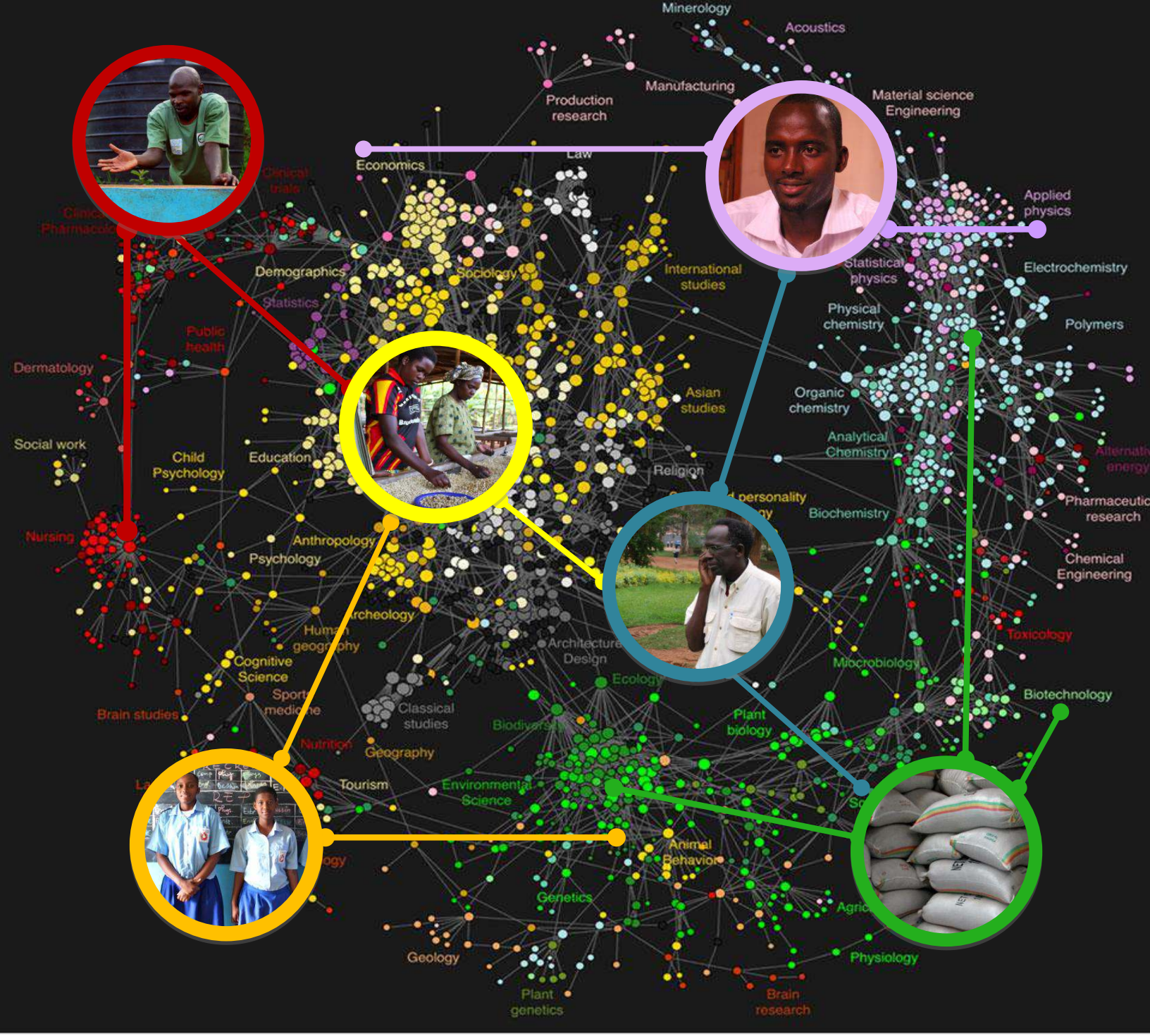

GLOBAL KNOWLEDGE INITIATIVE

LINK Analysis Rwanda

Critical Insights for Forging Purpose-Driven Knowledge Networks

Mapping Science, Technology, and Innovation Resources to Tackle a Coffee Pest Challenge in the Land of 1,000 Hills

January 2012

Structure of the Report

Cover art credits: The "Map of Science" produced by a research team including Johan Bollen, Herbert Van de Sompel, Ryan Chute, and Lyudmila Balakireva of LANL's Digital Library Research and Prototyping Team and Aric Hagberg, Luis Bettencourt, and Marko A Rodriguez of LANL's Mathematical Modeling and Analysis Group, and LANL's Center for Nonlinear Studies. Modifications by Sara E. Farley.

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Sara E. Farley (Chief Operating Officer); Amanda L. Rose (Program Officer), Andrew Gerard (LINK Program Associate), Christina Golubski (Public Relations and Outreach Program Associate), and Courtney O'Brien (International Programs Assistant)

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Finally, thank you to Christian Cilas at CIRAD and Thomas Miller at the University of California, Riverside for being willing to help the Faculty of Agriculture at NUR take on this challenge and grow the knowledge network required to succeed in scaling a solution. You helped to carve a path down which we hope others will walk.

The acceleration of technological development is changing the way individuals and institutions work, learn, collaborate, and communicate. The rise of silo-smashing, multi-disciplinary research is changing the structure of contemporary science. Scientific research that addresses global challenges in health, agriculture, climate change, and water increasingly cuts across disciplinary and geographic boundaries. Collaboration on these challenges demands that researchers learn how to communicate with and contribute to teams composed of multiple disciplines. The Global Knowledge Initiative terms this moment in time *The Collaboration Era*.

GLOBAL KNOWLEDGE INITIATIVE

Tools for Solving Shared Development Challenges through Collaborative Innovation

January 2012

Designing smart partnerships to tackle complex challenges

The acceleration of technological development is changing the way individuals and institutions work, learn, collaborate, and communicate. Additionally, the rise of silo-smashing, multi-disciplinary research is changing the structure of contemporary science. Scientific research that addresses global challenges in health, agriculture, climate change, and water increasingly cuts across disciplinary and geographic boundaries. Collaboration on these challenges demands that researchers learn how to communicate with and contribute to teams composed of multiple disciplines. The Global Knowledge Initiative terms this moment in time *The Collaboration Era*.

While positive changes abound, there are asymmetries still to be addressed. More information is freely available than ever before, but the data deluge and preponderance of resources often hinder locating what is needed. As well, often science, technology, and innovation capacity in the developing world proves insufficient to address local economic and social development issues. Science collaborations commonly exclude scholars in the poorest countries. In the end, those who need critical resources — technological, human, institutional, knowledge-based — to solve problems often cannot find and collaborate with those who have them.

Catalyzing collective action systems to solve complex development challenges requires a new approach that maximizes the benefits offered by global knowledge networks while confronting traditional asymmetries. The Global Knowledge Initiative (GKI), an international nonprofit organization committed to forging, optimizing, and sustaining global collaboration aimed at solving problems requiring solutions based in science, technology, and innovation, designed its LINK (Learning and Innovation Network for Knowledge and Solutions) program for exactly this purpose. LINK helps researchers and others (1) **locate** critical resources required for scientific research, teaching, and innovation to address shared challenges, (2) **enable** equitable collaboration through competitions, trainings, and capacity-building initiatives, and (3) **connect** resource seekers together with the global network of problem solvers to bring solutions to scale. This novel three-phase approach to building purpose-driven networks capable of collaborative innovation is being scaled across Africa, Asia, the US, and elsewhere by the Global Knowledge Initiative, with a third call for LINK challengers commencing in the first quarter of 2012.

LINK Rwanda: Building the 'dream team' to tackle potato taste

Since January 2011, the Dean of the Faculty of Agriculture at the National University of Rwanda (NUR), Dr. Daniel Rukazambuga, and his team of researchers have worked closely with the Global Knowledge Initiative through LINK to address a troubling agro-industrial problem in Rwanda, a taste defect in coffee known simply as "potato taste." Thought to be caused in part by the antestia bug, the potato taste defect jeopardizes both the quantity and quality of Rwandan specialty coffee, one of Rwanda's most profitable industries. Unaddressed, the incidence of potato taste may roll back recent gains experienced in the sector. Fifteen years ago, post-genocide development efforts zeroed in on rebuilding the coffee sector as a critical step forward out of the ashes. The results of such efforts by NUR, SPREAD (Sustaining Partnerships to Enhance Rural Enterprise and Agribusiness Development), PEARL (Partnership for Enhancing Agriculture in Rwanda through Linkages), the National Agriculture Export Board, and the Rwanda Agricultural Research Institute (ISAR), etc. were remarkable: smallholder farmers saw their coffee profits leap from 20 cents per kilo to US $2.00 per kilo, mainly through quality improvements, investments in technological upgrading, and capacity building. Now, these gains are at risk.

Compelled by the urgency of this need, an international volunteer team travels to Rwanda in January 2012 to join the LINK Rwanda coffee research team. Dr. Christian Cilas, head of the Pests and Diseases, Risk Analysis and Control Unit at CIRAD in Montpellier, France,

Dr. Thomas Miller, an entomologist at the University of California, Riverside in the US, and experts from the Global Knowledge Initiative will join the LINK Rwanda team and a diverse stakeholder community from NUR, private sector, government, and beyond. The team's goal: devise a multi-pronged strategy for ridding Rwanda's specialty coffee of the potato taste defect.

Innovative tools for addressing complex challenges

The Global Knowledge Initiative, in partnership with NUR, developed four novel tools to facilitate collaborative innovation among the LINK Rwanda team, and for use with subsequent LINK challenge teams. These tools were designed to (1) clarify the market, business, cultural, and political context underpinning the potato taste challenge to reveal determinants of possible solutions before new partnerships are forged, and (2) establish the baseline of collaboration within the NUR community to ascertain what resources — technological, human, institutional, communication-based, and knowledge-based — current partnerships deliver and what additional resources might be identified through collaboration. Each tool, described below, will be presented during a January 2012 expert workshop as inputs for building effective action-networks to respond to this and future challenges.

- ***Rwanda's National Science, Technology, and Innovation (STI) Context*** offers a broad sweep across Rwanda's innovation system. Often, STI-based development projects and programs are designed and implemented without taking into account the full breadth of factors that constitute a fertile or unattractive innovation ecosystem. To help actors avoid constructing partnerships ill-suited to the unique Rwandan innovation system, GKI undertook a narrative analysis of the national context — business, market, policy, cultural, and STI dimension — in which the potato defect challenge and subsequent STI-based challenges will be solved. This national STI context analysis serves as a tool not only for Rwandan stakeholders, but for possible foreign partners less well-versed in the Rwandan STI context.
- To assist collaborators in understanding the challenge of the potato defect in Rwanda, GKI developed ***Promoting Agricultural Knowledge and Innovation Systems; Ridding Specialty Coffee of Potato Taste,*** which analyzes the potato taste defect in the context of the STI inputs and framework conditions, interactions between stakeholders, and potential outputs that productive collaborative innovation arrangements might render. Again, this is a tool designed to enable the National University of Rwanda team and others to understand the full scope of the potato taste defect challenge, and be empowered to seek out partnerships designed to tackle it efficiently and effectively.
- GKI analyzed the National University of Rwanda's unique technological, human, institutional, collaborative, and knowledge-based resources and needs in the ***NUR Knowledge Partnership Landscape Analysis***. With a unique methodology and information from 25 university stakeholder interviews, the analysis gives collaborators a guide to the benefits, challenges, and opportunities associated with collaborating with the NUR team.
- ***The Global Knowledge Initiative's Challenger Profile*** zeroes in on the LINK Rwandan coffee research team, laying bare available versus needed resources for collaborative innovation around the potato taste challenge specifically.

Taken together, these tools clarify the pathway to partnership necessary to rid Rwandan specialty coffee of the potato taste defect. GKI welcomes feedback on these individual products, and on the locate-enable-connect approach that catalyzes collective action systems to solve development challenges, as implemented through LINK.

The significance of science, technology, and innovation for development cannot be overstated. According to the Organization for Economic Cooperation and Development (OECD), "Continuous technological change and innovation are among the main determinants of productivity growth and as such are necessary conditions for the welfare of nations and regions" (2001).

GLOBAL KNOWLEDGE INITIATIVE

Rwanda's National Science, Technology, and Innovation Context

January 2012

Table of Contents

The Rwandan Innovation System: An Introduction

Rationale for Taking an Innovation System Approach

Putting science, technology, and innovation (STI) to work for development

The significance of science, technology, and innovation (STI) for development cannot be overstated. According to the Organization for Economic Cooperation and Development (OECD), "Continuous technological change and innovation are among the main determinants of productivity growth and as such are necessary conditions for the welfare of nations and regions" (2001). Similarly, the UN Millennium Project Taskforce on Science, Technology, and Innovation asserts:

> *A nation's ability to solve problems and initiate and sustain economic growth depends partly on its capabilities in science, technology, and innovation. Science and technology are linked to economic growth; scientific and technical capabilities determine the ability to provide clean water, good health care, adequate infrastructure, and safe food (2005).*

These needs are even more pressing in least developed countries, where the comparative cost of missing out on the benefits of STI is far higher (Farley et al, 2007).

Taking advantage of STI for development requires a systems-based approach. Dubbed the Innovation System framework by its initial architects some 25 years ago, the perspective acknowledges that a country's innovation performance depends upon many actors, their individual capacity to support aspects of innovation, the linkages that connect them into productive networks, and certain framework conditions. Figure 1 illustrates the Innovation System and the numerous interactions that define it. Strong linkages among its three systems components—inputs and framework conditions, knowledge networks, and system outputs and outcomes—characterize a healthy innovation system (Global Knowledge Initiative, 2012).

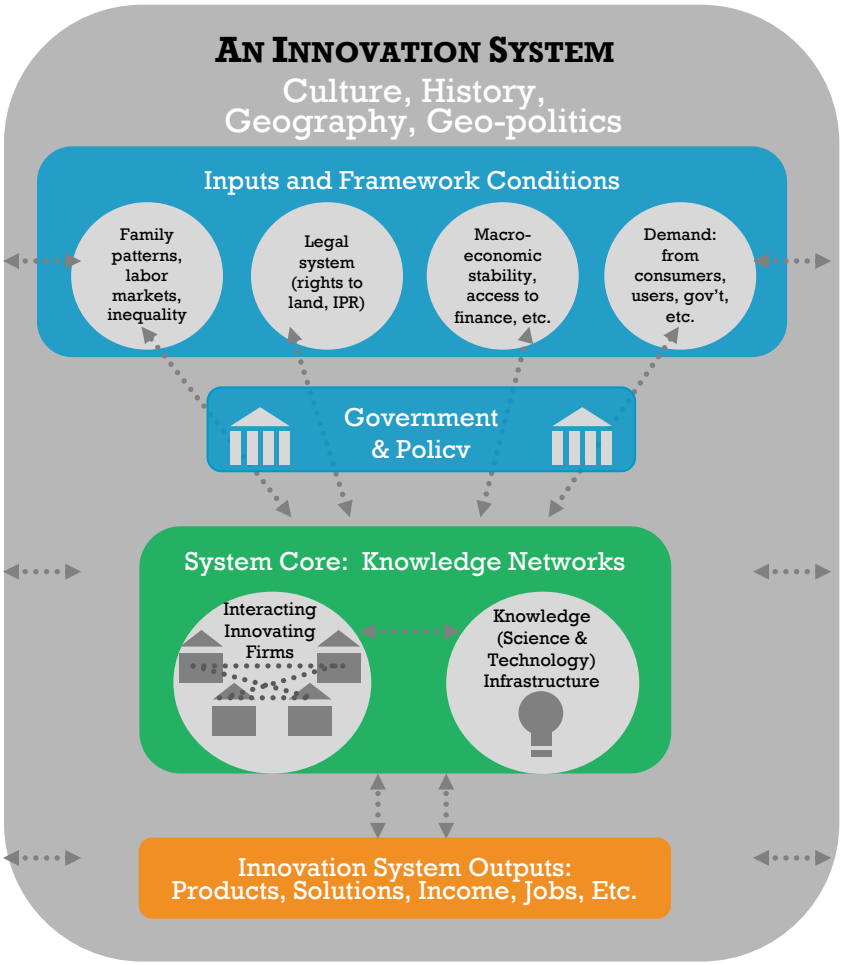


Figure 1: Global Knowledge Initiative, Collaborative Innovation Index, 2012

As this report makes clear through an examination of the Rwandan context, putting science, technology and innovation to work for development demands optimizing linkages, improving inputs and framework conditions, and nurturing knowledge networks.

