countries, Uganda commits part of the government budget—equal to 0.3 percent of GDP—to spending on research and development. Though this amount is short of the government's goal, it is higher than that of many Sub-Saharan countries. UNCST reports that nearly 800 researchers work on R&D, with close to 40 percent of them women. Of all these researchers, 53 percent work in government, 36 percent in higher education, 8 percent in business, and 3 percent in the private nonprofit sector.

Among Uganda's 27 universities, 6 offer science and engineering courses. The country's 33 vocational and technical institutes train students in technical skills needed in industry. Research activities are located in several places, including Makerere University in Kampala and Mbarara University of Science and Technology in Mbarara. Spending on science and technology is estimated at about $50 million. The Uganda Industrial Research Institute (UIRI) leads in the application of science to industrial needs, with a decade of successful research implementation and outreach and significant recent efforts to boost its capacity and outreach to key industrial sectors, from textiles to food processing to bamboo production.

The National Agricultural Research Organization has several research locations, as well as extension services in different areas, that have been conducting research and outreach for several decades. Relative to the public sector, very few private companies conduct research. Those that do are almost all foreign direct investors seeking to improve exportable products and build markets. Improving the record of industrial innovation and research capacity is a primary goal of the nation's science, technology, and innovation policy. (Additional information on Uganda's science capabilities is available in the annex.)

## THICK Findings and Issues from the Case Studies

In its 2007 report on science and technology in the least developed countries, UNCTAD points out that one issue of great importance is domestic knowledge systems that enable (or constrain) the creation, accumulation, use, and sharing of knowledge. Just as important is where the knowledge comes from and whether and how it can be retained and embedded locally. Uganda's prosperity will be tied to its ability to locate and embed knowledge from outside its borders for years to come. Given the globalizing knowledge system, Uganda may never become "self-sufficient" in knowledge, nor should that be a goal: none of the world's most advanced countries can claim "knowledge independence."

The following sections describe findings from the case studies, identifying locally available resources and noting where gaps exist. The case studies were conducted in Uganda and analyzed technology (T), human resources (H), institutions and infrastructure (I), collaboration and communication (C), and the knowledge base (K). Findings from each sector case are combined to allow for cross-sector analysis based on each dimension of the THICK framework.

In all the areas under review, the case studies found positive changes and capabilities in Uganda. Some of these positive aspects are noted in the following. Still, this chapter focuses on identifying the gaps in the system to provide input to an agenda for policy makers on where investment may help Uganda reach development goals. The tone is not intended to be negative, but rather to point out where improvement is needed.

### *T: Technology Resources Are Spotty*

Technology resources include tools and the knowledge to use them in industry. The THICK methodology considers the technology available in industry, the technology needed to move ahead, opportunities for technology transfer, and infrastructure that can support technological learning. This section details the technology available in Uganda's industries. The technology assessments conducted for the case studies focused on the extent to which capabilities were close to the market, whether they were part of a system, whether they contributed to research, and their ability to increase productivity. These capabilities can be built on to expand industry.

Most technology resources in Uganda are not proprietary (meaning they are not patented or otherwise protected by intellectual property laws), nor are they highly advanced or complex. But representatives with whom the team spoke said that the technical content of industrial production has increased, largely through foreign direct investment. For example, the entry of India's Quality Chemicals pharmaceutical manufacturing plant has significantly boosted the technological capacity of the health sector. Similarly, opportunities for technological learning through investments by India's Cipla Industries have improved the degree to which Ugandan chemists, engineers, and pharmacologists can learn using world-class technology.

Case studies and analysis revealed three categories of technology used, aiding the efficiency of business, creating an integrated value chain in some cases, and making it possible for some companies to conduct research and development. These technologies are the following:

- Processing technology: machines and computer-assisted design software used to make manufacturing production more efficient.
- Computing: computers used for supply chain management to track production, conduct accounting in line with international standards, and store data.
- Mobile telephony: cellular phones used to keep staff in touch with each other, trace products on the road, and connect researchers.

A number of technologies could enhance the value chain if they were more widely available and implemented, including the following:

- Machine tools used to cut materials would aid many kinds of manufacturing projects, particularly food storage; this would be particularly helpful for agro-processing and transport.
- Packaging and plastics of all kinds could create the kinds of packages that add value to agricultural products (such as breathable plastics for vegetables or foil wrap for coffee beans) and cosmetics created through ethnobotany.
- Logistical support (software and electronics) could enable computer-based inventory tracking.

Several firms reported having upgraded to ICT-enabled transport, logistics, and supply chain management systems. These firms reported a host of benefits, including enhanced competitiveness, efficiency, and the pairing of related processes that were not previously linked. For example, Ugandan firms that adopted supply chain management reported improvements in the efficiency of their trucking services that derived, in part, from faster turnaround times between treks. Managers monitored driver locations to make deliveries more efficient and reduce unauthorized stops. Uganda's Mukwano Industries, which manufactures a range of consumer goods, including oilseed-based products, migrated its supply chain management to a software system developed by SAP—an investment that promises to greatly boost efficiency. It also bought an ICT-based transport management system from a South African vendor.

According to sources at Mukwano, the processes that these investments improve include truck loading, links between distribution and transportation, and customer relations. With respect to truck loading, for some Ugandan firms—such as those in the newspaper sector—people called "counters" manually count all products loaded onto trucks. The loading is also performed manually. Sales orders are sent with the trucks to central warehouses and then goods are shipped to distributors. All products are back-ordered using a "first in, first out" system, meaning that packers must physically locate the oldest batches to ensure that goods closest to their expiration dates are shipped. The ICT system will enable faster, more efficient deliveries for Mukwano and others firms that rely on transport and logistics systems, increasing their competitiveness.

The transport and logistics sectors face many technological challenges, including getting fuel-efficient vehicles, dealing with poor road conditions, and tracking products. For example, migrating from a fleet management system that uses handwritten logbooks to one that creates an interface between fleet management and distribution data would significantly raise efficiency. Mukwano illustrates the point. Using its new software and global positioning system (GPS) hardware, real-time digital maps allow managers in Kampala to follow each truck in their fleet. With the click of a mouse on a computer-generated map, they can look down to the village level to locate a given truck. Using real-time playback, they can monitor how a given truck moves (at what speed, whether it has stopped) across its journey. Managers can remotely identify a truck's driver, speed, and contents. This affects customer relations because logistics staff can use this information to tell customers when deliveries will arrive. Such technology increases efficiency and productivity. Few firms in Uganda have implemented this technology, but examples from those that have can be instructive to others.

The benefits from using technology to enhance firms' productivity are not spread evenly across firms and sectors. The gaps among firms in access to software, hardware, and network connections are a problem for disseminating knowledge about technologies that would aid companies, particularly for small companies and independent farmers. The lack of basic infrastructure in electricity, wired telephony, and broadband Internet access hinders scientific development and technological adaptation. It is difficult to say to what extent the gaps in technology are harming industrial innovation and efficiency, but the gaps certainly impinge on firms' ability to link and, thus, to access useful knowledge.

An example of the absence of technology and its impact at the sector level can be seen in the National Chemotherapeutics Research Laboratory (NCRL), which works in the ethnobotany sector. Though the government earmarked funds to achieve consistent ICT connectivity, the lab did not have networked computers—greatly limiting its ability to keep abreast of research developments. For most Ugandan enterprises and institutions in the sector, their meager Web presence is barely sufficient to lure international partners with whom to collaborate. Opportunities in the ethnobotany sector—such as the potential to create interactive maps of ethnobotanical populations across the country to enable researchers to monitor flora and fauna populations for possible commercial development—are lost without chemical testing, mapping skills, software, and computing capabilities. Building capable ICT systems is not sufficient to provide these capacities, but it is a necessary step to diffuse knowledge.

Smaller firms are especially disadvantaged in terms of access to technology because they are not as able as larger firms to afford to apply a value chain approach to their business processes. For example, the production capacity of small Ugandan oilseed producers using outdated Ram press technology will never rival that of Mukwano or Bidco, which rely on more sophisticated technologies throughout the production cycles. Other significant gaps in technology access, use, adoption, and adaptation appear in the analysis of the case studies. Among the most prominent is that very few firms use technology throughout the production process (that is, across each step in the value chain). Most cases of technology use in industry occur at only one point in the process. In particular, there are few cases where software links production with raw material inventories or distribution processes—a part of supply chain management that is common in most manufacturing centers in other countries. The ethnobotanical sector illustrates the spotty integration of technology in what could otherwise be a more productive sector, because much of it is spotty, poorly documented, and conducted by people with a variety of skill levels.

#### *H: Human Resources Need Attention from Government and Industry*

Skilled workers are a critical aspect of a country's capacity to harness science and technology for growth and development. The THICK methodology focuses on six aspects of human resources: the numbers of available scientists and technical workers (with skills demanded by industry), the number of engineers, technical training opportunities (whether through formal training institutions, informal learning opportunities, or industry-based training), the number of students in the pipeline, management training, and entrepreneurial training.

Among the six sectors analyzed in the case studies, industry representatives agree on the need for increased opportunities for industrial internships and training. Beyond the obvious advantage of such arrangements, in terms of refining the skills of employees to respond to the rigors of a particular work environment, industrial attachment appears to be increasingly common in several sectors as a way to compensate for inadequate training through formal education. Specifically, nearly every industry profiled recognized the need for better vocational training and a willingness to work with local universities to improve the industrial relevance of the training offered. Of the sectors examined, energy and ICT are more likely to have formal science and technology-relevant skills training opportunities than those in transport, logistics, agroprocessing, or ethnobotany.

Several companies reported plans to significantly improve their training programs. New entrants, such as Quality Chemicals, described plans to hire highly skilled scientists in areas such as pharmaceutical manufacturing and ethnobotanical production and processing. But, although jobs may be available, it is not clear that trained people will be ready, because most of the companies interviewed said they could not find trained workers in the market. Instead, most workers need to be trained on the job.

Just 4 percent of the relevant age cohort is enrolled in universities in Uganda (Uganda National Council for Higher Education 2004). A 2008 analysis by UNCST shows that just three universities produce 97.5 percent of the country's highly skilled science and technology workers—Makerere University (90 percent), Mbarara (4 percent), and Kyambogo University (3.5 percent). These universities have well-trained faculty and good students that could help produce the next generation of science and technology workers if empowered with teaching tools, conducive teaching and learning environments, and connections to global knowledge partners required to facilitate success.

Despite growing science and technology enrollments in universities and efforts to boost the training of teachers, human resources challenges in science and technology are substantial. There are not enough training opportunities to meet industry demand—particularly for software demands in a number of industries, where engineers who can write or customize software are in short supply. Most software used in manufacturing is purchased from large international suppliers. This is not a drawback, because such software builds capability. But because of the dearth of software developers, firms use software off the shelf even when customization for local use would make it more appropriate for local needs. For one newspaper in Uganda, *The New Vision*, software was identified that could be used to organize circulation and distribution and to increase efficiency for transport and logistics. But the software is coded in U.S. dollars, not in Ugandan shillings. According to one interview manager, the newspaper had no software engineers who could customize the software, so the firm adapted to a less efficient software package.

As for science and technology skills among Ugandan graduates, a number of industry representatives noted a lack of basic skills, such as electronics repair and computing, as well as a lack of professional certification for specific capacities, such as chemistry. For example, energy sciences needed basic researchers in chemistry and geology as well as hydrology experts to aid research in energy and aquaculture. Furthermore, as noted by Uganda's Roads Agency Formation Unit, although the engineers working in government and planning have adequate technical knowledge, a host of soft skills—management, accounting, decision making, cost-benefit analysis, and so on—have weak representation. Recognizing this, the Ministry of Works and Transport plans to slash the number of civil engineers but invest in a substantial training program to improve their policy and planning skills.

Several industries reported the need to offer training to technology users too, such as short courses for farmers or for manufacturing workers on new technology, including ICT. The firms interviewed noted that practical experience is weakly integrated with formal training in most of the sectors examined. For example, at the Uganda National Bureau of Standards (UNBS), managers spend up to a year providing hands-on training to recruits so that they are prepared to use the technology on which the laboratory relies to conduct tests for industry. Training is predominately offered by companies with a large international reach, leaving out small and medium-sized companies, many of which assume that they do not have the resources to integrate industrial attachment opportunities for students into their business models.

Another human resources challenge for science and technology involves curriculum. The team could find little curriculum developed in collaboration with the private sector (such as through a national curriculum development review board with private sector representatives). One exception was in petroleum engineering and geology. There, government scientists and engineers are working with Makerere University to help develop curricula that teach students the geophysics needed in the mineral extraction field. In other fields, more attention needs to be paid to developing institutional mechanisms that integrate the voice of the private sector and the needs of industry in curriculum development and reform at all levels of education, from basic to vocational, tertiary, and graduate-level education.

*I: Institutional Resources and Infrastructure Are in Place but Need Strengthening*

Uganda's ability to harness science and technology for growth and development depends on institutional resources. When viewed from a knowledge or innovation system perspective, a wide variety of institutions influence a country's ability to use, adapt, diffuse, and generate knowledge. This may include institutions offering services in importing raw materials, customs and tariffs, metrology, standards, testing, and quality assurance, human resources education and training, law, policy, regulation, finance, and infrastructure. The THICK methodology offers a narrower view of institutional resources, with a view toward highlighting only the most influential institutions for applying science and technology to growth and development goals. Here institutional resources include key ministries and relevant parastatals, standard setting bodies, metrology and testing centers, educational and training organizations, research institutions, donors, incubators and science parks, producer associations, and financial institutions.

The existence of Uganda's National Council on Science and Technology (UNCST) signifies the intent to prioritize science and technology issues within government. These institutional resources provoke dialogue across line ministries, stimulating national-level dialogue on reforms related to science and technology—though such dialogue may be considered still emerging. For their part, line ministries conduct planning on a host of issues, increasingly noting the importance of science and technology for their sectoral domains of interest, suggesting an institutional appetite for greater coherence on science and technology issues.

A second positive finding concerns education and training institutions. Increased access to primary and secondary education and exploding enrollment at the tertiary level show that the demand for education is high, and institutions have been growing as a result. An example is the collaboration being established between the Uganda Ministry of Energy and Mineral Development. Staff in the ministry's geophysics research department are working with universities to create the curricula needed to adequately prepare future workers for the job market.

The operation of an ICT-focused government agency offers a third positive finding. This institutional resource is configured to support the development of the infrastructure, skills, institutions, and partnerships needed to maximize the contribution of ICT in industry, learning, and governance. More important, Uganda's ICT ministry has adopted a number of projects aimed at getting all 79 geographic districts online by 2010. This follows the ministry's role in spearheading the development of the National Data Transmission Backbone Infrastructure (NBI) and the Electronic Government Infrastructure (EGI) project. Regional initiatives, including the UbuntuNet Alliance, bolster these efforts by consolidating regional initiatives aimed at bringing enhanced connectivity to the research and education community.

A fourth welcome finding is the existence of business research and development institutions. The Uganda Industrial Research Institute (UIRI) engages in activities designed to facilitate rapid industrialization by identifying appropriate, affordable technologies that add value to local products so that they can be processed for national, regional, and international markets. The institute does this through focused research and development and by designing prototypes to help train and develop enterprises. Such institutions are particularly important as sources of technical assistance, knowledge, funding, and partnership creation for entrepreneurs seeking to shift away from subsistence farming or for firms seeking opportunities to increase the knowledge and technology content of their products and processes.

Finally, there are institutions whose mission is to ensure product standards, traceability, and quality. Although the institutional array may not be adequate to perform the entire range of functions required by industry, institutions devoted to quality assurance, standards, testing, and analysis (such as the Government Analytic Chemist, National Bureau of Standards, and UIRI) exist. For example, after the European Union imposed a ban on fish imported from Uganda, a rigorous effort to improve the capability of Ugandan fish exporters to comply with the EU's phytosanitary regulations included efforts to enhance the capacity of the Uganda National Bureau of Standards (UNBS). According to the United Nations Industrial Development Organization (UNIDO)—one of the donor organizations active in supporting the fisheries recovery effort—UNBS is essential to the future of an exportable product. Improving its capacity to perform quality and safety testing on fish enabled UNBS to serve the needs of industry.

Despite these recognizable achievements in institutional resources, harnessing science and technology for development requires facing a number of institutional challenges. Perhaps the most pressing involves the ability to access, adapt, and absorb technology and knowledge created elsewhere to solve local challenges. Despite consensus that modernizing key sectors depends on improving the ability of people, firms, and institutions to access and apply knowledge and technology, institutional barriers inhibit this. These barriers include those that inhibit importing, procuring, accessing, distributing, and integrating knowledge and technology from regional or global sources. Among the disincentives often cited in firm interviews are high tariffs on imported technology, despite the fact that importing machinery is the most common approach toward upgrading technology cited by African enterprises. Protracted delays that are due to burdensome customs procedures are another institutional constraint impeding access and use of knowledge generated abroad. In addition, excessive interest rates on loans for capital investment (averaging 20–30 percent) discourage would-be investors from upgrading technology. As long as some institutions advocate the importance of applying science and technology knowledge to development while others impose impediments on doing so, paralysis will exist.

Second, although Uganda has institutions charged with aspects of metrology, standards, testing, and quality assurance, their competence varies enormously. Because of lack of funding, information gaps about market demands (see the following section on the knowledge base), and ambiguity on institutional complementarity, standards are often neither established nor testable. The institutions active in metrology, standards, testing, and quality assurance in Uganda are the UNBS, UIRI, Uganda Government Analytic Laboratory (UAL), Chemiphar, SGS, and others (see the ethnobotany case study annex for a full description of each). The existence of several institutions in this space belies the fact that firms developing products for domestic consumption or export often do not receive the kinds of services and technical assistance they need to enter markets in compliance with established quality and safety standards. And except for the Belgian-owned Chemiphar, only the microbiology laboratory of UNBS is accredited, though UIRI has committed an investment to establish an accredited microbiology unit as well. In the words of the head of finance and administration of Chemiphar, "The international accreditation of a laboratory is like a visa to move products anywhere."

A lack of accreditation, added to the other institutional constraints undermining these institutions' capability, reduces their usefulness to producers seeking to enter markets domestically and abroad.

A third challenge involves the implementation capacity of a number of institutions relevant to science and technology capacity. In several cases, institutional capacity for planning is not coupled with institutional capability for implementation. For example, although some noteworthy accomplishments have been made, plans for overhauling the National Bureau of Standards and the Government Analytic Laboratory appear to have stalled at the planning stage—with the sole exception being the commendable turnaround on testing fish exports. In another example, according to a World Bank analysis of Uganda's transport sector, although a sector strategy is in place to guide the ministry's activities, both the government funding allocated to implement the strategy and the capacity to enforce certain aspects of it are inadequate (such as axle load requirements and traffic regulations). Though strides have been made on stakeholder dialogue and planning, institutions are less effective if they are not equipped to implement the plans articulated.

Where funding and connections to global knowledge (including through regional networks) are strong, Ugandan researchers perform world-class, highly relevant work. (See the annex for more detail.) Yet, according to the 2005 World Bank–supported Science and Technology Sector Profile of Uganda, nearly all research funding comes from donors, for work on problems of concern to and defined by them. So, few research institutions work on local challenges defined by domestic stakeholders. Most research focuses on health and agriculture. Yet the majority of universities in Uganda do not conduct any research, with the main exceptions being Makerere and Mbarara universities and a few emerging high-quality private institutions.

A fifth challenge involves the limited capacity of research organizations. The dearth of institutions to coordinate research and knowledge across sectors prevents research systems from contributing to national development. For example, health research efforts in Uganda—long considered crucial for national development—involve some 57 institutions (UNHRO 2000). Conceived as an umbrella organization to coordinate research, define research priorities, and ensure that knowledge and funding flow smoothly through the system, the Uganda National Health Research Organization (UNHRO) arose in response to the fragmented research system. Yet, a decade later, this institution lacks the human resources and funding needed to galvanize the kind of organization and cooperation in the sector to yield greater impact on health outcomes.

A sixth challenge often cited by businesses and entrepreneurs relates to financial institutions and the limited availability of financing for capital investment. For firms seeking resources to improve their technological capacity, expand production, or enhance their processes by applying knowledge, the lack of access to small loans discourages investment. Frequent reports of interest rates as high as 20–30 percent epitomize the barriers to knowledge investment facing firms and entrepreneurs. In addition, where opportunities for short-term skills upgrading and affordable technology acquisition occur, microfinance is rarely available. Steps should be taken to improve the capacity of commercial financial institutions and microcredit organizations to serve the needs of Ugandan industry.

Finally, there is a lack of science parks and incubators to create conditions conducive to research, technology development, and business support services. Though science parks are not a quick fix (nor are they a one-size-fits-all undertaking), when used effectively they offer a host of benefits for research and technology development, network facilitation, partnership creation, and innovation. Yet, with a few minor exceptions, Uganda's knowledge system lacks such support.

### *C: Collaboration and Communication Are Weak Links in the System*

Uganda's ability to access, absorb, and adapt knowledge results directly from related opportunities to collaborate and communicate with others within and outside its borders. Knowledge flows through institutions, including professional societies, extension services (such as agricultural extension services), conferences and demonstration events, access to ICT, online resources, and trade shows. Links between people, across sectors, and between public, academic, and private partners allow for the kind of knowledge exchange required for innovation. In this respect, 10 positive findings suggest that communication capacities in Uganda are improving, despite a number of challenges requiring attention.

Among the strengths in Uganda's communication capacity, a shift toward greater openness and increased sharing of information appears to be occurring. With about 160 radio stations, a surge in telephony, and growth in independent newspapers (key newspapers to emerge since 2000 are *The Red Pepper*, *The Observer*, and *The Sunrise*), the country's appetite for information exchange has increased in recent years. A move toward greater science and technology reporting may also be under way.

A tremendous increase in mobile telephony is a second noteworthy asset. The number of telephone subscribers in Uganda jumped from 276,000 in 2001 to 3.6 million in 2007. As mobile telephone penetration improves, so do opportunities for innovative uses of this technology—linking producers to consumers, researchers to users, private entrepreneurs to public partners, and so on. Through a program called FOODNET, farmers can use mobile phones to obtain up-to-the-minute crop prices, enabling them to negotiate better prices for their products. In another instance, ICT is used to improve fish processing in compliance with EU regulations for food safety. In transport and logistics, transportation managers interviewed in the newspaper industry described how each truck driver receives a mobile phone to facilitate communication about breakdowns, receive information about road and weather conditions, and transmit other information that might affect distribution to agents.

Computer penetration is a third positive aspect of the country's communication capacity. Sources in each of the sectors analyzed emphasized the importance of computers for tracking data, optimizing processes (distribution, sales, research, design, and the like) and linking to partners, customers, and users. Still, in 2007 there were just 9 personal computers per 1,000 people, so there is a need to build this capability.

In a fourth striking example of Uganda's positive outcomes in enhancing its communication capacity, it has leveraged opportunities to communicate to the general public the importance of science, technology, and innovation for society. September 2007 saw the country's first National Science and Technology week, during which hundreds of firms, public research organizations, government parastatals (such as UIRI and UNCST) came together to share with students, researchers, government, and civil society the important roles that science and technology play in enabling product development, business opportunities, advances in research, and other areas. Now in its four successful iteration, this national publicity effort to enhance society's appreciation for science and technology is noteworthy.

A fifth positive dimension is the frequency of innovative efforts to reach out and connect among actors engaged in ethnobotany, agroindustry, and transport and logistics. For example, a Ugandan organization called Traditional and Modern Health Practitioners Together Against AIDS and Other Diseases (THETA) uses an innovative communication strategy to link traditional healers in communities to a diverse team of modern health scientists who explain and disseminate good practices, help develop products, and foster collaboration. (See the ethnobotany case study annex for more details.)

ICT, the sixth positive sign of change, affords another opportunity for increased communication capacity in Uganda. Where ICT is used to develop or enhance products and improve processes, it exhibits demonstrable benefits. Successful applications of ICT include computer-aided design, plastics manufacturing, machine tools, and product distribution and supply chain management. As tools to boost efficiency, ICT is still largely untapped across the Ugandan landscape. The case studies suggest their high potential.

A seventh positive finding is the presence of extension services. Extension services are used to convey know-how, services, and technologies between producers and users, facilitating knowledge circulation (such as between researchers, policy makers, farmers, and entrepreneurs). Uganda's National Agricultural Advisory Services is one well-known example from agroindustry. Other noteworthy extension services include the Export Promotion Board's Biotrade Programme, the goal of which is to promote trade in natural ingredients to raise earnings, generate employment opportunities, and ensure sustainable use of the country's resource base (Export Promotion Board 2004). In the ethnobotany sector, the Biotrade Programme's program on natural ingredients for cosmetics and pharmaceuticals provides training in export development skills at the institutional and enterprise levels. The program also disseminates trade information and export data. Although existent in Uganda, extension services are inconsistent in terms of quality, impact, and reach (see the following).

An eighth observation of progress toward building communication capacity involves participation in regional planning initiatives. Among the regional planning organizations in which Ugandan ICT professionals participate are the African Network Operators Group, AfriNIC, and the African Internet Foundation. The African Network Operators Group is a promising initiative to train people in various industries to operate networks. Though reliant on donor funding, the regional organization provides short-term training to anyone interested in learning skills associated with network operations. AfriNIC is a pan-African initiative devised as a continental equivalent to ICANN, which authorizes Internet protocol (IP) addresses in the United States. AfriNIC addresses policy challenges common to African countries. Finally, the New Partnership for Africa's Development's ICT initiatives and the UbuntuNet Alliance offer regional forums for planning and collaboration. Participation in such initiatives shows that Uganda is taking a practical approach to increasing communication capacity by leveraging regional partnerships.

A ninth benefit is the growth in Ugandan professional societies and conferences that offer further opportunities to strengthen communication capacity. Organizations offering opportunities for dialogue, professional support, and networking include Uganda's ICT Association, the Uganda Institute of Professional Engineers, Women Engineers, Technicians, and Scientists, the Uganda Broadcasting Council, and the Uganda ISP Association.

Finally, site visits revealed various endeavors aimed at enhancing ICT research capacity—another positive aspect for communication capacity. The Institute of Computer Science at Makerere University, which boasts 25 faculty, 3 doctoral students, 300 graduate students, and more than 600 undergraduates, is among the country's few institutions performing research on ICT. In 2007 the institute launched an ICT-focused journal that publishes research generated by it and elsewhere. But ICT research accounts for a small portion of the activity taking place in training institutions. One source in Uganda asserted that, although Makerere University's investment in ICT research was advantageous for creating training opportunities, research priorities were determined without taking into account their relevance to industry. Without direct input from users and potential industrial partners, Makerere's research products are unlikely to elicit near-term changes in the efficiency or capability of Ugandan business using ICT.

Moreover, Uganda's progress toward realizing robust communication capacity is thwarted by a number of pressing challenges. These are described in the following, some of which receive attention but remain significant because of their complexity or the paucity of resources allocated to their amelioration. Others appear to persist largely unaddressed.

Minimal links between key actors in a knowledge or innovation system undermine any country's ability to tap local, regional, or global knowledge resources. In Uganda, few links exist between the research community, public research organizations, universities, industries, and users. Unlike the dynamic knowledge economies of OECD countries, where collaboration between industries and universities is common and public research organizations systematically link with both, institutional actors in Uganda remain isolated. Connecting functions in a knowledge society are often provided by intermediary organizations, such as industry associations, science parks, outreach centers, and extension services. Across the case studies, interviewed representatives from discrete sectors (industries, universities, the public sector) described frail or nonexistent links with other sectors.

For example, among public institutions charged with ensuring quality, safety, and adherence to standards, a senior official from the National Bureau of Standards argued that, although institutional collaboration lies at the heart of an effective standards and testing regime, fruitful areas for scientific exchange, collaboration, and joint research remain untapped. But the lack of links does not just result in missed opportunities for collaborative research. Rather, in areas such as standards and testing, knowledge gaps in market demand and industrial regulation limit otherwise exportable products to domestic use. Similarly, in the country's oilseed industry, sector experts say that the interaction between players is weak, leading to a poor flow of information and making the sector nontransparent (Agri-ProFocus 2006).

A second challenge relates to channels for diffusing knowledge in the innovation system. Where relevant research takes place or technology development occurs, knowledge diffusion is reduced by a lack of channels through which it might occur. Interviews yielded frequent accounts of industrially relevant research conducted at universities, technologies developed for which a perceived need exists in civil society, and repositories of business development information going underused, even when firms express strong demand for such information. The frequency of these occurrences suggests that less pressing than the challenge of generating new science and technology knowledge is the challenge of vastly enhancing explicit and efficient channels to distribute knowledge through the system. A need for knowledge is insufficient to ensure that required information—such as technical know-how, market intelligence, and knowledge embodied in technology—will make its way to those who need it.

A third challenge stems from the second. Extension services are in particular need in Uganda as a system for knowledge diffusion. Though these services exist in Uganda, they have been widely criticized for being based on a linear approach to innovation and overreliance on knowledge dissemination to users, as opposed to encouraging circulation of knowledge between users and producers to enhance demand-driven research and technology development. For example, the Oilseeds Producers and Processors Association was among the institutions that criticized extension services in the oilseed sector for uncoordinated coverage by extension service providers, wasted resources, duplicated services, poor dissemination of research findings to farmers (and vice versa), and a weak market information system (Agri-ProFocus 2006).

A further challenge is that weak connections to consumers and international markets thwart Uganda's efforts to adopt an export orientation for agroindustry and ethnobotany. These weak connections impose severe constraints on market development. For example, in the ethnobotany industry, market information critical to developing and exporting products (such as cosmetics) includes that related to sanitation and safety regulations, phytosanitary certification of raw materials used, general quality requirements, health and safety issues, documentation of adherence to the Convention on International Trade in Endangered Species (CITES) if relevant, and information related to acceptable packaging, marketing, labeling, and so on. Without this information, small producers using rudimentary technologies (galvanized grinders, locally fabricated distillers, mortar grinders) to manufacture powders and crude essential oils restrict their sales to local markets or sell unprocessed raw materials to buyers with better understanding of consumer and market needs, who then profit from value-added processing.

A fifth challenge arises from the growing yet still weak ICT capacity. The Global Competitiveness Index ranks Uganda 117 among 128 countries in proportion of mobile telephone subscribers and 111 in proportion of Internet users. Urban-rural disparities in access and inconsistent application of ICT to industrial processes limit its ability to strengthen processes and optimize product development or knowledge sharing. Underpinning the challenges associated with ICT growth are consistent power outages and high connectivity and energy prices, all of which diminish entrepreneurs' prospects of capitalizing on the benefits of ICT.

Limited Web access is a sixth challenge weakening communication capacity. Web access is essential for locating and using critical information in research, product development, and marketing. Without it, researchers cannot post their findings, publications, and materials online to make them accessible to the global knowledge community. Furthermore, Web-based resources provide a platform to establish a national presence and competence in emerging scientific areas or in market niches. A consequence of limited participation in online communities is that Ugandans are less likely to elicit knowledge partners and collaborators during their research. For example, Web-based databases allow plant biologists to scan bioinformatic data drawn from global observations of plant species. As Uganda seeks to expand ethnobotany, researchers need access to these data to learn about the species they are exploring for potential commercial use. Without Web access, they are relegated to reinventing the wheel—wasting time and resources. In institutions such as the National Chemotherapeutics Research Laboratory, which is charged with researching, developing, and commercializing ethnobotanical products, knowledge of such Web-based resources exists without the ICT capacity to use them.

*K: Knowledge Base Is Available but Not Easily Accessible*

The degree to which the knowledge base in Uganda offers sufficient science and technology information, ideas, resources, and tools to solve the challenges confronting industry or meet development needs can be measured in a number of ways. The THICK methodology focuses on six qualitative measures of the knowledge base:

- Technical data and reports.
- Research funds.
- Technical development funds.
- Regulations.
- Laws on safety and environmental protection.
- Indigenous knowledge.

Although clear-cut distinctions between human resources and the knowledge base from which they draw and to which they contribute are difficult to construct, the measures included in the THICK methodology are designed to include institutionally derived aspects of knowledge (laws, regulations, funding) as well as knowledge absorption dimensions (knowledge and enforcement of laws, funding, technical reports). In this way, the analysis assesses both the depth of the knowledge base and the degree to which the knowledge base is tapped effectively. Six positive findings about Uganda's knowledge base are highlighted as follows, along with seven key challenges.

A noteworthy positive finding relevant to Uganda's knowledge base is the existence of various repositories of sector-specific science and technology knowledge and organizations to facilitate the exchange of good practices. Organizations such as THETA, the National Chemotherapeutics Research Laboratory (NCRL), Export Promotion Board, Private Sector Foundation, Uganda Oilseed Producers and Processors Association (UOSPA), and Uganda Industrial Research Institute (UIRI) demonstrate the diversity of organizations seeking to enrich the knowledge content of industry. In their services to industrial, university, government, and civil society partners, each of these organizations disseminates good practices, research, technical services and support, and opportunities for networking and contact identification.

Analytic and advisory capacity also stems from the knowledge base. In a second positive finding, several examples described in the case studies indicate a competent advisory capacity in the form of technical reports and analyses. For example, various individuals and institutions produce comprehensive sector analyses underpinned by scoping missions, data gathering, and syntheses. Such technical reports are used to enhance decision making and priority setting. An oilseed sector study and an ethnobotany sector assessment of natural ingredients for cosmetics and pharmaceuticals serve as two particularly strong examples produced by a group with representatives from UOSPA, the National Planning Authority, Dutch partners, and the Uganda BioTrade Programme. In addition, assets include regional knowledge organizations, through which governments, institutions, people, and firms may collect and exchange knowledge. As regional integration becomes a higher priority, membership in sector-specific and cross-sectoral regional knowledge organizations appears to be increasing. Examples include participation in knowledge-sharing activities of larger regional organizations, such as the New Partnership for Africa's Development (NEPAD), as well as smaller organizations that collect and exchange information on a narrower set of topics, such as the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the African Network for the Chemical Analysis of Pesticides (ANCAP), and the African Malaria Network Trust (AMANET).

Another welcome finding about the knowledge base is the emergence of platforms for knowledge partnerships between private firms (including small and medium-sized ones) and entrepreneurs. Although not widespread, a number of programs were identified in which large companies (often with sophisticated production and processing techniques and highly developed technological capacity) partner with individuals and enterprises. Partners agree to experiment, research, or develop new technologies and processes on behalf of the industrial partner. In the oilseed sector, one of the two dominant processing firms, Mukwano Industries, partners with more than 32,000 outgrowers (small-scale and subsistence farmers). Mukwano provides the outgrowers with new oilseed varietals, optimized growing techniques, technology packages. A prenegotiated pricing arrangement guarantees outgrowers that the crops produced using the technology packages will be purchased by Mukwano. Thus the risk associated with experimenting with new inputs is minimized for the outgrowers. The firm-outgrower relationships serve as platforms for knowledge exchange, learning, technology, and process optimization.

A fifth positive indication of Uganda's advance toward deepening its knowledge base relates to research. Pockets of research and instances of international scientific collaboration reveal the country's growing research capacity. As the knowledge maps in the annex illustrate, Uganda maintains research strengths in infectious disease, food science and technology, tropical medicine, biotechnology, and other areas. Although almost entirely donor-funded, Uganda's researchers are beginning to demonstrate an ability to elicit research collaborators elsewhere and contribute to the global knowledge base.

Finally, although it accounts for a tiny portion of research activity, private sector research is occurring. For example, the second leading player in Uganda's oilseed and vegetable oil processing sector, Bidco, is exploring opportunities to produce palm oil domestically, reducing reliance on expensive Malaysian palm oil that is imported into Uganda for processing by the company. Bidco has a 20,000 hectare palm plantation under development on Bugala Island in Lake Victoria. There the company is building a training center for farmers. Integral to its plan is continued reliance on robust research and development capacity, which is critical to respond to changes to market needs and customer demands. The focus of the palm oil development research effort is to ensure that the palms grown produce the highest possible oil content at an appropriate standard of quality.

The positive findings previously described suggest that Uganda benefits from an ability to contribute to and elicit information from the science and technology knowledge base, be it the local knowledge base, regional knowledge base, or global knowledge base. Still, multiple challenges restrict the ability of firms, governments, and people to capitalize on available knowledge. Seven of these challenges are detailed in the following.

Endemic to the Ugandan knowledge system is a dearth of opportunities for knowledge exchange. Related to the challenges described above affecting communication capacity, too few opportunities to share ideas, collaborate over technology development, and engage in cross-sectoral problem-solving are fostered or exploited. Thus knowledge does not circulate within communities (university researchers, government ministries, and so on) and between communities to the degree it could. Moreover, little attention is paid to when and how knowledge (in the form of research, technology, advice, and the like) should be mined elsewhere as opposed to growing the capability for knowledge creation locally. Understanding where knowledge is located and when to prioritize scanning for it, accessing it, adapting, and using it is an essential but weak aspect of the country's knowledge system.

A second challenge confronting the knowledge base stems from weak and uncoordinated legal frameworks for the commercialization and protection of innovations in technology, products, and processes. There is insufficient capacity for intellectual property rights (IPRs), with little or no regulatory capacity, a lack of information about the existence or relevance of international rules and regulations, and a dearth of trained lawyers equipped to facilitate IPR agreements. An example from ethnobotany illustrates the negative impact that low IPR legal capacity may have on technological development.

THETA, in collaboration with a number of traditional medicine practitioners and researchers at public research institutions and universities, has developed three therapeutic products: one for malaria, one for the flu, and one for various skin conditions. The director of THETA described the research and development of the three compounds, which are derived from ingredients and practices used by traditional healers. Although THETA performed the research and analysis to validate the safety and efficacy of these compounds, the practitioners were the first to experiment with these ingredients. Because of the ambiguity of the intellectual property rights—do they belong to the healers, THETA researchers, or the funders?—the organization opted to restrict information on the ingredients of the compounds. The packaging does not contain detailed information on active ingredients. What information is printed on the labels is written in local languages to prevent international firms from exploiting the products in international markets. In their current state, the three products are not appropriate for export or wide-scale commercialization or even in line with national safety standards for pharmaceuticals that require labels to specify ingredients. Without a cadre of IPR-savvy attorneys to assist organizations such as THETA in clarifying and allocating intellectual property rights, Uganda cannot maximize the commercial benefits of its ethnobotanical assets, an impediment that has consequences for a number of sectors beyond ethnobotany.

A third challenge requiring attention pertains to regulations and knowledge dissemination regarding metrology, standards, testing, and quality assurance. The array of institutions charged with determining market demands for safety, packaging, content, and the like (for both domestic and international markets), establishing standards, testing products at various stages of development, and enforcing adherence to quality and safety standards in domestically produced and imported goods is insufficient. Although some of the weaknesses within the institutional array relate to other aspects of the THICK methodology, others bear on weak capacity to elicit critical information. Most tests requested by industry lie beyond the expertise of the Uganda National Bureau of Standards or require skills and equipment that it does not have, in addition to requiring certification of accreditation from the laboratory conducting the tests. But because international standards for quality and safety are a constantly shifting target, near constant investment in knowledge-scanning, precision equipment, and the human capacity to run the required tests and conduct analysis is required. The weak knowledge flows, between the standards and safety institutions and industry at home and abroad, result in knowledge gaps. Knowledge gaps in terms of standards vary in severity, with some sectors bereft of standards altogether, such as in the processing of natural ingredients into extracts, essential oils, and saps. These knowledge gaps weaken entrepreneurs' and would-be exporters' ability to develop their products in line with requirements for foreign markets. Until these knowledge flows are improved, reports of goods turned away at European shipping ports or refused by international buyers will be many.

Another knowledge-related challenge involves serious research gaps that render the knowledge base thin and inconsistent. For example, though touted as an area of strength in Uganda's research community, agricultural research is characterized by underinvestment in areas key to the modernization of the sector, as called for under the Plan for Modernization of Agriculture. Oilseed research on new varietals appropriate to conditions in Uganda, research on optimal inputs and practices to blend subsistence and cash cropping, and research on commercialization of wild plant and tree species offer three of many examples of blind spots in the agricultural research agenda, despite a widely agreed need for such research.

Another challenge derives from the low appreciation of science, technology, and innovation to solve problems. A host of industrial competitiveness challenges and national development needs require scientific knowledge, technology, and workers trained in science and technology if they are to be adequately addressed. Yet it is common that the national discourse on the importance of science and technology occurs in isolation of industries' and often government's discussion of how best to respond to pressing challenges. Deepening Uganda's knowledge base will entail enhancing the appreciation of how scientific and technological know-how can be used (and from where it may be accessed) to solve urgent needs.

Finally, challenges related to gathering and absorbing market information impede prospects for industrial growth and development, even as other knowledge resources are marshaled effectively for use in industry. Learning how to learn is essential here. Yet, systematically, Ugandan enterprises engaged in agroprocessing, ethnobotany, and other industries reported that they did not know how to gather market information or ascertain customer demand, particularly in foreign markets. The unmet need for more intermediary organizations, similar to Uganda's Export Promotion Board, that manage knowledge flow between industry and markets is still a challenge. Even some of the largest industrial players, such as Mukwano Industries and Bidco, cited knowledge bottlenecks and lack of reliable market information as the biggest constraints to their productivity.

Table 2 summarizes the positive findings from the case studies. It also summarizes the most pressing challenges in terms of their relationship with the five THICK dimensions. These positive findings and challenges are then contextualized in relation to the kinds of actions that policy makers should consider to address the needs of industry within the economy.

**Table 2. THICK Features**

| Thick Feature | Strengths | Challenges | Actions to Consider |
|---|---|---|---|
| Technology Resources | Foreign direct investment is bringing technology transfer in machining and processing. | FDI is not part of a targeted strategy and therefore is not part of a learning loop that helps knowledge stick at that local level. | Target set of policies and programs to ensure local sustainable development by building learning of skills and technology transfer into specific technologies being transferred. |
| | ICT (information and communication technologies) is being used to good effect in several sectors. | ICT-enabling environment is not conducive to wide use: problems in electricity, access to broadband and wireless hinder use. | Create network of centers for computer science research, development, and training. |
| | Where available, agricultural productivity technologies are being used effectively. | Small operators lack access to technologies that would improve productivity. Very few production centers have access to scientific know-how or advanced technology; technology is not consistently applied across the value chain. | Focus on building scientific capacity in six critical fields (see text and Recommendations section); local software capacity is very important for value chain enhancement. |
| Human Resources | Access to S&T related disciplines within higher education institutions is increasing as a result of government's commitment to see that a greater proportion of graduates take science and engineering (S&E) degrees. | Curriculum is theoretical and graduates often lack practical knowledge; curriculum is not tied to industrial processes, so students seldom have a chance to learn practical skills that can help solve problems within industry. | Create opportunities for industrial attachment for students, deepen industrial exposure, opportunities for training and internships in public science and research institutes, etc. and access to science centers. |
| | Some technical training options exist, mainly in ICT. | Many more technically trained people are needed by all sectors; lack of technical people is hindering innovation in all sectors. | Establish a network of high-quality technical and vocational training centers offering students the S&E related skills they need of relevance to industry and national development needs.These skills may be acquired through short-course degree programs and linked to foreign universities or training centers. |
| | Numbers of students have been rising; government gives incentives for students to study science and technology. | Most sectors lack certification opportunities for technical people. | Technical training centers are needed in areas of relevance to industry, such as metrology, standards, testing, and quality assurance. |
| Institutional Resources | Institutions for science and technology exist; STI strategies have been put in place. | Implementation opportunities are limited. | Focus and target science investments to those most likely to help industry by establishing cross-ministerial centers. |
| | Universities offer science and technology curriculum. | Access to tertiary science or technology education is severely limited by a number of factors (few professors to teach at tertiary level, lack of research equipment or mentors). | Identify ways to improve access to tertiary level education and training, emphasizing quality and relevance over access. |
| | Researchers on ground in some fields (virology, agriculture) perform very good scientific research. | Universities do not have enough seats to educate the students needed to fill future workforce, even though numbers have been increased. | Tie business associations into the targeted plans for science and technology investments. |

**Table 2. (*continued*)**

| Thick Feature | Strengths | Challenges | Actions to Consider |
|---|---|---|---|
| Institutional Resources (*continued*) | Business associations exist. | Associations are weak and poorly connected to other parts of the knowledge system. | Link business associations to academe and government through cross-cutting initiatives aimed at coordinating the national S&T system. |
| | Science park and incubators concept appears in plans. | Very little has been done to create science parks or business incubators. | Build science park adjacent to university locations. |
| | Standards and metrology institutions exist. | Standards and metrology institutions are seriously underresourced and weakly connected to innovation. | Invest in standards and metrology capacity; look for opportunities to do this at the regional level. |
| Collaboration & Comm Resources | Access to networked computing exists. | Penetration of technology is weak because of lack of computers and no access to network, to electricity. | Create cross-cutting initiatives as "grand challenges" that involve many stakeholders from different sectors. |
| | Extension services exist. | Extension services outside of agriculture are nonexistent. | Work with regional neighbors to create extension in manufacturing and packaging. |
| | Some organizations exist to share best practices and to demonstrate technology. | This capacity needs to be greatly increased and moved up the value chain to packaging, storing, and shipping of goods in all sectors. | Mandate government information center to collect data on labor, wages, and market prices. |
| Knowledge Resources | Regional organizations are being put in place to bring together knowledge from various sources. | Lack of access to the technical information that is already available. | Create government function to scan the globe for knowledge needed within specific industries or companies—look to worldwide resources that can increase local capacity with available knowledge. |
| | Government has created research funds for science and technology. | Dearth of opportunities for knowledge exchange across sectors (academic to business). | Include stakeholders from numerous sectors in panels to address growth of specific capacities and to identify knowledge that is needed, which can be gathered from neighboring countries or global centers of excellence. |
| | Business people say that the demand for educated staff and market information is not being met. | Significant lack of ability to gather market and labor data. | Mandate government information center to collect data on labor; need a labor market observatory. |
| | Some business associations are collecting market information on their own that could be shared with others. | Weak and uncoordinated regulatory and legal frameworks for commercialization that make it difficult for businesses to know the environment in which they are operating. | Direct stakeholder committees or foresight panels to determine which areas of regulation should be addressed first and to make recommendations about regulations. |
| | Some businesses see the benefit of accessing scientific knowledge, particularly in ethnobotany and in pharmaceuticals. | Low appreciation of the role of science to solve manufacturing and production problems. | Make commitment to science and technology at highest level of government; create incentives for industry to incorporate technical knowledge into production. |

*Source*: Compiled by authors.

CHAPTER 2

# Policy Recommendations

This section offers recommendations for the near and medium term, as Uganda implements its National Science, Technology, and Innovation Policy. The recommendations focus on building science and technology capacity in industry, with complementary and supporting efforts by the government and educational institutions. Table 3 consolidates the recommendations.

Underlying these recommendations is an emphasis on building the infrastructure that provides the public goods functions (highlighted in the third dimension of the THICK analysis—Institutions and Infrastructure) for science and technology. This includes a focus on intermediary organizations and functions such as metrology, standards, testing, and quality assurance and intellectual property protection. These investments should be combined with efforts to connect stakeholders to other knowledge partners, forming networked knowledge systems (as highlighted in the fourth dimension of the THICK analysis—Collaboration and Communication). Government-provided infrastructure and cross-sectoral connections will facilitate the exchange of knowledge .

The recommendations have been derived to fit the THICK methodology used throughout this report.

The case studies illustrate the significant gains already achieved in science, technology, human resources, institutions and infrastructure, collaboration and communication, and the knowledge base in Uganda. To consolidate the gains achieved and deepen the benefit to industry of entrenching these gains, this section discusses a number of recommendations that address this question: To what extent can science and technology improve key industrial sectors? Because it is unlikely that Uganda will be in a position over the next few years to make all the recommended investments

**Table 3. THICK Recommendations**

| | |
|---|---|
| 1 | In a joint initiative involving government and industry, create nation-wide investment strategies in six key areas that offer potential for near-term, high payoff for all five industries studied for this report. |
| 2 | Train paraprofessionals in select functions that can help bridge capabilities across sectors. |
| 3 | Focus on building the public support functions and institutions that are needed to create a robust and sustainable knowledge system at the national level. |
| 4 | Create opportunities for academia, industry and government to foster linkages, conversations, and shared priorities. Institutional mechanisms that cut across line ministries and bring industry to the same table as academia and government are encouraged. Their impact is clear in the experience of such countries as Chile, Thailand and Finland. Enabling professional associations to meet with, talk to and strategize with scientific researchers, engineers, and local businesspeople is also advised. |
| 5 | Gather and publish the economic and technical data needed within each country to track progress and plan future investments and build the regulatory and legal frame work needed for business. |

required to benefit industry, the recommendations identify the most critical, highest pay-off investments.

Recommended actions for the three critical stakeholder groups—government and the public sector, private firms and consortiums, and education and training institutions—appear as follows.

*Recommended Actions for Government and the Public Sector*

1. Convene a cross-sectoral National Science, Technology, and Innovation Council at the presidential level to ensure that science and technology investments are a priority that spans multiple ministries, the private sector, and the education and training sector. Special attention should be given to the infrastructure needs of the sciences and technologies that can serve a number of industries. As technology planning gets under way, a number of implementation aspects will require government attention.
2. Strengthen research efforts in six critical areas of science and technology (agriculture, health, energy, ICT, transport, and logistics by tying support to build capacity in education, research, and innovation in those disciplines to specific goals in Uganda's national development plans and strategies.
3. Analyze the institutional landscape in terms of knowledge partnerships with collaborators (across all key science and technology sectors, nationally or internationally) to ascertain opportunities to forge, optimize, and sustain knowledge partnerships in critical science and technology areas.
4. Fund the creation of a center for computer science research, development, and training to develop the capabilities needed to aid and support industry.
5. Convene panels to explore needs and opportunities in eight cross-cutting areas of science and technology pertinent to the needs of industry (see table 5).
6. Have government agencies take a leadership role in establishing standards for important technologies to be developed locally.
7. Use government agencies to help reduce science and technology infrastructure and equipment costs by procuring technology and scientific equipment in bulk and then selling or leasing it to industry. This can be done with large-scale purchases of items such as electronic scanners or chemicals by which government buying power can aid industry.
8. Negotiate licensing arrangements needed by local industry to provide part of the value chain that would be difficult for industry to finance, such as access to spectrum, botanical, or chemical product licenses.
9. Explore opportunities to pilot technology demonstration projects to show local businesses how to jump-start scientific processes or technological capabilities needed at the local level.
10. Have ministries work with industry to identify needed skills that can be the subject of technical training. Technical training centers operate most effectively if they are nonprofit; thus they should be run through a cooperative effort between government and academia, with advice from industry.
11. Strengthen the National Bureau of Standards' capacity in standards, testing, and quality assurance to aid Ugandan manufacturers and industrialists in producing goods for domestic and foreign markets.
12. Explore the best way to enable science and technology growth through changes to the tax and regulatory regime. Tax benefits that encourage companies to create jobs or conduct research are common in advanced countries. Tax regimes that encourage foreign direct investment tied to technology transfer can affect a country's technology base. Similarly, regulations that benefit business can be

written in a way to ensure worker safety and environmental health. Although Uganda is aware of the need for these functions, they need to be greatly enhanced and made more compatible with industrial development.

13. Fund an aggressive research and strategy-setting effort to launch a more robust, available, and adequately funded system to provide extension services, technology transfer agents, and information collection and sharing services. These services will propel industrial capability in terms of parlaying knowledge from the laboratory to the field and, most critically, back again.
14. Explore the viability of science parks as a way to encourage collaboration between academia, industry, and government.
15. Support a feasibility study for a labor market observatory that could serve as the locus of responsibility for data collection, trends analysis, and forecasting on science and technology human resource needs, industrial performance of research and training, and science and technology use.

*Recommended Actions for Private Firms and Consortiums*

1. Develop task forces for each of the six science and technology initiatives (agriculture, health, energy, ICT, transport, and logistics), led by industry leaders and associations, to devise near-term goals and actions (such as training workers or solving specific problems through public-private partnerships) that can build local capabilities.
2. Galvanize an existing consortium or create a coalition of industry representatives to analyze and share the needs of industry with government and academia on computer science skills, training, and research and development.
3. Create a group of industry experts to participate in a series of panels that explore needs and opportunities in eight cross-cutting areas of science and technology pertinent to the needs of industry (see table 5).
4. Identify participants for a cross-sectoral National Science, Technology, and Innovation Council with leadership at the Presidential level. The council's main goal will be to ensure that science and technology investments are a priority that spans multiple government ministries, the public and private sectors, and academia.
5. Have industry associations work with ministries to identify skill needs that can be the subject of technical training at vocational education and training institutions specializing in science and technology.
6. Collaborate with government and academia on an aggressive research and strategy-setting effort to launch a more robust, available, and adequately funded system for the provision of extension services, technology transfer agents, and information collection and sharing services.
7. Explore the viability of science parks as a mechanism to encourage collaboration between academia, industry, and government.
8. Spearhead a renewed effort to collect and publish data on science and technology in industry, starting with the labor market and including data on research and development.
9. Participate in a feasibility study for a labor market observatory that could serve as the locus of responsibility for data collection, trends analysis, and forecasting on science and technology human resource needs, industrial performance of research and training, and science and technology use.

*Recommended Actions for Education and Training Institutions*

1. Have universities conduct, for each of the six science and technology initiatives (agriculture, health, energy, ICT, transport, and logistics), audits of current

training and research capacity, identifying needs for staff, facilities, infrastructure, equipment, and contact with collaborators required to demonstrate capacity and excellence.

2. Convene a group of preeminent researchers and academics to participate in a series of panels to explore needs and opportunities in eight cross-cutting areas of science and technology pertinent to the needs of industry (see table 5).
3. Participate in an analysis of the institutional landscape in terms of knowledge partnerships with collaborators in key science and technology sectors at national or foreign universities and research institutes, to ascertain opportunities to forge, optimize, and sustain knowledge partnerships in critical areas of science and technology.
4. Identify participants for a cross-sectoral National Science, Technology and Innovation Council, with leadership at the presidential level. The Council's main goal will be to ensure that science and technology investments are a priority that spans multiple ministries, the public and private sectors, and academia.
5. Establish clear lines of communication and feedback with industry on science and technology curricula, pedagogy, and integration of research and practical experience in formal education and training. Collaborate with government to establish technical training centers for people inclined toward technology-based industries for which university training is not necessarily required.
6. Participate in a national, annual effort to collect and publish data on science and technology in industry, beginning with the labor market and including data on research and development.

Experts associated with this project asserted that Uganda may benefit more from connecting across sectors—such as exchanging knowledge among industrial research centers, academic labs, and professional societies—than it will from making any other investment aimed at science and technology. Improving channels of knowledge exchange between sectors may elicit more gains than new investment in science capacity simply because doing so leverages existing strengths and creates feedback loops that are crucial to expanding the knowledge system. Combined with better data collection by government and industry officials, these improvements could leverage existing capabilities.

For each dimension of the THICK framework, the highest-priority recommendations for action are presented in the following, organized by those pertinent for the near term (one year) and the medium term (five years). Additional recommendations are offered that apply to all the sectors studied unless otherwise noted. Examples from the case studies are used to highlight the possible benefits of implementing these recommendations at the sector level.

### Technology: Invest in Six Critical Science and Technology Areas to Support Growth

Two investments will trigger capacity-building in critical science and technology areas and so contribute to industrial growth. The first entails creating six national-level, cross-cutting initiatives in science and technology to address the knowledge needs of industry. These initiatives involve subfields of the sectors highlighted by this report and warrant immediate investment (table 4). The second set of investments can be made to plan for longer-term capacity building in eight additional key areas (table 5).

Scientific and technological learning is an important part of knowledge-based growth for each of the case study sectors examined in this report (see the annexes for more de-

**Table 4. Top Six Subfields of Science and Technology of the Six Profiled Sectors, in Order of Urgency**

| |
|---|
| Computer science |
| Civil and transportation engineering |
| Environmental science and engineering |
| Ecology |
| Food science and nutrition |
| Agricultural science and engineering |

*Note:* The six profiled sectors are health, agriculture, energy, ICT, transport, and logistics.
*Source*: Compiled by authors using data elicited through the ISI Web of Science.

**Table 5. Eight Additional Critical Fields of Science and Technology over the Next Five Years**

| |
|---|
| Biochemistry |
| Organic chemistry |
| Biotechnology |
| Geosciences |
| Plant and soil sciences |
| Chemistry—analytic and multidisciplinary |
| Engineering—industrial and mechanical |
| Energy and fuels, petroleum engineering |

*Source*: Compiled by authors using data elicited through the ISI Web of Science.

tails). It can be difficult for industry or government alone to identify and prioritize the fields of science that need investment. To aid this process, drawing on the scientific literature and our knowledge of Ugandan science and technology, the report team developed a list of subfields that are critically tied to the future of the six sectors and that need to be locally available to promote growth. The criteria used in selecting these six fields include the existence of some degree of national capacity in Uganda and evidence that each field is clearly important to every sector of the economy studied for this report. The fields are also codependent, and cross-fertilization among them will aid in their development.

The fields, listed as follows and in table 4, represent platform capabilities that can serve all the knowledge-based sectors in Uganda. There are overlaps among them, but each represents a specific field of training and skills that are often found in different departments, ministries, or schools and may benefit from cross-cutting relationships in Uganda.

- Computer science, with a focus on training programmers in open access software for industrial process management and supply chain management.
- Civil and transportation engineering, with a focus on engineering storage units and techniques for processing raw materials in agroindustry, biofuels, ethnobotany, and other areas, as well as the ability to transport raw, intermediate, and finished goods to and from markets safely and efficiently.
- Environmental science and engineering, with a focus on ethnobotanical plants, biofuel feedstock, and managing land for use in animal feed production, as well as on the impact of climate and climate change on the ability to produce feedstock crops, manage water, reduce impacts of drought and flooding, and ensure natural habitats for animals and people.

- Ecology, with a focus on the systemic aspects of regions of Uganda and on mapping the ecosystem relationships between all parts of the economy and regional ecology.
- Food science and engineering, with a focus on traceability of products from raw materials to finished goods to ensure quality and safety and on development of phytosanitary testing and regulations.
- Agricultural science and engineering, with a focus on two aspects: (1) agronomy—the application of soil and plant sciences to land management and crop production—applied to indigenous plant life, production of cashews and other crops, and biofuel feedstocks, and (2) genetic adaptation of seed stock to varying climates and soil conditions.

The team recommends that significant funds—between $2 million and $10 million over three years in each field—be invested to create collaborative research initiatives in each of these six critical fields. The fund amounts are based on analysis of funds committed to these or similar fields in other developing countries. Investment strategies should include cross-cutting initiatives instituted by government at the highest relevant level. The initiatives should include input and participation by companies and business groups, academic and government researchers, and local, regional, and international representatives.

Within each national science and technology initiative for the six fields profiled, the government is advised to strengthen research efforts by tying them to specific goals within their national strategies. For example, the case studies show weak capacity in bioinformatics, which limits the participation of local researchers in the global field of ethnobotany. So, enhancing the computer science–related aspects of bioinformatics would constitute an element of the health and ethnobotany initiative.

Each discipline-specific initiative should include a process for taking inventory of technology and human resource capabilities—with a specific effort to share capabilities whenever possible. Within each initiative, a task force of industry leaders and associations should develop a list of important near-term goals (such as training workers or solving specific problems through public-private partnerships) and identifying actions that can be taken to build local capabilities. Each initiative should also include a strategy to establish or strengthen international collaboration in that area. An example for the computer science initiative is a database on regional biodiversity that could be established in association with the Global Biodiversity Information Facility. This facility is a database that identifies unique species and the conditions and seasons in which they thrive. Uganda's database effort, in turn, could be part of the computer science initiative to build local data management and software capabilities. Incentives for cross-sectoral collaborations could be offered to encourage such links.

Computer science appeared on the top of the list and is related to each of the sectors studied for this report. Computer science centers exist in Uganda but are poorly funded. A center for computer science research, development, and training funded at $10 million over three years would go some way toward developing the capabilities needed to aid and support industry, according to industry representatives. Such a center should be realized as a combined effort by government, industry, and academia, with international partners in Africa and across the globe.

A related recommendation entails creating panels made up of stakeholders from industry, academia, and government to discuss eight additional fields of science and technology of critical importance to Uganda's economy (see table 5). For these fields, the team found less capability in Uganda than for the six most critical areas, but particular industries need these capabilities to be developed in local or regional centers. It is recommended that opportunities be identified to integrate international collaboration into developing domestic capacity in these fields domestically. A national plan is needed that will bring together the various sectors to discuss the level of local and regional capacity needed in these eights fields to benefit industry. Panels can be organized to create national plans for building capacities in these fields, including gauging interest in academic centers for doing so and identifying opportunities for regional and international collaboration. Such efforts can be made with a small investment in travel costs for workshops and communication among panel members.

Table 6 enumerates additional science and technology disciplines that relate to at least two or three industries studied for this report. Professional societies and academic departments involved in these areas should consider developing plans detailing how and why capacity could be built in these areas to deepen their relevance and impact for industrial growth and poverty reduction.

Each of the industries studied for this report requires a technology base for its growth and competitiveness—domestically and internationally. The technology base includes not just the technology available to any company in the industry, but the constellation of capabilities that enable the value chain of interdependent capacities to develop in a way that supports industry. For example, to develop advanced logistics services for tracking the shipment of palm oil, capabilities such as broadband, tracking software, electronic readers, and value chain management need to be developed. The technology base for these functions is partly a product of public investment in infrastructure and services and is partly provided by industry. Cooperation between the public and private

**Table 6. Areas of Science and Technology Relevant to Two or Three Industries in Uganda That Need Attention over the Longer Term**

| Field | Related Sectors |
|---|---|
| Biology | B, E, O |
| Economics and Sociology | A, E, O |
| Electrical Engineering | B, I, O |
| Instruments and Instrumentation | A, B, O |
| Operations Research and Management | A, I, T |
| Pharmacology and Pharmacy and Toxicology | B, E, O |
| Entomology | A, O |
| Marine and Fresh Water Biology | B, O |
| Microbiology | A, B |
| Mining and Mineral Processing | A, O |
| Polymer and Materials Science | B, O |
| Public, Environmental and Occupational Health | B, O |
| Remote Sensing and Imaging | A, O |
| Thermodynamics and Other Physics | B, O |

*Note:* B = biofuels, E = ethnobotany, O = oil and gas exploration, A = agriculture, I = information and communication technology, T = transport and logistics.
*Source*: Compiled by authors using data elicited through the ISI Web of Science.

sectors is essential to putting these capabilities into place. Planning for investments that will ensure interoperable applications must be part of the process; individual investments such as broadband or the purchase of electronic devices will be wasted if they cannot be linked to other parts of the value chain system.

The top-priority science and technology fields shown in table 4 require developing targeted policies and programs to ensure local, sustainable development. The objective is to foster science and technology capacity that serves the broadest spectrum of industries—not just one sector. To ensure this relevance, a cross-sectoral council, convened at the presidential level, may ensure that these investments constitute a priority that will span multiple ministries. Special attention should be given to the infrastructure needs of sciences and technologies that can serve a number of industries. As technology planning gets under way, a number of implementation aspects require government attention:

- Government agencies can aid industry by identifying standards for establishing important technologies to be developed locally. Input from industries can help the government identify infrastructure needs, but government action is often needed to choose and set standards.
- Government agencies can help lower costs by procuring products in bulk and selling or leasing them to industry. This can be done with large-scale purchases of items such as electronic scanners or chemicals, for which government buying power can aid industry.
- Government agencies can help negotiate licensing arrangements that might be needed by local industry to provide one part of the value chain mission that would be difficult for industry to provide, such as access to spectrum, botanical, or chemical product licenses.
- Government agencies may need to become involved in technology demonstration to show businesses how to get a scientific process or technological capability under way at the local level.
- Government agencies may be needed to help identify foreign markets for local products when a group of small businesses is unable to afford this kind of research.

These types of investment decisions are often defined through cross-sectoral panels involving citizens and industry representatives who meet and discuss long-term planning. The panels envisaged would provide a group of stakeholders who can articulate future technology needs and infrastructure plans and measure progress over time. In addition, they can play an accountability role by asking why certain milestones have not been reached.

### Human Resources: Train Paraprofessionals in Key Fields

Uganda should give prompt attention to creating technical training centers to train people who are not planning on receiving a university degree but who wish to work in technology-based industries. The businesses interviewed said that they are lacking the type of professional staff who receives training at the associate degree level at technical institutes. Such training is short of a full university education but generates educated, trained workers who can perform technical tasks—including writing software, fixing computers, managing networks, tracking products, ensuring product quality, performing chemical testing, drilling, surveying, and so on.

Uganda has placed a focus on improving higher education, but little attention has been paid to creating technical training centers such as the kind created and supported by Cisco. Extension services, company-based research, field testing, and other functions go unstaffed for lack of trained workers. Industry associations should work with government ministries to identify skills that can be the subject of technical training in the near term. Technical training centers operate most effectively if they are nonprofit; thus they should be run by a cooperative effort between government and academia, with advice from industry. The Cisco model could be tried for several sectors to see if it can be applied to basic skills in chemistry, agroprocessing, environmental testing, food science, and other areas.

### Institutions and Infrastructure: Create Centers to Ensure Standards and Quality

This report and the accompanying in-depth case studies have discussed the government's challenges in terms of offering standards and quality assurance services to industry. The National Bureau of Standards should be given increased funding to enhance its capacity to set standards, offer quality assurance for products, and make weights and measures for research and trade. Testing of traded products (both imports and exports) is a function usually provided by government, in partnership with industry. Metrology, standards, testing, and quality assurance are extremely important to any export-oriented economy. The scope and extent of these activities is vast, and the benefits that accrue to economies are wide-ranging. Successful industries are able to assure clients that their products meet standards for quality, interoperability, or functionality.