Taking an Innovation Systems Approach to Solve Complex Challenges in Rwanda

Less than two decades ago Rwanda emerged from one of the worst conflicts in human history that left over 800,000 of its then 7 million citizens dead. Quick to rise from the ashes, today Rwanda boasts one of Africa's most dynamic economies. In large part, the country's commitment to STI sets Rwanda apart from its neighbors. The Government of Rwanda, as led by President Paul Kagame, seeks to transition the country from a traditional agrarian society into a leading knowledge economy. President Kagame and others know transformation is possible through investment in two sectors: human capital and STI. For this reason, Rwanda incorporated STI into its national policy architecture at the highest levels. STI represents a cross-cutting theme in *Vision 2020*, Rwanda's overarching development plan.

> *"Rwanda's development shall ultimately depend on the development of our human resource base and that of the people, with whom we share our destiny … We shall continue to invest in our people and we shall strive to open up frontiers of science, technology, and research as we broaden our trade links with our neighboring countries and beyond."*
>
> - Address by His Excellency Paul Kagame, President of the Republic of Rwanda, Village Urugwiro, January 2005

While Rwanda's gains since the 1994 genocide are impressive, a number of complex challenges facing the small, landlocked country remain. Approximately 58.5% of Rwanda's 11 million citizens live below the poverty line (World Bank Databank, 2011). The skills base of Rwanda remains low: less than 10 percent of the labor force has attained some post-primary schooling, including vocational training (World Bank, Rwanda Skills Project Appraisal Document, 2011). The country's infrastructure, much of which was decimated during the internal conflict, remains wanting. Achieving the aspirations outlined in *Vision 2020* requires analysis to understand two key questions: Is the Rwandan innovation system optimized to address the country's persistent development challenges? If not, how might it be optimized to solve current and emerging challenges, particularly those that require science, technology and innovation for their amelioration?

Purpose and structure of the report

Against this backdrop, the Global Knowledge Initiative undertook a national STI context analysis in Rwanda. The analysis uses an innovation systems framework to examine critical innovation ecosystem components and dynamics: (1) innovation inputs and framework conditions, (2) knowledge networks and interactions, and (3) innovation outputs and outcomes. A description of the content offered within these three pillars follows.

Pillar 1 captures the baseline inputs that contribute to collaborative innovation in Rwanda. These basic conditions allow for more complex relationships further along the continuum from a factor-based economy to an innovation-led one, such as Rwanda aspires to become. Inputs and framework conditions are necessary but not sufficient to fuel an innovation-based

economy (GKI, Collaborative Innovation Index, 2012). Inputs and framework conditions for the sake of this analysis include STI policy and governance, raw human resources, and basic infrastructure.

Pillar 2 illustrates a nation's capability to progress from a factor-based economy to an efficiency-based one (World Economic Forum, 2011). As knowledge networks form and interactions deepen between government, the private sector, and universities, elements such as the availability of high technology products, laboratories, and the ability of the public sector to provide quality control and standards services to small, medium, and large-scale enterprises become essential. As with Pillar I, the indicators in Pillar II—knowledge networks and interactions—help measure a country's advances toward becoming a knowledge economy. Knowledge networks and interactions for the sake of this analysis include knowledge infrastructure, training and transforming human capital, and policies for collaborative innovation (Ibid.).

Pillar 3 captures the innovative products, services, and ideas created as a result of Pillar I's inputs and framework conditions and Pillar II's knowledge networks and interactions. Outputs and outcomes offer the evidence of a country's level of collaborative innovation capacity. For the sake of this analysis, innovation outputs and outcomes include knowledge contributions in terms of internationally recognized papers and patents, firm level investment in research and development, and progress towards specific STI-based economic and social development goals (Ibid.).

Finally, a conclusion section synthesizes the key messages across the three pillars, offering four recommendations for actors seeking to advance Rwanda's strides toward becoming a knowledge economy.

This analysis aims to provide insight for a number of audiences, including newcomers to the Rwandan context who may require background, potential partners seeking information about opportunities and barriers to collaboration, and Rwandans wanting a better understanding of the factors affecting the country's capacity to solve problems and promote development through STI. Laying bare the context for collaborative innovation at the national level inspired this work. Given the diverse audiences for which this analysis is intended, it may be used as a policy input, a planning tool for network construction, and as a reference document to spark broader dialogue and engagement within Rwanda's STI milieu. The report seeks to compress an extraordinary amount of information germane to STI in Rwanda into a digestible length. For readers hungry to explore further any of the topics discussed, a full list of works referenced follows the contents of the report.

Pillar 1 The Rwandan Innovation System: Inputs & Framework Conditions

Pillar 1 *captures the baseline inputs that contribute to collaborative innovation. These basic conditions allow for more complex relationships further along the continuum from a factor-based economy to an innovation-led one. Inputs and framework conditions are necessary but not sufficient to fuel an innovation-based economy (GKI, Collaborative Innovation Index, 2012). Inputs and framework conditions for the sake of this analysis include STI policy and governance, raw human resources, and basic infrastructure.*

STI Policy and Governance in Rwanda

Vision 2020 and the National Science, Technology, and Innovation (STI) Policy

Vision 2020, Rwanda's official development plan, outlines goals for transforming Rwanda from a least developed country to a "middle-income nation in which Rwandans are healthier, educated and generally more prosperous." (Ministry of Finance and Economic Planning, [MINICOFIN], 2000). The plan sets ambitious targets for the country as it continues its recovery from the 1994 genocide. Development targets include achieving an annual Gross Domestic Product (GDP) growth rate of 8% and a per capita GDP of US $875 (ibid).

Statistical Overview of Rwanda

Population: 11,370,425 (2011)

Country Size: 24670 sq km

National languages: Kinyarwanda, French, English

Current GDP growth rate: 7.1% (2010)

Gross national income per capita: $520 (2010)

Official Development Assistance as a percentage of GDP: approximately 14% (2005-2006)

Government effectiveness: Ranked 97th out of 210 countries

Major agriculture exports: Coffee and tea

Recognizing the important role of STI in development, the Government of Rwanda made STI a cross-cutting focus of *Vision 2020.* The government also devised a National STI Policy in 2006 to further outline how the "development of science and technology capacity in Rwanda shall support the development of the people of Rwanda within a prosperous knowledge-based, technology-led economy," (Office of the President, 2006). Figure 2 illustrates how a strong STI foundation supports the achievement of *Vision 2020*.

Four specific policy objectives make up the National STI Policy: (1) knowledge acquisition, (2) knowledge creation, (3) knowledge transfer, and (4) innovation culture. Unlike many other national STI policy statements, Rwanda's forwards an implementation framework outlining near-term actions, including establishing a National Council for STI (NCSTI) to enable cross-sectoral planning and coordination. The policy calls for the placement of STI representatives in each federal Ministry, establishment of District Innovation Centers (DICs) to support small enterprises and manufacturing in rural communities, as well as sustained funding for STI through a National Research Fund. Despite these plans, progress appears to be stalled in some aspects. The operational status of the NCSTI is vague, with only limited information available on its current activities and objectives. STI representatives have not been placed in all of the Ministries, and the 0.5% of the national budget to be used for the National Research Fund has yet to be allocated (Office of the President, *National STI Policy*, 2006). The objectives of the National STI policy are laudable, but the lack of demonstrated progress on a number of fronts points to the

government's challenge of prioritizing among many competing high-level needs. The slow uptake of certain reforms (i.e., making the NCSTI operational) indicates the need to foster a broader base of support for STI reforms beyond the highest political echelons.

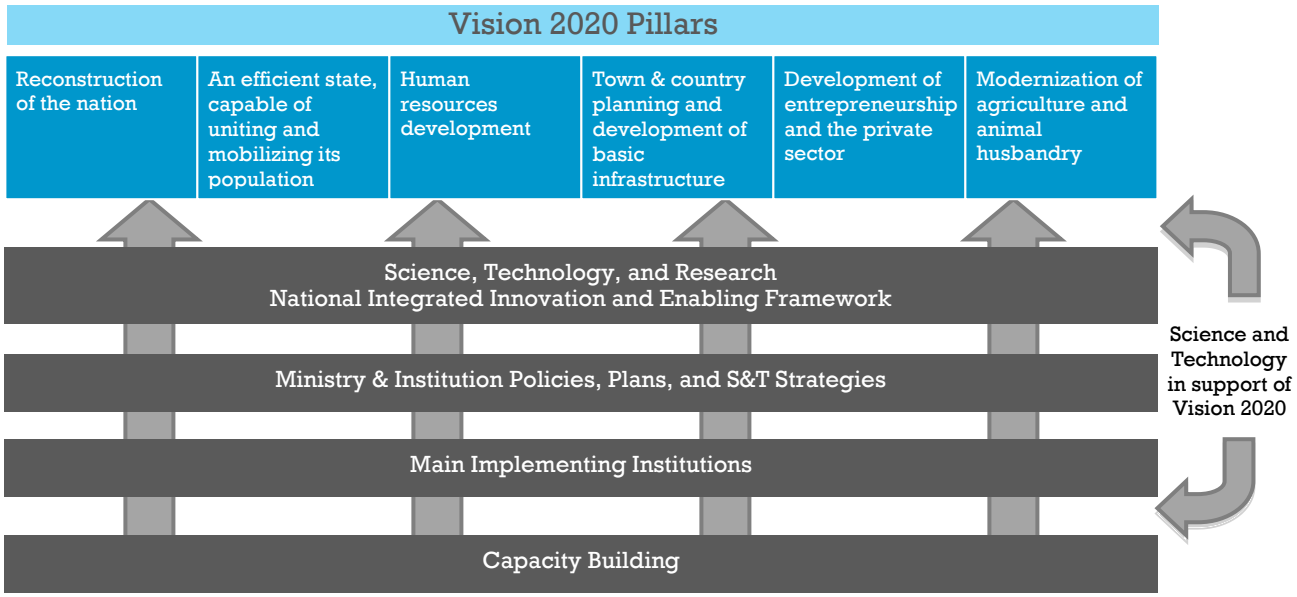


Figure 2: How a strong foundation of Science and Technology can support the development of Rwanda towards Vision 2020 (Office of the President, 2006).

Sector-based science, technology, and innovation policies

Rwanda's 2006 STI policy outlines 13 different sectors in which science and technology should be used to increase productivity and enhance capacity: education, energy, transport, agriculture, information and communication technologies (ICT), geo-information, water and sanitation, biotechnology, industry, private sector, tourism, environment, and health. For each sector, the policy emphasizes research and development (R&D), creating national guidelines, procedures, and standards, supporting entrepreneurship, and promoting new technologies. Agriculture and ICT shine as the two highest priority sectors, as emphasized in both *Vision 2020* and the STI policy. Details on the key STI policies in these two sectors follow.

Agriculture and Animal Husbandry: According to the National STI Policy, "agriculture and animal husbandry is the single most important sector in Rwanda," (Office of the President, 2006). Growing at an average of 4.9% over the past five years, agriculture in Rwanda accounted for 34.6% of GDP in 2010 (World Bank, Rwanda Economic Update, 2011). While the sector is growing, the labor composition is changing: From 2000 to 2006, the percent of the working population engaged in agricultural dropped from 89.5% to 79.5% (ibid). Also, in the past few years, the service sector overtook agriculture in terms of contribution to GDP. These changes demonstrate a shift in the economy away from agriculture and toward services, one of the goals of Rwanda's *Vision 2020* and a signal of a maturing economy.

The 2009 Strategic Plan for the Transformation of Agriculture in Rwanda (PSTA II) elaborates sector-wide actions necessary to achieve the agriculture-based goals of Vision 2020. The Plan seeks to "increase output of all types of agricultural products with emphasis on export products, which have high potential and create large amounts of rural employment; this under is sustainable modes of production" (Ministry of Agriculture and Animal Resources, 2009). Included in this goal are coffee and tea, Rwanda's two most important export crops [*See "Promoting Agricultural Knowledge and Innovation Systems; Ridding Specialty Coffee of Potato Taste: A Collaborative Innovation Case Study" for more extensive analysis*]. From 1997-2007,

coffee and tea accounted for 29% and 22% of all Rwandan merchandise exports, respectively, earning the country approximately US $268 million and US $203 million, respectively, over that time period (UNCTAD, 2010).

Information and Communication Technology (ICT): In 2000, the government of Rwanda created the ICT-led Integrated Socio-economic Policy (ICT4D) for Rwanda. The policy aims to propel the country into a knowledge-based economy over 20 years with four five-year National Information and Communication Infrastructure Plans (NICI). Each plan has its own goals, but together they constitute a comprehensive approach to creating a modern ICT infrastructure for Rwanda.

The first two plans, NICI-2005 and NICI-2010, aim to "support the strengthening of the economic base and improve the economic environment to accelerate development and growth towards achieving an information-rich, knowledge-based society and economy" (Government of Rwanda, 2005). The NICI-2010 in particular emphasized the development of the national ICT backbone and bringing ICTs into the daily lives of its citizens through e-government projects and an electronic identification system. The third plan, NICI-2015 aims to make ICTs integral to business and government services by promoting programs like electronic payment systems, online health insurance information systems, and workflow management (International Telecommunications Union & Rwanda Utilities Regulatory Agency, 2011). The fourth and final plan, NICI-2020, will aim to "consolidate the process towards achieving a middle-income status and an information-rich, knowledge-based society and economy" (Government of Rwanda, 2005). Other important STI policy inputs to the Rwandan Innovation System include the new Intellectual Property Rights policy (2009) and an ICT in Education Policy (2008).

Ministries governing STI

The *Directorate of Science, Technology and Research,* an agency under the Ministry of Education (MINEDUC), oversees science, technology, and research policy (Office of the President, National STI Policy, 2006). The Directorate aims to coordinate research, technological advancement, and innovation with Rwanda's development goals, especially through technology transfer, capacity building, and innovation promotion. To accomplish this task, the Directorate requires that all research and development activities within Rwanda register and be approved by the Directorate. The Directorate acts as the secretariat for National Council of Science, Technology, and Innovation (MINEDUC, Science, Technology, and Research, 2011), as indicated by the figure to the right.

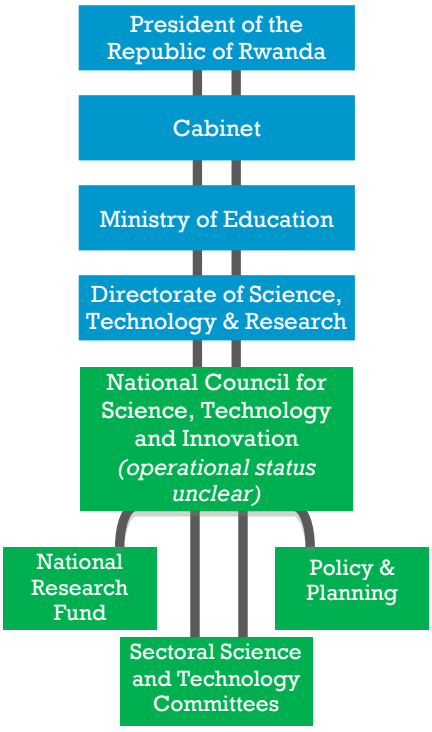


Figure 3: Ma'aji et al, 2009

The *Ministry of Information and Communications Technology* (MINICT), established in March 2006, also plays a major role in STI governance. MINICT falls under the responsibility of the Office of the President (MINICT, 2011). Its mission includes overseeing and coordinating the implementation of national information and communication technology (ICT) programs, including the National Backbone project aimed at constructing a nationwide fiber optic broadband backbone infrastructure (ibid). The table that follows notes additional critical innovation system actors based within the Rwandan government.