Metrology, standards, testing, and quality assurance are becoming more important as world trade becomes increasingly interdependent. Industrial countries spend about $1.50 per person on metrology, standards, and testing services (UNIDO 2005). For Uganda, a goal of eventually spending $30 million for these services is very high. But an initial investment of $400,000, with plans to increase funding over time, would help get started, according to UNIDO. This is an area where regional cooperative networks could potentially take the place of national institutions for aspects of metrology, standards, testing, and quality assurance not available nationally; cooperative agreements could be set up to provide standards and testing services in other places until Uganda can afford to provide these services locally. Indeed, regional initiatives such as Quality Infrastructure in the East African Community offer a platform for regional cooperation, with the goal of harmonizing metrology, standards, testing, and quality assurance activities in Burundi, Kenya, Rwanda, Tanzania, and Uganda.

Each of the industries studied for this report requires the functional supports listed. These supports are usually provided by governments but are not provided at an adequate level in Uganda. Support functions are not sufficient in themselves to create the conditions for innovation, but they are necessary, and companies cannot put technology into use without them. These services, as described, should become part of the planning for Uganda's science and technology systems.

Another aspect of industrial development promoted by government occurs through the creation of the tax, legal, and regulatory framework in which businesses operate. Such a framework usually provides support or guidelines to all industries in an economy. Parts of the system can be said to be industry-friendly, such as the offering of low tax rates for business development. At times, governments can choose to target support or constrain a particular industry based on national goals. For example, in the 1980s the U.S. government reduced penalties attached to antitrust laws to enable the semiconductor industry to cooperate on the development of new equipment.

Tax benefits set up to encourage companies to create jobs or conduct research are common in advanced countries. Tax regimes that encourage foreign direct investment tied to technology transfer can also affect a country's technology base. Similarly, regulations that benefit business can be written in a way that ensures worker safety and environmental health. Although Uganda is aware of the need for these functions, they need to be greatly enhanced and made more compatible with industrial development. Joint efforts to study these questions with officials from Uganda's neighbors may offer the best way of establishing these functions and guidelines in accord with industry and with regional norms.

Intellectual property protection and redress are functions of all knowledge-based societies. Invention disclosure and patent registration are complex processes, and many firms register patents in the Europe, Japan, and the United States to gain protection for products that will be traded on the international market. Even so, most countries develop their own offices to govern intellectual property rights activities within their borders and to aid negotiations with foreign direct investors. This function should be allowed to evolve over time, because most of the development being recommended in this report does not need domestic patent protection. Licensing from abroad may be needed, but a patent office is not required to negotiate a licensing agreement. This function can be put on a longer-term trajectory than some of the other recommendations made here.

### Collaboration and Communication: Build Opportunities across Sectors, from Academia to Industry

Uganda needs to make efforts to link various parts of industry, academia, and government to energize industrial development. More robust, available, and adequately funded extension services, technology transfer agents, and information collection and sharing services will propel industrial capability, in terms of parlaying knowledge from the laboratory to the field and, most critically, back again. These kinds of collaborative efforts are a hallmark of all knowledge-based economies.

Many industrial countries offer extension and technology transfer services to aid industry with research, development, testing, and evaluation. Governments in these countries contribute about $2 per person to a range of technology and manufacturing extension services (UNIDO 2005). These activities can take the form of science shops, such as those funded by the government of the Netherlands, to provide knowledge transfer from universities to industry. The government of Japan provides support through engineering centers around the country to aid industry with technology and engineering adaptation. Governments at the federal and regional (state or province) levels initiate these programs to encourage economic development and value-based business growth. Often, some cost sharing—in the form of user fees—is required of those taking advantage of the services. These programs are established to promote business networks, strategic alliances, and joint ventures to increase competitiveness.

Sharing knowledge between industry, academia, and government is another mark of a knowledge economy and a target for Uganda's transformation. Ideally, governments collect and make available to the private sector technical information about the capabilities of foreign research centers. These types of services range widely in size and in the depth of information made available, but they are a type of intelligence gathering that can be particularly valuable to users at a low unit cost. Perhaps the most highly developed of these services is offered by the Japan’s government-funded Science and Technology Agency, which collects and analyzes technical information from around the world. These agencies often collect user fees from industry, so total government funding is difficult to estimate. Like the standards services previously described, the cost of providing these services in Uganda would be considerable—about $40 million each per year. These services are more difficult to import or to access virtually than are metrology and standards services, because a lot of local learning must occur to make extension services viable. Accordingly, allocating some funding toward these services in the six critical areas identified in table 4 would constitute a step toward building sustainable science and technology capacity.

Science parks are another mechanism to enable collaboration between industry, academia, and government. Many countries provide support for the creation of science and technology parks by offering low-cost land and loans and extending tax breaks to companies that establish growth-based businesses in these centers. A similar program common to many countries is the provision of incubation services for small businesses. These services include financing, management and technical advice, and the provision of office space for small, technology-based startups. The Russian Federation has developed a network of centers and parks to aid businesses, such as the St. Petersburg Science and Technology Center. Chile, Turkey, and many other countries provide similar services through government-funded programs that aid industrial innovation. These services usually require some contribution from users, but governments can provide as much as half of the operating costs for these activities. It is unclear from the team’s inquiries whether science parks will play a role in near-term investments in innovation in Uganda.

## Knowledge Base: Enhance Data Collection Capabilities and Enhance the Regulatory Framework

Knowledge is at the heart of the processes being studied and described in this report. Advanced countries are able to create knowledge that adds value to products and makes them attractive to consumers. But even in these countries, the “new” part of the knowledge they create is only a small part of all knowledge being used. The bulk of knowledge needed to enable Uganda to put science and technology to use for industry is available within or outside its domestic market. In other words, the knowledge does not need to be recreated locally to be useful, but local learning may be—and probably must be—accomplished to use the knowledge. To access the basic knowledge that industry needs, a renewed effort toward collecting and publishing data on industry use of science and technology, beginning with the labor market and including research and development functions, is strongly recommended.

Developing data collection and technical assistance documentation in accordance with international standards is important. In particular, understanding the need of industry for trained workers is a metric that must be tracked continuously. This knowledge is needed to enable companies to plan for training requirements and for the academic sector to plan for education investments needed for the near and longer term.

A labor market observatory could be a first step in this process. Done in cooperation with the New Partnership for Africa's Development (NEPAD), with advice from the Organisation for Economic Co-operation and Development, this effort could cost less than $400,000 in its first year of operations, according to OECD officials.

Collecting data on research capacity is an important part of this function because these data are usually provided by governments to aid economic growth. Without such data, planning must rely on case studies such as those presented in this report, which can be useful for insight into one sector but do not shed light on the economy as a whole. A lack of data also hinders international comparisons. Low science and technology statistical capacity excludes Uganda from the international community of nations operating in the knowledge-based economy.

Establishing a technical knowledge center for each critical industry offers another important function to enable local businesses to stay abreast of important information, including regulations, laws, trade issues, finance, technical specifications, and other details about specific products. Situating these in existing university facilities or trade organizations offers an affordable approach to leveraging existing capacity. Building technical knowledge centers can be done in cooperation with other countries, because the information that will be collected could be used by a number of industries across Africa. An international effort would help initiate this work.

ANNEX 1

# Science and Technology in Uganda

Gauging Uganda's science and technology capacity requires analysis of many factors. No doubt, Ugandan institutions have built up national scientific and technological capacity over the past decade. Yet, the Global Competitiveness Index compiled by the World Economic Forum places Uganda at 116 of 128 nations in its 2007 index in terms of overall competitiveness as measured by gross domestic product, educational achievement, governance, finance, and political system. Despite its low rank, Uganda's efforts to improve its macroeconomy have resulted in an improved position on the index, and thus Uganda's position has risen to 69 out of 128 nations in terms of the strength of its macroeconomy. Uganda's economy also ranks fairly well in innovation (position 73) and market efficiency (position 85). The World Economic Forum considers Uganda as having a strong capacity to attract foreign direct investment, as having high-quality scientific research institutions and as having fairly good availability of scientists and engineers relative to other countries in the world.

According to a 2005 study of Uganda's economy, the median value added per worker in 2004 was $1,085. Export-oriented firms in Uganda fared better than the average firm, with a value added per worker of $2,901. Still, the overall median compared poorly to neighboring Kenya ($3,457) and rapidly developing countries such as India ($3,432) and China ($4,397).

Uganda's primary and secondary school education remains weak, though notable achievements have been made in enhancing access to education for all, including a program for universal primary enrollment. Tertiary education has been strengthened over the past decade, and the number of students has been rising. The number of tertiary institutions rose from 93 in 2002 to 155 in 2004, most with rising enrollments. Within the higher education system, basic science enrollment accounts for less than 1 percent of overall enrollment (perhaps 450 students in total). The National Council for Higher Education reports that enrollments in science and technology increased from 18 percent (19,042) in 2004 to 23 percent (28,852) in 2005. This increase was probably due to strong growth at technical colleges, from 1,695 students in 2004 to 2,084 in 2005.

Several universities in Uganda conduct research. The main academic research centers are at Makerere University and Mbarara University. Engineering schools include the Faculty of Technology at Makerere University and at Kyambogo University. These programs are growing rapidly (in both staff and students). The combined enrollment is about 1,000 engineering students. The Islamic University in Uganda-Mbale is producing graduates in information and computer science.

The Ugandan educational system has been criticized as not engendering a "culture of science." Some say that students are tracked away from scientific studies at the secondary level because of disincentives at secondary school levels and in university admissions processes. Moreover, university policies favoring liberal arts, inadequate infrastructure and lack of capital investment, lack of research or conditions that favor research for professors, and lingering perceptions of the "uselessness" of degrees in science" may influence students seeking bright futures to turn away from science areas (Muhumuza and others 2005, p. 6). Poor science education in secondary schools hampers the input of students at the tertiary level. These schools lack laboratories, equipment, modern curriculum, and adequately trained science teachers.

In all, academic staff in higher education institutions in Uganda numbered 5,258 in Uganda in 2005. Of these, 558 professors in Uganda (in all academic disciplines) had doctorates and the ratio of Ph.D. faculty to university students was 1:207 in 2005. In 2009 fewer than 10 new doctorates were awarded annually in science and engineering. Almost all of these are from Makerere University. (This is below the replacement rate for retiring faculty.) Among academics nationally, 2,167 had masters degrees, and 1,694 instructors had a bachelors degree as their highest academic level. More than 600 academic staff had not received a bachelors degree (National Council for Higher Education 2006, p. 23).

There were an estimated 2,105 engineers in Uganda in 1998. This number includes architects, surveyors, and civil, electrical, mechanical, and agricultural engineers. Table A.1 compares Uganda to neighboring countries in these workforce capabilities.

As reported by the World Economic Forum, Uganda has some good scientific research institutions concentrated in and around Kampala, the capital city. Ugandan research centers conduct internationally recognized health research, especially in epidemiology, clinical trials, and research on HIV/AIDS, malaria, and other infectious diseases. Published articles authored or coauthored by a Ugandan scientist or engineer have jumped from about 30 per year in the early 1990s to more than 300 per year. Ugandan scientists engage in active international collaboration with a number of countries around the world. Figure A1.1 shows the network of scientific collaborations in which Ugandan scientists participated in 2006.

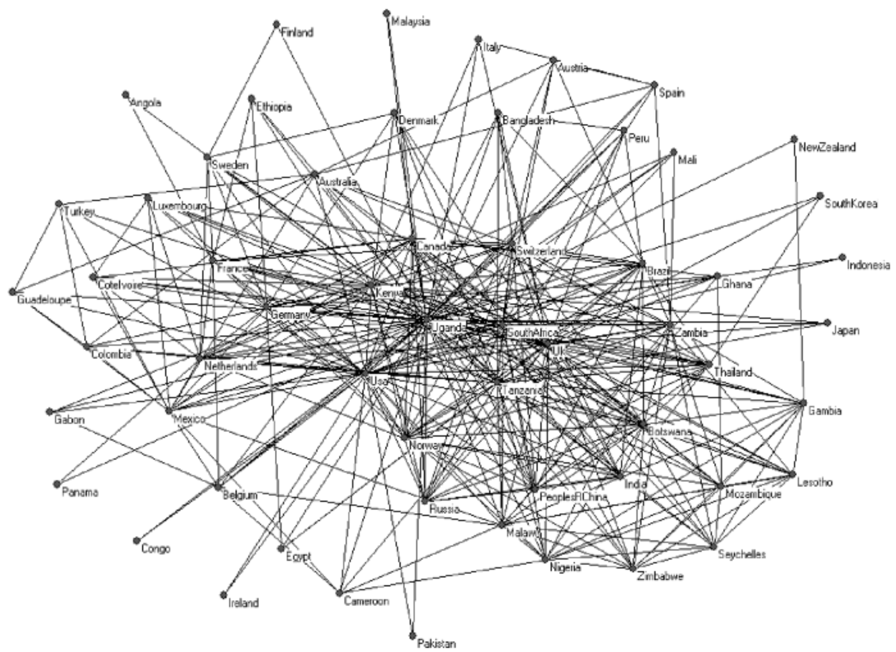
Figure A1.2 shows a map of the subjects in which Ugandan researchers published research results in refereed journals in 2004–06. The map shows the dominance of publications in the cluster of topics representing research in infectious diseases, virology, and immunology. Among other priorities, the quest to develop vaccines for HIV and malaria drives priority research in Uganda. The figure also shows strength in public

**Table A1.1. Professional Workforce in East Africa, Early 2000s**

| Country | Architects | Professional Engineers | Land Surveyors |
|---|---|---|---|
| Uganda | 120 | 280 | 30 |
| Kenya | 800 | 6000 | 350–400 |
| Tanzania | 120 | 6000 | 300–350 |

*Source*: Muhumuza and others 2005.

**Figure A1.1. Uganda's Global Network of Scientific Collaborations, 2006**



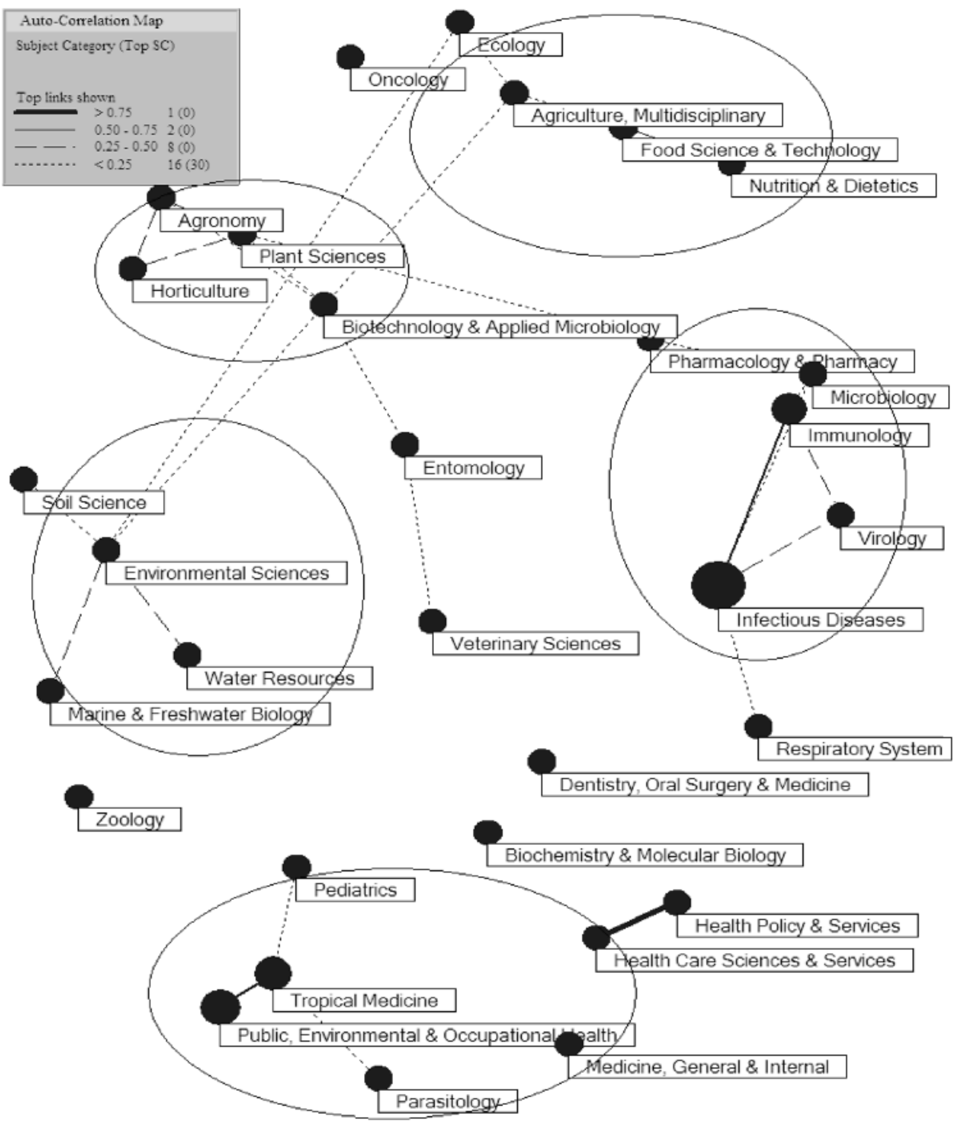

*Source*: ISI Web of Science.

health and tropical medicine. Three interlocking clusters show research capabilities in environmental sciences, agronomy and plant sciences, and agriculture and food science within the country.

As Figure A1.2 shows, most publications are related to health and agriculture, including clinical medicine, health science, biomedicine, and biology (which includes many agriculture articles). During 2004–06, more than 200 articles were published on infectious diseases, the top subject category. Of the 12 most frequently appearing subject categories for Ugandan scientific publications, 7 are related to health: infectious diseases, public, environmental, and occupational health, immunology, tropical medicine, general and internal medicine, virology, and parasitology. Publications related to ecology, plant sciences, environmental sciences, zoology, and agronomy rounded out the top 12 categories during 2004–06.

Government funding for research and development has typically been well below 1 percent of total government expenditures and less than 1 percent of GDP since 1990. Within the budget allocated to research activities between 1990 and 2001, more than half (44 billion shillings) was spent on medical and veterinary sciences in 385 registered projects. Much of this funding was spent on clinical trials, including construction of laboratories, staff salaries, purchases of medicines, and compensation of research participants. About 90 percent of research funding is provided by external donors and in some areas, such as health research, donor dominance of research

**Figure A1.2. Subject Areas in which Ugandan Scientists Published, 2004–06**




*Source*: ISI Web of Science.

resources is even higher. Research priorities are largely set by these donors, which may not always reflect national needs.

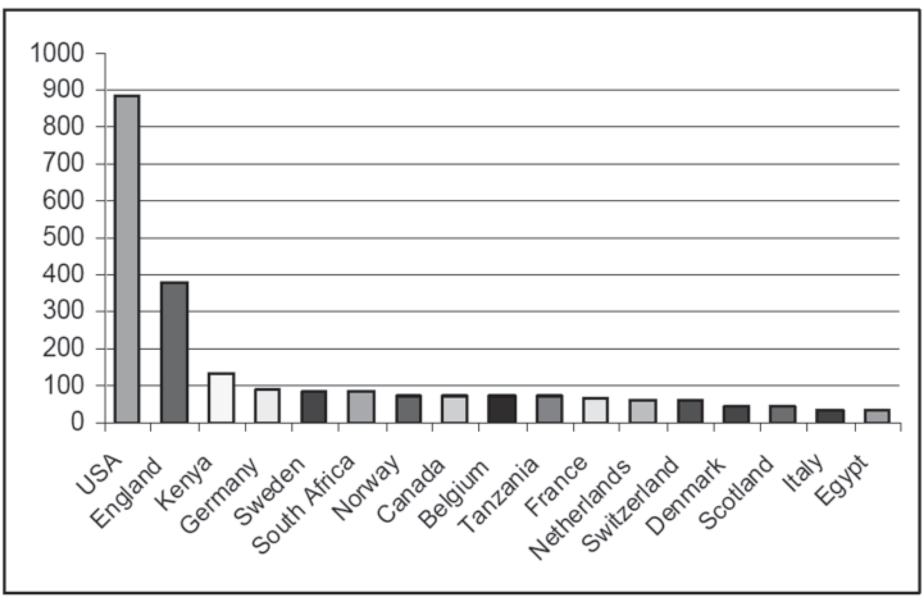
Collaborative patterns in research and development often reveal the character and strength of a science and technology sector. Researchers from Makerere University and the Ministry of Health (including the Uganda Virus Research Institute) frequently coauthor papers for publication. They also collaborate with Mbarara University, which produces fewer publications. The Joint Clinical Research Centre is administered jointly by Makerere University and the Ministry of Health and has a strong publication and collaboration record.

Another sign of improvement in the system is that Uganda's rate of international collaboration has increased. From 1992 to 2000, coauthorship increased by 15 percent and the number of collaborating countries increased by 50 percent. Ugandan researchers collaborate most often with scientists from England and the United States. Other European collaborators include researchers from Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Scotland, Sweden, and Switzerland. Regional collaborations, particularly with Kenya, Tanzania, and South Africa, are also important. Figure A1.3 shows a network map of the coauthorships between Ugandan scientists and researchers from another country in articles published in 2004–06. Uganda actively participated in regional and global research networks during this period. The figure also suggests that connections exist that could extend the reach of Uganda's international collaborations to other scientists.

The Ministry of Health has strong ties to the University of London School of Hygiene and Tropical Medicine and the University of Cambridge (Figure A1.4). The Uganda Virus Research Institute also has strong links with the University of London School of Hygiene and Tropical Medicine and with Johns Hopkins University, Columbia University, and the U.S. Centers for Disease Control (Figure A1.5). Mbarara University has a close relationship with Hamburg University in Germany and collaborates with researchers from the University of California San Francisco and other international institutions.

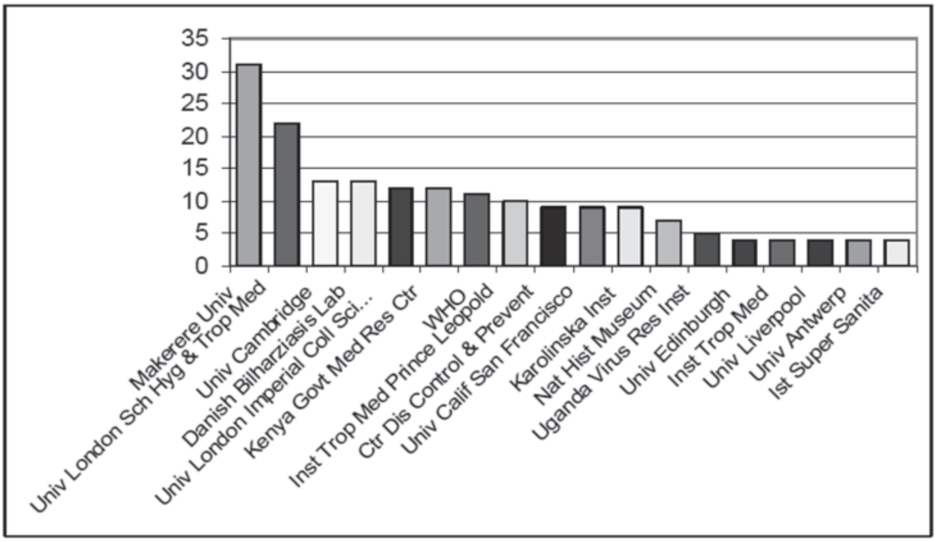
The most numerous regional collaborations are between the Uganda Ministry of Health and the Kenya Government Medical Research Center.

**Figure A1.3. Distribution of Uganda's Foreign Coauthors, 2004–06 (inclusive)**



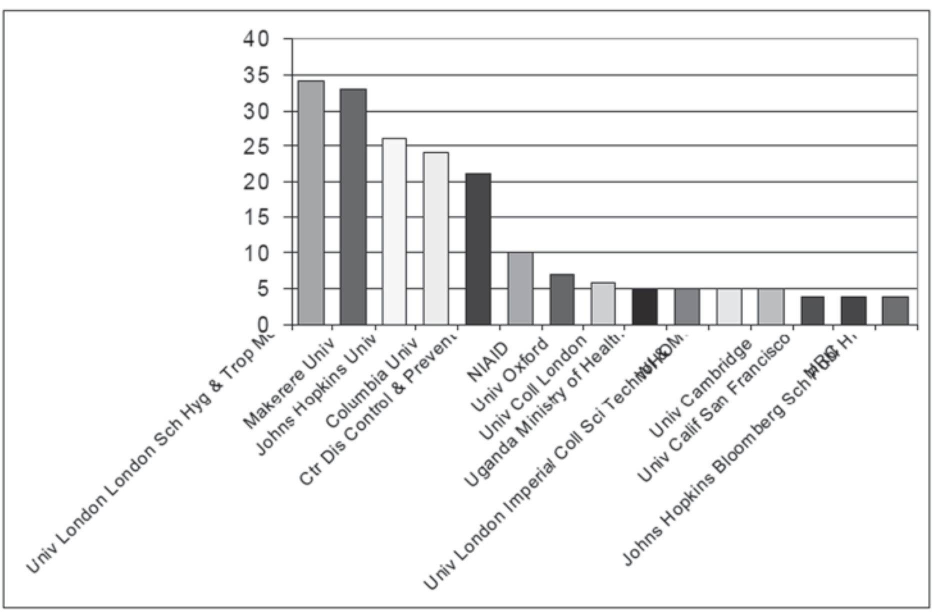

*Source:* ISI Web of Science.

**Figure A1.4. Institutional Affiliations of Coauthors of Authors from Uganda's Ministry of Health, 2004–06 (inclusive)**




*Source:* ISI Web of Science.

**Figure A1.5. Institutional Affiliations of Coauthors of Authors from the Uganda Virus Research Institute, 2004–06 (inclusive)**




*Source:* ISI Web of Science.

## Science Policy and Regulation

The Uganda National Council for Science and Technology's main goal is to advise the national government on "how to integrate science and technology in the national development process" (Muhumuza and others 2005, p. 60). The ministries of education, health, industry, agriculture, animal industries, and fisheries set specific science and technology policies and agendas and also work with associated parastatal agencies, such as the National Council for Higher Education and the Secretariat for the Plan for the Modernization of Agriculture. These agencies fund very little research and development: about 90 percent of research funding is provided by external donors. Research priorities are often set by these donors who, though well-intentioned, may not always understand how to invest locally to build sustainable capacity in science, technology, and innovation.

The Department of the Registrar General of the Ugandan Ministry of Justice and Constitutional Affairs is responsible for protecting copyrights and registering trademarks, patents, utility models, and industrial designs. This department has a small staff and little ability to coordinate with offices in other countries and with the World Intellectual Property Organization. Standardization, quality assurance, laboratory testing, and metrology are the responsibilities of the Uganda National Bureau of Standards (UNBS). Both institutions lack resources to fully support science, technology, and innovation.

The Uganda Industrial Research Institute (UIRI) has laboratory facilities for food and ceramics research, a ceramics processing demonstration plant, a food laboratory, high-precision instrument rooms, a silicate laboratory, and a mechanical maintenance workshop. Of the research resources available to business in Uganda, it is one of the most important and most advanced. Opportunities exist for users to access laboratory equipment and technical know-how among the staff.

ANNEX 2

# Agroindustry: Oilseed Sector Case Study

Uganda's agricultural sector serves as the economic and social backbone of the country. It is the main source of income, employment, food, and foreign exchange. When the sector grows, the economy grows with it, aiding the country's prospects for poverty reduction. Nearly 90 percent of Uganda's population lives in rural areas and earns their livelihood from agriculture. In 2002 the sector accounted for 31 percent of GDP—down from 51 percent in 1982, when industry and services were greatly depressed. In the 1990s agricultural commodities provided more than 90 percent of exports by value.

Of the four main agricultural subsectors—crops, livestock, fisheries, and forestry—crops account for the largest share in terms of both area and contribution to GDP (about 75 percent of agricultural GDP in 1995). Much of this output is for food crops for small subsistence households. Only one-third is sold to domestic and export markets.

Given its importance, agriculture has been at the heart of the government of Uganda's national development strategy since the 1980s. At present, the Plan for the Modernization of Agriculture encapsulates the government's strategy to raise the productivity of the sector to deepen its impact in terms of poverty reduction, national competitiveness, and job creation. According to the plan, however, agricultural productivity lags far behind the level it could be with successful application and use of science and technology skills, the application and widespread use of various knowledge inputs and technologies, and more dynamic links between researchers, producers, small landholders, and users. With few opportunities to access, use, adapt, and generate science and technology knowledge in the sector, the impact of the agricultural sector on the economy is far less than what it could be.[1]

## Overview

The oilseed sector influences the livelihoods of over 1.2 million Ugandans living mainly in the Northern and Eastern regions. The government identified the oilseed sector as a focal area for executing its plan for modernizing agriculture, emphasizing the transformation of subsistence agriculture to market-oriented farming. During the 1990s Uganda imported almost all of its vegetable oils, primarily palm oil. Concerted efforts by a number of private and public sector partners and several international organizations revived the sector, which now grows at approximately 3 percent per year.

Ugandan consumption of edible oil is low, averaging 3 kilograms, beneath the World Health Organization recommendation of 18 kilograms. Yet domestic and regional demand for oil is growing. In 2005 the demand for oil from vegetable oilseed was estimated at 70,000–90,000 megatons, with the domestic share account for less than half that—30,000 megatons. With the East African economic region having a market size of 85 million people within reach and the Common Market for Eastern and Southern Africa (COMESA) with over 367 million nearby, Uganda's strategic location presents it with an opportunity to command the oil market for Eastern and Southern Africa. How it exploits science and technology to boost production and extend its market reach may determine the sector's prospects for further growth.

Biofuels present another reason for development of the oilseed sector. With increasing demand from China, India, and elsewhere, opportunity for Uganda is mounting to boost production of soybean, jatropha, sugarcane, palm oil, rapeseed, canola, and sunflower.

The major oilseed crops in Uganda include sunflower, soya bean, cotton, sesame (simsim), ground nuts, oil palm, and essential oils (sheanuts, geranium, citronella, lemon grass, neem, mujaja, and mint). According to the director of the Uganda Oilseeds Producers and Processors Association (UOSPA), the oilseed sector faces three main challenges:

- Limited variety constrains commercial expansion into other product types and diverse markets.
- Most producers have dilapidated, outdated technology and cannot extract oil and standardize production to the level of market demand.
- Technological and institutional weaknesses make it difficult for most producers to validate quality. These knowledge-related bottlenecks and institutional constraints have held back prospects for value added in the sector.

Enhancing the productivity and competitiveness of Uganda's agroindustrial processing sector requires the following:

- Successful application of technology.
- Deepening of skills.
- Reorientation of various institutions.
- Enhancement of communication and links between key stakeholders.
- Improved use and dissemination of knowledge within the sector.

At each node in the oilseed value-added chain, attention is required to reap the benefits of applying science and technology to expand the sector. The following analysis addresses each of these dimensions, which correspond to the THICK methodology, in the context of Uganda's agroindustrial processing sector. The case study of Mukwano, presented in box A2.1, brings into relief each of these aspects of the THICK assessment, illustrating their interrelationships and influences on the sector.

The following sections present further analysis of Uganda's oilseed sector based on the THICK (Technology, Human resources, Institutions and Infrastructure, Collaboration and Communication, Knowledge base) methodology.

## Technology

According to Uganda's Plan for the Modernization of Agriculture (PMA), raising the incomes of subsistence farmers will require reorienting their production toward the market. As noted in the plan, the transformation of Uganda's agricultural sector toward greater productivity will depend, in part, on the adeptness with which producers and

**Box A2.1. Expanding Uganda's Capacity to Produce Oilseed Products: The Case of Mukwano**

Mukwano's story is that of a company driven to expand by harnessing technological learning opportunities and building a competitive advantage through deep links to markets and customers. Mukwano started out as a road transport and general trading company in the 1970s and gradually became the leader in Ugandan consumer and industrial products. Science and technology capacity were key to the company's ascent.

No longer a distributor of products manufactured elsewhere, today Mukwano produces a variety of products dominated by soaps and oils but also including plastics, detergents, beverages, sunflowers, stainless steel tanks, machine technology, confectionaries, tea products, plastic household items, plastic and cardboard packaging, and animal feed supplements. The largest corporate taxpayer in Uganda, Mukwano employs 7,000 people and has an annual turnover of $175–200 million in products.

Mukwano's market reach extends to 15 countries across Africa. The company maintains holdings in Kenya, Tanzania, and elsewhere. Its products are shipped across Eastern and Southern African countries and throughout the Common Market for Eastern and Southern Africa (COMESA).