Institution	Role
Workforce Development Authority (WDA)	Created to cultivate appropriate technical and vocation skills in the Rwandan workforce, in response to obstacles caused by overwhelming numbers of low- or no-skilled workers.
Ministry of Agriculture and Animal Resources (MINAGRI)	Oversees many of Rwanda's STI-based research, outreach, and application efforts. The Rwanda Agriculture Research Institute (ISAR), for example, carries out research in agronomy, animal, and environmental sciences. It is the apex body for coordinating agricultural research activities in Rwanda.
Ministry of Trade and Industry (MINICOM)	Endeavors to create a dynamic and conducive business environment within the country. Progress can be seen from Rwanda's recent rise in The World Bank's *Doing Business 2012* rankings.
Rwanda Bureau of Standards (RBS)	Inspects laboratories, hygiene standards, personnel qualifications, imported products, and local industries.
Rwandan Development Board (RDB)	Coordinates work between federal ministries to spur development with specific economic clusters. Oversees intellectual property rights (IPR) policy, offers business training, and encourages investment in Rwanda.
Rwanda Investment and Export Promotion Agency (RIEPA)	Promotes both foreign and domestic investment, eases the establishment and development of businesses, and facilitates and assists export-oriented policies and businesses.

Source: Government of Rwanda, 2011

Rwanda's Raw Human Resource Base

Education policies and reforms

Human resource development constitutes a major thrust of *Vision 2020* and a serious challenge facing the Rwandan economy:

The severe shortage of professional personnel constitutes an obstacle to the development of all sectors. Lack of adequately trained people in agriculture and animal husbandry hampers modernization of this sector, whilst a shortage of technicians and competent managers severely constrains the expansion of the secondary and tertiary sectors (MINICOFIN, 2000).

Rwanda's Human Resource Base

Life expectancy at birth: 51.1 (2010)

Primary school enrollment (% of gross): 151% (2009)

Annual national investment in education: 26.9% of total government expenditures went toward public education (2010)

Efficiency of public expenditure in education: 88.7% of public education expenditures went to public education (2011)

Length of basic education: 9 years

Over the last decade, educational reform served as a driving force behind Rwanda's rapid transformation. The establishment of MINEDUC's Non-Formal Education unit targeted the serious problem of illiteracy "so that more citizens could take part in the economic and social transformation of their country" (MINEDUC, *Achievements 2003-2010*, 2010). In just 10 years, the illiteracy rate dropped to 25% (from 48% in 2000), with significant reductions expected in the coming years (ibid). Tackling illiteracy and other basic education needs remains a focus, but as the Rwandan economy transitions from agriculture-based to knowledge-based, educational reforms must address increasingly sophisticated skill needs. With the backdrop of this changing context, the recent Education Sector Strategic Plan (ESSP) 2010-15 places special emphasis on entrepreneurship, ICT, and science education, while also pushing aggressively toward increased access to Technical Education and Vocational Training (TVET). To improve the

science capacity of Rwandans entering the workforce, the ESSP highlights the establishment of science-friendly school environments, the development of higher quality curricula with greater emphasis on science and technology, and increased recruitment of higher quality teachers trained in science and technology. Further, in 2009, Rwanda added a practical skills assessment to the more conceptual, theoretical examinations historically used to evaluate student learning (MINEDUC, *ESSP 2010-2015*, 2010).

> *In Rwanda, education is a top priority because we consider it the key for unlocking our development objectives. All studies have shown that investments in human capital have invariably produced high economic returns. We have no doubt that education empowers people, enlightens them, and in the end creates wealth for them.*
>
> - President Paul Kagame, 2010, in a speech at Greater Atlanta Christian School

Outside of primary and secondary education, Rwanda looks to enhance raw human capacity by expanding the quality and number of TVET and higher education institutions and increasing emphasis on training in STEM (science, technology, engineering, and math) based fields. Pillar II of this study provides an overview of the TVET and higher education systems, including the current status of and priorities for transforming and training Rwanda's human resource base.

Organization of and support for the Rwandan education sector

Rather complex in nature, the Rwandan education system offers a variety of degrees, each requiring differing levels of education from various types of schools to gain entry. Beginning at the primary level, the government requires 9 years of basic education: 6 years of primary school and 3 years of lower secondary school. Rwanda is a positive outlier here: it is the only other country in the East African region besides Kenya to require some secondary level schooling for the general population. Students' scores on government-administered exams largely dictate the path students follow after secondary school. Multiple and varied post-secondary education options exist, as depicted in the table below.

Post-Secondary Degree Pathways in Rwanda	
Degree Name	**Equivalent/Description**
Ph.D.	Doctorate
MA	Masters
A0	Bachelors
A1	College Diploma
A2/D6	Upper Secondary Completed
D7	Lower Secondary + 4 Years in Education, Health, Agronomy or Commerce
D5	Lower Secondary + 2 Years in Education or Health
D4	4 Years of Secondary Education
ENEM	Primary + 2 Years Vocational Training
EMA/ENA	Primary + 2/3 Years Secondary Education
OQ/ CERAR/ CERAI/ ENTA	Various forms of at least some Primary Education with Vocational Training
Source: Ministry for Public Service and Labor and Human Resources & Institutional Capacity Development Agency, 2009	

Education comprises a large part of the Rwandan government budget. In 2010, 26.9% of total government expenditures went to education (UNESCO, 2011). Compared to other East African countries, Rwanda is in the middle of the pack. That same year, Kenya spent 21.3% of government expenditures on education while Burundi spent 27.7% (ibid). Of expenditures from the government, 43% goes directly to the school districts (MINEDUC, *ESSP 2010-2015,* 2010). Data indicates that this investment is paying off. Primary completion rates are on the rise:

in 2008, only 53% of enrolled students completed primary school, but by 2010, the rate rose to 75.6% (MINECOFIN, 2011). Moreover, the transition rate from primary to upper secondary school increased to 90.2% in 2009/10, up from 78.6% in 2008 (ibid). However, even with near universal primary education and a guarantee of three more years of secondary education, the gross enrollment in secondary school languishes at just 26% (East African Community, 2011), a low figure by comparison to regional counterparts, as featured below.

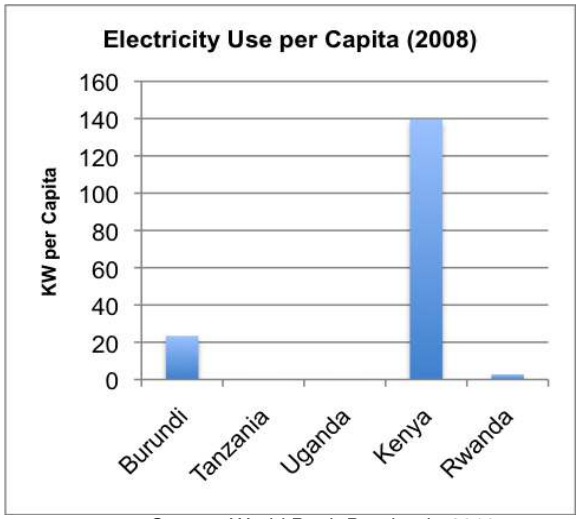
Regional Education Indicators				
	Rwanda	Tanzania	Uganda	Kenya
Primary enrollment (% gross)	129 (2009)	106 (2010)	133 (2009)	110 (2009)
Secondary enrollment (% gross)	26 (2009)	34 (2010)	28 (2009)	45 (2009)
Tertiary enrollment (% gross)	4.8 (2009)	--	4.1 (2009)	4.1 (2009)
Source: East African Community Statistics Database, 2011				

Basic Infrastructure of Rwanda

While the *2011-2012 Global Competitiveness Report* of the World Economic Forum (WEF) ranked Rwanda only 101 out of 139 countries in terms of infrastructure, the country still leads the five-country pack that constitutes the East African Community. The WEF defines well-developed infrastructure as that which connects the national market to other regions at low cost and reduces the negative effect of distance-to-market on economic competitiveness. WEF uses the quality of transport, energy, and telephone infrastructure to determine a country's overall infrastructure rating. Half of the calculation depends on transport infrastructure, including roads, railways, ports, and air transport. The remainder of the calculation accounts for the quality of the electricity supply, number of telephones lines, and number of mobile phone subscriptions (World Economic Forum, 2011). Details on infrastructure for information and communication technologies and scientific research can be found further in the study under Pillar II: Knowledge Networks and Interactions, as these are critical resources for bringing such interactions to life.

Electricity and energy

Two statistics exemplify the challenges Rwandans face due to inadequate and expensive electricity supply: (1) eighty-five percent of Rwandans use wood as their source of energy (Ministry of Trade and Industry, 2011); (2) as of 2011, only 10% of households had access to electricity (Rwanda Development Board, Investment Opportunities: Energy, 2011). Cost is a limiting factor: in 2009, the cost was 24 US cents per kilowatt-hour, over twice that of its neighbor Tanzania at 10-12 cents per kilowatt-hour (Ministry of Trade and Industry, 2011). As Rwanda prepares for the transition to a



Source: World Bank Databank, 2010

knowledge-based economy, the country must address this energy bottleneck. Rwandan businesses suffer an average of 13.59 power outages per month, each lasting over 4 hours (World Bank Group, 2006). The Sub-Saharan Africa regional average is 10.45 power outages a month, though they are typically longer by about 2 hours than those in Rwanda. In total, power outages cost Rwanda businesses 8.7% of sales, compared to 9.2% in Tanzania, and 10.2% in Uganda (ibid).

Alternative energy offers a potential opportunity for Rwanda. The country enjoys considerable hydroelectric potential, as well as an estimated 55 billion cubic meters of renewable methane gas deposits in Lake Kivu (Rwanda Development Board, *Investing in Rwanda – An Overview 2010*, 2010). However, a lack of infrastructure stymies progress. Investments are being made, but slowly. The first phase of a US $16 million project to extract gas from Lake Kivu is underway with plans to expand production to 100MW (Rwanda Development Board, Investment Opportunities: Energy, 2011). Additional investments are planned. Construction of hydropower plants is underway in Rwanda, including the large Nyabarongo plant, which is expected to generate 27.5 MW. Additionally, the Ministry of Infrastructure reports that, in the last three years, at least 28 micro-hydroplants have been built or are under construction or assessment (Ministry of Infrastructure [MININFRA], 2008).

Transport infrastructure

Roads: A landlocked country, Rwanda relies on a reliable and safe road system to access and strengthen the country's domestic and external markets. Major roadways between urban centers are relatively well-maintained; however, outside of these major thoroughfares, poor and sometimes non-existent roads make many rural areas difficult to reach. National paved roads comprised only 24% of Rwanda's road systems as of 2008 (Ministry of Trade and Industry, 2011). Poor rural road infrastructure, combined with the fact that an estimated 50% of the country's population lives more than an hour from a major market, constitute constraints for the Rwandan economy in terms of trade access and value chain integration. The average cost to export in Rwanda is US $3275 per container; inland transportation and handling accounts for over half of this bloated figure (World Bank, *Doing Business 2012,* 2011). Comparatively, the average cost of exports for the rest of Sub-Saharan Africa is a far lower at US $1960 per container (ibid).

Airports: Rwanda boasts six airports, two of which are international. In total, the country's airports transport about 150,000 passengers per year. The most common route in and out of the country is Kigali airport via Nairobi, Kenya. The Government of Rwanda invested US $635 million in a larger Bugesera International Airport located 40 kilometers outside of Kigali (Rwanda Development Board, Investment Opportunities: Infrastructure, 2011). They plan to open the Bugesera airport by 2016 and expect the facility to accommodate 3 million passengers per year (Government of Rwanda, *Request for Expression of Interest*, 2011).

Transport Alternatives: There is no railway in Rwanda. In 2009, as part of a larger regional infrastructure construction effort, the African Development Bank approved US $8.15 million in funds to study the feasibility of building a railway from Isaka, Tanzania to Kigali, rehabilitating the Dar-es-Salaam to Isaka line, and constructing a separate line from Tanzania to Burundi (African Development Bank, (2009). Estimated costs for this regional infrastructure initiative top US $5 billion and financing is expected to come through public-private partnership (Rwanda Development Board, Investment Opportunities: Energy, 2011). Sources currently conflict regarding the progress of the study and subsequent construction. Some water transport is taken on Lake Kivu, which connects Rwanda to the Democratic Republic of the Congo. It primarily consists of small, chartered boats that seldom run. In 2009, feasibility studies for daily water transport project on Lake Kivu for 15-20 tons of cargo and 120 passengers with two

ships were conducted. Despite the need, the project did not go forward because of the lack of maritime regulations and the lack of a navigation chart for Lake Kivu (Hansen, 2009).

Cold storage and value addition infrastructure

As of 2008, Kigali airport supplied 30 tons of cold storage capacity (Rwanda Development Board, 2010). Used primarily for exporting horticulture products, including flowers, fruits, and vegetables, Rwanda plans to increase its currently limited cold storage capacity in the coming years (*East African Business Week*, 2011). In April 2011, as part of the Global Agriculture and Food Security Programme and the current Land Husbandry, Water Harvesting and Hillside Irrigation Project, the World Bank promised US $50 million to Rwanda to improve the productivity, water and land management, and value chains surrounding Rwandan agriculture. Phase One of the World Bank project includes cold storage facility construction (Government of Rwanda & World Bank, 2011; World Bank, 2009).

The commodity sectors in which Rwanda has developed some capacity for value-addition include several export-oriented crops, specifically coffee, roses, and pyrethrum (a naturally-occurring insecticide derived from chrysanthemums). Investors also have shown interest in expanding value-addition to herbs, silk, essential oils, and specialty vegetables (World Bank, *Building Science Technology and Innovation Capacity in Rwanda,* 2008). Enhancing the value of many Rwandan products requires increasing capacity across Rwanda for improving market knowledge, agricultural research, firm-level management, and postharvest processing. The World Bank's Alfred Watkins and Michael Ehst, in particular, emphasize Rwanda's opportunity to develop a strong food-processing capacity, which in turn would contribute both to enhancing food security and increasing incomes for stakeholders along the value chain. Low technical and technological capacity of farmers, business staff, and training institutions constrain these efforts presently (World Bank, *Building Science, Technology, and Innovation Capacity in Rwanda,* 2008).

Water

According to the Government of Rwanda, only 76.2% of Rwandans have access to safe drinking water within 500 meters in rural areas and 200 meters in urban areas (MINICOFIN & IMF, 2011). The government estimates daily consumption of water at 8.15 liters per person in rural areas, far below the international standard of 20 liters (MINICOFIN, 2000). Somewhat counter-intuitively, Rwanda's water scarcity does not derive from a lack of natural endowment. The country possesses reserves sufficient to provide water for domestic consumption and agricultural purposes due to substantial rainfall (between 900 & 1800 mm per year) and abundant lakes and waterways. Rather, the constraint is weak infrastructure to provide access to potable water at scale. The Ministry of Infrastructure reports that in 2004, Rwandans only used 12.22% of all available water resources (MINIFRA, 2008). Eighteen water treatment plants, largely serving urban areas, clean the water for the country, with just 32% of Rwandans obtaining water from a tap, and a mere 3.4% with direct, private access to that water source (ibid).