*The future belongs to research and development*

Mukwano spends roughly 5 percent of its budget on research and development (R&D), including on consultants who perform testing, soil sampling, and the like. As the company seeks to maintain market share and diversify into more value-added products, it recognizes that investment in R&D offers an optimal strategy to gear for the future. Research in the pipeline includes a number of projects exploring the possibility of substituting seed oils for crude palm oil to avoid importation. Projects in sunflower, soya bean, maize, cotton, and tea are also under way. Many of these agrobusiness research initiatives rely on a network of outgrowers—small farmers (even those with just 1 hectare) who partner with Mukwano to grow seed under development or who can be contracted to experiment with other technologies being researched by Mukwano. Some 32,000 active smallholders partner with the company.

Of its many research projects in oil seeds, Mukwano's sunflower project is one of its most promising, demonstrating how the company seeks to use scientific research and technology development to establish a market niche. The current sunflower seed grown by Mukwano is the product of a great deal of research. This special seed—the Panner 7351—required extensive research and testing. Mukwano sought a seed with a particularly high oil content (30 percent), high quality, and suitability to Uganda's unique soil, moisture, and other conditions. The research behind Panner 7351, which was performed by a South African seed breeding company, came at a high price. Now Mukwano is looking at the parent crop with hopes of creating a better seed through research that it will finance and perform in Uganda. If successful, its research effort will end reliance on the expensive South African breeder.

Mukwano's decision to take on the sunflower project was made easier by the availability of various national and international partners with whom the company is collaborating. The U.S. Agency for International Development (USAID) offered assistance, as did several nongovernmental organizations (NGOs), to help farmers experiment with new seeds. Mukwano sent its team to Lira, where the oilseed projects of several organizations are under way. There it assessed the viability of 18 hybrid seeds from around the world, experimenting with them on pilot plots. The oilseed cluster in Lira offers an advantage to Mukwano as it reaps the benefits of a host of nearby knowledge and technology partners able to support and complement its R&D efforts.

Regarding where and when to perform R&D, one Mukwano manager explained that "the choice is really driven by the market. We have been hit by the high cost of palm oil. So the incentive to do R&D comes from the need to push through the wall. It's always better to spend little money to maintain the edge than a lot of money to redevelop entire areas when we are failing." Yet Mukwano's choice to invest in research and technology is never taken lightly. The company's financial directors expect to understand the return on investment for every proposed technology as well as the anticipated payback time for every research-related investment.

*Opportunities to improve science and technology skills sharpen competitive edge*

Another strategy that Mukwano uses to maintain its competitiveness is investing in skills and training for its staff of more than 7,000. Mukwano's training programs take many forms. It hires in its labs a number of fresh graduates who work in its technology, engineering, and food chemistry divisions. These graduates are given extensive on-the-job, hands-on training. The result is not always continued employment: although some graduates are offered jobs, others are not deemed adequately prepared. For most of the company's employees who are unskilled or low-skilled technicians, opportunities to receive training through Nakama Vocational Institute are sometimes available, as are apprenticeships in mechanics and construction.

It is up to each department manager to identify staff who require more skills. Once the determination is made that skills upgrading is required, the company makes the investment required to procure the skills. For example, if a new accounting software package is introduced or a new computerized customs program rolled out, Mukwano would finance training for all staff who need to understand these changes.

Information and communication technology (ICT) is an area in which all staff require competence. According to firm managers, not one Mukwano staff can afford to miss ICT training. The company relies on Orion, a supply chain management software package, though it plans to migrate to SAP. Using Orion, staff perform a host of duties—from handling raw materials to managing human resources to managing product flows. The company's planned migration to SAP will involve comprehensive training for staff from each division, who will then lead a cascading training plan that ultimately includes all Mukwano employees. Today Mukwano's 3,000 low-skilled employees have inadequate ICT capacity. The company seeks to introduce hand-held ICT tools and personal digital assistants (PDAs) to scan inventory and track shipments and plans to dovetail extensive ICT training into the SAP rollout to ensure that ICT skills become ubiquitous across the firm.

*Knowledge partnerships can transform new ideas and technologies into profit*

Mukwano's success derives, in part, from its extensive links with markets, customers, suppliers, researchers, business support organizations, and government. The company places a premium on identifying opportunities to enhance its capacity to comply with export certification, control quality, and take advantage of new technologies. Partnerships with the International Standards Organization, Uganda National Bureau of Standards, and Uganda Industrial Research Institute further its quest for excellence. It also depends on extensive distribution networks to reach customers overseas.

To respond to specific challenges, such as development of a new sunflower seed, Mukwano leverages its knowledge partnerships with research institutes, including the Uganda Industrial Research Institute (UIRI) and Kawanda Agricultural Institute in Lira. Mukwano is also a member of the Uganda Oilseeds Producers and Processors Association, Uganda Export Promotion Board, Private Sector Foundation, and Uganda Manufacturers Association, among others.

Formal partnerships with scientists are not as plentiful, nor do they occur as frequently as some senior managers believe the company should pursue. The challenge is one of priorities—managers often prioritize putting out immediate fires over working toward longer-range objectives. One division manager noted that incentives to establish such partnerships have not been made clear to staff.

*Disadvantaged by weak transport and logistics capacity*

For the land-based transport of its agroindustrial products, Mukwano relies on its trucking company, AK Transporters, which has about 115 trucks for long-haul transport. Shipping from international suppliers brings products destined for Mukwano's factories through Mombassa, Kenya.

Transportation is a large expense for the company because of factors beyond its control. Because rail freight is so much slower than trucking (14–30 days versus 4 days), Mukwano opted to purchase its own containers at a cost of $2.5 million, an expenditure the company could have forgone had rail been a viable option. But even road transport is more costly than it should be. Specifically, poor road conditions make the trek from Mombassa to Kampala take an average of four days instead of the two days it could take if the trucks were able to travel at legal speeds. The difference in cost between road and rail for transporting a ton is approximately $30 ($110 per ton on road versus $80 per ton by rail). Because competitiveness must be considered in regional and global terms, Mukwano and its competitors are disadvantaged by the high cost of shipping and transport.

*Reducing import dependence through research and technology improvements*

One of Mukwano's most important products is vegetable oil derived from oil palms. Although such palms could be grown in Uganda, Mukwano imports crude palm oil from Malaysia. Management cites labor costs as the reason for the import dependence. But Mukwano's main competitor, Bidco, is not content to stay dependent on Malaysian crude. Through a partnership with the government, Bidco has created a farm to explore opportunities to produce palms locally. Once established, Bidco's palm oil processing and production costs are expected to decrease because it will no longer have to pay for the Malaysian palm oil to be shipped by ocean liners and, subsequently, in trucks from the ports. Bidco's bid to become the country's first palm-producing manufacturer of cooking oils increases the pressure on Mukwano to explore new opportunities for adding value to maintain market share.

suppliers access, use, adapt, and generate technologies required to improve yields, quality, and processing. The following issues pertinent to technology are those most salient for the sector.

### *Technology and Competitiveness*

Much of the technology used in the processing of oil from oilseeds in Uganda is outdated. Most producers use a crude oil expeller, which is a very old technology. Newer, more hygienic, faster technologies that use less power with higher success rates exist but are not widely used in the country. Part of establishing and meeting quality standards entails learning which technologies are required to facilitate that process and then accessing those technologies.

A survey conducted by the Uganda Industrial Research Institute (UIRI) on Ram and motorized press performance found that the difficulty in using these technologies posed a deterrent to employment in the sector. Most of the Ram Press operators interviewed intimated that they no longer process sunflower seeds continuously because of lack of labor, noting that workers have grown averse to the hard work involved in using the outdated technologies. One Ram Press owner who previously employed five people was forced to return to contract farming for Mukwano Industries after all his staff abandoned their positions because of the arduousness of the processing entailed in the oilseed pressing technology. When technology is not appropriate, adopters will not use it, even if it means choosing not to go into processing and missing out on opportunities to produce a higher value-added product.

### *Investments in Technology Facilitate Firms' Technological Upgrading*

The extremely high interest rates on loans to businesses in Uganda (often 20–30 percent) create an obstacle to investments in technology by small producers in the oilseed sector and other institutions (including laboratories engaged in testing). Access to financing for technology is particularly difficult to attain for smallholder farmers. The same UIRI survey of Ram and motorized press operators found that microfinance is rarely a viable option as a result of factors such as unattractive interest rates on loans, the marginalization of women by investment banks, and land tenure issues (land is currently not considered a real asset in the rural setting).

Potential programs and solutions to increase access to funding for technology development and distribution challenges include the Technology Acquisition Fund (TAF), started by the Private Sector Foundation (PSF) to introduce new technologies in Uganda based on a Malaysian model. The foundation's goal is to facilitate the commercialization of ideas by providing funding for up to half of the costs borne by successful awardees. Awardees are selected through competitions. PSF reaches out to universities, farmers, and firms as partners. It also sponsors a business plan competition to encourage innovation through competition, with an allocation of about $20,000 per recipient (for up to 30 winners) per year.

### *Needed Dissemination of Available Technologies*

A review of technologies in the National Agricultural Research System (NARS) shows that Uganda has access to improved technologies, but many of these technologies remain on the shelf. Some have not been commercially developed, packaged, and marketed for the benefit of most subsistence farmers. Even when technologies have been developed for transfer, there has often been inadequate multiplication by both the public and private sectors for distribution to farmers. The Uganda Seed Project limits its activities to a few commodities, including beans, maize, and soy. Propagation of vegetative materials is outside the project's mandate, yet vegetative propagated crops (such as coffee, Irish and sweet potatoes, cassava, and bananas) are important in the economy of Uganda.

Even where the private sector has developed interest in the multiplication of planting materials, NARS has not had the capacity to provide adequate foundation seed. In the oilseed sector, this problem is particularly acute with respect to sunflowers. This state of affairs has been partially attributed to the poor links between the research system, extension services, and the private sector. The research system has lacked the resources to produce adequate breeder and foundation seed, and there are currently no modalities by which the research system could invest in production of foundation seed and sell the technology to the private sector on a commercial basis. Despite the PMA's calls for "resources to be made available for the adaptation, demonstration and dissemination of promising technologies within easy access of farmers," the challenge of limited access to available technology persists.

### *A Focus on Value Chains Helps Producers and Suppliers Make Technology Choices*

A cultural shift toward value-added approaches in agriculture involves pushing producers and suppliers to ask questions related to technological capacity, research, market access, etc. UIRI has tried to promote the idea of "following the value chain from farmer to market place" to offer a more integrated approach to technology upgrading and productivity enhancement. Newer, more holistic conceptions of innovation that address technology constraints and opportunities—at the farm level all the way through to the market place—give decision makers, investors, and entrepreneurs a more accurate picture of the technological challenges and opportunities that merit attention.

#### *Technology Upgrading Offers a Way to Reduce the Costs of Transport*

On-farm processing presents an option for improved efficiency in the oilseed sector. Under current conditions, a few large processing plants across the country process the majority of the oilseeds produced. Once the oil and seed cake are produced, those products must then be transported back to the places from which they were harvested. Transportation occurs twice in this model, driving up the price. Exploring the potential of farm-based processing might provide a way to reduce the cost of transport. However, widely used, on-farm technology (such as the Ram and motorized press) has proven outdated and inefficient, particularly compared to the large-scale, imported technologies used by Mukwano and Bidco. Improving the technological inputs at the farm level to process oilseeds would render several benefits, not just in terms of increasing the availability of cooking and heating oil. Additionally, the prospect of at-home production of biofuels excites those intrigued by the promise of single-household energy production for lighting and heating.

#### *Storage and Packaging Technologies Fail to Meet International Demands for Quality*

The growth of the oil industry is hindered because too little raw material is available at any given time because of the poor investment in storage and transport to maintain harvested material and ensure consistent supply to buyers. Buyers favor large-scale industrial farms, even when the product is available from small-scale farmers, because of the inconsistency of supply. Without sufficient storage capacity, small-scale farmers cannot contract with buyers who might otherwise purchase their oilseed stock. A related technological challenge pertains to packaging technology. Interviewed producers describe a dearth of food-grade, quality packaging materials. A role for the National Bureau of Standards might be to describe and monitor the use of appropriate materials for packaging and for labeling.

### Human Resources

Analysis of the human resources dimensions of Uganda's oilseed sector reveals that a number of skilled scientists, engineers, and entrepreneurs contribute to the growth of the sector. However, university-level preparation appears to be inadequate in certain key science and technology areas for which the sector requires well-trained graduates. Some firms are taking on the responsibility to train employees themselves, providing opportunities for industrial attachment and skill upgrading for employees.

#### *Weakness in science and technology reduce sectoral productivity*

Several science and technology skill weaknesses hold back the development of a vibrant oilseed sector. The skill weaknesses noted by firms and public research institutions contacted relate to the operation of processing technologies. Producers consistently describe the engineering aspects of training as weak. Skills relating to innovating new products from raw material—the product development skills—are also thin. The Executive Director of the Uganda's Oil Seed Producers and Processors Associations (UOSPA) stated that the host of skills related to entrepreneurialism are wanting within the country; this is true at the farmer level and at the level of those individuals doing value-addition and processing. The Chief Operations Manager at Mukwano elaborated,

> The training [in Uganda] is not adequate at present. If you are in manufacturing, there are so few industries here in Uganda. You are really looking for industry-specific scientists. If you are in soap, you are looking for someone with industry specific knowledge in chemistry, etc. Things like technology internships in industry for science and technology grads would help a lot but we don't see this occurring nearly at the scale that it is needed. We do take on a lot of students in our labs doing lab technology, engineering, etc. and we end up hiring some of them but many lack the base level skills upon which we can augment them to the point that they are hirable.

### *University-level Training Requires a More Hands-on, Practical Approach to Teaching*

Employers cite serious skill gaps within university graduates, calling to question the degree to which university training adequately prepares Ugandans for work in the sector. According to sources contacted, the notion of innovativeness and technology for development has not taken hold within the cadre of university professors imparting knowledge to students in agriculture. The notion that Uganda's economy is factor-driven is reinforced through teaching at the cost of emphasis on skills related to propelling the economy forward through increases to efficiency and increasing innovative capacity. The result is little emphasis on the critical skills required to solve real challenges: ICT skills, critical thinking and problem solving, industrial engineering, business skills, numeracy, etc. Most notably skill weaknesses related to the operation of processing plants and engineering are described as weak even within university graduates. An emphasis on skill development to enhance entrepreneurialism would improve the orientation of university training too.

Large employers within the sector also bemoaned the degree of generality of the curriculum offered at university level. Balancing the need to develop well-rounded graduates with industry's demand for specialized knowledge in chemical engineering, food chemistry, animal feed product development, etc. requires a coordinated effort between industry, university, and those institutions, such as the National Council for Higher Education, focusing on strengthening the training sector for national development. Ideally, representatives from all sectors should meet together frequently to revise and revisit the curriculum offered within the training setting to assure relevance to employers' needs.

### *Firm-level Training Offers an Opportunity to Support Science and Technology Skill Formation*

Firms differ with respect to the proportion of highly skilled science and engineering personnel they hire. For example, Bidco has a much higher proportion of highly skilled science and technology employees than does Mukwano. Mukwano has 7,000 employees, just 2 of whom have masters degrees, whereas Bidco employs 700 people, several of whom have masters, including all supervisors who are required to be at the masters level.

Both firms responded to the challenge of the need for well-trained employees by embracing various in-house programs for skill upgrading. Mukwano's efforts are highlighted in Box A2.1. Bidco's efforts began in 2005, when the company brought on board trainers from Kenya and India to conduct training in advance of starting operations in Uganda. The firm felt this was important to provide firm-based training because between 80 and 90 percent of employees join the company fresh from their first degrees and require extensive training. Training is conducted in tranches. The first tranche lasts for six months. Periodic hands-on training extends thereafter. Because almost all of

Bidco's production and processing is computerized, a great deal of training is offered online. As well, the company sends employees to Kenya for training, where Bidco has another factory. Firm-to-firm training also takes place, through which employees from the Kenyan factory come to the Ugandan factory for skill development and vice versa when particular processes are introduced or changed. For example, Bidco Uganda offered a 7- to 10-day training course for both Ugandans and Kenyans on new techniques for soap-making, facilitated by engineers from Belgium, Kenya, and India.

Both Mukwano and Bidco offer industrial attachment opportunities to students still engaged in formal training at the university level. Approximately 20 students per year participate in Bidco's internships. Still, many students perceive that their worth in the market place will increase if they attain masters-level certification. Thus, Bidco loses a number of its university-educated hires who opt to return to university for postgraduate study. In response Bidco now directly contacts universities (primarily Makerere and Kyambago University in Uganda and Dar Es Salam University in Tanzania) to take on graduates and offer them hands-on training.

### *ICT Skill Gaps Reduce Firms' Competitiveness*

The challenge of weak ICT skills permeates the oilseed sector. Particularly for large oilseed producers and processors such as Mukwano and Bidco, managers find that new hires are slow to acclimate to computer use because they have so little exposure prior to graduation. Even for those students who have received ICT training at the university level, their knowledge of theory often overshadows their familiarity with using ICT to perform tasks. Practical skills for the knowledge workplace are not yet well developed within the academic setting. By contrast, interviewed sources at Bidco opined that Kenyan graduates come to the job with more practical training in ICT.

## Institutional and Infrastructure Resources

Uganda's institutional resources in the oilseed sector vary in terms of sufficient science and technology capacity to buttress a growing area for agro-industrial processing development.

### *Institutions That Link Producers to Buyers Exist (Such as Uospa), but More Are Needed*

One of the sector's most vibrant institutional assets is the Uganda Oil Seed Producers and Processors Association (UOSPA). An association formed to contribute to the revitalization and capacity building of the edible oil industry for poverty reduction and agro-industrial processing development, UOSPA serves as the main advisory body for the sector. It collects, analyzes, and disseminates information on various aspects of the industry and facilitates regional and international networking. In addition to its advisory services to farmers, processors, and consumers, it facilitates research and other activities to develop the sector. UOSPA has also developed a value chain to promote domestic production of vegetable oil under the guiding policy of import substitution. Using a seed variety developed by the National Agricultural Research System (NARS) with support from the Vegetable Oil Development Project, UOSPA has adopted a holistic, integrated, sectoral innovation systems approach to add value across the oilseed chain that provides a platform for improvement, primarily for small holder farmers who are organized in groups by UOSPA. UOSPA also provides links to market services, connecting farmers to market intermediaries who will buy from the farmers. However, many other small landholders feel pressure to sell their harvests to middle men at reduced rates immediately after harvest because they lack the market links and storage facilities required to hold their harvests and sell them at times when fewer producers are eager to unload. This scenario allows middle men to offer below-market prices to the producers whose harvests they purchase. For buyers who require guaranteed supplies to enter into a contract, the lack of storage is often a barrier around which small producers cannot find a way, leaving the door open for opportunistic middle men. With more institutions that provide storage facilities and organize buyers and suppliers, small landholders would be able to fetch higher prices for their oilseeds, which would encourage greater investment into technology and other inputs to improve production.

The Export Promotion Board (EPB) is another institution that partners with firms to help producers gain entry into foreign markets. To date, the Export Promotion Board has helped several firms tap foreign markets. Yet its programs are small in comparison to the demands of the sector.

#### *Weak Standards, Testing, and Quality Assurance Institutions Dampen Prospects for Enhanced Exports*

With all agricultural products, quality between harvests can vary. The capacity to ensure standards is imperative for any producer seeking to maintain relations with a buyer. For most oilseed products, the country does not have any descriptive standards in place. Thus, growers cannot use agreed upon standards to orient their production for quality or quantity. The dissemination of such standards falls under the aegis of the Uganda National Bureau of Standards (UNBS). However, the degree to which UNBS stays abreast of international standards and ensures that they are made known to industry was called to question over the course of interviews with numerous contacts. Specifically, the International Standards Organization (ISO) has issued ISO 659, which is the reference method for the determination of the oil content of oilseeds, as well as ISO 17059:2007, which pertains to the extraction of oil and preparation of methyl esters of triglyceride fatty acids for analysis by gas chromatography, ISO 734–1:2006, which addresses oilseed meals and the determination of oil content, and ISO 658:2002, which details the determination of content of impurities for oilseeds.

#### *Lack of Laboratory Accreditation Severely Constrains Industry's Ability to Export*

In the words of the Head of Finance and Administration for the Belgian-owned laboratory Chemiphar, "The international accreditation [of a laboratory] is like a visa to move products anywhere." Without the ability to guarantee the reliability of the tests performed by a laboratory, goods may be seized and destroyed at the border. Accreditation of a laboratory offers exporters a guarantee that they can enter the market. Thus, accreditation is a tool for agro-industrial processing competitiveness that the Ugandan government has underinvested in within its scheme to promote the modernization and growth of the sector. Not only does a lack of accreditation mean that various kinds of testing and analysis cannot be certified by a lab, but the opportunities for publishing are also minimized. Other than Chemiphar, only one other laboratory in Uganda is accredited (UNBS' microbiology lab), which means any product or process tested by any other laboratory in Uganda is not in compliance with international norms for quality and safety. Beyond impinging firms' ability to sell their goods on the international markets, unaccredited laboratories constrain research too.

### *UNBS' Weak Capacity Hinders Sectoral Growth*

The range of institutions that address various dimensions of quality, standards, testing, and quality appears to be less than adequate in responding to the range of requests for the services an export-oriented, agriculture-based economy requires (refer to the Health Sector Analysis on Ethnobotany, in which these institutions are described in greater details). Questions to answer in thinking through the challenges facing those institutions concerned with quality, traceability, standards, and testing include the following: Are the institutions constrained by lack of human resources, technology, know-how, partnerships, etc.? Or do institutional challenges stem from other problems?

With respect to UNBS (which most interviewed oilseed producers cited as a key institutional partner), the staff number 160 people, only 2 of which have Ph.D.s, with 18 MSc holders. When asked what the biggest constraint to UNBS' success was, interviewed sources there stated that, indeed, the technology itself is constantly stretched to meet the ever-evolving sensitivity requirements entailed in emerging standards for quality and safety issued around the world. However, technological constraints pose less of a challenge than do staffing constraints. For example, each piece of testing equipment requires two staff with sufficient skill. Yet, the available institutional budget to train staff to run and maintain the machines is not adequate. At the same time, fresh graduates from university lack the skills required and the practical exposure to conduct reliable tests. In fact, most university-trained recruits require a full 12 months of training to compensate for their dearth of hands-on practical knowledge. Almost every cited training opportunity within UNBS is sponsored by an international donor, and most of the training provided takes place outside of the country. Noteworthy among these training programs is that of United Nation's Industrial Development Organization's (UNIDO) Integrated Programme, through which staff are being trained to transition from classical to practical methods with a focus on (1) training in quality management systems for the labs, (2) analytical work itself, and (3) maintenance and trouble-shooting of equipment. According to UNIDO's assessment of UNBS' institutional challenges, priorities for the institution to consider in improving its relevance to the oilseed and other agro-industrial sectors include expanding commercialization of its services and extending accreditation beyond its microbiology lab so that clients have an incentive to use UNBS' services instead of opting for Chemiphar, which has capacity and accreditation to perform tests in several areas.

### *Preferential Treatment by Government Discourages Firms*

Though government has been successful in partnering with various private sector firms, small landholders, and institutional partners such as UOSPA to develop the sector, its mode of partnership is perceived by some to be inconsistent. For example, Mukwano's efforts to reduce reliance on imported Malaysian palm oil have been less successful than those of Bidco. Senior management sources at Mukwano complained of the GOU's inconsistent allocation of incentives provided to potential investors at Bidco. By contrast, Mukwano has elicited less assistance from government in developing its oilseed area. The perception that incentives are provided inconsistently lends itself to jealousy and distrust within the sector. Harmonizing incentives to lure investment is another critical aspect of maintaining an even playing field for new market entrants and established market players.

## Collaboration and Communication Capacity

Weak communication capacities challenge firms, institutions, and international partners whose efforts to link and collaborate are often hampered by poor ICT and too few opportunities to coordinate efforts for the development of the oilseed sector.

### *Outdated Extension Services Sometimes Fail to Link Users to Producers*

The Uganda National Agricultural Advisory Service (NAADS) constitutes the cornerstone of the PMA's extension efforts. Crippled by allegations of inadequate emphasis on smallholder farmers, NAADS suffered a series of setbacks that culminated in a short-term hiatus of the program altogether. President Yoweri Museveni has reinstated NAADS; however, criticisms of its shortcomings persist. According to the director of UOSPA, the evidence of NAADS effectiveness at transmitting knowledge and technology between farmers, researchers, and the NARO system is thin. Following NAADS interventions, farmers' behaviors often do not change. According to the Executive Director of UOSPA, even though a system of extension workers across the country was designed to address various dimensions of agricultural production and agronomy, including postharvest handling, marketing and market links, nutrition (with some link to child health), and policy and lobbying (advocacy), these services are "totally inadequate." The NAADS extension services relied on a linear approach to innovation. In keeping in line with the new oilseed sector strategy, "Weaving the Oilseed Web," the sector is trying to reorient toward a perspective that addresses the oilseed farming system (a sectoral innovation system approach) that embraces an integrated production system. The question is this: How does the oilseed sector connect to other commodities and other kinds of production?

If NAADS operated optimally, farmers should be empowered to democratically prioritize the NAADS services they desire; to prioritize their needs; to develop and implement plans; and to monitor and evaluate their progress, as well as the progress of the NAADs system. Farmer groups would be able to contact services and other information sources. Service providers would be more active in providing farmers with information that they need and research organizations clearly involved in working with farmers on the technologies and other information that farmers and other clients require (Opondo et al. 2006). As an institution designed to foment these links, NAADS has suffered from the challenge of catalyzing successful collaborations and establishing credibility. Insufficient clarity on the roles and responsibilities of farmers and farmer fora members is a concern, because guidelines from the NAADS secretariat undergo continuous revision. Knowing how to engage NAADS is not clear to many farmers. Current communication mechanisms limit timely flow of information to the local level and from the local level upward. Thus, limited internalization of roles and responsibilities has resulted in few viable feedback mechanisms on service delivery from farmers to farmer fora and opened the door to unhealthy power dynamics as certain empowered actors co-opt the decision-making process or contract provision (Opondo et al. 2006).

### *Large Processors Recognize the Utility in Enhanced ICT Capacity*

As the description of Mukwano exemplifies, ICT training has become a critical asset for oilseed processors. Mukwano's adoption of the Orion software package and its plans to migrate to SAP for supply chain management demonstrate the firm's enthusiasm to embrace ICT as a way to more efficiently handle raw materials, organize human resources, and manage product flow. Yet, for the 3,000 low-skilled employees of Mukwano, ICT skills are almost nonexistent. For an export-oriented firm facing high competition in the market place from Bidco and others, addressing employees' low ICT capacity has become a high priority. Eager to embrace handheld ICT tools and personal digital devices to scan inventory and track goods through shipment, Mukwano plans to provide all employees with training in ICT.

#### *Weak ICT Capacity Thwarts Connection to Knowledge Partners*

The consequence of weak ICT capacity at the farm level is that producers who may have product cannot communicate with potential purchasers because they lack a means of connecting. Opportunities to connect with knowledge partners such as universities and National Agricultural Research Organization (NARO) institutes are fewer when virtual means of connecting cannot compliment face-to-face collaboration. The result is that knowledge produced in one part of the value chain may not be transmitted to another part where it is needed.

#### *Outgrower Farmers Collaborate with Big Firms, but Links Could Do More*

Oilseed farmers fall into one of four categories: subsistence; sometimes sellers; small commercial with a little subsistence; and totally commercial. But these groups are not well defined. They often bleed into each other, with many farmers in between groups. Because the household enterprise level lacks a holistic approach to farming, planting, production, and the use of the products grown, opportunities to see the value in the other enterprises implied in the products that farmers produce are lost. Instead, value addition is often defined in the context of contractual arrangements with Mukwano and Bidco. Sadly, for many out-growers, when the pilot initiatives for Mukwano or Bidco finish, the farmers often revert to subsistence farming. UOSPA is moving forward with a more integrated program, with a small amount of support from the Danish government, guided by the belief that the relationship between subsistence farmers, sometimes sellers, small commercial, and large commercial growers could provide a platform for innovation and product diversification. For example, Mukwano partners with approximately 32,000 subsistence and sometimes sellers who grow pilots for various strains of sunflower seeds, etc. If these small farms were better organized to work together to overcome institutional and technological weaknesses, their products would fetch better prices and they would be able to guarantee consistent supply to large buyers, which would create more income to invest in technology to explore other possible products.

#### *Weak Market Links Minimize Opportunities for Product Diversification*

Linking to local, regional, and international markets and deepening an understanding of consumer demands constitute key challenges at present. Without deeper knowledge of markets, producers miss opportunities to develop products for which clear demand exists. For example, a by-product of oil extraction is seed cake. Producers know that these seed cakes could have a number of marketable uses outside Uganda. For example, seed cake can be used as animal feed, and it has certain safety advantages that animal-based feed products do not (e.g., there is no threat of contracting mad cow disease from eating seed cake). These secondary product areas elicit very little effort and attention in terms of market development, however.

Beyond strengthening the capacity of institutions to tap international markets and transmit market desires into opportunities for producers, there exists a challenge with respect to organizing marketing and standardizing the way products are sold (e.g., kilos, grams, tubs, tubes, powders). Too little information is disseminated regarding quality standards and specified parameters for content, etc. so that all producers target their production to the market standards. The challenges highlighted in the Ethnobotany sector analysis regarding the weak level of communication between government institutions responsible for standards and private producers seeking to implement them (such as standards for quality, safety, labeling, etc.) undermine producers' efforts to innovate in the oilseed sector as well.

#### *Collaboration Within the Sector Is Strong, but It Could Improve*

Because research is now more liberalized in the agricultural sector and involves not just NARO but universities, other national institutions, UOSPA, and the farmers themselves, producers recognize that their research agenda is far larger than current research efforts. Deepening research collaborations that include each of these players is imperative. At present, farmers are strongly linked to UOSPA, which in turn maintains good ties with NARO and with Makerere University. UOSPA appears to maximize its role as a knowledge broker between the university and the public research institutions. However, this means the interface between farmers and the universities and public research institutes is not as direct as it could be. Improving farmer-university-institute collaboration is important. This vision is taken up in UOSPA's sector strategy that seeks to create a platform that would bring together farmers, researchers, etc. to create collaborative mechanisms for research, production, and value addition. Furthermore, UOSPA is developing regional offices in Lira and elsewhere to ensure ground-level collaboration with its key constituents, extending its reach beyond Kampala.

The large commercial entities in the sector also report that collaboration with institutions designed to maintain links with a range of partners constitute highly valued assets for the firms. Mukwano partners with the Uganda Oilseeds Producers and Processors Association, etc., the Uganda Export Promotion Board, the Private Sector Foundation, the Uganda Manufacturers Association, etc., among others.

#### *Opportunities for Regional Partnership Provide a Way to Link to Knowledge Partners*

Trade fairs constitute a popular mechanism for Uganda's oilseed processors to maintain links with markets. Mukwano attends trade shows, especially in the region, including shows in Kenya, Tanzania, Rwanda, and Burundi. Bidco also reports that international trade shows, primarily in Africa, offer a way to foster links with potential buyers and collaborators. The Uganda Manufacturers Association is perceived by both as a valuable membership organization in facilitating these kinds of opportunities.

#### *Regional Partnerships Can Strengthen Local Institutions*

Improving the competitiveness of Ugandan oilseed products in the region could be facilitated by improving the collaboration between quality and standards organizations. A platform for regional collaboration on quality and standards is the Quality Infrastructure in the East African Community initiative (see website: http://www.eac-quality.net/). The initiative asserts that there is an urgent need for better regional coordination at all levels: legal framework, human resource capacity, infrastructure and logistical support, public awareness, networking and communication. To this end, its goal is to harmonize regional standards, quality, metrology, and testing (SQMT) activities and build a client-oriented infrastructure complying with international standards in Burundi, Kenya, Rwanda, Tanzania, and Uganda. Members include Kenya Bureau of Standards, Rwanda Bureau of Standards, Tanzania Bureau of Standards, Uganda National Bureau of Standards, Kenya Weights and Measures Department, and Tanzania Weights and Measures Agency. In 2007 the initiative launched the East African Community Quality Web portal that is shared by the five national standards bodies. If properly managed and utilized, the Web portal will contribute to the dissemination of information on matters of standardization, quality assurance, metrology, and testing and help build a quality culture in the region that bodes well for the oilseed sector as for the other agro-industrial sectors in Uganda.

## Knowledge Base

Uganda has taken significant strides to deepen its science and technology knowledge base in the oilseed sector, though a number of opportunities have not yet been taken.