Pillar 2 The Rwandan Innovation System: Knowledge Networks & Interactions

Pillar 2 *illustrates Rwanda's capability to progress from a factor-based economy to an efficiency-based one (World Economic Forum, 2011). As knowledge networks form and interactions deepen between the government, the private sector, and universities, elements such as the availability of high technology products, laboratories, and the ability of the public sector to provide quality control and standards services to small, medium, and large-scale enterprises become essential. As with Pillar I, the indicators in Pillar II — knowledge networks and interactions — help measure a country's advances toward becoming a knowledge economy. Knowledge networks and interactions for the sake of this analysis include knowledge infrastructure, training and transforming human capital, and policies for collaborative innovation (Global Knowledge Initiative, Collaborative Innovation Index, 2012).*

The Knowledge Infrastructure of Rwanda

ICT infrastructure

Knowledge Infrastructure Statistics:

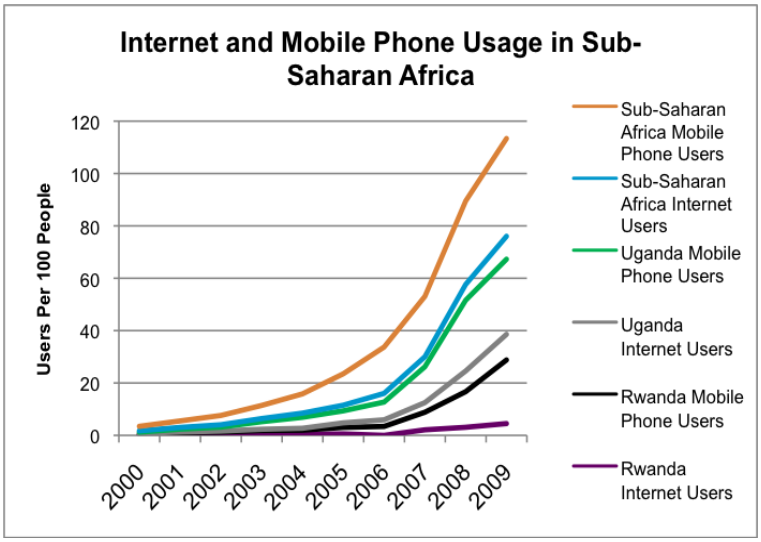
No. of cell phone subscriptions: (per 100 people): 33.4 (2010)

No. of Internet users (per 100 people): 5.3 (2010)

Average Internet bandwidth per user: 2008 bit/s (2010)

No. of fixed telephones (per 100 people): .37 (2010)

The government's commitment to the ICT sector has spurred substantial progress in terms of infrastructure investment and Internet and telephone access. For example, in 2007, the government re-invested 40% of the US $100 million profit made by the government-owned *Rwanda Telecom* into the country's ICT infrastructure (World Bank, Regional Communications Infrastructure Program Project Appraisal Document, 2008). Buttressed by this and other investments, the Government of Rwanda announced the completion of the nationwide 2,300-kilometre fiber-optic cable in early 2011 (Tafirenyika, 2011). The cable, which covers the entire country, connects with the Seacom undersea cable along the east coast of Africa and has a total of 7 regional links to neighboring countries (Tafirenyika 2011; Rwanda Development Board, 2010). Other ICT-based projects include the construction of a National Data Centre and Regional Communication Infrastructure (Rwanda Development Board, Departments: Information and Communication Technologies, 2011).



Source: World Bank Databank, 2010

Despite these investments, much work remains, as indicated in the figure to the left. In terms of mobile phone use, in 2010 Rwanda had only 33.4 mobile users per 100 people while Uganda had 38.38

and Kenya an impressive 61.63 per 100 people (International Telecommunications Union [ITU], 2011). These rankings reveal that while Rwanda's performance is not atypical for the region, it still lingers at the bottom of the global pack (World Economic Forum, 2011).

Notorious on the African continent for its impressive growth in terms of Internet user growth, Rwandans' appetite to connect is unmatched. In terms of Internet use in 2010, Rwanda's Internet users total just over 530,000, or about 5.3% penetration as a percentage of population (UNESCO, 2011). This constitutes a higher penetration than in Tanzania (676,000 users with 1.6% user penetration in 2010) (ibid). While the gross user rates in Rwanda may not seem spectacular, the growth rates are: Rwanda experienced an 8900% growth in the Internet user base in 2010, compared to 1900% growth in Kenya and 488% growth in Tanzania (ibid). As well, Internet bandwidth is exploding in Rwanda: In 2010, the country had 2008 Bit/s of Internet bandwidth per Internet user, compared to Uganda's 822 and Kenya's 1928 Bit/s of Internet bandwidth per Internet user (ITU, 2011).

Laboratory infrastructure

A 2009 joint study by the African Development Bank and the Rwandan Ministry of Science and Technology investigated the quality of laboratories and scientific infrastructure in both private sector firms and public institutions of research and higher education. The report found that of the eight institutions of higher education surveyed, seven have "fairly adequate academic staff capable of research and development" (Ma'aji et al, 2009). The table below provides the lab infrastructure assessments given in the report. The study found most Rwandan institutions bereft of modern equipment and lacking either adequate funding and/or coordination mechanisms to promote regional collaboration with relevant private sector industries (ibid).

Data Analysis on Higher Learning Institutions & Research Institutes in Rwanda			
Institution	**Laboratory Facilities**	**Workshop Facilities**	**Relevant STI Discipline(s)**
National University of Rwanda (NUR)	Fairly adequate	Inadequate	Applied & Pure Sciences, Engineering Technology
Kigali Institute of Science and Technology (KIST)	Inadequate	Inadequate	Engineering Technology
Kigali Health Institute (KHI)	Adequate	Not applicable	Health (medical)
Kigali Institute of Education (KIE)	Data not available	Data not available	Teacher training
Institute of Agriculture and Animal Husbandry (ISAE)	Very adequate	Not adequate	Agriculture, Animal Husbandry
Agricultural Sciences Institute of Rwanda (ISAR)	Adequate	Not applicable	Agriculture
Science and Technology Research Institute (IRST)	Very adequate	Adequate	Technological innovation (research projects)
Source: Ma'aji et al, 2009			

The same report analyzed the research and development facilities of 18 private sector companies. While potential exists for these companies to participate in research and development, most suffer from little to no funding, meaning the labs are underutilized and primarily used for quality control. However, the story varies somewhat by sector. The ICT and energy-supply companies surveyed in the study offer the greatest potential as research and development partners. Both have adequate facilities with research and development capacity (ibid).

Innovation Centers

A key thrust of the National Science, Technology, and Innovation Policy is the development of Innovation Centers. Envisioned as institutional linkages between fledgling entrepreneurs and the resources (e.g., facilities, administrative and training services) they require to develop, market, and eventually sell their ideas, the "Business Development Centers," (BDCs) also known as community innovation centers, are designed to tap innovation and creativity in the Rwandan community (UNECA, 2011). Overseen by the Rwanda Development Board, the BDCs will serve as "central innovation and entrepreneurship hubs that will identify challenges and opportunities in society and seek ways to address them" (ibid). Each of the country's 30 districts will have at least one BDC that will provide a range of services focused on developing small and medium-sized enterprises. While a number of "community innovation centers" and district telecenters exist in Rwanda, it is unclear whether these centers are official BDCs or will be transitioned into BDCs at a later date. For example, the community innovation center in Bugesera, which opened in July 2010, supports farmers and entrepreneurs through business development education and cooperative management training (United Nations News Center, 2010). In a second example, the Rubona Innovation Center, with a planned location near the campus of the National University of Rwanda, will respond to needs of the Rubona community by addressing challenges in the prevalent dairy, cattle, and fisheries markets.

In addition to the innovation centers, the government is in the pilot phase of developing an ICT TechnoPark in Kigali (Rwanda Development Board, Investment Opportunities: ICT, 2011). Through the ICT TechnoPark, which represents a strategic partnership between the Government of Rwanda, Carnegie Mellon University and the African Development Bank, proponents seek to "position Rwanda as the East African Centre of excellence on information and communication technology… attract foreign direct investment and create high valued jobs" (ibid). With an expected cost of about US $115 million, as of 2010, construction on the ICT Park was stalled due to lack of funding (ibid).

Training and Transforming Rwanda's Human Capital

Labor market profile and needs assessment

As noted previously, the Government of Rwanda understands that through education and skills development, Rwanda's human resource base can transform into the engine of a knowledge economy. Specifically, the government realizes its citizens require proficiency in math and science because, now more than ever, they enter labor markets that "increasingly demand modern knowledge and skills, readiness to take initiatives, and ability to solve problems and to innovate products and processes," (Ottevanger et al, 2007). In today's rapidly changing global economy, the critical economic development issue is no longer whether countries should build

Statistics on Rwanda's Trained Human Capital Base:

Tertiary enrollment (% of gross): 5% (2009)

Tertiary STEM students in public education (% of total): 56% (2010)

TVET enrollment: 16% (2011)

Ph.D. holders at higher education institutions (% of university staff): 25% (2009)

STI capacity, but what type of capacity to build and how to build it, given each country's constraints and unique starting points (Watkins and Ehst, 2008).

Over the past decade, the Government of Rwanda has made significant strides in STI-based capacity building. However, because of the long-term nature of the returns on these investments, the labor market profile still largely reflects that of a traditional agriculture-based economy. Agriculture constituted the focus of 76.7% of the workforce (in 2006 figures). Of this cadre, 71.3% are non-wage or subsistence farmers (World Bank, 2009). Of those remaining, 18.2% work in services with just 5.1% in manufacturing, according to 2006 figures (ibid). Most workers in Rwanda lack formal education. Only 2% of agricultural workers accessed the formal education system after the primary level (World Bank, Skills Project Appraisal Document, 2011). In the private manufacturing and service sectors, the percentage of people with post-primary educational attainment rises to 22%. Of the public sector, which comprises only 3% of the Rwandan workforce, 57% studied beyond primary school (ibid). These statistics are telling: a Rwandan worker who completed lower secondary school earns a wage that is on average 46% higher than their counterpart with only a primary-level education. The differential between salaries of TVET (technical and vocational education and training) graduates and primary school leavers is even larger, with TVET graduates making an average of 73% more than their counterparts who did not attain TVET certificates (World Bank, Skills Project Appraisal Document, 2011).

The need for skills reverberates across the Rwandan economy. A 2009 skills audit conducted by the Rwanda Private Sector Federation found that Rwanda suffers from a 40% short-term skills gap, indicating a 40% difference between available and required skilled labor (Ministry for Public Service and Labor and Human Resources and Institutional Capacity Development Agency, 2009). The biggest labor gaps exist in the private sector and for technician-level workers. Rwanda has only 42.2% of the technicians and 53.3% of the professionals it needs on a national level. When looking at the private sector in isolation, the skills gap widens. The private sector has only 17.4% of its needed technicians and 24.9% of professionals (ibid). Additionally, a lack of high-level technical staff often restricts Rwandan firms' capacity to plan for and realize an advanced research and development agenda (Ma'aji et al, 2009). Many companies do not employ such highly skilled personnel due to the associated high costs. Instead, they choose to employ mid-level staff like technicians. Thus, gaps experienced on multiple skill levels limit the productivity potential of Rwanda's private sector.

Technical and vocational education and training (TVET)

Rwanda's TVET system offers a vehicle for enhancing the Rwandan labor force's skills; however, demands for skill-upgrading outstrip the system's current capacity to meet them. Approximately 170,000 Rwandans enter the work force unqualified for work each year (African Development Bank & Organization for Economic Cooperation and Development, 2008). In 2009, TVET schools accommodated approximately 50,000 students (ibid). Beyond the question of access, business representatives question the quality of education in the TVET system. In 2008, the government reported that only 52% of employers express satisfaction with the job performance of those who receive TVET training and 54% percent of employers stated they would prefer on-the-job training for their workers (MINEDUC, *TVET Policy*, 2008).

Recognizing the massive skill gap in the current labor force, the Rwandan government declared TVET an educational priority in *Vision 2020*. The goal is for TVET to receive 2.3% of the national budget by 2012. With distribution of public expenditure on post secondary education at 11.2% of total education spending, Rwanda is on its way to accomplishing that goal (UNESCO, 2011). The Government of Rwanda also established a goal of increasing the absorption rate of TVET graduates into industry from 25% in 2006 to 75% in 2012 (MINEDUC, *TVET Policy*, 2008).

To oversee these changes to TVET education, the government created the Workforce Development Authority (WDA) in 2007. The WDA aims to create around 100 training schools and 12 technical schools throughout the country to expand access to TVET training opportunities (ibid). The National TVET Policy, put forth in 2008, also outlines several major areas of reform, including the creation of a national TVET qualifications framework, setting national occupational standards, promoting "job-makers" through business incubation and improved labor market information, and enhancing technical school teachers' qualifications. With these changes, Rwanda places itself on the vanguard of TVET system reformers in the region. A 2011 Ministerial Forum entitled "A Regional Exploration of Pathways Toward Harmonization of Math and Science Curriculum in the East Africa Community" highlighted Rwanda's laudable effort to research the needs of industry and to align post-basic curricula with those needs. (World Bank, *Harmonizing Secondary Math and Science Curriculum in East Africa*, 2011).

Tertiary STEM (science, technology, engineering, and math) education

The Government of Rwanda has stimulated higher education through legislation and policy over the past six years, especially in STEM-based fields. The table below provides an overview of institutions created in response to the country's growing demand for higher education. In 2009, only 5% of Rwandans within the age range of a typical university student pursued higher education in Rwanda. The Education Strategic Plan 2010-15 states that 56% of these students at publicly funded universities study science subjects (MINEDUC, 2010).

Institution / Policy	Description
National Council for Higher Education (NCHE)	Created by the 2005 Higher Education Law; responsible for creating national university qualifications and enforcing those standards though accreditation
Student Financing Agency for Rwanda (SFAR)	Created by the 2005 Higher Education Law; provides loans, grants, and scholarships to qualified students pursuing higher education, especially those from low-income families and those studying education or science
National Research Council (NRC)	Aligns and supports Rwandan research towards national development goals; requires that each higher education institution develop a research component with relevant infrastructure and equipment
2008 Higher Education Policy	Emphasizes building science and technology capacity, incorporating ICT into learning systems, supporting research, innovation, and knowledge transfer, and sustaining collaboration among universities and between universities and private corporations
MINEDUC, Achievements 2003-2010, 2010	

Rwanda is home to 20 institutions of higher education, including two universities dedicated to STI-based teaching and research. These are the National University of Rwanda (NUR) and the Kigali Institute of Science and Technology (KIST). KIST, Rwanda's first technological institute, was created as the national focal point for STEM training. It offers degrees in computer engineering and information technology, civil engineering and environmental technology, and applied sciences and mathematics, among others (KIST, 2011). One major advantage KIST brings to Rwanda is its Center for Innovation and Technology Transfer, which creates technologies and increases their use in communities throughout the country. Despite its mandate for science and technology and its new laboratory facilities, KIST lacks the research funds needed to perform the full span of research and development activities to which it aspires (Ma'aji et al, 2009).

The National University of Rwanda (NUR), the host institution of the Global Knowledge Initiative LINK team (Learning and Innovation Network for Knowledge and Solutions), is the country's largest university. Specializing in STEM subjects such as water resources and environmental

management, agro-forestry and soil management, ICT, medicine, and agricultural sciences, NUR aims to be the engine behind Rwanda's emerging "entrepreneurial and innovative economy" (NUR, 2011). Currently, the university employs 535 research and academic staff, of which 16% have their Ph.D. and 22% are in training for their Master's or Ph.D. The university is currently training 700 post-graduate students, the majority of whom study STEM subjects. NUR faculty and staff often are looked to as the domestic knowledge trust, and frequently serve as government advisors and consultants on development aid projects. In 2011, the Global Knowledge Initiative conducted a series of extensive interviews with NUR faculty, staff, and students, primarily from the Faculty of Agriculture, to begin establishing a collaboration baseline for the Faculty and NUR more broadly. Preliminary results of the primary research effort are available in GKI's *National University of Rwanda Knowledge Partnership Landscape Analysis* (2012).

Policies for Collaborative Innovation

Collaborative innovation stakeholders

In Rwanda, the government represents the largest and most active promoter of collaborative innovation. It puts forth a host of polices, incentives, and approaches aimed at creating an environment conducive to knowledge sharing and partnership. Explored in the following sections, many of these policies and incentives target the private sector as the key beneficiary. According to Rwanda's 2011 Industrial Policy, "public–private partnerships are an essential aspect of STI capacity building. The Government of Rwanda has an indispensable role to play in supporting essential research, providing basic education, and creating an environment that will enable the private sector to create the jobs that will diversify the economy and generate wealth" (Ministry of Trade and Industry, 2011).

Enabling Collaborative Innovation in Rwanda

Total R&D staff in Rwanda: 1001 (2009)

Ease of Starting a Business ranking: 8/183 (2012)

Average number of days to start a business: 3 (2011)

Foreign Direct Investment (FDI) (% of GDP): 2.28% (2009)

Tax deduction for R&D: 100%

As noted in the introduction, interacting firms constitute critical actors in a robust innovation system. Available data depicts a Rwandan private sector that is growing and consolidating from a small and increasingly outward-oriented base. In 2009, Rwanda's private sector contributed over 50% of government revenues. In 2010, over 3000 new businesses registered in Rwanda. However, to truly flourish, the private sector requires "access to technological know-how and established distribution channels abroad" (World Bank, *Rwanda Economic Update*, 2011). A few established organizations exist to address just this need. The Rwanda Private Sector Federation, the most notable private sector support organization in the country, "promotes and represents the interests of the Rwandan business community" through advocacy, networking, and capacity building initiatives. Producer associations also constitute important private sector stakeholders, especially in promoting agricultural knowledge transfer and enterprise development. Producer associations tend to organize by sector. For example, there are more than 15 cheese processors' associations active in the in Rwanda's dairy sector (Ratumu, 2009).

As in many developing countries, a significant amount of innovation in Rwanda occurs outside of formalized mechanisms. In 2006, Rwandans operated over 600,000 household enterprises

and employed over 700,000 individuals, far more than the 72,000 private sector enterprises formally reported (Institute of Policy Analysis and Research-Rwanda [IPAR-Rwanda], 2010). According to the IPAR-Rwanda, "the majority of household enterprises are not registered for local taxes and operate from residential homes or no fixed location, but they play a key role in poverty reduction and the creation of non-farm employment." While these ventures often go "unrecognized and unrepresented" in formal linkage and development strategies, they typically represent "dynamic enterprises that engage in intensive innovation processes in order to satisfy customer demand and expand their markets" (Kraemer-Mbula & Wamae, 2010). Capitalizing on the innovation capacity of such informal enterprises requires targeted, inclusive strategies to integrate them into formal value chains.

Universities and national research institutions serve as important sources of new knowledge within Rwanda. Many of the country's "knowledge institutions" conduct research and create new technologies, often in reasonably well-equipped labs or workshops. However, a number of factors hamper the transfer of that knowledge, whether in the form of research or technology, from the lab to local businesses or into agricultural production processes, etc. Among the many reasons for this disconnect, the system suffers from a scarcity of individuals responsible for facilitating this transfer process. In agriculture, for example, the ratio of farmers to extension officers is 13,000 to 1 (World Bank, 2009). Second, sectors tend to exist in isolated domains, or silos, with little interaction between and among them. Efforts to improve sectoral and disciplinary interaction within the Rwandan innovation system appear to be underway, such as through the District Innovation Centers and TechParks. In a further example, the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM), a consortium of 29 universities in Eastern, Central, and Southern Africa of which NUR is a member, aims to expand the continent's pool of agricultural researchers and policy professionals while also better connecting those professionals to the farmers and communities they seek to serve (RUFORUM,

Agricultural Research and Training in Rwanda: A Case Study in Collaboration

According to the International Food Policy Research Institute (IFPRI), "collaboration among national agencies and with regional and international agencies continues to be a significant aspect of agricultural research and development in Rwanda" (2010). The Rwanda Agricultural Research Institute (ISAR) collaborates on joint projects with universities like the National University of Rwanda, as well as with centers of the Consultative Group on International Agricultural Research (CGIAR). Rwanda also participates in the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and the Forum for Agricultural Research in Africa (FARA).

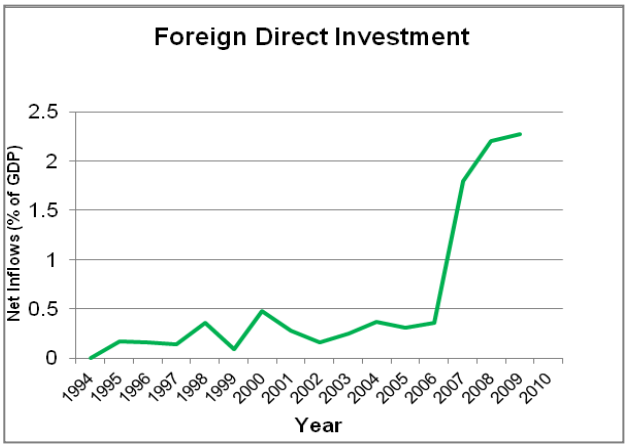
In 2009, investment in agricultural research in Rwanda totaled 3.6 billion Rwandan francs (US$ 19.2 million PPP dollars), or an investment of $0.51 in agricultural R&D for every $100 of agricultural output in Rwanda. This limited budget is dependent on donor and development bank funding (IFPRI, 2011). Donors include the Belgian Development Agency (BTC); the Food and Agriculture Organization of the United Nations (FAO); DFID; the Swedish International Development Cooperation Agency (SIDA); the Alliance for a Green Revolution in Africa (AGRA); the Rockefeller Foundation; the governments of Germany, the US, and the Netherlands; and the CGIAR centers. Even with this high level of participation from international organizations and donors, opportunities for improvement remain. IFPRI notes the need to focus investments on raising staff qualifications, as well as improving the translation of research results in agricultural development outcomes (Flaherty & Munyengabe, 2011). In sum, while many partners already congregate in Rwanda's agricultural innovation domain, without better collaboration between research, training, producer, and user communities, knowledge generated will not translate into innovations of the kind needed to promote environmentally sustainable economic development.

2011). A brief overview of other partnerships focused on delivering results in agricultural research and innovation follows in the textbox above.

International partners and donors represent another important group of collaborative innovation stakeholders in Rwanda, as depicted in the previous textbox. Many have long-standing partnerships with Rwanda, while others emerged more recently. For example, the development of the Rwandan ICT sector benefits from significant support from Korean telecommunications firms. Additionally, Rwanda's ties with China and India appear to be increasing in number and value. In 2009, Chinese companies operating in Rwanda completed projects totaling almost US $500 million within Rwanda's borders. Ties between the two countries are expected to increase over the next few years, with collaborations in power plant construction, road infrastructure improvement, and distribution of ICTs under discussion. Rwanda's partnership with India dates to the 1990's when a series of cooperative agreements led to a number of technological and economic collaborations. Education represents an important focus of the bilateral relationship, over 500 Rwandan students have received post-secondary training in India (World Bank, *Rwanda Economic Update*, 2011).

Policies to encourage private investment in STI in Rwanda

Rwanda actively recruits STI-based investors to finance various activities. Rwanda's open Foreign Direct Investment (FDI) Policy opens the door for such solicitation. Currently, there is no restriction on FDI entry and establishment. The government treats foreign investors as nationals and screens neither the amount nor the sector of investment. Levels of investment, though relatively small by global standards, are rising. Net annual FDI inflows averaged US $33 million in 2001-2004, growing tenfold to US $372 million in 2005-2008 (Ministry of Trade and Industry, 2009).



Source: World Bank Databank, 2010

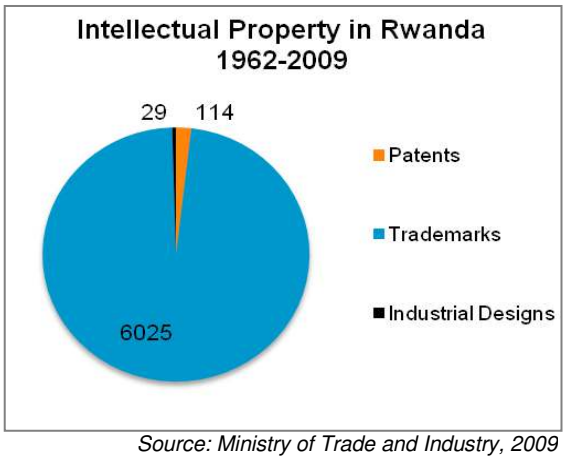
Beyond flexible FDI arrangements, Rwanda encourages business development and investment by offering three types of special economic zones: single export-processing zones, export-processing zones, and free trade zones (Rwanda Development Board, 2005). Considered the "flagship of Rwanda's incentives regime," companies that meet certain criteria are eligible for free economic processing zone benefits, including duty exemptions on plants, machinery and equipment and value-added tax (VAT) exemptions on imported raw materials (Rwanda Development Board, 2005). In the free trade zone in Nyandungu, for example, the government is enhancing the roads and electrical systems to connect the zone and the current Kigali Industrial Park (MINECOFIN, 2011).

Intellectual property rights (IPR) policies and processes

Rwanda adheres to the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), signifying alignment with international intellectual property rights (IPR) standards. The government recognizes three forms of intellectual property: patents, copyrights, and utility models. Rwanda considers intellectual property rights as private rights, thus the state is not charged with the defense of such rights. However, Rwandan law provides for civil action against infringement of rights, injunctions, and criminal penalties for violation of IPR. The Rwanda intellectual property law also prohibits circumventing technological protection measures. In 2008, the government created the Commercial Court branch of the High Court of

Rwanda to render verdicts in matters germane to IPR and other commercial issues. As of 2008, no cases had been brought before it (Ministry of Trade and Industry, 2009).

In 2009, the country rewrote its IPR policy, moving IPR administration to the responsibility of the Rwandan Development Board (RDB), which is also responsible for registering and administering matters related to companies and secured transactions. Due to low capacity, low patent application rate, and the high costs of intellectual property examination and registration, Rwanda applied to and successfully joined the African Regional Intellectual Property Organization (ARIPO) under the Harare Protocol in September 2011. This means that any patent registered in an ARIPO member state is also valid in Rwanda (Harare Protocol, 2007).



Source: Ministry of Trade and Industry, 2009

Since the country gained independence in 1962, Rwanda has registered 114 patents, 6025 trademarks, and 29 industrial designs, granted to both Rwandan nationals and foreigners (Ministry of Trade and Industry, 2009). Patent applications are on the rise. In 1996, Rwanda received 673,342 patent applications, and by 2006, that number jumped to 994,324 (World Bank Databank, 2011). Granted for 20 years, patents require an annual renewal fee. Royalty and licensing fees only recently began contributing to Rwandan revenues. From 2000-2010, the country received a total of US $62,083,320 in royalty and licensing fees, of which 99% was raised in 2008 alone (ibid). The 2008 spike was largely due to unexpected revenue from the telecommunication company TIGO license fees that totaled approximately US $61,000,000 in 2008 dollars (MINICOFIN, 2011).

Knowledge transfer policies and processes

In the recent past, weak internal knowledge transfer characterized the Rwandan innovation system. While the World Economic Forum (2011-2012) ranked Rwanda 48th out of 139 economies in terms of FDI and technology transfer, the United Nations Development Programme (UNDP) ranked Rwanda very low in terms of diffusion and creation of technology as a percentage of its GDP (Ma'aji, 2009). Such a difference in international rankings reveals that Rwanda is capable of attracting external investment, but is less able to catalyze it into domestic innovation.

> *"We have seen time and again that neither business nor government alone can flourish without the other. Government support enhances strategies to foster private sector growth and sustainable economic development … But it is only in partnership with business that wealth creation commensurate with the needs of the people, as well as prosperity, will happen.*
>
> - President Paul Kagame in a speech at the Africa Commonwealth Business Council, October 2011

Like many developing countries, Rwanda imports a large majority of its advanced technologies from other parts of the world. In doing so, it increases opportunities for technology transfer within its borders, but it is unclear if Rwanda fully exploits the opportunities presented by foreign knowledge transfer. In 2006, only 1.31% of Rwandan firms used technology licensed from foreign companies, much lower than the 12.38% of firms within the rest of Sub-Saharan Africa (World Bank Enterprise Survey, 2006).

Unsatisfied with the status quo, Rwanda's President Kagame issued a challenge to the country's university community in 2011: become "active agents of development" by integrating knowledge transfer into the very mission of the university. Faculties at the National University of Rwanda, for example, responded quickly to this call by developing community outreach plans to be integrated into their annual plans. Three other efforts illustrate the degree of attention paid nationally to the work of enhancing the rate and impact of knowledge transfer among critical actors in the Rwandan innovation system. First, the Rwandan Development Board offers the "Knowledge Transfer Partnership," which provides access to technical expertise, credible business and university partners, and assistance with proposal and business plan development as a means to "better use knowledge, technology and skills that reside within the Rwanda Knowledge Base" (Rwanda Development Bank, Knowledge Transfer Partnership, 2010). Second, a number of technology transfer centers exist in Rwanda, though many struggle to overcome nagging dissemination and community uptake challenges. Finally, the government's Agricultural Research Institute (ISAR) created a Technology Transfer Unit to increase linkages between researchers, end users, and entrepreneurs. The unit aims to integrate farmers into the analysis of appropriate technologies created at ISAR and to influence the vision and demand of farmers through training (Rwanda Agricultural Research Institute, 2009).

Pillar 3 The Rwandan Innovation System: Outputs & Outcomes

Pillar 3 *captures the innovative products, services, and ideas created as a result of Pillar I's inputs and framework conditions and Pillar II's knowledge networks and interactions. Outputs and outcomes offer the evidence of a country's level of collaborative innovation capacity. For the sake of this analysis, innovation outputs and outcomes include knowledge contributions in terms of internationally recognized papers and patents, firm level investment in research and development, and progress toward specific STI-based economic and social development goals (Global Knowledge Initiative, Collaboration Innovation Index, 2012).*

Knowledge Outputs Produced Through Scientific Collaboration

Exploring Rwanda's scientific collaborations through co-authorship

Scientific collaboration is on the rise in Rwanda. In just five short years, the number of joint publications in scientific and technical fields jumped almost 500% — from 12 in 2005 to 59 in 2010 (Thomas Reuters Web of Science, 2011). Joint publication serves as a proxy for science partnerships, as other measures of collaborative science are scarce. Since 1995, scientists and researchers in Rwanda coauthored a total of 329 published journal articles with global partners. While that figure is rising, most of Rwanda's East African counterparts outperform it in terms of co-authorships. Over that same time period, researchers in Uganda coauthored 3674 papers with international counterparts, Tanzanian researchers coauthored 4433, and Kenya researchers coauthored 9377 (Thomas Reuters Web of Science, 2011).