### *Research Bottlenecks Hold Back Industry*

According to the PMA, Uganda's agricultural research must emphasize development or importation, adaptation, and adoption of improved high-yielding, disease- and pest-resistant plant and stocking materials. Research must also put additional emphasis on farm power and tillage, postharvest handling, and agro-processing technologies to reduce drudgery, particularly on women, increase productivity, reduce losses, add value, and improve quality. According to sources interviewed, the dominant research challenge for oilseeds is the breeding program. Growers have a limited number of varieties. For example, there are only two varieties of sunflowers appropriate for growth in Uganda at present, and the research effort is too small to develop more. Research in oilseeds is not just the domain of the public sector. Indeed, the private sector is putting money into oilseed research. As the Chief Operations Manager of Mukwano explained, "Regarding where and when to perform R&D, it is really driven by the market. We have been hit by the high cost of palm oil. So the incentive to do R&D comes from the need to push through the wall. We hire a lot of consultants in a lot of areas. It's always better to spend little money to maintain the edge than a lot of money to redevelop entire areas when we are failing." At present, Mukwano has several projects looking at substituting seed-based oils for crude palm oil to avoid the high costs associated with the importation of palm oil from Malaysia. Mukwano conducts research on sunflowers, soy bean, maize, cotton, and tea with the intention to diversify toward a wider range of oilseed crops.

Another aspect of the oilseed research agenda is the need to develop a domestic capacity for seed breeding. Mukwano's Panner 7153 seed, which offers the highest-quality oil and highest concentration (30 percent), is very expensive and is purchased through South African breeders. Through research and development, Mukwano seeks to work with the parent crop to create a superior seed in Uganda. If fruitful, this research would allow Mukwano to stop purchasing the expensive seeds from the South African breeder. USAID has partnered with Mukwano in the pursuit of optimized oilseeds.

A University of Michigan study by Rita Laker-Ojok estimated the rate of return for research in the Uganda oilseed sector (sunflower, soy beans, and maize) between 1985 and 2006 at 29.8 percent. Given the high rates of return to research, incentives to move forward with the research agenda should stimulate continued commitment to oilseed research.

*Oilseeds Could Be Used for Biodiesel, but More Research Is Required*

Strengthening the oilseed sector has repercussions that go well beyond food security. Biodiesel is another avenue for potential commercial production within the oilseed sector. Yet, at present, Ugandan producers lack the knowledge needed to take advantage of this market opportunity. More research is required. A November 2007 conference on Biofuel Markets in Africa sponsored by the Center for Technical Assistance under the African Union elicited the attention of the Executive Director of the Uganda Oilseed Producers and Processors Association as an opportunity to learn what possibilities for development of oilseed-based biofuel Ugandan producers might explore.

*Expanding the Knowledge Base Can Help Oilseed Firms Outpace the Competition*

Importers of oilseeds into the country are two: Sun Fola and Hybrid Pana. Of the two major processors of oilseeds, Bidco is trying to promote palm oil through a development program that it has launched on Sesse Island in Lake Victoria. Bidco's is a 7-year program, with a young crop at present. Historically, importing palm oil from Malaysia was more affordable than growing it in Uganda, even despite the high costs of transportation. Bidco suspects that palm can be grown successfully in Uganda and that when it is, the reduced costs of transport required to import palms grown abroad will advance Bidco's bid to become the dominant market leader in Uganda, overtaking Mukwano. When firms invest in deepening their science and technology knowledge, as Bidco is doing, the possibilities to dominate the competition increase.

*When Firms Lack Market Information, They Fail to Exploit Some Business Opportunities*

One of the challenges confronting the large oilseed processors relates to market information and knowledge bottlenecks. Specifically, when crude palm oil is processed, it results in palm fatty acid (PFA), crude palm sterine (CPS), and crude palm olein. This is at the first stage of distillation. The PFA and CPS are used in soap, and the olein is used in vegetable oil. The process of soap manufacturing also produces some additional fat that can be used as a cooking substance. Yet, because of incomplete market information and unclear measures of demand in the African market, Mukwano does not sell this secondary product (the cooking substance). Interviewed managers at Mukwano explained that because the processing of soap might in fact produce more fat and vegetable oil than the market needs, the firm runs the risk of overproducing the product, which would render the option of producing it less profitable. So, instead Uganda imports such secondary products from outside the country even though they are produced by Ugandan firms. The Chief Operations Manager of Mukwano explained that the ratios are the problem. Unless Mukwano figures out how to ameliorate its market knowledge bottlenecks, the potential to add value in these secondary products is lost.

*Private Sector Research Propels Innovation in the Sector*

Both Bidco and Mukwano demonstrate private sector's commitment to research in Uganda's oilseed sector. In the case of Bidco, its foreign joint venture partners in Kenya, Singapore, and Malaysia each conduct in-house research as well. A shared laboratory for product development and formulation is used by representatives from each of Bidco's subsidiaries, with a fair amount of R&D conducted jointly. Bidco describes research and product development as existing along a spectrum. Sometimes small changes to formulation—a new soap color, a new fragrance—are sought. Other research endeavors seek to yield entirely new products and processes.

Guiding its research efforts, Bidco has a research strategy that largely emphasizes its research and development plans in the oilseed sector. Mukwano also performs R&D based on the perception of market demand for new products or changes to existing products. With research projects underway in sunflower, soy bean, maize, cotton, and tea, Mukwano is an active contributor to Uganda's agro-industrial research landscape. Both private sector players demonstrate an appetite for knowledge generation and exchange that benefits the sector.

#### *No Adequate Research Policy Guides the Oilseed Sector's Development*

The PMA argues that "agricultural research is not adequately co-ordinated and the mandates and roles of different institutions in the sub-sector are not harmonized for maximum efficiency and effectiveness in the delivery of services to the subsistence farmers. The UNCST, as an apex organization in the national research system, is compromised by lack of adequate human and financial resources. This is partly due to lack of a comprehensive agricultural research policy that would define the goals, objectives, institutional roles and resources for agricultural research." To the extent that the oilseed sector is held back by lack of a clear research policy, this should be addressed. Indeed, the PMA committed the government to undertake the formulation of a national agricultural research policy that will provide the objectives and principles for agricultural research and define the institutional arrangements, including roles and links among key players. Creating the legal framework and proper coordinating environment in which research can be performed in the sector will only foster its continued growth.

#### *Immediate Business Challenges Trump Long-range Investment and Planning in Research*

Of those commercial producers interviewed, very few had engaged with scientists to explore areas for research and development jointly. In the case of Mukwano, a division head expressed remorse at not having had more partnerships with the scientific community, recalling just two separate visits from scientists to the plant. For managers such as the one interviewed at Mukwano, the challenge is one of priorities: Does a manager prioritize putting out the immediate fires or working toward longer-range objectives? Learning to balance opportunities for knowledge exchange with daily demands will engender greater knowledge use, dissemination, and generation in the oilseed sector.

## Notes

1. The Plan for the Modernization of Agriculture notes, "On-farm yields are less than one third of the yields on research stations and most households continue to depend on low input-low output technologies, particularly the hand-hoe (93 percent of the farm households rely almost entirely on the hand-hoe for cultivation). Post-harvest losses remain high, at about 25 percent, and most of the agricultural produce is sold in its primary form with little or no value addition. Most farmers continue to produce a wide range of commodities on their farm due to lack of guidance on selection of profitable enterprises and knowledge of product markets and prices."

ANNEX 3

# Health: Ethnobotany Case Study

Uganda's health sciences research capacity is heavily centered in a few research locations, dominated by the Makerere University research labs. The GOU Ministry of Health laboratories also produce a number of papers published in internationally recognized journals. Additionally, University of Mbarara publishes or co-authors several dozen papers in health and related fields annually. In 2000, 57 organizations conducted health research in Uganda, most of which were university departments. More than 60 percent of these organizations reported that less than 20 percent of their work was oriented toward research.

Few private companies provide health services in the country. An exception is Med Biotech Laboratories, which conducts state-of-the-art epidemiological research on malaria, making it unique—no other private company in Uganda reports conducting health-related research and development. Government funding for health sciences research and development is nearly nonexistent. Donors provide 99 percent of the funding for research in the sector. International collaboration in health sciences is very common, shown by the percentage of all papers that are co-authored with a foreign counterpart. As is the case with many developing countries, Uganda has a very high percentage of articles co-authored with researchers from developed countries. The British Medical Research Council, Johns Hopkins University, the University of California San Francisco (UCSF), and the Centers for Disease Control collaborate frequently with researchers at Ugandan institutions.

Four firms dominate Uganda's fledgling pharmaceutical industry: Medipharm Industries Ltd., Uganda Pharmaceutical Ltd., Rene Industries Ltd., and Kampala Pharmaceutical Industries Ltd. The industry faces stiff competition from imported drugs, mainly from India. Industry representatives say that high capital investments in technologies such as flash dryers are among the constraints holding back development of the sector.

The demand for scientific and technological capacity and services in health-related fields is high in Uganda, but it is also changing. Both the Ebola virus and the AIDS virus appear to have originated in or around areas in Uganda, making the country an important site for immunological and virological research. This has increased demand for locally available researchers who can work with foreign experts. Furthermore, Uganda's combination of good research capacity in epidemiology and experience with clinical trials has made the country an international center for vaccine research and development for HIV/AIDS and malaria. In fact, the first HIV vaccine trial in Africa was conducted in Uganda in 1999 at the Joint Clinical Research Centre. Similarly, the health care needs of Uganda have changed with the emergence of diseases such as HIV/AIDS, highland malaria, and the reemergence of infectious diseases like tuberculosis.

## Overview

Ethnobotany is the study of the relationship between plants and people. The study focuses on how plants have been or are used, managed, and perceived in human societies and includes plants used for food, medicine, building, divination, cosmetics, dyeing, textiles, tools, currency, clothing, rituals, and social life. The use of plants for cosmetics and pharmaceuticals is the focus of this sector study.

The demand for health care in Uganda is rapidly increasing as a result of population growth and shifting demographics. Between 1971 and 2002, Uganda's population leaped by 177 percent.

Even as Uganda's demand for health care increases with its growing population, the vast majority of Ugandans (between 70 and 80 percent) rely on traditional healers for day-to-day health care. In some rural areas, the percentage of Ugandans who partake in traditional medicine is around 90 percent, above the 80 percent average for developing countries estimated by the World Health Organization (Kamatenesi-Mugisha and Oryem-Origa 2005). Plants and plant-based medicines not only constitute a key ingredient in many traditional treatments, but many plants that may be cultivated in Uganda can be used as ingredients for major pharmaceutical drugs used globally.

A focus on medicinal plants goes to the heart of some of the major questions regarding conservation and the use of biological diversity that Uganda faces. Conservation and livelihoods are closely linked with medicinal plants. If conserved, medicinal plants will continue to provide benefits in terms of healthcare, income, and cultural heritage. The most pressing conservation issues to be considered in developing Uganda's medicinal plant sector include the following:

- How can species and their genetic diversity be conserved?
- How can sustainability be assured in cases of both wild collection and cultivation?
- How can people's interest in medicinal plants serve as a motivator for conservation of habitats and their species?

The livelihood issues include the following:

- How can the health benefits of medicinal plants best be made available at local, national, and international levels?
- How should the responsibilities, benefits, and costs of managing and exploiting these resources be distributed?

## A Growing Sector for Investment

Global trade in natural ingredients has increased dramatically in the past 10 years, with trade in herbal medicines estimated at $13 billion annually and growing in excess of 10 percent per year (CBI Market Surveys 2003). These developments on the global front present Uganda with an opportunity to harness its rich biodiversity and the ongoing interest by the private and public sectors and civil society for naturally derived remedies to treat health problems (UNCTAD 2005).

Globally, roughly 50,000 plant species have been used medicinally. This represents by far the biggest use of the natural world in terms of number of species. The use of medicinal plants is increasing worldwide, related to the persistence and, in some cases, expansion of traditional medicine throughout the world, coupled with a growing interest in herbal treatments. A study of the top 150 proprietary drugs used in the United States in 1993 found that 57 percent of all prescriptions contained at least one major active compound that was either derived from or patterned after compounds from biological diversity (Grifo and Rosenthal 1997).

In some cases, chemicals extracted from plants are used directly as medicines: for example, reserpine (lowers blood pressure, extracted from serpent-root *Rauvolfia serpentina*), ephedrin (a decongestant, from the shrub *Ephedra*), and digitalin (used to treat irregularities in heart rhythm, from foxglove, *Digitalis* sp.). In other cases, chemicals are extracted from plants and used as chemical building-blocks to create new compounds, which are then used as drugs. For example, progesterone (used as an oral contraceptive) is manufactured from diosgenin, found in certain species of the yam, *Dioscorea* sp. Some drugs, including some of those that are synthesized from inorganic sources, were inspired in their historical development by the physiological activities of chemicals found in plants. Aspirin, which is today synthesized inorganically, was inspired in its development by folk uses of the bark of the willow, *Salix*, to treat fever (Plantlife International 2008).

The richness and abundance of Uganda's medicinal plants is striking. Uganda's medicinal plants and natural ingredients for cosmetics include *Aloe* (both *vera* and *ferox*), *Artemisinin*, Moringa, shea nut, papain, citronella, lemon grass, garlic, *Prunus Africana*, Warburgia, Pyrethrum, and neem.

### *Becoming Globally Competitive in Ethnobotany Requires Enhanced Science and Technology Capacity*

Uganda's demand for pharmaceutical ingredients is met primarily through imports, with 85 percent of the products used locally imported and a mere 10–15 percent produced locally. The local cosmetics industry is also highly import-dependent, with products such as essential oils, perfume materials, toilet cleaning preparation, etc. imported from South Africa, Brazil, Israel, Germany, etc.

Developing Uganda's medicinal plant sector requires adapting its production capacity to meet certain market entry requirements, including sanitary and safety regulations, phytosanitary certificates, general quality requirements, social and health and safety issues, CITES (which governs the trade in endangered species), and packaging marketing and labeling standards. Most buyers define their own quality requirements, such as the Good Manufacturing Practices (GMP) and ISO 9000. Certified GMP standards also exist for active pharmaceutical ingredients. Cosmetic ingredients and raw materials for pharmaceuticals exported from developing countries may not necessarily require certification to GMP, but all buyers expect the supplier to understand and implement the requirements of GMP. The same applies to Good Agricultural Collection Practices (GACP). In the medium term, it is expected that GMP certification will become standard requirements for all supply chains. Today's manufacturers of finished products apply increasingly stringent requirements on their suppliers to ensure consistent manufacturing, quality control, and traceability. In spite of Uganda's high reliance on medicinal plants, the medicinal plants used are threatened by unsustainable harvesting practices, habitat loss, ineffective policies, and limited local involvement in their conservation. Medicinal plant conservation requires robust management systems in favor of conservation or sustainable production (or both) at sites where the plants grow if sector expansion and commercialization is to occur (Kamatenesi-Mugisha and Oryem-Origa 2005).

Enhancing the productivity and competitiveness of Uganda's natural and pharmaceutical ingredients sector requires successful application of technology, deepening of skills, reorientation of various institutions, enhancement of communication and links between key stakeholders, and better use and dissemination of knowledge within the sector. At each node in the value-added chain, attention is required to reap the benefits of applying science and technology to grow the sector. The following analysis addresses each of these dimensions, which correspond with the THICK methodology, within the context of Uganda's ethnobotanical sector. The case study of Quality Chemicals Ltd., which is presented in the following, box A3.1, brings into relief each of these aspects of the THICK methodology, illustrating their interrelation and influence on the sector.

The following sections present further analysis of Uganda's ethnobotany sector according to the THICK (Technology, Human Resources, Institutional Resources, Collaboration and Communication, Knowledge Base).

## Technology

According to Uganda's Plan for the Modernization of Agriculture (PMA), "Improving the welfare of poor subsistence farmers will require that they re-orient their production towards the market. More of their production must be marketed to enable them to earn higher incomes." As noted in the PMA, the transformation of Uganda's agricultural sector toward greater competitiveness and increased incomes for subsistence and small-scale farmers entails the adoption, adaptation, and use of technology and knowledge for enhanced productivity. However, at present, the potential for development of Uganda's natural ingredients for pharmaceuticals and cosmetics sector is thwarted by the weak utilization of existing technology for the cultivation, harvesting, storage, extraction, and processing of plant-derived products. Interviewed sources from a range of private and public sector-based organizations reported several technology-related challenges, highlighted in brief as follows.

### *Opportunities for Technology Upgrading and Technological Learning Abound*

The allure of Uganda as a site for health sciences research—combined with its attractive environment for cultivation of various botanical ingredients—renders Uganda an ideal location for foreign investment into the natural and pharmaceutical ingredients sector. To this end, changes to the TRIPS agreement have repercussions for Uganda's potential as a regional manufacturer of plant-based products, including pharmaceuticals. According to TRIPS, only Least Developed Countries can manufacture generic versions of patented drugs (such as anti-retrovirals for the treatment of HIV/AIDS and artemisinin combination therapies for the treatment of malaria). With 230,000 of its own citizens requiring ARVs, 1.3 million Ugandans infected with HIV/AIDS, and an estimated 60 million attacks of malaria per year (more than two attacks per person per year on average), Uganda's domestic market alone for these drugs is substantial. Growing its ability to gather, analyze, and extract the inputs for drugs, as well as furthering its capacity for research into promising areas for commercialization of known therapies derived from ethnobotanical remedies used by traditional healers, offers Uganda a way to tap the opportunities in its own backyard.

**Box A3.1. Expanding Uganda's Capacity to Produce Pharmaceuticals: The Case of Quality Chemicals Limited**

*Enemies of development: HIV/AIDS and malaria*

Despite remarkable progress toward combating poverty and disease, Uganda's development prospects are still dampened by two diseases: HIV/AIDS and malaria. Although a concerted effort to reduce the incidence of HIV/AIDS in Uganda, which peaked at 18 percent in 1992, succeeded in lowering that rate to 6.2 percent, the scourge lingers. Today some 230,000 ugandans require anti-retroviral treatment (ARVs) to manage the disease (WHO 2007). Yet, just 96,000 Ugandans receive it, leaving nearly two-thirds of sufferers without treatment.

Global deaths that are due to malaria number 1 million annually, and 90 percent of these occur in Africa. However, this estimate does not capture the full effect of the burden of the disease on the health system. Because malaria covers a continuum that extends from asymptomatic infection to severe acute illness or death, many survivors of the disease bear the toll of those nonlethal effects of the disease (e.g., anemia, low birth weight, hypoglycemia, etc.) without attributing it to malaria. According to the WHO's 2006 Africa Malaria Report, malaria was the principle cause of death for 18 percent of African children under five. Seventy-four percent of the population of the Africa region lives in areas that are highly endemic, with 19 percent living in epidemic-prone areas. Both Uganda and Mozambique are in the latter. Some 4,487,069 cases of malaria in Uganda were reported in 2005, down from over 10 million the year prior. In Mozambique, reported cases in 2005 numbered 5,896,411.

The high prevalence of malaria is a significant drawback for social and economic development across Africa. For Uganda, which is among the most malaria-endemic countries in Africa, the GDP loss from the disease is estimated at $11 million, which translates to 5 percent of the health expenditure of the country. At the level of the household, a single episode costs a family an average of almost $9 in lost productivity because of the inability to work. With a GDP per capita of just $300 (World Bank 2006), this constitutes a loss of 3 percent of annual income with every episode.

Since 2001, the WHO has recommended an artemisinin-based combination therapy (ATP) as the first-line treatment against uncomplicated malaria in settings where malaria is resistant to conventional treatments such as chloroquine or sulfadoxine-pyrimethamine (SP). Yet, to date, no company manufactures artemisinin-based treatment in Uganda. Rather, the standard practice is to purchase pharmaceuticals manufactured in India and elsewhere and import them.

In 2005, global demand for single-dose treatments of ATP outstripped global supply by 60 million (WHO 2005). The surge in demand for ATP presents Uganda with an extraordinary opportunity to link its expertise in plant science to opportunities available to enhance technological learning using quality processing technology through public-private partnership. With respect to HIV/AIDS, the inadequacy of the country's ART program begs for a solution in which every Ugandan who needs ARVs receives them.

*Enter Cipla Ltd.*

Through an agreement between President Museveni, Quality Chemicals Limited, and Cipla Ltd., a $38 million factory—the first in Africa to produce full triple-therapy generic retrovirals for HIV/AIDS patients—is being built in Uganda. The factory—Quality Chemicals Limited—will manufacture both HIV/AIDS and malarial medications. Built on the outskirts of Kampala, the 12-acre facility includes a main plant and an auxiliary building for utilities, boilers, generators, transformers for power stabilization, and compressors for compressed air. For HIV/AIDS treatment, the factory will produce the anti-retroviral combination therapy Triomune, which contains lamivudine, stavudine, and nevirapine. According to the Ugandan Ministry of Health, Triomune currently costs about $40 per month in Uganda. Emmanuel Katongole, managing director of Quality Chemicals Ltd., said the price could be reduced by 30 percent to 35 percent, which would increase access to anti-retrovirals within Uganda and across East and Central Africa.

In addition to ARVs, Quality Chemicals Ltd. will produce the anti-malaria medication Lumartem, which contains artemisinin and lumefantrine, but is significantly cheaper than the WHO-recommended first-line brand with the same ingredients, Coartem.

"Government commits itself to its promise of purchasing the ARVs for AIDS patients and artemisinin-based combination therapies for malaria from the factory for hospitals," declared President Museveni during the inauguration ceremony on October 8, 2007.

The pharmaceutical company Quality Chemicals Ltd. partnered with the Indian pharmaceutical company Cipla Limited, one of the world's largest producers of generic drugs, to launch the endeavor. Cipla is providing the technology, technical assistance and training, and the expertise that comes with having built similar manufacturing plants across the world. For its part, Quality Chemicals Ltd. will mine Uganda for scientists, engineers, and technicians equipped with the skills to learn how to manufacture pharmaceuticals according to the quality-processing methods. Benefits that will accrue to employees, in addition to employment, include the extensive training and exposure to technology that will deepen the capacity of staff as knowledge workers and potential innovators. For those Ugandans growing artemisinin, the benefit of secured contracts offers security to those producers who can deliver a consistent supply to the company for processing.

Initially the factory will produce about 2 million anti-retroviral and anti-malarial pills daily, which will later increase to 6 million daily, or 1.8 billion pills annually. The Ugandan government will be the first client to purchase medications from the factory. Subsequently, the factory will export anti-retrovirals to neighboring countries (Burundi, Kenya, Rwanda, Tanzania, Democratic Republic of Congo, and Sudan), beginning in early 2008 after the Ugandan government has purchased its supply (*Kaiser Daily HIV/AIDS Report* 2007).

*A surge in demand for science and technology human resources*

At full capacity, Quality Chemicals Ltd. is expected to employ an estimated 500 people, including 200 scientists. According to a review of Uganda's Science and Technology sector, with just 2–3 percent of total tertiary enrollment in Uganda in science and engineering and a mere 10 Ph.D.s in science and technology produced annually, Uganda's capacity to produce sufficient human resources is inadequate to take advantage of the opportunity presented by Quality Chemicals Ltd. . The current rate of science and technology human resources production is hardly sufficient to replace the retiring Ph.D.s within the university system, let alone train for an expanding science and technology sector and the needs of the private sector. If Uganda's tertiary training system cannot provide the science and technology human resources required by Quality Chemicals Ltd., the employees will be brought in from overseas.

For its part, Quality Chemicals has adopted a plan for skills training to offer Ugandans an opportunity to acquire the skills needed to perform successfully at the plant. During the first year of operation, 40 Indian scientists and engineers will oversee the manufacturing operations while simultaneously instructing 95 local hires in the process and content knowledge needed. These 95 Ugandans must have attained an MSc degree—in engineering, pharmacy, and other relevant science and technology fields—and have some pertinent experience. Cipla's human resources training plan entails reducing the proportion of Indian expatriates working at the factory (whose wages are four times that of the Ugandans) so that within 2–3 years the Ugandans will be self-sufficient.

*An opportunity for technological learning and mastery*

The technology required for quality pharmaceutical manufacturing is expensive and complex. From primary products to packaging and handling materials, each aspect of the production process must adhere to international standards for hygiene, sanitation, and purity. A tour of the factory revealed the extreme measures to be taken at each stage of production to ensure the purity of the pharmaceuticals produced. The technology entailed in the production process is costly and must be imported from overseas. Technology was selected by Cipla and Quality Chemicals Ltd. that could be serviced locally despite being sourced overseas from the United States, Europe, and Asia. Cipla advanced Quality Chemicals some $4.2 million in equipment and technology as well as free technology transfer, according to Quality Chemicals Ltd. Director of Finance, Fred Mutebi Kitaka.

Although access to Cipla's technology offers Quality Chemicals and its employees an opportunity for technological learning not available to those without access to this technology, it has also exposed inadequacies in the technology used in some parts of the supply chain upon which Quality Chemicals relies for competitiveness. Take artemisinin for example. Uganda's climate is ideal for production of this plant, which allows for a reduction in the cost of importing artemisinin from India, China, or Vietnam. In fact, companies such as Afro Alpine Pharma Ltd., which is located in the Kabale region of Uganda, are now growing artemisinin and have engaged in contracts with Cipla for this purpose, with plans to grow over 22,000 acres. The challenge for Afro Alpine Pharma Ltd., according to the Marketing Director of Quality Chemicals, is a technological one. At present, the company does not have the extraction technology required to produce artemisinin at 100 percent purity. Rather, the company can only extract to 95 percent purity, insufficient for the production of quality pharmaceuticals. To compensate for the lack of technology, the Ugandan-grown artemisinin is exported to India, where it is extracted to 100 percent purity and then shipped back to Uganda. A similar story line exists for other supplies, including purified chemicals and materials such as various gases, excipients, sucrose, etc. for which the technology does not exist in Uganda to produce the needed inputs at the required level of purity and quality. Meeting the demand for quality and safety required for pharmaceuticals manufacturing entails enhancing the technological capacity of a whole host of suppliers, processors, and partners linked to Quality Chemicals Ltd. through the whole production process.

*Institutional partnerships contribute to competitiveness*

Uganda's National Drug Authority has provided consistent assistance to Cipla and Quality Chemicals Ltd. over the course of designing and testing the production process to ensure compliance with standards. Both the World Health Organization's and the United States' standards for production design were used to assure that the pharmaceuticals produced comply with international standards. Cipla elicited certification from the United States Department of Agriculture and the World Health Organization for Quality Chemicals as an additional Cipla plant, as opposed to a stand-alone Ugandan venture, which reduced the bureaucratic barriers for Uganda in eliciting authorization from these organizations as a certified manufacturer.

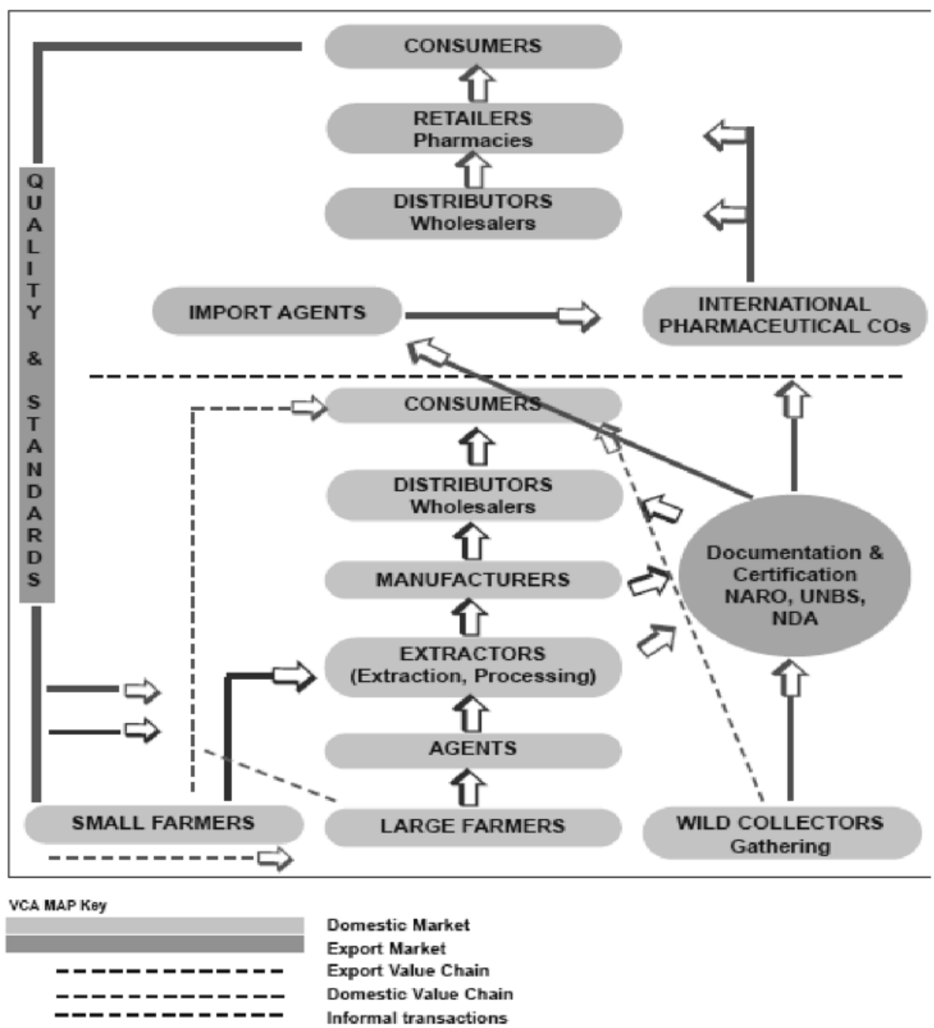
*A catalyst for African innovation and sectoral growth*

The Quality Chemicals Ltd. venture is not only likely to enhance employment opportunities for Uganda's scientists, engineers, and technicians, but the factory likely will decrease the cost of anti-retrovirals and other drugs by reducing transport and customs costs and creating economies of scale. Users of the anti-malarial drugs will benefit from the lower costs for transportation and shipping of artemisinin when it is harvested locally. Beyond the obvious benefits to users of the products produced by Quality Chemicals, the development of the facility constitutes a significant step forward for Africa in terms of growing its own pharmaceuticals sector. Both companies engaged in the partnership express hope the factory will have an equally profound commercial impact by spreading knowledge and acting as a first step toward Africa developing a pharmaceuticals base of its own.

An exciting opportunity exists for Uganda to marry its potential for ethnobotanical research and commercialization with its recent capacity-building effort to manufacture pharmaceuticals for HIV/AIDS and malaria patients. The $38 million manufacturing facility of Quality Chemicals Ltd. (highlighted in the preceding box)—the construction of which was nearly complete as of October 2007—showcases Uganda's ability to rapidly absorb state-of-the-art technology in pharmaceutical manufacturing. The opening of this facility will catapult a pocket of Ugandan industry to the highest international standards for quality, production, and safety, as established by international markets and the

WHO. As the Quality Chemicals Ltd. case highlights, however, the availability of the sophisticated technology provided by the Indian pharmaceutical giant, Cipla, requires that Ugandans take full advantage of the opportunity for technological learning afforded through this investment. At the same time, other nodes within the pharmaceutical supply chain—such as the artemisinin growers in the Kabale region—that have not yet increased their use of technology for production, processing, and transport will minimize Uganda's competitiveness as a manufacturer of pharmaceuticals unless investments are made to increase their science and technology capacity. Figure A3.1 depicts the pharmaceutical supply chain, along with opportunities for technological upgrading that warrant attention and investment.

**Figure A3.1. Pharmaceutical Value Addition Chain Map**




*Source:* Uganda Export Promotion Board

*Processing Technology Is Largely Crude and Outdated*

According to the United Nations Commission on Trade and Development (UNCTAD) and the Uganda Export Promotion Board's BioTrade Program, small producers across the country and individual collectors of wild species are the main producers of ethnobotanical ingredients. Processing is undertaken at two different levels: by small producers, using rudimentary technologies (galvanized grinders, locally fabricated distillers, mortar grinders, etc.) for powders and crude essential oils, and by large companies, using modern technologies for extraction and distillation processes. As the former is far more common than the latter, it is common to find companies contracting out the refining process to factories in Europe to complete processing. This choice constitutes a lost opportunity for value-addition that could take place within Uganda were the technology to do so procured and utilized.

*Weak Technology Reduces Producers' Ability to Guarantee Supply*

Lack of storage facilities and inconsistent electricity mitigate producers' ability to stockpile enough raw materials to manufacture some kinds of products at quantities large enough to guarantee the degree of consistency in supply that distribution agents demand. As well, electricity capacity also impacts storage. One producer of moringa oil products reported receiving an average of just three days and two nights per week of consistent electricity supply to her manufacturing facility, which is insufficient to generate a competitive supply. The cost of procuring a generator is generally an option too expensive for small-scale entrepreneurs and innovators to take.