A Bird's Eye View of National and International STI Collaborations in Rwanda

No. of co-authored papers in 2010: 59

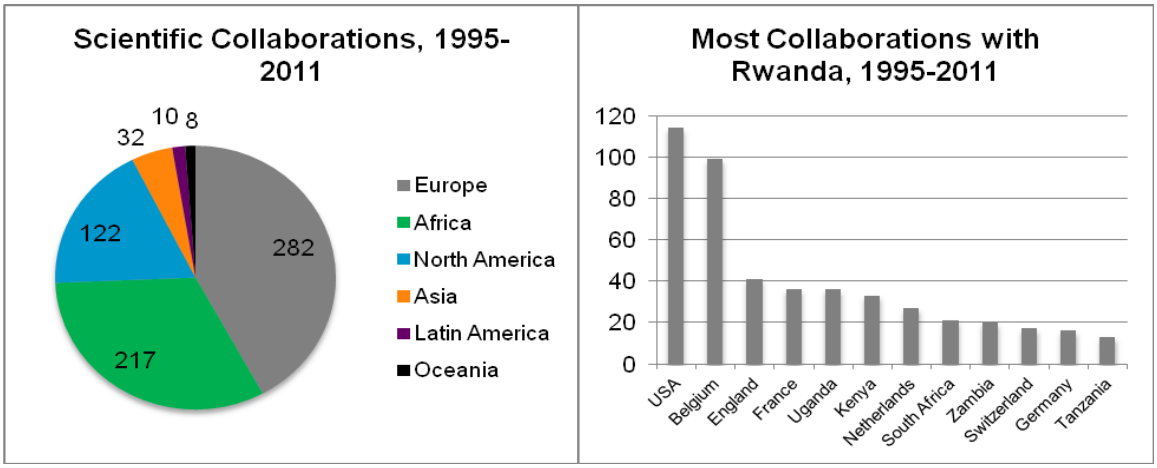
Percentage increase of co-authored papers over last 5 years: 500%

Countries with most co-authored papers with Rwandan researchers (1995-2011): United States and Belgium

Subject-matter areas in which most collaborations take place: Medicine & Health

Rwanda collaborates consistently with a few non-African international partners, but works with a varied list of fellow African countries: 32% of all publications from 1995-2011 occurred with partners from their continent (Thomas Reuters Web of Science, 2011). Between 1995 and 2011, European authors coauthored 42% of Rwandan publications. Partnerships with Belgium made up almost a third of all European collaborations. England, France, and the Netherlands also constitute a significant portion of European partnerships. North American partnerships with Rwanda are comparatively few, with only 18% of all joint publications from 1995-2011. However, that percentage represents collaborations with the United States almost exclusively. When these numbers are analyzed by country, not region, the US is Rwanda's most frequent collaborative partner (Thomas Reuters Web of Science, 2011).

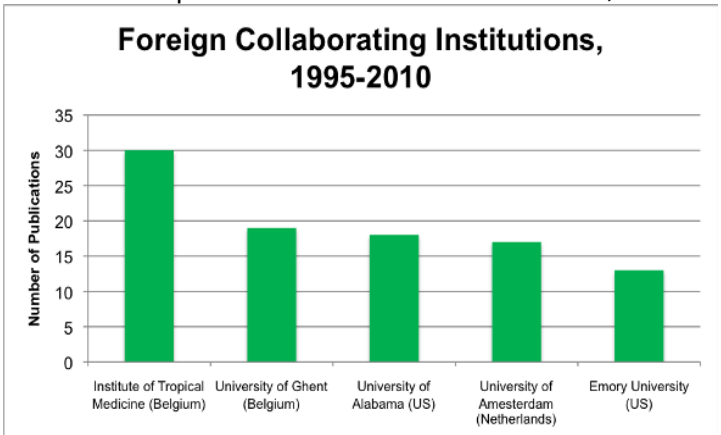
Top collaborating institutions in and with Rwanda

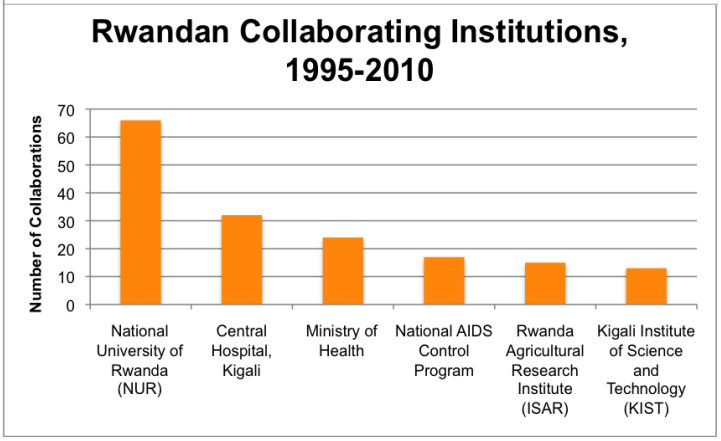


Source: Thomas Reuters Web of Science, 2011

In Rwanda, government research institutions and universities employ most of the country's scientists and researchers. Private sector is not generally well-represented in this picture because of the relatively small role its stakeholders play in research and development (explored in greater detail below). In the past 15 years, the faculty of the National University of Rwanda (NUR) contributed the greatest number of scientific publications to the national total, with 66 total co-authored papers. Others follow per the figures below.

In terms of joint publications, Rwandans collaborate most frequently with the Institute of Tropical Medicine and the University of Ghent, both in Belgium, followed by the University of Alabama in the US. Discounting health and medicine collaborations (the largest disciplinary focus), the most active foreign partner for Rwandan researchers is Uganda's Makerere University (Thomas Reuters Web of Science, 2011).



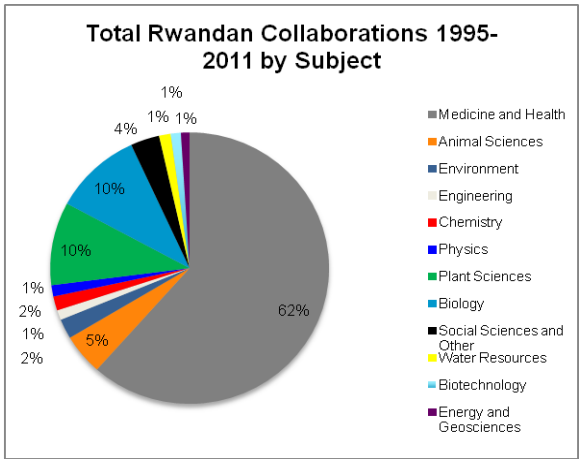


Source: Thomas Reuters Web of Science, 2011

Subject-matter focus of Rwandan collaborations

Medicine and health dominated the subject-matter focus of Rwandan co-authored publications from 1995-2011, with 62% of the total number of papers written. The other 38% of joint publications covers a broad array of scientific topics, including plant sciences, biology, and animal sciences. Co-authorship in the areas of geosciences, water resources, and engineering represent less than 1% of the total.

Such minimal output in these critical scientific and technical areas reveals a mismatch between Rwanda's development needs and the disciplinary focus of its researchers. In 15 years, Rwanda produced just three internationally published papers in energy and fuel, though Rwanda's energy needs are great. Similarly, in that same time period, Rwandans published only seven papers in engineering. The lack of engineering-focused output mirrors the needs expressed by industry. The private sector experiences a 51.4% skills gap for engineers, meaning employers require double the number of qualified engineers that are available (Ministry for Public Service and Labor and Human Resources and Institutional Capacity Development Agency, 2009).



Private Sector Outputs and Outcomes

Government reforms and incentive programs beginning to pay off

In the last decade, the Government of Rwanda exerted tremendous effort to create an attractive, enabling environment to entice private sector investment. The benefits of strategic reforms and incentives are now being felt. In 2011, the World Bank and the International Finance Corporation released their latest *Doing Business* report in which Rwanda was named one of the ten most improved economies in the world. In overall ease of doing business, Rwanda's ranking jumped from 70th in 2010 to 45th in 2012 (World Bank & International Finance Corporation, 2011). In terms of "Starting a Business" and "Getting Credit", Rwanda ranks 8th in the world (ibid). The Rwanda Development Board (RDB) responded to the report by noting that public-private dialogue precipitated many of the reforms that led to Rwanda's jump in the *Doing Business* standings and in total investments made. According to the Rwanda Chamber, a total of 766 local, foreign, and joint venture projects worth US $4.35 billion were registered between 2000 and 2010 (Kanyesigya, 2011). Registered investment projects peaked in 2009 with US $1.1 billion committed (Kanyesigya, 2011).

STI in Rwanda's Private Sector – An Overview

Total Agriculture R&D Investment: $19.2 million (2011)

Growth rate of agricultural sector: 4%

No. of new businesses per year: 3,028 in 2009 (2010)

Joint-venture projects 2000-2010: 766 (2010)

Donor or government research grants (% of all research grants): 90% (2009)

Economic transitions and growth projects

Diversification of the economic base away from depending primarily on the agriculture sector constitutes a major thrust of efforts in Rwanda's transition to a knowledge-based economy. In just the last decade, the Rwandan economy experienced a surge of economic output in the service and non-manufacturing industrial sectors (e.g., construction, mining, energy) sectors. Specifically, these sectors experienced the highest growth rates between 2004-2009, with 10%

each. This figures stands in stark contrast to the growth rate of the agriculture sector, which was just 4% of GDP between 2004-09, minus adjustments (Rwanda Development Board, *Investing in Rwanda — An Overview 2010,* 2010). Within the mining industry specifically, only 25% of approximately US $200 million of potential output is currently exploited. Opportunities for enhancing processing and diversification of ores and stones abound (ibid). Continued growth in the ICT sector, which cuts across all of Rwanda's economic sectors, is anticipated. Over the last three years, the Rwandan ICT sector attracted approximately US $500 million in investment by both private and public sector actors. Currently, three players dominate growth in the ICT sector in Rwanda — MTN Rwanda, TiGO and Rwandatel (ibid).

A key indicator of the output-orientation of Rwanda's economy is income per capita. On this score, Rwanda's progress makes it an African stand-out. Gross national income per capita rose from US $310 (2006) to US $520 (2012). This figure indicates Rwandans generally are better off in terms of income potential today than they were five years ago, even amidst the global economic crisis. However, the relative *distribution* of those benefits is in question. According to the World Bank, "one of the concerns in Rwanda is the high level of income inequality that may hamper progress in reducing extreme poverty" (World Bank, *Rwanda Economic Update*, 2011). Driving factors behind growing income inequality include differences in the education level of heads of households and regional disparities. The World Bank remains optimistic that this income inequality will decrease in the coming years, especially given the growing population of Rwandans benefiting from universal education programs and policies that target reducing the rural-urban divide, such as *Vision 2020.*

Private sector STI-based outcomes limited by lack of investment

Though the private sector accounts for 97% of employment in Rwanda, the sector's lack of investment in research and development limits its contribution to generating new science and technology-based solutions. The report entitled "Mapping Science and Technology for Industrial Development in Rwanda" found that, in the private sector, there "is no adequate commitment or provision in…industry's budgetary allocation for Research and Development" (Ma'aji et al, 2009). Among the firms surveyed for the report, none allocate funds for research and development; over 90% of research grants in Rwanda derive from public or donor sources. The report found that research supported through donor and public funds often is not well aligned to market needs, which certainly contributes to the mismatch between development challenges and concentrations of scholarly activity around few disciplines (ibid). The disconnect between research and development activities on the one hand and market needs/real-world uptake of research findings through innovation on the other restricts the potential economic and development impact of such investments.

Achieving enhanced STI-based outcomes from private sector requires further inquiry

The picture regarding private sector involvement in generating STI-based solutions in Rwanda remains opaque in some regards. Data on the firm-level picture of the Rwandan private sector, especially their STI-based needs and opportunities, is difficult to pinpoint and validate. A handful of initial inquiries into companies' needs and opportunities, notably the Private Sector Federation's Skills Audit, indicate an important and valuable step in filling this data gap. Additional questions, including those listed below, merit attention by stakeholders engaged in the Rwandan innovation system. Clarifying the context in which current and future private sector actors can contribute meaningfully to STI-based solutions constitutes an immediate need for hastening the emergence of a knowledge-based economy in Rwanda that catalyzes much needed purpose-driven knowledge networks.

- Given the Rwandan government's intent to increase the proportion of GDP derived from non-agricultural enterprises, what private sector goods and services will be of the highest demand (both domestically and for international trade) in the next 5 to 10 years time? What implications for skills training and human resources development will this goods/services profile render?
- Given industry's demand for up-skilled labor, what should Rwanda's future graduates possess in terms of key STI skills required to add value and promote growth in Rwandan industry?
- With an emphasis on increasing the value-added capability of industry, what technological inputs, collaboration / cooperation arrangements, knowledge resources, and other tools are considered requisite inputs? And what outputs / outcomes constitute likely results of these investments in 5 and 10 years time?
- With the incentives offered by the Government of Rwanda, why are private sector enterprises not more active in research and development? What needs are not being met, or opportunities not being realized by the private sector in terms of their investment in science, technology, and innovation?

Progress Toward Achieving *Vision 2020*

Indicators of progress

Progress toward achieving Rwanda's *Vision 2020* development goals is a key measure among the many innovation output and outcome indicators assessed in this analysis. Rwanda has seen exceptional growth in a number of areas. GDP growth in recent years has been higher than expected, 11.5% in 2008 over a projected 8.5%, and with it, government revenues have increased as well (MINECOFIN, 2011). While the growth rate slowed to 7.5% in 2010, the rate is still higher than the projected 5% for the region. Even with the global economic crisis, the economy has been stable due to a "prudent fiscal stance with a strong focus on priority spending" and support from its growing coffee, tea, and tourism industries (World Bank, Rwanda Economic Update, 2011).

According to the World Bank, Rwanda's increase in the share of GDP generated by manufacturing and service sectors in recent years demonstrates progress toward achieving its *Vision 2020* objectives, as framed in the shorter term Economic Development and Poverty Reduction Strategy (World Bank, Skills Project Appraisal Document, 2011). A 2011 World Bank study states, "Despite recent hits related to the global economic crisis, the manufacturing and particularly the service sector have become increasingly significant in Rwanda's steadily expanding economy" (ibid). Heralded as a major source of the country's economic growth in recent years, the service sector generated approximately 60% of GDP in 2010, compared to just 37% in 2001 (ibid).

Rwanda's investments in infrastructure delivered benefits, adding to the realization of increased outputs and positive outcomes across the private sector. Electrical power, production, and capacity grew beyond 2008 targets. As well, production of key food security crops almost tripled the target goal in 2009-10 (MINECOFIN, 2011). Better food crop production, achieved in large part through crop intensification efforts, improved food availability, intake, and nutrition across the Rwandan population (World Bank, *Rwanda Economic Update*, 2011). In terms of water and sanitation, Rwanda surpassed its target to provide safe drinking water for 70% of the

population and met its goal to provide hygiene facilities for 45% of the population (MINECOFIN, 2011).

Additional work still to be done

Though Rwanda has experienced tremendous gains in the last decade, progress toward achieving the country's stated development goals requires a "higher and more appropriately skilled workforce" (World Bank, Skills Project Appraisal Document, 2011). As the service and manufacturing sectors grow, new and more advanced skill sets will be required. The World Bank asserts that "in addition to greater levels of literacy, numeracy, science and specific vocational and technical skills, workers on any level and in any profession or occupation need to have 'catalytic skills' to allow them to function in a more complicated and continuously changing work environment" (ibid). The data indicate that efforts focused on increasing primary enrollment must be better balanced with those targeting technical and professional skills enhancement. Only 23.4% of secondary schools were equipped with the required science facilities (kits, laboratories) in 2009 (MINEDUC, *ESSP 2010-2015*, 2010). Further, the ratio of girl students enrolled in science courses in public higher education institutions lingers at 30%, missing the target of 32% (MINECOFIN, 2011). By ensuring young Rwandans, both males and females, have tools needed for scientific inquiry, and access to tertiary science and math-based education, Rwanda's advance toward knowledge-economy status will only progress.

Conclusions

A number of conclusions may be drawn from the portrayal of Rwanda's science, technology, and innovation context. The previous chapters offered dense but brief snapshots of the inputs and framework conditions, knowledge networks and interactions, and outputs and outcomes realized within Rwanda's innovation ecosystem. The question is this: what does it all mean for actors within the system and outside of it seeking to maximize opportunities to innovate? Four key messages emerge, each of which gains even more practical relevance in the subsequent analytic products: *Promoting Agricultural Knowledge and Innovation Systems; Ridding Specialty Coffee of Potato Taste: A Collaborative Innovation Case Study* and the *National University of Rwanda's Knowledge Partnership Landscape Analysis* (Global Knowledge Initiative, 2012).

Strong political support for STI sets Rwanda apart

Rwanda benefits from a tremendous amount of high-level support for science, technology, and innovation. Strong political commitment on behalf of the country's highest-ranking leaders, most notably President Paul Kagame, has fomented Rwanda's accelerated transformation over the last two decades. Bolstered by this political will, Rwanda undertook dramatic, crosscutting reforms nearly unthinkable in other contexts. Reforms that led to the impressive rise in Rwanda's "Doing Business" score and the abrupt conversion in the language of classroom instruction from French to English offer but two examples. Rwanda is also adept at recognizing opportunities to enhance its innovation capacity and identifying savvy ways to exploit them. Joining ARIPO instead of cultivating an internal cadre of intellectual property experts makes the point.

Lackluster involvement in research and development characterizes private sector

The Government of Rwanda works actively to foster an environment conducive to STI-lead growth and development. However, the enabling environment is but *one* of multiple ingredients necessary for a vibrant, productive innovation system. Such a system also requires a robust core of interacting, innovative firms and knowledge-based infrastructure and institutions. The analysis of the Rwandan national STI context reveals that targeted efforts to strengthen this core are needed. Troubling is the realization that the Rwandan private sector invests only modestly in research and development, as indicated by the African Development Bank's findings (Ma'aji et al, 2009). With such great economic incentives offered by the Rwandan government, why does the private sector not invest more significantly? What barriers — monetary, skill-based, knowledge gaps — do industry confront? The government encourages public-private partnerships as one mechanism to increase the level of private sector investment in STI-based activities; however, it is unclear if firms have the capacity, knowledge, and/or incentives to engage in this way. Current data on the status of Rwanda's private sector is difficult to find. Such obstacles point to the need for enhanced information access to promote collaborative innovation among Rwandan innovation system actors.

Gains achievable by linking education to industry needs

Many individuals and institutions within the Rwandan innovation system recognize the need for STI capacity building and take steps toward this aim. Investment in the country's TVET system and emphasis on ICTs in the classroom illustrate but a few of the many reforms Rwanda has undertaken to enhance the human capital base. Potentially more transformative, however, is the process underway to align education outcomes with the specific needs of industry, such as through the National Skills Audit conducted in 2009. Many education reforms manifest in economic outcomes and outputs in the long-term, revealing benefits several years after their implementers and instigators leave their positions of decision-making power. Attuning long-term reforms to short-term political and business calculus challenges every economy in the world.

However, by focusing on specific, urgent skills needs of existing and emerging industries, Rwanda stands to gain in the short-term. At most, an effort to assess and rationalize the skills Rwandan graduates amass through the education sector is likely to spur positive change across the Rwandan innovation system. Given the small size of Rwanda's private sector, which serves as a barrier to substantially larger private sector STI-based investment in the short term, attuning supply to the precise STI labor market needs is essential. In the least, such an endeavor would offer an illuminating experiment in improving the responsiveness of education to labor market needs.

Getting back to basics

In general, Rwanda's achievements in promoting STI are laudable; however, one has to ask if the country is, at times, so eager to catapult itself to the next level that some of the basics may be overshadowed. For example, Rwanda's commitment to enhance its ICT infrastructure is noteworthy, but such investments should not displace others needed within a knowledge infrastructure. Updating a university's soil science laboratory may be just as valid as delivering 200 new laptops to the school's library. A review of Rwanda's STI priorities reveals the need for a more thorough assessment of whether the scales have been tipped in favor of or at the detriment of its knowledge infrastructure investments. Similarly, the research profile of the country demonstrates what may be an imbalance in research priorities toward those areas of interest articulated by donors. With health and medicine constituting the lion's share of research collaborations, questions concerning the responsiveness of research to the demands and challenges of the 80% of Rwandans working in agriculture, must be answered.

To close, Rwanda's most valuable assets within the national science, technology, and innovation context are its people. National leadership and passion for STI distinguish the country and bode well for the implementation of intended reforms. With the vitality and commitment of Rwandans and *Vision 2020* offering a roadmap toward a more prosperous future, the ingredients exist to propel Rwanda toward becoming not just an engine of innovation for Africa, but for the world. To explore how opportunities for innovation, research, and collaboration can be used to tackle a specific challenge in Rwanda's most essential sector — agriculture — the Global Knowledge Initiative's *Promoting Agricultural Knowledge and Innovation Systems* offers the interested reader a detailed exploration.

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Researchers and companies with a stake in improving the quality of Rwandan coffee find themselves at a crossroads. They broadly agree that the potato taste defect needs to be eliminated if Rwanda is to continue growing its specialty coffee industry. However, there is little or no clarity on how to successfully rid the country's crop of the defect, who should be involved in the effort, or how various stakeholder contributions can be optimized to generate a collective solution.

GLOBAL KNOWLEDGE INITIATIVE

Promoting Agricultural Knowledge and Innovation Systems

Ridding Specialty Coffee of Potato Taste: A Collaborative Innovation Case Study

January 2012

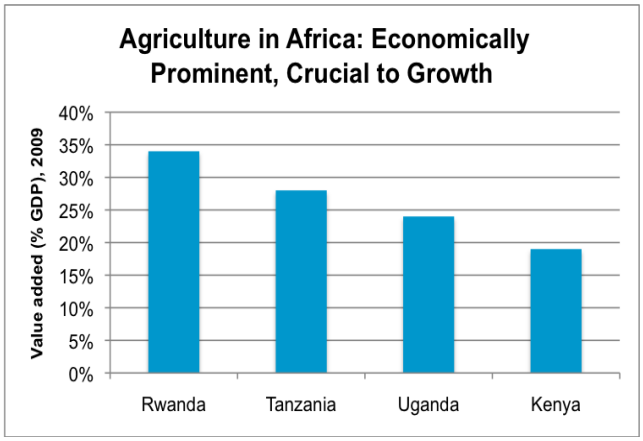
Table of Contents

Unpacking the Challenge

Introducing the LINK Challenger and the Potato Defect Challenge

The son of a farmer, Daniel was just six years old when his family fled Rwanda for Burundi to escape the escalating tensions tearing at the fabric of Rwandan society. When hostilities in Burundi intensified, Daniel's father moved the family again, this time to Tanzania. Daniel ultimately returned to Rwanda after over thirty years of living and working abroad. Even seven years after the 1994 genocide, Daniel found his country still in a painful process of rebirth and in need of individuals poised to contribute. In the years before his return, Daniel studied at Sokoine University of Agriculture in Tanzania and at Imperial College London, where he earned his M.Sc. in Applied Entomology. After completing his Ph.D. in Crop Production and Protection at the University of Reading in the UK, he worked to promote agricultural development in Tanzania and Uganda. While conducting agricultural field research, he watched as the rural subsistence farmers around him fell further and further into poverty despite their hard work. His passion for poverty alleviation grew, driven by a belief that agricultural science holds the keys to improving Africa's food security, growing the economy, and, most importantly, providing such farmers decent, stable wages. Daniel returned to Rwanda energized and ready to help build his country's agricultural future through research and development. He now serves as the Dean of the Faculty of Agriculture at the National University of Rwanda (NUR), the country's largest university.

The timing of Daniel's return was fortuitous. In 2003, the African Union Assembly agreed upon the Consolidated Africa Agriculture Development Programme (CAADP) goals. CAADP set ambitious food security targets including raising agricultural productivity in each signatory country by 6% each year and increasing public investment in agriculture to 10% of national budgets per year across Africa. These goals constitute critical benchmarks for achieving sustainable development across the continent. With Africa's population predicted to double by 2050 and the specter of global climate change looming, Africa must develop sustainable, homegrown agriculture for food security and economic development (Bremner et al., 2009).



Source: World Bank Data, 2011

Although CAADP is an agreement between governments, its implementation largely depends on the research and development capacities of African universities. During the 2009 Ministerial Conference on Higher Education in Agriculture in Africa (CHEA) held in Kampala, Uganda, ministers of education and agriculture affirmed the critical role higher education institutions play in achieving CAADP. The ministers committed to "a renewed and vigorous emphasis by African governments on restoring the quality of higher education in agriculture" (CHEA, 2009).

In Rwanda, these concerns are especially acute. With a population of roughly 11 million people packed into an area the size of Maryland, Rwanda exhibits the highest population density in Africa (U.S. Department of State, 2011). Landlocked, exceptionally hilly, and difficult to farm, agricultural improvements in Rwanda require creativity and scientific expertise.

One cannot talk of Rwandan agriculture without referencing coffee, one of the country's most

significant agricultural commodities. Rwanda's environmental characteristics, historical success in coffee production, and burgeoning specialty coffee industry combine to make it a dominant player on the international coffee market. In 2009, coffee exports made up approximately 6% of Rwanda's exported goods and services (exports of services decreases the relative share of coffee to this figure; in fact, between 1997 and 2007 coffee made up 29% of merchandise exports) (World Bank, 2011; UNCTAD & the Ministry of Trade and Industry, 2010). That same year, higher quality "specialty" grade coffee composed approximately 19% of Rwandan coffee exports and 31% of coffee export earnings (Boudreaux, 2011; UNCTAD and the Ministry of Trade & Industry, 2010; Rwanda Ministry of Agriculture & Animal Husbandry and Ministry of Trade and Industry, 2008). Specialty coffee captures a greater market price than that of lower quality "C" grade coffee: in 2006, specialty coffee brought US $0.45 per pound more than its C grade counterpart. Notwithstanding the price differential, other coffee sector trends point to the growing importance of specialty coffee for the Rwandan economy. Although coffee export volumes have not increased much over the past ten years in Rwanda, earnings from coffee have more than doubled (Boudreaux, 2011). Substantial advances in Rwanda's capacity for value-addition and quality control explain the price difference; however, a particular defect known as "potato taste" and a possible insect culprit—the antestia bug—may jeopardize these impressive gains..

Background on the Challenge

What is the potato taste defect?

As the Rwandan specialty coffee industry grew in the early 2000s, coffee roasters occasionally noticed a foul potato odor emanating from Rwandan beans. By the late 2000s, incidents of notable coffee buyers shying away from purchasing in Rwanda were reported. "Potato taste defect" was blamed. Named appropriately, the defect causes coffee made with tainted beans to taste like…potatoes. Understandably, this causes an unpleasant experience for coffee drinkers and creates a deterrent for international coffee buyers. Rwanda's Strategic Plan for Agriculture notes that Rwanda experienced income loss because the potential of tainted beans turned away some high-end and large-quantity buyers. SPREAD (Sustaining Partnerships to Enhance Rural Development) Director Jean-Claude Kayisinga emphasizes this point, "It's terrible. I'm going to give you an example. [There was] a roaster. It was ready to [make] a contract with Target, the US department store. The problem is they didn't want to send Rwandan coffee to Target because of [the risk of potato taste]" (Kayisinga, 2011). Dr. Daniel Rukazambuga, GKI's LINK Challenger, realized the severity of the potato defect challenge when a representative of *Intelligentsia Coffee and Tea* told him they were worried about the quality of Rwandan coffee. The representative stated potato taste might threaten the fledgling specialty coffee industry, not to mention Intelligentsia's plans to buy Rwandan coffee.

While the evidence and negative impact of the defect is growing, the specific cause remains unknown. Rwanda's Strategic Plan for Agriculture prioritizes "identify[ing] the cause of the 'potato taste'" and "implement[ing] as an urgent matter a programme to correct it" (Ministry of Agriculture and Animal Resources, 2009). Despite the remaining questions, potato taste defect remained absent from the quality coffee research agenda until recent years. There are a few reasons for this omission. First, potato taste defect primarily affects crops in Rwanda and Burundi, countries that historically produced low quality coffee. The problem became more serious only as the Rwandan coffee industry moved toward producing specialty coffee, in which quality deficiencies pose a serious liability. Fortunately, efforts by the Rwandan government,

international non-governmental organizations, and coffee companies are underway to mitigate the potential impact of the defect on Rwanda's specialty coffee industry. The desire to aid these efforts and fill resources gaps critical to conquering the potato taste challenge inspired this analysis.

Regional dynamics slowed initial efforts to link antestia bug and potato taste

The antestia bug plagues coffee crops throughout East Africa. It damages coffee cherries and forces farmers to dispose of affected ones. Researchers hypothesize that as antestia attacks coffee cherries, it injects saliva containing a toxin, pyrazine, which causes potato taste. Researchers also believe pyrazine may enter coffee cherries punctured by non-insect enemies too, like hail. British colonialists undertook early research on the antestia bug in Tanzania and Uganda in the first half of the twentieth century. They achieved some success using integrated pest management methods to mitigate antestia's negative impacts on coffee, including using natural enemies in Uganda (Wardle, 1929).

Evidence of Antestia bug
Ref. Global Knowledge Initiative

Antestia does not seem to be linked with the potato taste defect outside of Rwanda and Burundi. As such, the linkage between antestia bug and potato defect remained generally unexplored until the early 1990s in Burundi. A team from the French agricultural research organization CIRAD (Center for International Cooperation in Agricultural Research for Development) undertook the first prominent research effort to establish linkages between the antestia bug and potato defect in the early 1990s. CIRAD investigated this relationship and tested methods of controlling the antestia bug. Authors Bouyjou, Cilas, Decazy, and Fourney published papers on the taste defect that posited a relationship between antestia and the potato defect. They noted that further research was needed to understand the nature of the connection between antestia bug populations and potato taste (Bouyjou, 1999; Cilas et al, 1998). Sadly, before the research team could complete their work, civil war engulfed Burundi, and shortly thereafter, the 1994 Rwandan genocide broke out. The conflict in Burundi did not end in a meaningful way until after peace agreements in 2002 and 2003, approximately ten years after CIRAD's original research on potato taste. CIRAD did not continue the project.

Revitalized efforts address multiple aspects of the challenge

With limited resources and little baseline data on causes of the potato taste defect, some stakeholders in the Rwandan coffee sector searched for methods to identify potato taste in coffee prior to roasting. One such person is Timothy Schilling the former head of SPREAD. The premise of his and others' approach is simple: if one catches damaged beans before they go to market, international buyers' confidence increases. To this end, Timothy's organization, the Global Coffee Quality Research Initiative, partners with Iowa State University and SPREAD to develop light spectrum technology to identify the potato taste defect in green parchment beans prior to roasting (Schilling, 2011).

Others like LINK Challenger Daniel Rukazambuga focus on farm-level strategies to control and identify the antestia bug. Small-holder coffee farmers lose an estimated 10% of their crop due to irreparable damage by the pest (Schilling, 2011). Compelled to act, Daniel and his colleagues at the National University of Rwanda partnered with the Rwanda Agriculture Research Institute (ISAR) and the National Agricultural Export Board (NAEB) to address potato taste defect from

the ground up. Daniel plans to use data gathered at the *Cup of Excellence* (see page 23 for more information) held in October 2011 to track potato flavor at district and even farm-level. If coffee cuppers can determine which cooperatives produce the most defected beans, Daniel will use these farms for baseline data on antestia bug populations. Daniel aspires to create a profile of the antestia bug in Rwanda as a first step toward thwarting its attack.

Researchers and companies with a stake in improving the quality of Rwandan coffee find themselves at a crossroads. They broadly agree that the potato taste defect needs to be eliminated if Rwanda is to continue growing its specialty coffee industry. However, there is little or no clarity on how to successfully rid the country's crop of the defect, who should be involved in the effort, or how various stakeholder contributions can be optimized to generate a collective solution. The following analysis aims to bring clarity to this ongoing debate, and offer individuals and institutions a clearer pathway through which to bring their resources and expertise to bear on this shared challenge.

Presenting The Challenge Context Analysis

Organization of the analysis

To afford readers access to a clearer pathway toward partnership, this report unfolds as described below. First, the potato taste challenge is examined using a **Challenge Map**. Daniel and his research team completed a challenge mapping exercise in June 2011 in Butare, Rwanda, facilitated by the Global Knowledge Initiative. The challenge map helped the team deconstruct and relate a broad range of issues that bear on solving the potato taste defect. Challenge mapping also aided the team in identifying how various stakeholders might work together to solve this shared challenge. The Challenge Map section concludes with a visual illustrating four potential pathways through which a solution might be generated.