*Enterprises Lack Technological Capacity to Perform Rudimentary Tests*

Because of the low level of technological diffusion and use within enterprise, it is the case that a number of technology-dependent tests that would otherwise be performed at the enterprise level are not carried out. Thus, the responsibility resides with the Uganda National Bureau of Standards (UNBS), the Uganda Industrial Research Institute (UIRI), and other institutions to carry out the entire range of testing procedures for firms. For example, there are 10 parameters that should be tested for edible oils, according to UNBS. Within these 10, 4 of them "should be carried out the level of enterprise": (1) acid value, (2) moisture, (3) fat content, and, (4) relative density (using a density meter). These tests could be done using simple technologies and equipment, such as a moisture meter. The parameters for testing edible oils that are more difficult and appropriate for national-level laboratories are (1) peroxide value, (2) iodine value, (3) refractive index, (4) heavy metals, (5) saponification value, and (6) insoluble impurities. With low science, technology, and innovation capacity in enterprise, the onus is on UNBS and other institutions to compensate for low technological capacity, which slows production processes and reduces firm-level efficiency.

*Insufficient Technology Reduces Laboratories' Testing Capacity*

Within those institutions charged with ensuring the quality, standards, and traceability of Ugandan products, technology-related challenges are common. Often cited as a key constraint to institutions' ability to perform required quality, safety, and traceability tests, a lack of sufficient technology (in the form of equipment and the skills to use it) appears endemic in most institutions charged with performing such tests. For example, the Government Analytic Laboratory currently uses gas chromatography machines for many of their tests. At present, they have two such machines. For the laboratory to fulfill its function, interviewed sources reported that four such machines would be needed. Furthermore, to test for heavy metals, an atomic absorption machine is required, which the lab does not have. With respect to microtoxins, the technology currently used by the lab cannot detect microtoxins at the levels required by international markets. Thus, the lack of technology undermines the ability of the lab to perform reliable analysis. The Government Analytic Laboratory also has the only machine in the country that can perform DNA tests. As micropathogens become a greater problem in agriculture and in health, laboratory staff assert that demand for two such machines now exists.

Hand in hand with the challenge of too little equipment is the dearth of skills to maintain the sophisticated equipment that the laboratories rely upon. In fact, the Government Analytical Laboratory described the limited opportunities for skill upgrading to repair and maintain the laboratory equipment as one of the biggest impediments to the performance of not just that institution but of all institutions in Uganda performing similar laboratory testing.

In a separate example, lack of reliable power hinders the ability of laboratories to perform. For example, UNBS chose not to purchase a backup generator to compensate for the frequent brownouts that are due to the high cost of operating it. As such, during the weekends, UNBS must shut down its power, which includes power to its server, as the consequence of power outages would be detrimental to its computer equipment. Thus, no staff can access e-mail over the course of the weekend, nor may they work with their equipment. As well, all of the samples in every lab but the microbiology laboratory, which is furnished with its own backup power supply, are vulnerable to degradation when the power goes out.

#### *Some Available Technologies Are Not Used to Enhance Productivity*

Interviews at the National Chemotherapeutics Research Laboratory (NCRL) illustrated a mismatch between the technological needs of the growing sector and the utilization of available technology. Questions surround where—along the value chain in the manufacturing of cosmetics and other products derived from ethnobotanical materials—technology could play a role in adding value. Clearly, available tools such as Global Positioning System (GPS) technology could be used for monitoring plant populations, timing harvests, and promoting conservation practices. Yet such available technologies often go unused or are not appreciated for the benefits they would offer.

#### *Insufficient Technology Minimizes Marketing Opportunities*

Some ethnobotanical products are not able to reach the market because of lack of know-how regarding standards and technologies required for packaging, labeling, etc. As well, several producers of various ethnobotanical ingredients cite the limited technological infrastructure associated with cost-effective distribution as a limiting factor in the development of their businesses.

### Human Resources

Analysis of the human resources dimensions of Uganda's ethnobotany sector reveals a high degree of strength that the sector exhibits in terms of human capital. Many well-trained, highly skilled human resources work in the field of ethnobotany.

Site visits and interviews revealed one of the sector's greatest assets to be its human resources. A number of highly skilled scientists, entrepreneurs, and engineers are already active in the sector, performing research, product development, and process optimization. For example, National Chemotherapeutics Research Laboratory (NCRL) has 15 staff—all of whom hold masters degrees in ethnobotany and other specialties (including botany, nutrition, chemistry, etc.). NCRL's director has a Ph.D. in chemistry. An additional three MDs contribute to NCRL's work, addressing policy issues. Another five medium-skilled workers serve as laboratory technicians.

A growing ethnobotany sector offers a tremendous opportunity for private sector employment. The new partnership between Quality Chemicals Ltd. and Cipla presents a tremendous opportunity for employment and technological learning in pharmaceutical manufacturing, quality production techniques, etc.—with major implications for job prospects and on-the-job training of chemists, pharmacologists, chemical engineers, plant engineers, etc. In fact, as explored in box A3.1 presented on the company, Uganda's current production of postgraduates in the sciences and engineering related to pharmaceutical manufacturing will not be sufficient to respond to the need for employees created by the entrance of this firm.

#### *Hands-on Science and Technology Skills and On-the-Job Training Are Often Weak*

Interviews with a number of organizations, including Chemiphar Laboratory, Uganda National Bureau of Standards, THETA, the Foundation for Innovative New Diagnostics, and Genuine Natural Products, revealed a shared sense of dissatisfaction regarding the level of preparedness of Ugandan graduates entering the ethnobotany sector. Skills gaps that bear on ethnobotany relate to the manufacturing, testing, and business development aspects of ethnobotanical enterprises (including pharmaceutical development and manufacturing). Weak business skills, in particular, create a bottleneck in terms of industrial development. In one interview with a diagnostics and vaccines developer, the CEO noted that the biological knowledge base of Ugandan graduates was satisfactory. Where substantial training and skills up-grading is needed is in those dimensions of business development that require manufacturing knowledge, hands-on processes utilizing modern equipment, etc. To generate these skills, industrial exposure over the course of academic training is warranted, yet such opportunities are seldom integrated into formal degree coursework.

Furthermore, the combination of knowledge, skills, and technology required to perform certain kinds of testing required to produce edible products, ointments, and supplements must be performed at accredited laboratories. At present, these types of tests can only be performed in one laboratory in the country—the Belgian-owned Chemiphar Laboratory—begging the question of which skills Ugandan laboratory scientists and technicians should improve to be able to perform such tests locally.

#### *Opportunities for Dialogue Between Traditional Healers and Scientists Afford a Conduit for Science and Technology Knowledge Transmission*

Many of the traditional uses of medicinal plants that could be studied, analyzed, and explored for standardization and commercial product development are known only to the traditional health practitioners. Creating fora in which traditional health practitioners can enter into dialogue with scientists and entrepreneurs to exchange good practice and experience are important. One such institution designed with this goal in mind is THETA (Traditional and Modern Health Practitioners Together Against AIDS and Other Diseases). Through its Training and Capacity Building program, THETA spearheads efforts in improving the skills of traditional health practitioners, thereby building sustainable partnerships between them and biomedical workers and the community.

## Institutions and Infrastructure

Uganda's institutional resources in the ethnobotany sector vary in terms of sufficient science and technology capacity to buttress a growing area for commercial opportunity within the health sector.

### *Pockets of Ethnobotanical Research Present a Key Institutional Resource*

Research capacity in ethnobotany constitutes a key institutional resource for sector development. Namely, a number of researchers are contributing to the understanding of Ugandan ethnobotany at Makerere University, National Chemotherapeutics Research Laboratory (NCRL), THETA, and elsewhere. A conference on July 22–26, 2007 at Hotel Africana on Drug Discovery from African Flora, chaired Dr. Maud Kamatenesi-Mugisha, a Ph.D. ethnobotanist investigating maternal health and herbs, profiled a number of Ugandan researchers active in the field. Among the research presented was that of Dr. Kabasa, J.D., on ethnomycology from Makerere's Faculty of Veterinary Medicine and that of Mirium Ojok, Faculty of Science at Makerere, on phytochemical and evaluations of plants used in reproductive health care in Uganda. Although most of the research appears focused upon Ugandans use of Ugandan plants, the potential for further international collaboration in ethnobotanical research is tremendous.

### *The Sector Is Challenged by a Number of Institutional Weaknesses and Lack of Coherence Among Existing Institutions*

For companies seeking to use natural ingredients and ethnobotanical materials as means to produce manufactured or raw products, a number of institutions that address traceability, standards, and quality are critical partners. When these institutions concerned with the rules and regulations pertaining to safety, packaging, export, standards, and traceability perform their jobs successfully, they equip firms with the knowledge they need to compete internationally. When safety standards are not established, testing is not performed, or the market's demand for quality is not translated into specifications a producer can follow, firms' potential to compete in world markets diminishes. For those Ugandan producers of natural products seeking to penetrate global markets, weak institutions confound their efforts. Although a number of relevant institutions exist, as a group they are not strong enough to take on some of the challenges in ethnobotany with respect to traceability, standards setting, testing, etc. Box A3.2 highlights the primary institutions engaged in these activities.

A reorganization and rationalization of those institutions involved with safety, standards, and regulation are needed at the national level. As to which standards producers should seek to achieve, the standards of the market itself (and particularly the international market in which Ugandan producers seek to be competitive) should hold sway. For example, the EU's standards should dictate Uganda's standards for fish with respect to pesticides, toxins, etc. The same orientation toward global standards should dictate the development of Uganda's ethnobotanically based pharmaceuticals, etc. Implementing the capacity to test and export agro-industrial products that meet global standards (not just Ugandan standards) implies tremendous effort to compensate for

**Box A3.2. Uganda Institutions Engaged in Standards, Testing, and Traceability**

Neither the sufficiency of individual institutions concerned with standards and traceability nor the complementarity between them is adequate to respond to the needs of a growing export-oriented agro-industrial sector. What modicum of national capacity for testing exists within the country is weighted toward the fruit, vegetable, and food products sector, particularly fish. According to the Executive Director/Technical of the Uganda National Bureau of Standards, "In general terms, the testing capacity at the national level is non-existent." The vast majority of products enter the domestic market without getting tested at all. Outside of food and agriculture, for those other sectors of the economy for which testing is critical (e.g., building materials, electrical equipment, petroleum products, tires, etc.), almost no visible national capacity exists to conduct tests on quality and assess adherence to any standards of safety, etc. According to the director of Uganda's Industrial Research Institute, "Traceability is a huge bottleneck for agro-industry right now with little structure or coherence to achieve the standards required by international markets." The development of pockets of capacity in traceability is the result of specific demand and not a function of government planning and prioritization in this area. AGOA raised the specter of doubt that Uganda has the institutional strength to take advantage of market opportunities for products such as organic produce.

1. *Chemiphar Laboratories:* In terms of which institution is best suited to perform various tests and monitor and enforce standards, Chemiphar Laboratories—a Belgian-owned private laboratory—offers two advantages unique to the institutional landscape: it is the only accredited laboratory in the country outside of one unit within UNBS (the microbiology laboratory) and it is capable of performing tests with a fast turnaround. Chemiphar is a tremendous asset for Uganda. It was the first laboratory in all of Africa to accommodate the newest ISO standards and the first in the world to be accredited outside of Europe (Chemiphar received its accreditation in microbiology and in chemistry from BELAC). Chemiphar performs residue monitoring, characterization, and standardization testing. It has also started creating regional cooperative authorities, such as with the Ugandan Ministry of Agriculture, through which Ugandan honey producers have now gained entrance into the EU market.

2. *Uganda National Bureau of Standards:* Most tests requested by industry lie beyond the expertise of the Uganda National Bureau of Standards (UNBS) or require equipment that UNBS does not have, in addition to requiring certification of accreditation. International standards for quality and safety are a constantly shifting target. As new equipment allows for greater and greater precision to detect toxins and other materials in smaller and smaller quantities, the international standards change accordingly. Near-constant investment in precision equipment and the human capacity to run these tests and conduct the analysis are beyond the reach of most Ugandan institutions. Furthermore, every test on a specific item (a fish filet, a banana, coffee, etc.) requires specific inputs, expertise, and accreditation. In fact, it is not the lab that gets accredited but its capacity to conduct specific kinds of tests. Thus, it only makes sense for a lab to seek accreditation for a specific test once a high enough demand for it is expressed by industry, university, or government. Fifty percent of the activities of the Uganda National Bureau of Standards (UNBS) address safety and quality testing of products imported into Uganda. The other proportion of work is predominately focused upon (1) conducting tests upon products already on the market to ensure their safety, (2) performing safety and quality tests on locally produced goods destined for the local market (about 30–40 percent of UNBS' services), and (3) a small effort focused on research devoted mainly to the development of standards (for example, there might be a need to formulate a standard on edible sunflower oil; in such a scenario UNBS would research the oil available on the market to generate parameters for mineral content, pH, etc. , these parameters would be used to develop a standard for Ugandan producers). Additionally, less than 5 percent of UNBS' services target goods in development for export, a low proportion that reflects the limitations rendered from a lack of accreditation.

3. *Uganda Industrial Research Institute:* For its part, the Uganda Industrial Research Institute (UIRI) offers about 100 tests: vitamin analysis, protein analysis, mineral analysis, materials tests (tensile strength, bending, etc.). UIRI only started in 2003, so the institution still needs more time to develop its capacity in testing.

4. *Government Analytic Laboratory:* Though primarily concerned with forensics, the Government Analytic Laboratory is another institution that performs some work related to standards and traceability. According to interviewed sources, the lab tests a number of products for both internal and external markets; however, it too lacks accreditation. Sources explained that if the Government Analytic Laboratory had the required capacity, eliciting accreditation would not be difficult, but achieving sufficient capacity is the challenge. Challenges facing the laboratory include the prohibitive cost of the infrastructure and equipment to meet the capacity to perform the tests for which accreditation is sought. For example, nowhere in Africa is it possible to purchase some of the reagents required for testing. Helium at 99.99999 percent purity can only be purchased in Europe. Similarly, all the quality chemicals are purchased overseas and are then heavily taxed upon importation into the Uganda. Slowness to ship such products from Europe stalls performance. Other challenges include the cost of information technology and the cost to train staff in the technically sophisticated processes entailed in performing testing. It is not clear how the performance of standards and traceability testing responds to the mandate of the Government Analytical Laboratory or whether the lab seeks to demonstrate its competence in this area as a means to establish a niche within the array of similar institutions within the country.

5. *SGS:* Another player is SGS—a European-owned export inspection and certification company that also performs testing.

6. As to how these institutions relate with respect to research, UIRI takes on the lion's share of industrial research that complements its testing capability. Particularly where the research capacity of a specific firm/entity may be low (e.g., for grain millers), UIRI conducts research on behalf of various constituencies.

7. The cost of low standards, testing, and traceability capacity is high for any agro-industrial firm. The impact to Ugandan industry as a result of insufficient capacity for safety and quality was made vivid during one of the several fish bans that the EU imposed on fish from Lake Victoria. According to Chemiphar Laboratories, the cost of the ban totaled $1 million in lost revenues per week. At that time, without an accredited laboratory within the country, the standard practice prior to Chemiphar's entrance to Uganda was to ship fish (and other products) to the EU where testing was conducted at the ports. In the cases in which various shipments of products failed to pass safety and quality tests, the products were destroyed. Both in terms of the cost of shipping and the loss in sales, the system offered producers no indication of whether their products could be sold in the EU in advance of shipping them there. Even though this situation has been remedied with respect to fish as a result of Chemiphar's establishment in the country, because of the high cost of Chemiphar's services, many producers of other products (such as pineapples, etc.) continue with this same roulette-wheel approach to export (i.e., ship the products to the EU without safety, quality, or marketing assurances and see what happens).

the weakness of the regulatory capacity at present. Currently, Uganda boasts no umbrella agency akin to the U.S. Food and Drug Administration, under which multiple sectors are governed and regulated. Without this, great disparities between products and whole sectors render Uganda's agro-industrial base inconsistent in terms of quality, safety, and marketability.

#### *Without Accreditation, Government Laboratories Do Not Serve Industry*

The lack of laboratory accreditation severely constrains the ability of the aforementioned institutions to serve industry. In interviews with NCRL, the interviewees reported that they could not publish based on analyses from their laboratory because of the lack of accreditation. Thus, to publish, they must purchase the services of Chemiphar and then publish based on their results. The high cost of Chemiphar's testing serves as a tremendous disincentive to publish.

### *When Small Firms Cannot Bear the Cost of Testing, Opportunities for Value-added Production Are Lost*

Another cost related to inadequate capacity for testing is borne by entrepreneurs seeking to commercialize their ethnobotanical products internationally. The costs related to quality certification for chemical compounds are beyond the resources of most small-scale entrepreneurs. Before a product can be processed for exports, several questions must be answered: What is the aflatoxin level?, etc. Without this information, the grade of a plant-based oil, for example, cannot be assessed. Thus, in the case of one interviewed producer of moringa oil, it was unknown whether the product was of a quality high enough for premium pricing or too low to fetch such prices because the grading could not be determined by the firm. This lack of clarity is due to the lack of testing that cannot be performed affordably anywhere in the country: "It could be our product is good enough for other things . . . the end user could be creating very high value added products, but we don't even know this. If the end user is producing edible supplements with our oil, for example, then we are getting a raw deal here."

### *Government's Appreciation of the Role of Ethnobotany as a Growth Sector Is Beginning to Increase*

The invisibility of the ethnobotany sector to policy makers and the public is a key challenge for growth and development of the natural ingredients market. Absence of an institutional framework and the lack of national standards for the production and processing of extracts and essential oils for the local and international market pose sector challenges cited by the United Nations Commission on Trade and Development and the Uganda Export Promotion Board's assessment of the sector. However, with a Committee on Herbal Medicine within the National Drug Authority and a deepening appreciation within the Ministry of Health for the potential role for ethnobotany within the economy and within the domain of public health, government attention to ethnobotany appears to be increasing. Some sources assert that ethnobotany continues to maintain a lower status in terms of research and funding priorities compared to "modern" or "advanced" health research. Among the objectives of the Ad Hoc Committee on Herbal Medicine, currently led by the Director of the National Chemotherapeutics Research Laboratory, is the establishment of standards to police the open market. According to the Director, "At present, even if you put cyanide out on the market, there is no mechanism to police that. The challenge is injecting knowledge into the public space. The demand for natural substances is very high because people believe in this—traditional medicine—very much, especially with diseases like TB for which general therapies often may make people worse, which becomes an incentive for traditional medicine."

### *Lack of a Coherent Policy Framework Reduces the Prospects for Sectoral Development*

Ten years ago, the Uganda National Health Research Organization (UNHRO) was put in place to link practitioners of traditional medicine with major institutions dealing with health research, set priorities, partner with international partners, etc. UNHRO was conceived as an institutional umbrella devised to harmonize policy, regulations, and funding across traditional medicine research, modern health research, etc. Yet, to date, this institution exists in name only. Although a UNHRO Secretariat is funded and the structure is in place, the organization lacks any degree of institutionalization. By contrast, Kenya has a functional institution that functions in the way UNHRO proposes to. The Kenyan institution is called the Kenya Medical Research Institute (KMRI); it links traditional medicine to Kenya's modern health research sector. The low priority of ethnobotany as a field for research or commercial development—added to the disconnect between the modern health research and caregiving sector and the traditional medicine sector—result in the need for a bridging institution in Uganda to pull these agendas together and craft a coherent research policy.

In regard to current policy frameworks, none explicitly supports the development of natural ingredients, but rather the sector is accommodated within the general development frameworks, such as the Plan for the Modernisation of Agriculture (PMA) and Poverty Eradication Action Plan (PEAP) that emphasize commercialization of agriculture and the sustainable use of natural resources for poverty alleviation. In fact, UNCTAD's number one recommendation for development of the sector is to create an institutional coordinating framework in trade- and environment-related issues. Coupled with that, the same assessment recommends developing national standards for raw material production and processing for natural ingredients.

#### *A Sector Strategy Provides a Road Map for Sector Development*

UNCTAD together with the Uganda Export Promotion Board developed a sector strategy that serves an institutional resource for the sector. The document combines the cosmetic, pharmaceutical, and food components into one strategy, owing to the similarity in issues and actors. This strategy, spearheaded by UNCTAD, the Uganda Export Promotion Board, and supervised by the Ministry of Tourism, Trade, and Industry, is presented as a joint intervention for the three product groups, addressing the enterprise and sector level issues.

#### *Business Planning and Science and Technology Financing Merit Greater Attention*

Even when expenditure is made for equipment, such as for an atomic absorption spectrophotometer that can analyze the mineral content in a plant sample, often funds are not allocated for consumables or for the skills upgrading required so that staff may learn how to use and maintain the equipment. Such is the case at NCRL. This misallocation of resources exposes a kind of institutional oversight that is endemic to many institutions within the sector.

A perception exists that the few national opportunities for innovation funding (such as the President's Innovation Fund) favor large-scale industrialists. A gap exists in terms of small-scale funding for entrepreneurs working on innovations. This scale is particularly relevant to the ethnobotany sector, in which herbalists, traditional healers, and lone entrepreneurs might develop a product and seek a small amount of financing for testing and for business plan creation.

### Collaboration and Communication

Weak communication capacities challenge the firms, institutions, and international partners whose efforts to link and collaborate are often hampered by poor ICT and too few opportunities to coordinate their efforts for the development of the ethnobotany sector.

#### *Weak ICT Capacity Thwarts Connection to Knowledge Partners*

Human resources constraints and minimal ICT capacity have thwarted large-scale success in terms of commercialization and knowledge dissemination between partners. NCRL, for example, had not one single networked computer, though funds to achieve consistent ICT connectivity had been earmarked. Furthermore, Ugandan enterprises and institutions have only minimal Web presence to lure international partners to players in the sector to Uganda.

Such ICT-based tools as GPS have particular relevance to ethnobotany. For example, the potential to create an interactive map of the ethnobotanical populations across the country could strengthen researchers' ability to monitor populations for commercial development. But such a tool hinges on dependable ICT access generally and on the capacity to access GPS and use it resourcefully.

### *Deeper Use of Bioinformatics Could Enhance Uganda's Presence in the Global Ethnobotany Community*

Another critical information gap prohibiting development of the ethnobotanical industry relates to bioinformatics. In a scenario in which a biologist wishes to identify an indigenous plant, he or she first needs to find out if anyone else has observed the plant and what properties have been recorded, etc. Today, this process is facilitated through a few essential Web-based tools (e.g., databases) in which data on identified plants may be accessed by anyone. In these online databases, researchers exchange knowledge and grow the available stock of information in the field. Anyone can access this information and can add to the repository of knowledge. Without ICT capacity at NCRL, the ability to process data, present it, and extract it for policy is limited. As a tool for conservation, bioinformatics is an essential asset.

### *More Incentives for Collaboration Could Foster Stronger Links between Scientists*

The culture of sharing scientific and technological knowledge and disseminating it is not endemic in Uganda. Some scientists report difficulty accessing equipment and machinery to perform their research because access is sometimes restricted to only the most senior or politically connected scientists. Perceptions that UNCST has not fostered sufficient incentives to collaborate and conduct joint research and technology development projects abound.

### *With Greater Collaboration, Universities, Industry, and Public Institutions Could Strengthen the Ethnobotany Sector*

The linkages between the universities and the institutions performing testing and traceability work are frail if existent at all. What were described by some interviewed sources as fruitful areas for scientific exchange, collaboration, and joint research between universities, industry, and government laboratories remain restricted to one strand of the "triple helix" (i.e., just public labs or only within the universities). The Deputy Executive Director-Technical of UNBS reported that institutional collaboration lies at the heart of an effective standards and testing regime. For example, if UNBS seeks to develop a standard for banana juice, it must convene a technical committee. This technical committee should include representatives from the manufacturing sector, consumers, academia, researchers, etc. Thus, even though links between communities appear weak, awareness of their importance seems high.

Similarly weak links between the academic, industrial, and public communities prevent dissemination of research through the sector. Though knowledge is produced, in the form of papers at Makerere and testing at NCRL or UNBS, etc., weak lines of communication between users, researchers, universities, and industry prevent the transmission of knowledge through the ethnobotany sector.

### *Developing the Ethnobotany Sector Entails Overcoming the Divide between University and Industry*

The lack of links between the universities and private sector limits Uganda's potential to foster the technology partnerships required to develop and commercialize some of the products that can be derived from indigenous plants. This same disconnect challenges agro-industrial development in oilseeds, corn, etc. Additionally, the National Agricultural Research Organizations (NARO) are perceived by other institutions (NCRL, etc.) as distant from the needs of farmers, entrepreneurs, and those institutions seeking to move forward with commercializable products. Developing collaborative partnerships with universities and various parastatals (UNBS, NDA, etc.) is something that researchers and product developers realize should be a priority. But information barriers—not knowing what goes on in these institutions, or what avenues of research within the university might play a role in the product development processes—minimize these types of interaction and the incentives to pursue them.

### *Capacity for Collaboration Needs to Increase for Laboratories*

UNBS seeks to establish common quality standards (ISO 17025) among other Ugandan laboratories to ensure capacity for collaboration and outsourcing. As well, UNBS partners with UIRI to train laboratory assessors to conduct evaluations of laboratories to ensure they operate in compliance with the ISO 17025 standards. It might be fruitful to determine the requirements for accreditation and determine how close the ISO 17025 standards are to these. This exercise could be performed at the national and regional levels.

Kenya and South Africa have many labs that complement one another. The approach for institutional rationalization should not be to create one mega-lab. Concerns abound that inefficiency and bureaucracy would prevent such an institution from developing its responsiveness to the needs of market, which is what a competitive lab must do to stay relevant.

### *Opportunities to Participate in Professional Societies Abound*

Possibilities exist to strengthen Uganda's participation in regional fora for research and development of medicinal plants, etc. For example, NAPRECA (Natural Products Research for Eastern and Central Africa) started in the 1980s to organize and support researchers from East Africa doing plant research, synthetic work, research in botany and other biological sciences, and to discover medicines. The Chair of NAPRECA is at Makerere University. The Regional Initiative on Traditional Medicine in Africa (RITMA) offers a similar opportunity. Another professional resource is the Uganda Group of the African Network of Ethnobiology (UGANEB).

Particular to Uganda's laboratories, a Ugandan Laboratory Association is being created at present. Perhaps this new organization will offer a forum for discussion of institutional rationalization and complementarity.

### *Increased Collaboration between Institutions Active in Testing, Standards, Quality, and Traceability Could Help Overcome Institutional Weaknesses*

It seems that there is some precedence for collaboration between some of the organizations doing work in testing. For example, in the development of the honey industry, Chemiphar conducted the initial characterization and standardization work. As well, its residue analysis revealed a higher standard, to which producers would need to adapt their production. This higher standard was then adopted by the Uganda National Bureau of Standards. In this way, a public-private partnership formed between Chemiphar and UNBS. Whether this kind of collaboration is commonplace or a template for wider-scale public private partnership is not clear.

Other areas in which business support institutions need to deepen their links to industry include business financing, research, technology development, and enterprise capacity development.

#### *Regional Markets for Ethnobotanical Products Are Opening*

Regional markets for ethnobotanical products are developing. Ugandan companies have exported raw materials, ingredients, and finished products across the region and to a few international markets. Countries in the regional market include Kenya, Tanzania, South Africa, and Rwanda. Further enhancements to quality, sustainability, and supply will only strengthen Uganda's competitiveness in these markets.

#### *Weak Links to Markets Disadvantage Firms*

Weak links to market translate into misinformed suppliers who fail to produce products that are in demand. At present, no standards exist for the processing of natural ingredients in Uganda. It is interesting to note at this level that even the large companies producing extracts and essential oils still produce crude products, which are not refined to buyers' specific requirements. Enhancing the links between the market and suppliers is essential to develop the sector.

### Knowledge Base

Uganda has taken significant strides to deepen its science and technology knowledge base in ethnobotany, though a number of opportunities have not yet been taken.

#### *When Firms Use Available Business Support Services, Industry Thrives*

Several knowledge resources exist in Uganda that an entrepreneur in the ethnobotany sector can access to enhance productivity and deepen expertise on various aspects of quality, testing, and traceability, etc. As to where a company may seek help learning about traceability and standards issues, one source of information and funding is the Private Sector Foundation (PSF). PSF has assisted a number of companies in acquiring their organic certification and achieving HACCP certification. PSF also facilitates communication between firms and the Uganda National Bureau of Standards certification unit, performing such services for firms focusing on water, dried fruit, etc. with the provision of grants. The Foundation also seeks to help firms attain Eurogap certification so they may legally export products to Europe. They provide these services for 50 percent of cost. The funding for this comes to PSF through World Bank support, with an annual disbursement of $700,000 per year. Over the past seven years, PSF assisted over 1,500 companies with these issues.

The Export Promotion Board is another knowledge resource for domestic firms seeking entry into foreign markets. Within the natural ingredients and ethnobotany sector, the Export Promotion Board partners with 15 firms, working on products including moringa oil, geranium oil, bark products, quinine, aloe, etc. As well, the Board conducts assessments of companies' production processes to ensure their sustainability and export potential.

### *The Biotrade Programme Deepens the Knowledge Base*

An important knowledge resource for stakeholders within the ethnobotany sector is the Biotrade Programme, sponsored by UNCTAD and the Export Promotion Board, which is successfully deepening the knowledge base regarding ethnobotanical materials, commercial opportunities, etc. through technical reports, sector strategies, etc. In 2003 the Export Promotion Board's Biotrade Programme initiated a baseline study to determine the potential within 12 "tradable sectors" related to biodiversity (including both products and services). The assessment of these 12 sectors yielded four priority biotrade areas, one of which is "natural ingredients for food, cosmetics, and pharmaceutical industries," defined to include heavy oils, extracts, cosmetics, etc.

One of the challenges addressed through the Biotrade Programme is the limited appreciation on behalf of government of the value in natural resources. According to sources interviewed, when the government explores selling tracts of natural forests, it does not consider the unique organisms, enzymes, and therapeutics existent in the plants of that forest. Deepening the knowledge base entails developing an understanding within government of the value in the forests. The dialogue with government has stalled at the message "Let science and technology drive development." The unaddressed questions surround the value of science and technology in driving development.

### *Inadequate Knowledge on the Intellectual Property Rights Associated with Ethnobotany Hinders R&D and Sector Development*[†]

A gap in terms of intellectual property rights (IPR) capacity within the legal community prevents institutions seeking to move forward with commercialization of various ethnobotanical agents from doing so. In interviews with THETA, the director described the organization's ability to research and develop three specific compounds (one for malaria, one for skin, and one for the flu) based on ingredients and practices described by traditional healers. THETA performed the research and analysis to validate the safety and efficacy of these compounds. However, because of the ambiguity of the IPR—do they belong to the healers, THETA researchers, the funders?—the organization opted to restrict information on the ingredients of the compounds, which means they are not appropriate for export or in line with national safety standards for pharmaceuticals, which require that ingredients are described in full. Without a cadre of IPR-savvy attorneys to assist organizations such as THETA and NCRL, Uganda cannot maximize the commercial benefits of its ethnobotanical assets.

### *Improving Knowledge Dissemination Among Ethnobotany Stakeholders Would Enable Product Commercialization*

One of the biggest challenges for ethnobotany relates to knowledge dissemination and commercialization. As the director of the National Chemotherapeutics Research Laboratory explained, "Things may be useful on the ground, but people don't know who uses them, who should use them, or where they are available. Our institutions check safety and effectiveness. We want to know how these products are clinically effective." However, the capacity of NCRL to bring potentially commercializable ethnobotanical remedies to market is woefully insufficient. With over 100 requests for such services per year, NCRL admits that it does not have the human resources to respond to the demands for both research and business development services that it receives from potential entrepreneurs. NCRL estimates that a sizeable domestic market for neutraceuticals exists—consumers would prefer to purchase ethnobotanical goods from domestic suppliers rather than those international suppliers from whom they currently import.

NCRL is just one of a handful of institutions positioned at the crosshairs of "the modern health research system" and the realm of traditional healing, in which indigenous plants, animals, and minerals are used for therapeutic purposes. Traditional and Modern Health Practitioners Together Against AIDS and Other Diseases (THETA) is another. Functions performed by these two institutions range from standardization of ethnobotanical formulations, testing, and analysis to research, development, commercialization, and dissemination of new knowledge. Building up both of these institutions' capacity to perform these functions at the scale required by industry would enhance the prospects for sectoral development.

University research in ethnobotany is not aimed toward commercialization. Gaps within the research priorities of Uganda's universities result in knowledge gaps from the perspective of commercialization of indigenous plants. The university system favors synthetic research. Beyond this area, universities' capacity in ethnobotanical research is weak. Thus, the private sector perceives little value in partnering with the university. One interviewed source complained, "If you talk to them about going into production, they will not understand you and they will say the funding is only for synthetic research. We need joint funding in which synthetic research is co-joined with funds for applied research and product development."

### *By Exploiting a Comparative Advantage in Public Health, Ugandan Researchers Can Build Up Their Expertise in Ethnobotany*

In terms of national priority and human resources capacity, Uganda has a comparative advantage in public health as compared to ethnobotany. A strategic objective may be to explore the overlap between these two areas. In one interview, the director of an ethnobotany research and commercialization institution suggested that research into health behaviors extend more explicitly into what indigenous products are in use and what commercial value they have. Right now, the public health agenda stops short of addressing product development and commercialization aspects. It is here that collaborative relationships, financing, policy, and efforts to partner with the ethnobotanical industry may warrant increased attention.

For industry, most research and development is very expensive for the small and medium enterprises engaged in the sector to take up on their own. Collaborative arrangements have been initiated between the companies and research organizations such as NCRL, but this is sometimes expensive for firms, whereas for public agencies their priorities often do not match to the needs of companies.

### *Uganda Lacks a National Policy on Ethnobotany and Traditional Medicine Research*

Good Manufacturing Practice (GMP) is required by the National Drug Authority (NDA) for all pharmaceutical companies manufacturing finished products. However, the legislative framework to regulate the sector in Uganda is almost nonexistent, with the exception of a few policy requirements by institutions such as NDA. More broadly, Uganda has no research policy that adequately addresses traditional medicine, ethnobotany, etc., though a draft policy on traditional medicine is currently under discussion. This draft contains a section on implementation with a focus on the commercial sector and Uganda's potential to make use of medicinal plants.

### *Lack of Information About Available Technologies and Finance to Access Them Prevents Firms from Increasing Their Productivity*

In interviews with small-scale entrepreneurs seeking to develop ethnobotanically based products, lack of finance for technological upgrading was cited repeatedly as a barrier to firm growth. Often it is not a lack of information about automated technology to make production processes faster and easier, it is a lack of access to capital to invest in such technological upgrading to render the benefits associated with doing so.

ANNEX 4

# Energy Case Study

Uganda's total energy consumption is around 5 million tons of oil equivalent per year. This makes Uganda's per capita energy consumption about 0.2 tons of oil equivalent, which is one of the lowest per capita rates of consumption in the world. About 65 to 70 percent of wood used is burned as fuel for households. Several process industries—sugar, tea, tobacco, baking, pottery, and brick making—depend heavily on biomass for thermal energy. More than 90 percent of energy needs are from sources other than electricity or fossil fuels, as shown in table A4.1. The energy sources most used are also ones that are difficult to renew, particularly wood fuel and charcoal. Charcoal and biomass (a renewable resource) consumption is increasing at about 6 percent per year, with a potential for shortages in the future. Particular pressure for energy is being placed on the sector by the growth of urban-based populations.

As in other Sub-Saharan African countries, there is a positive correlation between poverty and reliance on wood and other biomass for energy use. Daily brownouts have stunted Uganda's economic growth by an estimated 1 percent of the country's GDP, or $256 million annually. Lack of energy is holding back industrialization and the service sector. It is also putting more pressure on the environment, because energy needs that cannot be met with electricity are being satisfied with biomass, leading to deforestation and indoor air pollution.

The economic costs of underserved electricity demand are estimated at $38.9 cents per kilowatt hour. Overall, the power sector generated 1,887 gigawatt hours in 2005, which decreased to 1,610 gigawatt hours in 2006, as a result of the power crisis. Electricity output at the Nalubaale and Kiira dam complex has declined from around 200 megawatts in January 2006 to 120 megawatts in spring, 2007 as a result of an extended regional drought. It is projected to decline further to 80–90 megawatts later in 2007 if the drought continues. The installed capacity of this dam complex is 300 megawatts, but it is not currently operating at its peak capability because of droughts. Demand is 380 megawatts at peak times and

**Table A4.1. Sources of Ugandan Energy Consumption**

| Source | Percentage |
|---|---|
| Wood fuel | 80 |
| Charcoal | 10 |
| Petroleum | 5 |
| Crop Residues | 4 |
| Electricity | 1 |

*Source*: Uganda Ministry of Energy and Mineral Development.

**Table A4.2. Load Growth Projections from the Uganda Ministry of Energy and Mineral Development**

| | 2001 | 2002 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|
| Energy (GWh) | 1,437 | 1,544 | 1,849 | 2,751 | 4,396 | 6,961 | 11,946 |
| Peak Demand (MW) | 270 | 289 | 345 | 496 | 783 | 1,219 | 1,910 |

*Source*: Uganda Ministry of Energy and Mineral Development.

**Table A4.3. Power Generation on Uganda's Grid, 2006 (megawatts)**

| Hydro | Percentage | Thermal | Percentage | Total |
|---|---|---|---|---|
| 300 | 99 | 2.12 | 0.7 | 303 |

*Note*: Another source reported that thermal power generation represented 23 percent of generation output in 2006.
*Source*: Uganda Ministry of Energy and Mineral Development.

**Table A4.4. Electricity Generation in Uganda, 2001–05 (megakilowatt hours)**

| | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Total electricity generated | 1,577 | 1,702 | 1,757 | 1,896 | 1,857 |
| Hydro | 1,575 | 1,701 | 1,756 | 1,894 | 1,856 |
| Diesel | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| Annual load factor (percentage) | 71.4 | 80.8 | 71.9 | 82.0 | 88.8 |

*Source*: Uganda Ministry of Energy and Mineral Development.

290 megawatts at base load. Peak demand is expected to be between 411 and 649 megawatts by 2010; annual growth in demand for electricity is 7 to 9 percent and is expected to grow at approximately this rate until at least 2016.

Uganda's electricity is generated from hydroelectric plants and thermal power plants. As of 2003, only about 10 percent of Uganda's 3,200 megawatt hydroelectric power potential had been developed. The main source of power currently: Nalubaale and Kiira dam complex at the mouth of Lake Victoria. The share of thermal power is expected to increase because of the drought-induced decline in hydro power. However, thermal power is about three times as expensive to produce as hydropower.

Chronic power shortages are attributed to the following:

- Increased demand, particularly in urbanizing areas.
- A prolonged drought, combined with overwhelming reliance on hydroelectric dams for electricity generation.
- An unreliable distribution system.
- Delays in commissioning additional generation capacity.

To address this, the government has procured two 50-megawatt short-term thermal power plants and is planning to procure an additional 50-megawatt thermal power plant under the proposed Power Sector Development Operation (FY2007).

### *Oil and Natural Gas Sector Overview*

Prior to the discovery of oil and gas reserves in Uganda in 2006, Uganda did not produce petroleum. Production of petroleum from oil and gas reserves is in the planning stages at this time. Currently, the imports of petroleum and petroleum derivatives account for approximately 16 percent of the national import bill, a huge percentage of the cost of imports compared to that of other countries. Uganda has the 23rd highest retail petroleum prices in the world. Prices in Uganda rank fifth highest in Africa.

Uganda has discovered reserves of petroleum in the western Rift Valley. This has resulted from the Petroleum Exploration and Production Department explorations within the Albertine Graben. Five oil seeps have been identified over an expanse of the graben, but production has not yet begun. In July 2007, Heritage Oil and Gas announced that it discovered natural gas in western Uganda. Tests confirmed the accumulation of gas at 14 million cubic feet per day. The oil reserves at the Kingfisher well in Lake Albert could be 10 times bigger than initially believed. Heritage Oil and Gas estimate the reserves at 2.4 billion barrels. The flow rate is 14,000 barrels of oil per day. This is the largest find in Uganda as of this writing. A private oil company (foreign) has indicated the presence of between 100 and 300 million barrels of crude oil; the company has drilled three wells, and initial tests suggest that the oil is good quality.

As D. Kamaugasha (2005) has noted, the combined effects of economic growth and rapid population growth have led to the emergence of a middle class of people with access to cars and other machines that require energy. This has had a direct impact on energy, especially upon petroleum product consumption, which has increased dramatically since 1994. The country is dependent upon imported petroleum for all these needs. The cost is high and made higher by the high customs taxes levied on imports through Kenya and because the product is generally delivered by truck.

Domestic electricity sales revenues were $116 million in 2006. Some electricity was exported in the past, but this is no longer happening (as of 2006). In the case of petroleum, all of the product is imported, amounting to about 700,000 cubic meters in 2005:

- Transport sector petroleum imports: gasoline, aviation gas, and diesel.
- Industry sector petroleum imports: fuel oil.
- Residential and commercial sector imports: kerosene and liquid petroleum gas.

All petroleum is currently imported by truck tanker, mainly from Kenya. Plans exist to install an oil pipeline from Mombasa to Eldoret, Kenya, will be extended to Namanve, Uganda (near Kampala). The project will entail building an 8-inch diameter, 320–kilometer pipeline with an annual capacity of 1,200,000 cubic meters. Uganda and Kenya governments each own 24.5 percent of the equity-based capital, and the private sector will own 51 percent of the equity. Tamoil East Africa won the contract to build the $100 million (Ugandan shillings, 165 billion) pipeline in August 2007. The pipeline should take about 18 months to complete and could be operational as soon as the end of 2008.

The oil and gas firms operating in Uganda are listed in table 4A.5. The vast majority of these firms are foreign-owned. (Overall, foreign direct investment inflows into Uganda from 2000–2005 totaled $200 million, with a large part of this dedicated to mineral extraction, according to UNESCO.[1]) None of the foreign-owned firms reported having any research and development activities within Uganda. Any scientific research in this sector is sponsored by the governmental ministry. As the UNCTAD report on Least Developed Countries notes, mineral extraction industries investing and operating in lesser-developed countries on the whole are foreign-owned, and a large share of their foreign exchange earnings are retained abroad. The operations often have links internationally, but few forward and backward links within the host country. As

**Table A4.5. Areas of Science and Technology Critical to Advancing Oil and Gas Exploration, Extraction, and Refining**

| Related field of science or engineering | Ugandan capacity (yes or no) | Suitability for collaboration (high, medium, or low) |
|---|---|---|
| Geology | Yes | Medium |
| Petroleum Engineering | Yes | High |
| Geochemistry and Geophysics | Yes | Medium |
| Geosciences, Multidisciplinary | Yes | Medium |
| Paleontology | No | High |
| Chemical Engineering | No | Low |
| Physical Geography | Yes | Low |
| Mineralogy | No | Medium |
| Geological Engineering | No | Medium |
| Remote Sensing | No | High |
| Electrical and Electronic Engineering | Yes | High |
| Meteorology and Atmospheric Sciences | No | Medium |
| Oceanography | No | High |
| Hydrology | Yes | Medium |
| Mining and Mineral Processing | Yes | Medium |

*Source*: Compiled by authors based upon Thompson-Reuters data trend interviews.

a result, knowledge diffusion by a foreign firm can be weak. Ministry staff are aware of this trend attached to FDI in exploration and extraction; they have been developing plans to address this issue.

### *Addressing Needed Science and Technology Infrastructure*

The following table shows the areas of science and technology that are critical to advancing oil and gas exploration, extraction, and refining. These are the fields that need to be built up, at least to some basic capacity of knowledge absorption, for Uganda to move forward in this sector.

In some fields, the local capabilities exist to absorb knowledge, but in other fields the local capabilities are not available. The second column in table A4.5 shows whether some local capacity exists to absorb knowledge should Uganda establish collaborative activities or a study program in this area. In the third column, there is an assessment of the suitability of this field of science for collaboration. The assessment of suitability for collaboration is made based upon the scale and scope of the science or engineering. If the science or engineering has high entry costs or high maintenance costs and is therefore a field in which Uganda will find it difficult to make investments in the near term, the assessment of suitability for collaboration (as opposed to building domestic capability in the short run) was judged to be higher.

The costs of establishing greater capacities in geophysics are lower than for other sciences because most of its subfields do not require very expensive laboratory facilities or experiments. Thus, the possibilities for using virtual links to existing educational resources can also be high. To the extent possible, Uganda could build upon existing capabilities and knowledge and then find ways to bring in additional knowledge as needed, based upon the scale and scope of the science or engineering required.

**Table A4.6. Oil and Gas Companies That Are FDI- or Ugandan-Owned**

| Oil and Gas Company | FDI- or Ugandan-Owned? |
|---|---|
| A. S. Ali Petroleum Ltd. | FDI |
| Agaba Services Ltd. | FDI |
| Agip (Uganda) Ltd. | FDI—has office in Kampala—origins unknown—has a shareholder in Rome, Italy |
| Benzina Uganda Ltd. | FDI |
| Caltex Oil Uganda Ltd. | FDI |
| Chevron Oil Uganda Ltd.—owned by Calext Petroleum Corporation | FDI |
| Dalbit Uganda Ltd. | FDI |
| Delta Petroleum Uganda Ltd. | FDI |
| Engen Uganda Ltd. | FDI |
| Esia Petroleum Ltd. | FDI |
| Fina Exploration Uganda Ltd. | FDI |
| Fuelex Uganda Ltd. | Kampala-based—but assumed to be FDI |
| Gapco Uganda Ltd. | FDI |
| Germasu Enterprises Ltd. | FDI |
| Haba Petroleum Uganda Ltd. | FDI |
| Haijico Oil (Uganda) Ltd. | FDI |
| Hardman Petroleum Africa | FDI |
| HARED Petroleum Ltd. | FDI |
| Hashi Emprex Uganda Ltd. | FDI |
| Hass Petroleum (U) Ltd. | FDI |
| Heritage Oil and Gas Ltd. | FDI: Canada |
| Interglobe Services Ltd. | FDI |
| Jovenna Uganda Ltd. | FDI |
| Karoda Petroleum Ltd. | FDI |
| Kengrow Industries Ltd. | FDI |
| Kenlloyd Logistics Uganda Ltd. | FDI |
| Kobil Uganda Ltd. | FDI |
| KPI Petroleum Company Ltd. | FDI |
| Libra Energy Ltd. | FDI |
| Mafuta Products Ltd. | FDI |
| MGS International Uganda Ltd. | FDI |
| MOGAS Uganda | FDI |
| Moil Uganda Ltd. | FDI |
| Mukwano Industries Uganda Ltd. | FDI |
| Pearl Petroleum Ltd. | FDI |
| Petro Scope Uganda Ltd. | FDI |
| Petro Uganda Ltd. | FDI |
| Petrocity Enterprises Uganda Ltd. | FDI |
| Petro-Fina Uganda Ltd. | FDI |

**Table A4.6. (*continued*)**

| Oil and Gas Company | FDI- or Ugandan-Owned? |
|---|---|
| Petrolink Uganda Ltd. | FDI |
| Phemex Uganda Ltd. | FDI |
| Phoenix Petroleum Uganda Ltd. | FDI |
| Rio Oil Ltd. | FDI |
| Samalien Petroleum Products Enterprises Ltd. | FDI |
| Shell (Uganda) Ltd.: Subsidiary | FDI: The Netherlands |
| Standard Petroleum Uganda Ltd. | FDI |
| Tamoil East Africa Ltd. | FDI |
| Total Uganda Ltd. | FDI |
| Tullow Oil | FDI |
| Uganda Petroleum Co. Ltd. | Ugandan-owned, or at least the only one registered under the National Oil Companies |

*Source*: Compiled by authors based on Lexis-Nexis data.

## Technology

Technology know-how in the oil and gas exploration field and in any future refining industry are all sourced outside of Uganda. There are no technical resources developed strictly within Uganda to serve this sector. Moreover, there are currently no extension services aiding the oil and gas sector in new technology processes or in research and development practices. No firms contacted report any research planning, outside of the government ministry. The Danish Government has provided funds through the Nordic Trust Fund to help establish geological and petrochemical laboratory facilities at the Petroleum Exploration and Production Department of MEMD, which are underway. These centers are staffed with capable Ugandan scientists and engineers, all of whom were trained in foreign countries and who have returned to Uganda. Furthermore, the Norwegian Government is providing funds through NORAD for institutional development and capacity-building for the petroleum exploration sector in Uganda, although there appears to be a shortage of high-level technical people available to conduct research within this program.

UEME invested $13.6 million for system improvements in the energy sector over the first 22 months since it took over and has committed to invest $65 million during the first five years, although all the investments are for hardware—with no plans for research investment. Similarly, the government Ministry of Energy and Mineral Development has created an energy fund, but the vast bulk of these funds is dedicated to hardware and infrastructure improvement, with a small amount of funds going to renewable energy source research and development.

## Human Resources

The Ministry of Energy and Minerals Development reports that there is an overall shortage of energy-related human resources in Uganda, particularly in the oil and gas exploration fields (geophysics, hydrology, seismology). The number of workers trained in the energy research fields overall is not known, but the World Bank reported in 2002 that 1.7 percent of males and 1 percent of the total Ugandan labor force had vocational training in electricity. The extent of these skills is unknown.

**Table A4.7. Public Educational Institutions Offering Ordinary Diplomas in Electrical (ODE) and Electrical Installation (EI) Courses**

| *Central* | | |
|---|---|---|
| Institution Name | Type of Institution | District |
| Nakawa | Vocational Institute | Kampala |
| Lugogo | Technical Institute | Lugogo |
| Masaka | Technical College | Masaka |
| Nyamitanga | Technical Institute | Mbarara |
| Rugando | Technical Institute | Mbarara |
| Kabasanda | Technical Institute | Mpigi |
| Kamengo | Technical Institute | Rakai |
| Masulita | Vocational Institute | Wakiso |
| St. Kisubi | Technical Institute | Wakiso |
| *Eastern* | | |
| Institution Name | Type of Institution | District |
| Busitema Agri | Technical College | Busia |
| Nalwire | Technical Institute | Busia |
| Iganga | Technical Institute | Iganga |
| Pioneer | Technical Institute | Iganga |
| Jinja | Vocational Institute | Jinja |
| Nile Vocational | Technical Institute | Jinja |
| Kaliro | Technical Institute | Kamuli |
| Ahmed Sseguya | Technical Institute | Kayunga |
| Amugo Agro | Technical Institute | Lira |
| Lira | Technical College | Lira |
| Elgon | Technical College | Mbale |
| Kasondo | Technical Institute | Pallisa |
| Madera | Technical Institute | Soroti |
| Butaleja | Technical Institute | Tororo |
| Butaleja | Technical Institute | Tororo |
| Tororo | Technical Institute | Tororo |
| *Southwest* | | |
| Institution Name | Type of Institution | District |
| Bushenyi | Technical College | Bushenyi |
| Kabira | Technical Institute | Bushenyi |
| Kareka | Technical Institute | Bushenyi |
| Kyamuhungu | Technical Institute | Bushenyi |
| Kabale | Technical Institute | Kabale |
| Burora | Technical Institute | Kanungu |
| Nyakatare | Technical Institute | Kanungu |
| Kisoro | Technical Institute | Kisoro |
| Kibatsi | Technical Institute | Ntungamo |

*Source*: Compiled by authors based upon Ugandan government data, Ministry of Education, and Ministry of Energy and Mineral Development.

The Ministry staff has been working with Makerere University to establish coursework and degree programs in oil and gas exploration and its related fields. See Table A4.7. Engineers employed by government are working with the academic sector to train engineers who will be able to work on the oil and gas reserves extraction as well as on petroleum refining in the future. Under the Energy Advisory Project, The Ministry of Energy and Mineral Development provides training in solar photovoltaic technology. In 2005, workshops trained 106 instructors at technical institutions. This could presumably be extended to oil and gas research skills, but there are no plans for this development.

A sizeable diaspora of engineers can be expected throughout the world, but, of these people, the number who would be able to address oil and gas exploration and refining is unknown. Informal plans exist to identify these people and bring them on temporary visits to Uganda to aid in research in exploration and, eventually, in refining.

Some private technical institutions also provide courses in energy-related subjects, but again, most do not work on oil and gas exploration topics. These private institutions are listed in table A4.8.

## Institutions and Infrastructure

The domestic institutional resources to conduct research and development related to the oil and gas sectors are few in number. They include the following:

- Uganda Industrial Research Institute.
- Ministry of Energy and Mineral Development (MEMD), which oversees Uganda's power sector.
- Rural Electrification Agency (unclear if it conducts research), which funds the West Nile Rural Electrification Company, a small off-grid project.

The Uganda National Bureau of Standards had plans in place to set up a petroleum testing laboratory. This laboratory is very poorly funded, however, and has few resources to aid in extraction and refining industry should they be further developed.

Uganda was also planning to install software for a National Petroleum Information System, but this effort has not yet been funded.

## Collaboration and Communication

The technical sectors in Uganda have professional societies designed to exchange information among interested parties, and these organizations are responding to the existence of oil and gas reserves by hosting workshops and providing information on the Internet. Only the Ministry of Energy and Mineral Development has focused specifically on this need. These organizations include the following:

- African Science and Technology Exchange (located in Kampala).
- Department of Water Resources Development.
- Ministry of Energy and Mineral Development.
- Petroleum Exploration and Production Department.
- Uganda Institute of Professional Engineers, which has 595 members in the fields of civil engineering, electrical engineering, and mechanical engineering.
- Uganda Motor Industry Association.
- Uganda Renewable Energy Association.
- Women Engineer Technicians and Scientists in Uganda.

**Table A4.8. Private Institutions That Provide Courses in Energy-Related Subjects**

| Institution Name | Region |
|---|---|
| Nile Vocational Institute | Central: Kampala |
| Vocational Training School Bbira | Central: Kampala |
| Waggamubulizi VTC | Central: Kampala |
| Katwe VTC (Fasert) | Central: Kampala |
| Kampala Polytechnic Mengo | Central: Kampala |
| Al-Kawuthar Education Centre | Central: Kampala |
| Savanah VTI | Central: Kampala |
| Mengo Institute of Technology | Central: Kampala |
| St. Ngondwe Academic cum-Tech SS | Central: Kampala |
| St. Jean-Marie VTI Mengo- Kisenyi | Central: Kampala |
| Lubaga Youth Development Association | Central: Kampala |
| Bbowa Community Polytechnic | Central: Kampala |
| Mizigo Parents School | Central: Kampala |
| Kikaaya V School | Central: Kampala |
| St. Charles Lwanga Technical Institute, Butende | South: Masaka |
| Ssanje V Technical School | South: Masaka |
| Lkaya Polytechnic | South: Masaka |
| Kiteredde VTI | South: Masaka |
| Busoda Nakyenyi VTC | South: Masaka |
| John Wilson VTC | South: Masaka |
| Ocboway VTC Kalisizo | South: Masaka |
| Ibanda Technical School | Southwest: Kabale |
| Rukore Community Polytechnic | Southwest: Kabale |
| Amuja Vocational and Industrial Training Centre | Southwest: Kabale |
| Kasese Technical Institute | West: Kasese |
| St. Matia Mulumba Polytechnic | East |
| Benedictine VTC | East |
| Pioneer Technical Institute | East |
| Cavi Technical Services | Northeast |
| Human Technical Development Centre | North: Lira |
| Amuka VTC | North: Lira |
| Tumaine African Foundation | West Nile: Arua |
| St. Joseph's Technical Institute Virika | West: Kabarole |

*Source*: Compiled by authors based upon Ugandan government data, Ministry of Education, and Ministry of Energy and Mineral Development.

There are no other mechanisms for feedback from the informal sector and other sectors of society into a research and development plan by the Ministry. Nevertheless, the Ministry staff maintains active contacts with international knowledge resources to apply these resources to needs within Uganda. This is a strength within the Uganda system.

At the regional level, the Committee of Energy for the East African Community (EAC) offers the opportunity for Ugandan scientists and engineers to work with regional counterparts on research and development activities, as well as to share technical information.

## Knowledge Base

The knowledge base within Uganda in oil and gas exploration and related research and development is addressing the opportunities for accessing oil and gas reserves found in the region. Government officials, in particular, are aware of the needs as well as the gaps in their capabilities. Plans exist to fill these gaps. The private sector is dominated by foreign investors, very few of which have research and development capabilities to bring to Uganda. Those few firms that do have capabilities have not yet brought these to Uganda. This is a link that could potentially access knowledge resources to aid the Ugandan industry. The Ministry staff is also aware of the needs for intellectual property management, including licensing needs for oil and gas exploration equipment as well as in refining. They have very few capabilities to actually register intellectual property themselves.

The standards process has made accommodations to support the research sector, as previously noted. The standards institution is not well connected to regional or international standards bodies operating in the same or similar sectors, which may be a drawback over time. This could be changed with additional resources to allow that agency to scan the globe for important developments and technologies.

## Notes

1. The Least Developed Countries Report, 2007, UNCTAD.

ANNEX 5

# Transport and Logistics Case Study

According to an UNCTAD review of Uganda's development prospects, infrastructure in Uganda is a major impediment to export expansion and growth. "Infrastructure" in this sense includes transport infrastructure (e.g., road, rail, and air) and production support infrastructure (e.g., power, telecommunications, and water). Because Uganda is a landlocked country, infrastructure means the difference between goods flowing in and out of the country smoothly and weak trade capacity. The efficient flow of goods from a landlocked country requires good roads and railways infrastructure and efficient port handling facilities. As well, efficient logistics systems are crucial for trade. Logistics refers to the technologies, processes, and people required to deliver the right item in the right quantity at the right time in the right place for the right price (Versi 2007). It follows that the more efficient a country's logistics capability is, the greater is the volume of trade; the greater the volume of trade is, the more prosperous everybody along the chain becomes. Here Uganda has not fared well. A decrepit railway system has forced Ugandan entrepreneurs to rely on trucking across the country's poorly maintained roads. For producers who rely on goods shipped from overseas, reliance on Kenya's Mombasa Port hurts competitiveness too. The port handles 95 percent of Uganda's external trade traffic and is renowned for the problems of congestion, which increase costs. Customs bonds for exports and imports transiting through Kenya account for an additional 4 percent of costs (DTIS, 2006).

In the absence of comprehensive rail connections, haulage is mainly carried out by trucks on some of the worst roads in the world. This means delays, and delays cost money, making Africa as a whole the most expensive continent in the world in terms of moving goods (Versi 2007). Because Uganda's transport capacity is dependent, to a certain degree, upon that of Kenya and its other neighbors, through which Ugandan-bound goods must pass, efficiency at the borders can further reduce transport efficiency. For example, the poor performance of rail transport in Kenya necessitates intensive use of higher cost road services. In addition, transporting a container from Mombasa to Nairobi costs $700, whereas from Mombasa to Kampala it costs $2,000, adding to the cost of production for Ugandan goods. Also, the cost of transportation of petroleum products by pipeline is excessively high for Uganda because of the lack of competition from the railways. In sum, weak infrastructure imposes major cost on both imports and exports, making them more expensive and thus less competitive.

The influence of infrastructural inadequacies in Uganda extends to areas of great potential, both for export expansion and employment creation. For example, it affects the tourism sector, a fast-growing export for Uganda. Despite the high number of tourist attractions around the country, infrastructure constraints render such sites inaccessible. In a second example, for the agricultural sector, one of the key challenges as the result of a weak transport and logistics sector is the cost in terms of post-harvest loss because of poorly maintained roads and overloaded trucks that lose their loads.

Adding to the sobering picture of Uganda's infrastructure, power shortages plague Ugandan industry. Over the past two years or so, Uganda has experienced electricity shortages and an unreliable supply of electricity because of limited generation capacity. The effect of this shortage is increased dependence on more expensive thermal power to supplement existing hydro-based electricity. Individual companies have had to invest in diesel generators, increasing costs, which threaten firms' viability and competitiveness. The price paid by firms who must compensate for insufficient power supply is substantial. Mukwano, for example, pays almost 500 Ugandan shillings per unit of power generated by its in-house generators. This is substantially higher than the 200 Ugandan shillings cost per unit of power provided by the Ugandan power company. The firm estimates an annual loss of $700,000 on self-generated power that otherwise could have been invested elsewhere in the company had the power supply been stable. Considered from a regional perspective, Uganda's power capacity falls short. The cost of power in Uganda is approximately 30 percent higher than in Tanzania or Kenya. Furthermore, because the country has extra production capacity, Kenya is able to dump its power in Uganda, a particularly ironic situation because Kenya purchases power from Uganda.

With respect to ICT, the subsector is amid rapid change. According to the World Economic Forum's Networked Readiness Index 2006–2007, Uganda ranked 100 out of 122 countries in terms of e-readiness, which includes technological readiness, firm-level technology absorption, laws relating to ICT, FDI and technology transfer, mobile telephone subscribers, telephone lines, Internet users, and personal computers. Total fixed phone lines as of June 2007 numbered 154,383, with 0.36 phone lines per 100 inhabitants. Mobile telephony is fast-growing in the country, with 3.575 million cellular subscribers as of June 2007. Teledensity for mobile phones is far higher in urban areas, however; 35 percent of households in Kampala have mobile phones versus 7 percent nationally. Competition is increasing as several new Middle Eastern–owned mobile telephony companies enter the Ugandan market. ICT in education is also eliciting more emphasis. Until recently, telecommunications infrastructure had been provided by two fixed-line operators and three mobile telephone operators. However, the opening up or expiry of the protection in the sector has seen entry of other service providers, with the opportunity for further reduction of costs (UNCTAD 2006).

Computer use and ICT connectivity are also on the rise in Uganda. Personal computers per 1,000 population number 9, whereas the number of PCs per 1,000 inhabitants surged from 24 in 2001 to 147 just four years later (UCC statistics). Still, connectivity remains challenging, with just 900 kilometers of fiber optic in Uganda as of 2007 and a meager 1 percent of schools connected to the Internet.

For those firms and entrepreneurs who learn how to successfully confront challenges related to transport, logistics, and ICT, the difference is evident in terms of firm competitiveness. This sector study relies heavily on analyses from two sectors: the newspaper and the supermarket sectors, in addition to pertinent examples drawn from the industries profiled in the other sector studies. The rationale for selecting newspapers and supermarkets derives from two observations: (1) the success of firms in both sectors relies on firms' adeptness to overcome transport and logistical hurdles to ensure that goods are delivered as quickly as possible, and (2) the contrast between the two sectors provides an interesting comparison between a sector in which businesses produce a product at a central location that must be distributed to customers spread across a wide geographic area (newspapers) and another in which goods are produced in various locations (both locally and internationally) after which they must be transported to a central location to which customers come in search of them (supermarkets). The case study of *The New Vision* newspaper described in box A5.1 introduces a number of the THICK-related challenges faced by a firm in Uganda's newspaper sector.

The following sections present further analysis of Uganda's transport and logistics sector according to the THICK (Technology, Human Resources, Institutional Resources, Communications Capacities, Knowledge Base) methodology.

## Technology

As The New Vision case study in box A5.1 illustrates, a number of technology-related constraints hinder Ugandan firms in their quest to improve production, enhance quality, and penetrate markets more successfully.

### *Poor Infrastructure Capacity Reduces the Competitiveness of Ugandan Firms*

Regarding transportation challenges, the costs borne by export-oriented firms that must transport their goods to the ports in Mombasa or via land routes across the continent are far higher than they otherwise would be were train and road construction and maintenance a greater priority. Mukwano offers a vivid example of the constraints one exporting company faces. Because of a lack of reliable and efficient railway services from Mombasa to Kampala, Mukwano invested $2.5 million in containers that would not be required if railways were functional. At present, rail service from Mombassa to Kampala for a container takes, on average, between 14 and 30 days. By comparison, truck drivers can manage that trip in 4 days. However, the company estimates that were the roads more serviceable, that same trek could be made in just 2 days (by either rail or truck). In terms of lost revenue, the difference in cost between road and rail for transporting a ton of product is a $30 difference (road is $30 more expensive per ton, with a cost of $110 per ton on road and $80 per ton on the rail). In terms of regional competitiveness, Ugandan manufacturers are disadvantaged by the high costs they bear as a result of poor roads and ineffective rail, which, in effect, increase the cost of production.

The price of Uganda's poor road conditions is borne by distributors and manufacturers of goods for export or country-wide distribution, driving up the cost of production of Ugandan goods, which in turn reduces competitiveness. For example, the *Monitor* newspaper spends about 24 million Ugandan shillings per month on spare parts for its fleet of vehicles used for transport. If the roads were better, the likely amount the transportation manager predicts would be required is as little as one-half that, roughly 12 million Ugandan shillings. To quantify the cost of the poor roads in terms of tires, the newspaper assesses rates of replacement. A new tire today should function for 60,000 kilometers. Yet, the average lifespan of tires used on Uganda's poor roads is just 30,000 kilometers.

**Box A5.1. Transport and Logistics as Keys to Competitiveness: *The New Vision***

Newspaper readers in Uganda fall into two camps: *The New Vision* readers and *Monitor* readers. The difference comes down to preference and ownership. *The New Vision* is government-owned, whereas the *Monitor* is Kenyan-owned.

Interviews and site visits with both newspapers revealed the extent to which a newspaper is a "perishable product" that withers and loses its marketability if it arrives to customers too late. With 32,000 copies of the *Monitor* and some 45,000 copies of *The New Vision* printed daily, the tight race between newsmakers in Uganda comes down to a game of logistics. For managers at both papers, the most important daily achievement happens—or fails to happen—at 6:00 a.m., when every paper printed should have made it to its point of sale, be it a hotel, a street-side agent, or a store-based distributor. The technological, human resource-based, and logistical hurdles that must be surmounted every day to ensure that papers are produced, transported, and end up safely in the hands of readers make the difference between profit and loss, as the following case study of *The New Vision* illustrates.

*Few automated processes means slower production*

The actual printing of the paper is one of few automated processes at *The New Vision*. Each night, the paper is printed on a set of large sheets. These large sheets are manually placed in the proper order, manually counted, and then packed by hand by the circulation staff. Twenty-six people are employed in circulation. These staff are charged with packing papers, writing labels, strapping bundles together, and counting the papers. With technology, each of these processes could be automated, as they are for nearly every newspaper in a developed country.

Furthermore, when the process of circulation is performed by people instead of machines, occurrences of theft are higher. Between 200 and 300 copies of the paper are stolen each night during the circulation process. These stolen copies are then sold on the black market. After circulation completes the process of assembling and bundling the papers, the bundles are weighed and counted. A comparison of the weight of the papers going out the door each night contrasted to the weight of the paper going in reveals the losses incurred.

Managers understand the cost of low technological intensity in terms of efficiency. One manager explained that he recognizes that people can never be as accurate or efficient as computers in terms of labeling papers or organizing them in trucks to facilitate the most efficient distribution. An investment of $50,000 for a new software system could overcome this weakness. A software package produced in South Africa and India would allow automated labeling and facilitate trip-planning to coordinate distribution of papers along routes in the most efficient way possible. Using the software package, papers would be printed and labeled route by route and batched exactly to ensure that only those batches labeled for a specific route are packed into vehicle.

*ICT weaknesses reduce efficiency in production and circulation*

Across the production and distribution processes, a lack of technology slows production and forces reliance upon manual labor. As compared to newspaper distribution systems in the United States, those in Uganda do not rely on subscriptions. In the United States, subscriptions are aggregated according to postal codes. Production and distribution are then organized according to the postal codes, which can be monitored with satellite surveillance. Papers are then packed into trucks using computer-aided processes that ensure optimal packing configurations. The trucks destined for specific postal codes are driven to larger distributors, who then dispatch the papers to both commercial and residential customers. Through the subscription model, the money is paid by customers at the beginning of the year. Uganda's model is the opposite. First, there are no postal codes. Second, customers prefer to be billed for the papers after receiving them. Thus, it is far more difficult to predict exactly how many papers must be printed on a given day. Factors that influence the likelihood that a given edition of the paper will be widely demanded include the cover story, the weather, political events, and the time at which the paper reaches the market (in specific, whether it hits the shelves before the competition or after).

Migrating to an ICT-enabled system to track and monitor sales and demand would make the production manager better equipped to know how many papers to print on a given night based on relevant variables. Instead, managers look at weather data from the previous day (instead of weather from one year before, which might also be relevant in determining what kind of weather conditions to expect) as well as the roads data collected from drivers. Without satellite monitoring to facilitate the collection of meteorological data and a computer-based system to gather and analyze information on road conditions, managers make the best decisions they can with few tools to help them. Additionally, unaided by ICT, the individuals who pack the trucks must rely on guesswork to assemble newspaper bundles into a logical pattern to facilitate quick unpacking for the drivers as they distribute the papers along their routes. In short, adopting ICT would provide numerous opportunities to enhance the efficiency, reliability, and ease of newspaper production and distribution that *The New Vision* does not enjoy at present.

*Knowing the market requires technology*

Determining how many papers to print each day is a tricky calculation when few data are tracked, recorded, or saved in a format amenable to scanning, sharing, and business planning. *The New Vision* employs a technologically limited system for distribution that often results in costly mishaps in terms of determining how many newspapers to transport to given points of sale. As a general rule of thumb, the number of copies of the newspaper to be sent to a given point of sale should be large enough to ensure that all customers seeking to buy a paper find one available. However, if the distributor drives 15 copies to an agency and only 10 copies are sold, the remaining 5 are returned to the newspaper, at a loss to both the distributor and the newspaper. The newspaper caters for approximately 12 percent returns each night. When the prediction of how many newspapers is wrong—because of lack of meteorological data, poor road conditions that prevent vehicles from accessing the sales point, etc.—returns can increase to 15 percent or more. Ideally, *The New Vision* would like to decrease returns to just 1 percent, given that every additional percentage of inventory returned costs the company 900,000 Ugandan shillings. The question for managers is how improving logistical capacity can reduce these losses.

The answer lies in improving the mechanisms of distribution between the newspaper production facility in Kampala and the 4,000 vendors and 400 agents and subagents around the country who distribute and sell the newspaper every day. If enabled to optimize distribution to this network of suppliers, the newspaper would seek to ensure that, for any agent selling 10 copies or less, it does not provide any returns. Circulation software would cater for 3 percent returns for agents selling between 11 and 20 copies and a slightly larger return rate for agents selling more than 20 copies. These calculations could be determined at the touch of a button, facilitating improved production. As the Sales and Marketing Manager of *The New Vision* noted, the technology lacked by the company is, in fact, a crucial stepping stone toward enhanced competitiveness. He explained, “Sixty-five percent of all [newspaper] commerce is within 30 km of Kampala. So Kampala is Uganda. The other 30 percent is in 7–8 other centers. Then the remaining 5 percent is everything else. In order to sell in Kampala, we want to sell 24,000 copies every day. The balance will go through out the country. Through technology, I want to make my circulation outside of Kampala more efficient since it’s cheaper to sell in Kampala. With more efficiency I could reduce the returns and use that efficiency to expand the market in Kampala.” In other words, improving the efficiency of distribution will mean fewer product losses, which will mean more profit for the company.

To attain the efficiency sought by the Sales and Marketing Manager, *The New Vision* is considering investment in a range of technologies. First, it is considering investing in GPS for delivery vehicles. The cost at present is prohibitive, however, because the cheapest GPS system is 100,000 Ugandan shillings per month. Second, the company is hopeful that an investment in remote inputs that connect agencies to the newspaper production facility could further reduce returns. For example, if a distributor in Mbarara were equipped with a handheld PDA, he or she could remotely input how many papers were sold in a given day. The newspaper could then adjust the account instantaneously to record what was sold and predict next week’s delivery. Such a technological leap would be a vast improvement over the current system, in which unwanted and unsold newspapers are returned to the production facility and counted.

The difference between papers out and papers back in reveals how many papers were sold and thus how much the various agents and distributors should be billed. Third, a computer-based distribution system would allow for a more scientific assessment of market needs. Relying on staff to physically locate last year's record of sales is far more haphazard than an automated system that brings up last year's sales record for a given day and uses those data to establish estimates for production for the following year.

Another aspect of knowing the newspaper market relates to investment in research. *The New Vision* performs some market research and also pays for research conducted by outside firms. In the past, it has purchased opinion study research, surveys, and industry research from outside vendors, including media research produced by the Steadman Group. Still, the annual research budget for the paper ranges from a meager $6,000 to just $10,000.

*Weak science and technology skills reduce efficiency*

Aware of the need to boost science and technology skills among its 400 person-strong staff, managers at *The New Vision* prioritize opportunities to advance the skill level of their employees. In particular, managers are concerned with the low level of computer skills. Previous trainings on various Microsoft programs, including Word and Excel, have been offered by the firm to select staff. An advanced Excel training course provided staff with an additional opportunity to improve the familiarity with the program. Still, the Sales and Marketing Manager reported that "computer skills of our staff are a long way off of where they need to be. If I said to my circulation managers, 'Here's the data in Excel, manipulate it in Excel and come back to me where there are trends,' they would struggle. They can use Excel to calculate percentages, but that's where their ICT skills stop."

*Weak infrastructure reduces competitiveness*

A combination of traffic congestion in Kampala and a poorly maintained roads infrastructure outside of the capital renders the challenge of daily distribution all the more difficult. To overcome daily problems on the roads, drivers rely on mobile phones to alert the production facility and other drivers regarding driving conditions, breakdowns, etc. All too frequently, the dispatch in Kampala receives reports of tire punctures and other mishaps that result from the potholes, uneven surfaces, and mudslides that render roads impassible or dangerous. For example, for trucks going north, the typical drive takes four times longer than it should if the roads were well maintained. The cost per kilometer is also higher because of the number of breakages incurred by the poor roads. In some cases, the roads are so bad that the company abandons them all together: before the Arua road connecting Karuma to Arua was repaired, newspapers were flown via Eagle Air, which was costing an additional 500 Ugandan shillings per newspaper each day. When driven, the costs of transport decrease to 400 Ugandan shillings per newspaper, at a savings of 100 Ugandan shillings per newspaper, a direct benefit to firms as a result of improved road conditions.

*Weak links with business support organizations force firms to fend for themselves*

Collaboration with those institutions charged with enhancing firms' industrial capacity is almost nonexistent for *The New Vision*. When asked why the company does not take advantage of such services offered through UIRI and others, sources contacted explained that they do not know what services are available because the outreach to industry on behalf of such organizations in Uganda has been insufficient. Furthermore, managers do not perceive that government or any institutions in the country would be interested in supporting ICT training or other science and technology dimensions of firm development. So long as resources within parastatal organizations and universities are perceived as irrelevant to *The New Vision*, the benefits of such collaboration will remain out of reach.

*Insufficient power cripples firm production*

Intermittent power supply to *The New Vision* further impinges upon the firm's ability to produce newspapers efficiently and reliably. The impact of inadequate power can be seen through an example. During one of the frequent power outages, the entire e-mail system was paralyzed. Because the two 230-kilovolt backup generators at the paper were not receiving power as the result of a decision to cut down on the cost of fuel to maintain them, the facility lost power to its e-mail server, which caused it to malfunction rendering e-mail inaccessible for two full weeks. Not until a new server was purchased was the firm finally able to import e-mails from the old server to the new one, which disrupted the work of the journalists and freelancers whose contacts were unavailable during that time.

The current load-sharing program in Kampala ostensibly provides businesses with a "12-on, 12-off" program, in which firms are supposed to receive 12 hours per day of power. If they seek more, they must rely upon their own generators to provide it. Managers reported that this load-sharing program is improving; however, frequent brownouts force *The New Vision* to rely on self-generated power several hours per week, increasing production costs substantially.

*Inadequate Power Supply Serves as a Disincentive to Multinational Firms*

Another challenge related to logistics and industrial competitiveness more generally is the power supply. According to a senior finance manager at Mukwano, the cost of self-generated power is nearly 150 percent higher than that which is purchased through the power supply company. In 2006 Mukwano spent an additional $700,000 on self-generated power that it otherwise would not have spent had the power supply been stable. The irregularity of power availability acts as a disincentive for multinational companies considering opening a Ugandan subsidiary. In the case of Quality Chemicals, for example (see the ethnobotany sector analysis), the cost of development includes the construction of a stand-alone power generator capable of running the entire pharmaceutical manufacturing plant, because the likely power outages it will experience would surely have deleterious consequences for the kind of hygienic, high-quality production processes used for pharmaceutical manufacturing. This additional cost serves as a disincentive for multinational corporations interested in expanding their operations in Uganda.

*Technological Change Offers Possibilities for Cost Reduction and Growth in the Sector*

Transport sector experts assert that compared to gravel roads, low-volume sealed roads offer tremendous potential for reduction of cost in road maintenance and extensification of the road network. Furthermore, there is a high degree of political will to support research and to adopt new technologies or processes for better roads in Uganda and elsewhere across the region. In fact, concerted efforts are under way to pilot new roads that employ recent advances in materials science. Specifically, a move away from gravel toward sealed roads heralds reductions in maintenance costs. However, firms will not experience these benefits until such technological change is taken up across the country.

## Human Resources

Analysis of the human resources dimensions of Uganda's newspaper and supermarket sector reveals that few engineers and entrepreneurs contribute to the growth of the sector. Plagued by a deficit of ICT skills, management-related skills, and hands-on experience with technology, interviewed firms reported a high degree of frustration with the adequacy of training provided by Uganda's education and training system. To compensate for these inadequacies, some firms are taking on the responsibility to train employees themselves, providing opportunities for industrial attachment and skill upgrading for employees.

### *Industrial Attachment Is Used a Strategy to Compensate for Inadequate Vocational Training in the Transport Sector*

Many employers deem the level of vocational training in Uganda "very poor." In interviews with staff from the *Monitor*, for example, the Transportation Manger described the training offered at technical and vocational training institutions as too theoretical in nature, "We would prefer someone who has learned in a garage and who is learning parts of a car as opposed to someone coming from one of the vocational institutions. If people learned from a garage, they would do well here. But these guys have learned about cars from books only. So, we source employees from garages instead."

To offer the kind of practical skills they seek in recruits, some companies have started to implement on-the-job training. The *Monitor*'s Transport Division had four students as of September 2007 who study mechanical engineering at Kyambogo University. The *Monitor* provides them with an industrial internship, with the understanding that following the completion of their studies, if a position becomes available, they will be hired. If no positions become available, the *Monitor* recommends the interns to other companies.

Across the firms interviewed, the technical and vocational education and training (TVET) was described as very low. When future auto mechanics can be trained in their field without ever getting to disassemble an actual car, their training lacks the kind of hands-on aspect needed to prepare industry-ready employees.

### *Weak ICT Skills Characterize the Majority of People Employed in Transport and Logistics-Related Professions*

Interviews at *The New Vision*, the *Monitor*, and *Game* supermarket repeated the same low assessment of most Ugandan graduates' ICT skills. Namely, ICT skills are weak enough to negatively impact firm competitiveness. For instance, at *The New Vision*, prior to firm-sponsored ICT trainings, none of the university degree holders had sufficient ICT capacity to utilize such standard software packages as Word or Excel. When firms must expend internal resources to compensate for weaknesses in university-level training, the cost is reduced competitiveness. Interviews with managers at Game supermarket offered a similar description. In particular, distribution managers observed that most suppliers in Uganda lack the ICT skills to communicate with the supermarket sufficiently. The impact of their low communication is the inability to get the supplies to Game in time, which disincentivizes the store to stock Uganda-produced goods. In such scenarios, distribution managers often drive to their suppliers to communicate with them in a costly attempt to overcome poor ICT capacity.

### *Engineers Lack Soft Skills, Which Impinges on Uganda's Transport and Logistics Planning Capacity*

Interviews with staff at the Road Agency Formation Unit within the Ministry of Works and Transport painted a promising picture in terms of engineering human resources in the transport sector. Specifically, in terms of the preparedness of engineers, contacts asserted that the cadre of civil engineers within the Ministry appears to be adequately prepared for the tasks entailed in performing the engineering-related aspects of working in the transport sector. However, for those civil engineers working in government, the need to know procurement and management is just as pressing as the need to know the technical aspects of the profession. The problem in terms of human resources capacity is in these softer skills, not in the technical knowledge.

Planning and operations requires aptitude in problem solving, economics, critical thinking, team-working, and management—elements of engineering training in Uganda that may require greater attention. The Entebbe-based policy group of the Roads Agency Formation Unit would benefit immensely from an increase in staff competence in these soft skills. According to one transport economist in the unit, "The transport operations are changing, so we have a need to adapt our skills to the new changes. This calls for training and skill reorientation. We don't have a stand-alone institution for transport regulation. This is spread between institutions. So, though we have engineers and economists, the skills in transport regulation are quite weak." Indeed, the World Bank is one donor beginning to invest more money in training in this respect to complement the Ministry's plan to reduce the number of staff but ensure that they are more highly skilled.

#### *ICT Training at the University Level Is Not Commensurate with Industry Needs*

According to sources interviewed working in the ICT industry, the problem with ICT training in Uganda is a dearth of teachers with ICT industry experience. Overreliance on rote learning, as opposed to learning by doing, often renders the ICT coursework stale and irrelevant to the needs of industry. By contrast, in the United Kingdom, the majority of lecturers in Internet technology (IT) were persuaded to go back into industry, and thus they possess an invaluable industry perspective. In Uganda, few IT professionals would accept university appointments. In the case of the director of one Kampala-based IT firm, the choice to hire bachelors degree holders instead of masters degree holders was based in the decision to offer in-house training that would advance fresh graduates' industry-related IT skills faster and with greater relevance than would additional years of university-based schooling. The director designed an intensive work-study program in which, during the final year of university, students would receive firm-based training. He explained, "Every minute they were not in class, they were with me, that way I got a team of engineers who were keen to learn but I didn't pay overtime! I would get the type of person I wanted to get through this work-study program."

#### *Training Opportunities in ICT Are Increasing*

In addition to the Uganda Communications Commission, the ICT industry benefits from a handful of other institutional resources created to assist the fledgling industry. For example, Ugandans take part in the African Network Operators Group, which offers two-week training courses for anyone seeking network operating and maintenance skills, through an initiative that receives funding from the World Bank, United Nations, ISO, etc. Companies in the ICT industry, such as MTN, send their employees to receive training through the institution. Ugandans have also been part of the continental movement to offer African IP addresses. Through an institution created for this purpose, AfrNIC, Africans (not just Ugandans) can access ICT training, adding to the institutional resources available to the sector.

### Institutions and Infrastructure

Institutional capacity to address the challenges related to transport and logistics vary in terms of sufficient capacity to buttress these critical aspects of Uganda's industrial development.

### *Uganda Has Sustained Long-term Political Commitment to the Transport Sector*

President Museveni has long promoted the transport sector, spreading the clear message that the sector constitutes a critical ingredient in opening the country to international commerce and binding the peace process. To this end, the World Bank has been very active in transport in Uganda for a number of years. The Bank is also involved in rail privatization and concessions, with an emphasis on connecting the Uganda-Kenya lines. The goal is to develop the Mombasa Corridor in order to get exports out of Uganda more quickly and efficiently. Guiding the transformation of the sector, government has articulated a Master Plan for roads and transportation, but very little money or priority is placed on overhauling what is described by the Director of Uganda Industrial Research Institute as an utter "nightmare" of a sector.

### *Weak Regulatory Capacity Slows Reform in the Transport Sector*

The transport sector is adversely affected by a weak regulatory structure. For example, drivers licenses are no longer required for cars. Additionally, there are no weight controls for trucks going over bridges, nor are loading rules issued or enforced. Meager enforcement capacity renders the existing laws weak in terms of implementation. Regarding road building and maintenance, these tasks are taken up by separate groups of contractors with little coordination between them. Without improved regulatory capacity, Uganda lacks the institutional capacity to ensure that reforms make a difference in the longer term.

### *Transporters Cite Rules Enforced by the Uganda Revenue Authority as Impediments*

The Uganda Revenue Authority serves as an important player in the transport and logistics sector. It is this institution that is responsible for tax collection and therefore establishes rules for customs payment at international border crossings in partnership with the East African Customs Union (EACU), which also includes Kenya and Tanzania. Charged with (1) creating a common external tariff regime for goods originating from outside East Africa, (2) establishing common customs laws and regulations, which will apply uniformly in the partner states, and (3) harmonizing and simplifying customs procedures and documentation, EACU is a key institutional partner for the Uganda Revenue Authority in enhancing the efficiency of border crossing for goods destined for Uganda.

According to the Distribution Manager for Game supermarket, who oversees the company's transportation unit, industry pays the price when transporters linger idly at the border. Specifically, inefficiency in terms of paperwork and goods-checking slows Game's transporters by an estimated 12 hours as they stand by at the border, waiting for inspectors. Game's Distribution Manager explained that, in an attempt to increase tax revenue, the URA requires trucks to pass through the border in a convoy. Instead of commencing their transport once they clear customs, transporters now sit, waiting for their convoys to assemble, at a high cost in terms of efficiency and total transport time.

### *Institutional Reform Is Under Way in Uganda to Improve the Performance of Ministries and Deepen Ties to Civil Society*

A recent restructuring within Uganda's Ministry of Works, Housing, and Communication focused upon realigning institutions and narrowing focus upon key goals. Resulting staff reductions and increases to the skill profile of remaining staff herald a radical shift in the way the reformed Ministry seeks to do business. The effectiveness of this reform will determine the ability of the Ministry to move forward.

A recent addition to the institutional landscape is the Uganda National Roads Authority (UNRA), which is charged with the overall responsibility of managing the roads network. As well, a new Roads Fund has been organized to consolidate funding on roads A concern in Uganda has been the extent to which civil society has been excluded or included from the process of future planning for roads development. Now the UNRA should incorporate this concern in moving forward. A Road Users Association in Uganda should offer opportunities for discussion regarding advances in the sector that deepen the dialogue with civil society further.

## Collaboration and Communication

When firms find ways to integrate ICT and linkage strategies into their operations, the difference is visible in terms of improved production capacity and enhanced competitiveness. Too frequently, however, Ugandan firms exhibit weak communication capacities. Large firms with international partners are often an exception, whereas small Ugandan firms typically demonstrate less articulated links and communication capacity.

### *Efficiency That Enhance Communication Capacities Greatly Improves for Larger Farmers*

The example (shown in box A5.2) of Mukwano's bold attempts to improve fleet management and logistics capacity—in order to raise the speed and efficiency with which goods are shipped to customers—exemplifies the importance of supporting communication capacities to surmount infrastructure challenges.

In a similar example, Game supermarket has adopted a computerized system called Mocha to manage ordering, stocks, and flows of goods. Mocha is an integrated system through which every aspect of the supply chain is linked to a Web-based program that automates reordering, shipping, distribution, and stocking. At the point of sale, when a customer rings through at the checkout, the information from the barcode of each item purchased is automatically uploaded to a central server. Each night, all transactions are consolidated and analyzed by Mocha. Stock reports are generated each morning so that distribution managers can keep tabs on those items most in demand. For example, if a manager learns that Nomi Super Foam laundry detergent sold extensively during the day, the next morning the system would automatically trigger a reorder from the supplier. For goods purchased from international suppliers, Mocha calculates automatically the number of days required from issuing an order to receiving a shipment and adjusts the level to which stocks can be sold before reordering. ICT facilitates far more precise and reliable methods for supply-chain management than non-computer–enabled methods.

### *Quality, Standards, and Testing Institutions Exhibit Weak ICT Capacity*

Lack of ICT capacity in the Government Analytical Laboratory, National Chemotherapeutics Laboratory, and other quality, standards, and testing institutions perpetuates the status quo of limited knowledge dissemination and partnership creation in Uganda. For the Government Analytical Laboratory specifically, it is the case that, without a website or working IT capacity, all reports are published physically. If parties are interested in accessing them, they must travel to the laboratory and request a physical copy. Low ICT capacity radically diminishes prospects for collaboration that would be available using the Web.

**Box A5.2. Using Science and Technology to Improve Product Management and Logistics: Mukwano's Transition to an Electronic Fleet Management System**

Barring improvements to the road or rail networks, ICT offer manufacturers another route toward enhanced efficiency in transport and logistics. The efficiency of a trucking fleet derives, in part, from the quickness of the turnaround time between treks. It is often the case that drivers park and waste valuable time. Through ICT-enabled tracking systems, managers can monitor drivers and create disincentives for making unauthorized stops. Upgrading toward ICT-based transport, logistics, and supply-chain management systems offers a host of benefits that enhance competitiveness and efficiency and allows for the pairing of related processes that are not linked when managed without these tools.

A site visit to Mukwano Industries revealed that the firm is currently migrating its supply-chain management to SAP. Simultaneously, it has purchased a new ICT-based transport management system, called VDO, from a South African vendor. Some of the processes that these investments will improve include truck loading, links between distribution and transportation, and customer relations. With respect to truck loading, at present, people called "counters" stand by and manually count all products to be loaded into Mukwano's trucks before they begin their distribution circuit. The loading of goods onto trucks is then performed manually. Sale orders are sent to the central warehouses, and then goods are shipped to distributors. All products are back-ordered using a "first-in, first-out system," meaning that the packers must physically locate the oldest batches to ensure that the goods closest to expiry are the ones shipped out first. But people make mistakes. Relying on people and manual labor for this task, Mukwano risks confusing shipments when the wrong batches of goods are sent out at the wrong time to the wrong customers. Using an ICT system such as SAP, automated batch location offers a faster, more efficient option.

Regarding the ability to link distribution and transportation, the gains in efficiency that are possible by migrating from a fleet management system that utilizes handwritten log books to one that creates an interface between fleet management and distribution data entail a significant jump in terms of efficiency. For example, using VDO, Mukwano managers can access real-time digital maps that allow them to follow each specific truck in their fleet. With the click of a mouse on a map, they can look down to the village level to know precisely where a given truck is. Using real-time playback, they can monitor how a given truck moves (at what speed, whether it has stopped) across the whole journey. Managers can know the driver, the speed, and the contents of the truck remotely. This relates to customer relations; staff in logistics can utilize this information to communicate with customers to assure them that a given delivery will arrive at a precise time.

VDO stands in stark contrast to Mukwano's previous nonautomated system. Historically, the firm's fleet management system relied on the utilization of log books. Drivers were responsible to record the date, speedometer reading, kilometers traveled, time in and out, all lubricants used, and the purpose of journey. This written narration was fallible, however, because drivers could omit or edit the data they entered. Furthermore, for the data processors who tried to input the written scripts into Excel spreadsheets, the process was laborious and failed to take advantage of the power of the Internet. Because the old system was not Web-enabled, opportunities to collaborate and engage in decision making in real-time were limited to those individuals looking at the same piece of paper or gathered around a particular computer. The VDO system will constantly update data on fuel averages, mileage per vehicle, drivers' histories, maintenance schedules, etc., to facilitate more precise maintenance and management.

### *Integration of ICT into Production Processes Is Rare for Ugandan Firms, Particularly Small and Medium-Sized Enterprises*

Processes that could be drastically enhanced through the application of ICT and automated technologies remain reliant on manual labor to both maintain employment and exploit low-wage labor. For example, at the *Monitor* (one of the two major national newspapers), production processes, including sorting and loading, are performed completely by hand. These are the least technology-oriented aspects of the production process, in fact, and require hundreds of contract workers each night to assemble, bundle, organize, and load the papers for distribution. Even counting papers is done by hand. Another example of inefficiency related to low ICT penetration in newspaper production is demonstrated through the processes relied upon to distribute newspapers during weather-related events. When experiencing flooding, which occurs frequently, the main roads in Eastern Uganda are largely under water, yet drivers do not know which roads are impassable until arriving at them. Instead of using GPS, Google Earth, or any meteorological software, the newspaper relies upon trial and error to determine backup routes. In one instance in September 2007, trucks met on either side of a washed out road and sent the newspapers across by canoe.

#### *Transport Planning Could Be Improved with Successful Integration of ICT*

Another way in which ICT can be used to enhance efficiency within transport relates to transport planning. Here again, this advantage is not being realized by Ugandan firms because of low ICT capacity in industry. For example, at the *Monitor*, the Transport Division has no computerized system to organize and plan the transport of journalists to various meetings and interviews. Journalists could make a plan for their week that would be organized and optimized to ensure availability and fuel efficiency on behalf of their drivers. Yet, no such system is in use. Transportation in other media houses runs according to such systems, such as at *The Nations* in Kenya. There, the newspaper has a computer system whereby journalists set their schedules for reporting and interviews, entering a weekly plan into a computerized system. Using this system, the transport managers craft a plan that also allows for sufficient standby cars for emergencies and just-breaking stories.

The two dominant distribution models for retailers in Uganda are (1) the traveling salesman model, in which traveling, independent agents pick up goods from a central distribution area (a depot) and sell them to stores within a various geographic area, such as for Unilever, for example; and (2) a controlled distribution system, such as that for Coca Cola. The use of ICT in distribution for tracking and monitoring deliveries, scheduling of trucks, etc. is much more commonplace in the latter than the former. The mobile phone, however, offers the traveling sales agents the ability to communicate with their vendors to know when stocks run low. Still, the mobile phone does not replace an integrated computer-based data management system.

#### *Regional Collaboration in Transport Policy Appears to Be Improving*

Emerging regional opportunities for collaboration in the transport sector offer Uganda an opportunity to share experience and link national reforms to those of other countries on the continent. For example, the Sub-Saharan Africa Transport Policy Program (SSATP) is a unique partnership of 35 African countries, 8 regional economic communities, and 3 African institutions—UNECA, AU/NEPAD, and the African Development Bank—national and regional organizations, and international development partners. Together these partner institutions are collaborating to achieve the goal of ensuring that transport plays its full part in achieving the developmental objectives of Sub-Saharan Africa: poverty reduction, pro-poor growth, and regional integration. The program is currently funded by the European Commission, Denmark, France, Ireland, Norway, Sweden, United Kingdom, the Islamic Development Bank, and the World Bank.

### *Improving Public-private Partnership in Transport Is Key*

Public private partnerships constitute an aspect of government's plan to improve the transport sector. According to sources interviewed at the Roads Formation Unit, managers' appreciation of the need to work differently has increased the emphasis on developing partnerships outside of the government and the technical community. The creation of the Road Fund requires that various planners and implementers understand how road pricing works and how to determine the implications of reforms. According to a transport economist at the RAFU, "To convince Ministry that users should pay for services, we need to partner more with industry. If we don't understand road pricing, then we can't further the potential in public-private partnerships. It's about improving your process knowledge as opposed to content knowledge."

### *Collaboration Between Sectors Could Be Improved to Address Transport Challenges*

Collaboration between RAFU and such organizations as the Institute of Professional Engineers offer opportunities to deepen expertise and widen the network of partners from which Ugandan institutions can draw resources in addressing challenges related to transport and logistics. Intermittent experience collaborating with UIRI and the African Development Bank suggests, however, that too little priority has been given to addressing shared challenges by working with critical partners across different disciplines and sectors (public, private, university, etc.). Enhancing government's capacity to seek out and deepen partnerships is another dimension of collaboration that appears to elicit too little attention at present.

## Knowledge Base

Despite the availability of an array of global knowledge resources on transport and logistics, Uganda's access of these tools appears limited. Better integration of available knowledge resources will help industry overcome challenges related to producing, transporting, tracking, and distributing goods produced in the country.

### *Too Little Priority Placed on Roads Research*

In Southern Africa, more high-tech methods for road construction and composition elicit a fair amount of research funding and attention. CSIR in South Africa is a key contact in this regard. By contrast, Uganda conducts minimal roads research, with a few projects, conducted at university, relating to materials for road construction and road maintenance and axle load control measures. Contacts interviewed emphasized that far more research in the sector is required. The Ministry of Works is home to a materials laboratory; however, financial shortfalls render recurrent costs a challenge to cover. Financing research on new technology is beyond the Ministry's budget at present; thus, the Ministry has no line item for research. Instead, it pursues a piecemeal approach when funding becomes available.

A low-volume roads project funded by World Bank offers an example of the kind of research capacity needed within the country. The objective of the project is to determine which local materials can be used to reseal some of the low-volume roads. Although the research capacity of Makerere's Technology Department or that of Kyambago could pursue further relevant research, funds are lacking. India's Central Road Research Institute serves as a model of the kind of knowledge resource that would be ideal for Uganda.

*Deepening the Knowledge Base in the Transport Sector Entails Scanning for Technological Options and Devising Solutions that Work in the Local Context*

According to the Sub-Saharan Africa Transport Policy Program (SSATP), a number of innovative technologies are required for the sector to progress in terms of quality and capacity.

> Unpaved roads generate a continuous cycle of deterioration which requires substantial amounts of replacement gravel—a sacrificial "wasting" layer which is rapidly being depleted in a number of countries, in the process raising serious environmental concerns. Fortunately, there are a number of proven, low-cost bituminous surfacing options that offer economical and sustainable solutions to the gravel road option. In this regard, there is a need to depart from the conventional practice of "fitting the materials to the specifications" which often renders potentially useful locally available materials unutilized. A new approach of "fitting the specifications to the materials" will apply a more customized and tailored design corresponding to the local climate, natural materials available in the area, volume and load of the traffic and, in many cases, will economically justify sealing gravel at traffic thresholds of less than 100 vehicles per day as opposed to the conventional approaches that require levels in excess of 200 vehicles per day.

This is the philosophy behind SADC's Guideline for Low-Volume Sealed Roads, developed to capture best regional and international practices in all aspects of provision of Low-Volume Sealed Roads. However, embracing this strategy implies that Uganda will prioritize research and development efforts in the sector to determine the "customized and tailored" approach most appropriate for the conditions in the country.

A national strategy on roads offers a valuable knowledge resource for cross-sectoral dialogue, policy, and planning

A national strategy on roads offers a knowledge resource for stakeholders in the sector across the different modes of transport. Additionally, the Ministry of Works and Transport oversees a road safety initiative that draws upon various stakeholders for its implementation. Efforts to create a National Transport Master Plan signal a commitment on behalf of government to consolidate the various knowledge resources available into an overarching strategy for sector development.

*ICT Policy and Research Appear Disconnected from Industry*

Although strides have been made by both government and university to improve Uganda's capacity to develop ICT policy and research capacity, some experts argue that these initiatives are divorced from the needs of industry. According to the director of one Ugandan IT firm, "The current challenge is with policy . . . Policy makers need to understand that the biggest spenders in ICT are not private sector but government. The technology they use is dated because the decision makers do not appreciate the role of technology in business yet." Enhancing government's appreciation of the role for technology in Uganda's development would likely shift the focus of policy toward industry and ensure greater relevance to Uganda's industrial development. Similarly, for research, some experts argue that Uganda's ICT research capacity is irrelevant to industry needs. The Presidential ICT Roundtable offers a high profile forum to discuss the need to bolster industrial relevance in this aspect of ICT knowledge as well.

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