The following section, **Pillar 1: Inputs and Framework Conditions**, presents a brief history of the Rwandan coffee sector, specifically focusing on the cultivation of specialty coffee. This section also relates the trajectory of Rwandan specialty coffee to the individuals that stand to benefit most from, and contribute to, a robust specialty coffee sector: Rwandan smallholder coffee farmers.

Rwandan specialty coffee is dependent on a diverse array of actors – farmers, industrialists, governments, non-governmental organizations (NGOs), and universities – working toward a common goal: increased incomes through the export of high quality coffee. In **Pillar 2: Knowledge Networks and Interactions,** attention is paid to the sectoral dynamics that facilitate coffee sector growth in Rwanda, and the challenges of focusing such a diverse network on a shared challenge like the potato defect. This section includes a discussion of the need for improved, expanded knowledge networks and analysis of some prominent collaborators active in the sector. The Global Knowledge Initiative devised "Collaboration Scorecards" as tools to explore institutions' track record of collaborative innovation in the coffee sector.

Finally, in **Pillar 3: Potential Outputs & Outcomes of Solving the Potato Defect Challenge**, the authors ask what it means to solve Rwanda's potato defect challenge and how this goal might be achieved. The chapter ties together many analytic threads — the challenge map, a value chain analysis, and various knowledge network visualizations — to construct a possible scenario for collaborative innovation. The scenario details how a successful, concerted effort to solve the potato taste challenge might be organized.

The Global Knowledge Initiative developed the ***Promoting Agricultural Knowledge and Innovation Systems*** report through primary and secondary research conducted between March and December 2011. Some 15 interviews with researchers at the National University of Rwanda and administrators at Rwandan coffee organizations were conducted, generating many novel insights that are presented for the first time in this document. Secondary sources include reports produced by academic institutions, the Rwandan government, and non-governmental organization.

The purpose of this analysis is to explore the multiple dimensions of the potato taste defect challenge, highlight ongoing efforts underway to address aspects of this challenge, and expose those areas in need of increased attention and action. This tool offers insight and strategies to spur an expanded network of actors focused on solving a shared challenge: eliminating potato taste defect in Rwandan specialty coffee. This analysis complements two other LINK products on Rwanda from the Global Knowledge Initiative. The first is the *National Science, Technology, and Innovation Context Analysis* that provides a meta-level overview of the challenges and opportunities at play in the Rwandan innovation system. The second is the National University of Rwanda's *Knowledge Partnership Landscape Analysis*, which provides institution-level insight into the collaboration baseline of the Faculty of Agriculture and others at NUR.

Building a Challenge Map

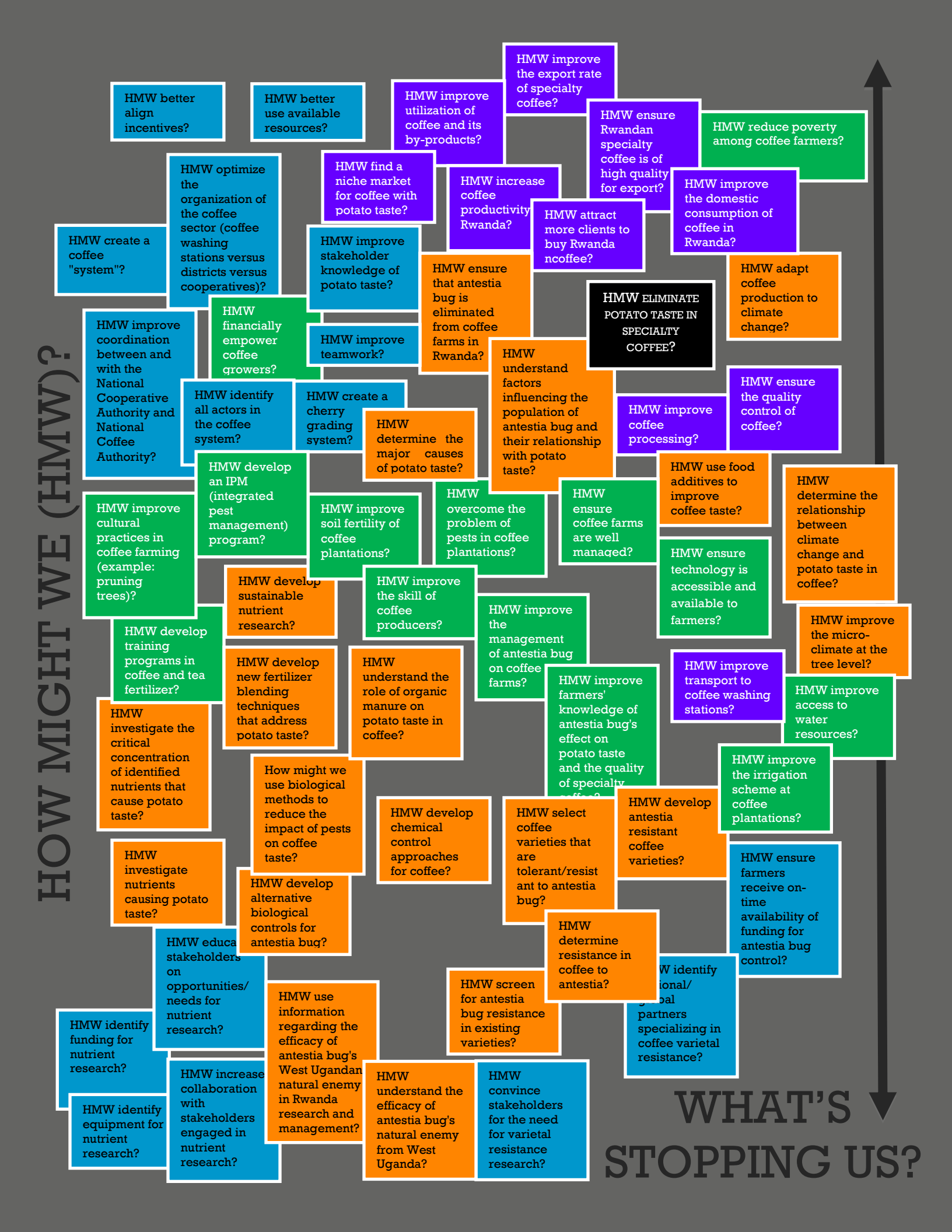
What do nutrient research, farmer incentives, irrigation schemes, and coffee transport systems have in common? According to coffee and pest experts at the National University of Rwanda, each plays a vital role in solving the riddle of the potato taste defect in Rwandan specialty coffee. Understanding *how* these and other factors relate to one another and bear on solving the potato taste defect, however, is not necessarily apparent. With multiple interactions and stakeholders at play, relating actors, resources, context, and dynamics together renders sustainable solutions complex in their implementation if not in their design too. Without fully appreciating complexity, efforts to eliminate potato taste in specialty coffee may be unsuccessful. Further, unnecessary resource overlaps and/or oversights may result if stakeholders do not understand how they fit in to a broader effort to solve a shared challenge. To clarify how would-be collaborators might contribute to a solution, experts from the National University of Rwanda representing a host of pertinent specialties — agricultural economics, integrated pest management, soil science, farmer outreach — gathered in June 2011 to "map" the potato taste defect challenge.

Challenge mapping enables users from diverse backgrounds to understand how their seemingly disconnected work and expertise might contribute to solving a shared challenge through collaboration. For example, through challenge mapping the NUR experts explored which potato taste "sub-challenges" they could individually address vis-a-vis those other sub-challenges that require action by others, such as national agricultural institutions, buyers, or international partners. Through challenge mapping participants visualized critical barriers that, if not addressed directly, might impede the creation and implementation of potential collaborative solutions. Developed by Min Basadur, challenge mapping provides a strategic process for jump-starting collaborative innovation independent of the content of the challenge. Examples of its successful application include Proctor & Gamble, the multinational consumer product company, which used challenge mapping to identify inefficiencies that, once addressed, saved the company over US $600 million per year in process improvements. In a second example,

foodservice company Con Agra used the creative-thinking tool to develop a dozen concepts for new food products and consumer testing approaches (Basadur, 2001).

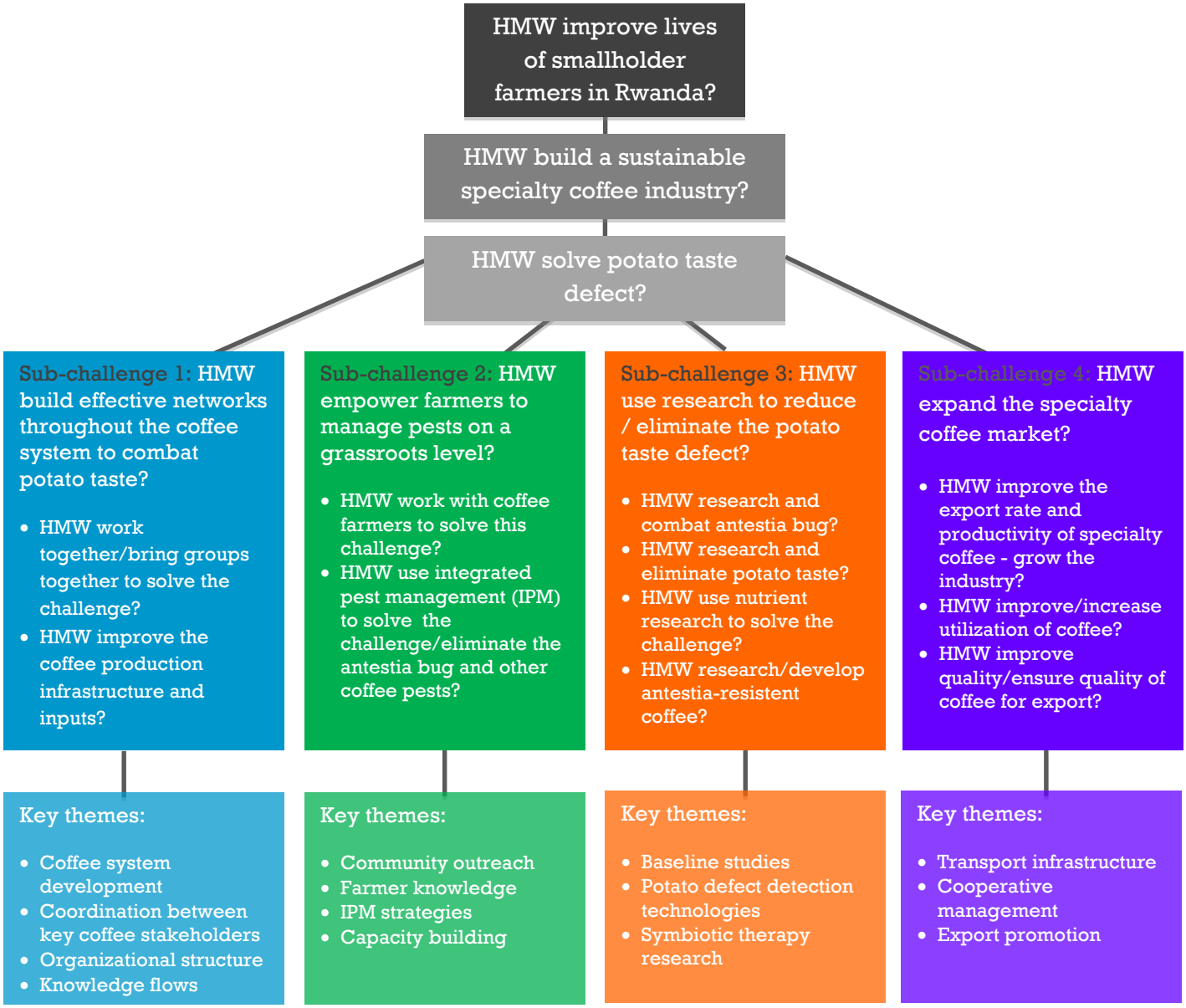
The challenge map below, while not exhaustive, offers a visual representation of the inter-connected sub-challenges that bear on solving the "seed" challenge presented by LINK Challenger Daniel Rukazambuga. Stated as a question, that challenge reads: *"How might we eliminate potato taste in specialty coffee?"*

Creating the potato taste challenge map was a collaborative exercise in itself. Experts representing diverse disciplines from soil science to agricultural economics posed related challenges per their personal experience and expertise. The challenge map relates these various contributions of the map's designers to one another. The placement of individual sub-challenges follows a specific organization. Challenges that present a critical barrier to solving the potato taste challenge are positioned below the seed challenge (*"How might we eliminate potato taste in specialty coffee?")*. Challenges that provide a rationale for solving the seed challenge expand the problem definition and are placed above the seed challenge. The map moves downward from high-level, meta challenges placed at the top to those sub-challenges that are more self-contained. These follow below. The coloring of the map organizes the sub-challenges into thematic groupings that can be used to develop an action plan. These groupings are explored further in the subsequent sections of the report. Thus, the content derived from the potato defect challenge map frames the analysis that follows in this report. In fact, it is from the mapping exercise that the team derived insight into plausible research and linkage strategies that might enable a long-term solution to the potato taste defect challenge.


HOW MIGHT WE (HMW)?
HMW better align incentives?
HMW better use available resources?
HMW improve utilization of coffee and its by-products?
HMW improve the export rate of specialty coffee?
HMW ensure Rwandan specialty coffee is of high quality for export?
HMW reduce poverty among coffee farmers?
HMW optimize the organization of the coffee sector (coffee washing stations versus districts versus cooperatives)?
HMW find a niche market for coffee with potato taste?
HMW increase coffee productivity Rwanda?
HMW improve the domestic consumption of coffee in Rwanda?
HMW create a coffee "system"?
HMW improve stakeholder knowledge of potato taste?
HMW attract more clients to buy Rwanda ncoffee?
HMW ensure that antestia bug is eliminated from coffee farms in Rwanda?
HMW ELIMINATE POTATO TASTE IN SPECIALTY COFFEE?
HMW adapt coffee production to climate change?
HMW improve coordination between and with the National Cooperative Authority and National Coffee Authority?
HMW financially empower coffee growers?
HMW improve teamwork?
HMW identify all actors in the coffee system?
HMW create a cherry grading system?
HMW determine the major causes of potato taste?
HMW understand factors influencing the population of antestia bug and their relationship with potato taste?
HMW improve coffee processing?
HMW ensure the quality control of coffee?
HMW develop an IPM (integrated pest management) program?
HMW use food additives to improve coffee taste?
HMW improve cultural practices in coffee farming (example: pruning trees)?
HMW improve soil fertility of coffee plantations?
HMW overcome the problem of pests in coffee plantations?
HMW ensure coffee farms are well managed?
HMW determine the relationship between climate change and potato taste in coffee?
HMW develop sustainable nutrient research?
HMW improve the skill of coffee producers?
HMW improve the management of antestia bug on coffee farms?
HMW ensure technology is accessible and available to farmers?
HMW develop training programs in coffee and tea fertilizer?
HMW improve the micro-climate at the tree level?
HMW develop new fertilizer blending techniques that address potato taste?
HMW understand the role of organic manure on potato taste in coffee?
HMW improve transport to coffee washing stations?
HMW improve access to water resources?
HMW investigate the critical concentration of identified nutrients that cause potato taste?
HMW improve farmers' knowledge of antestia bug's effect on potato taste and the quality of specialty
How might we use biological methods to reduce the impact of pests on coffee taste?
HMW develop chemical control approaches for coffee?
HMW select coffee varieties that are tolerant/resistant to antestia bug?
HMW develop antestia resistant coffee varieties?
HMW improve the irrigation scheme at coffee plantations?
HMW investigate nutrients causing potato taste?
HMW develop alternative biological controls for antestia bug?
HMW ensure farmers receive on-time availability of funding for antestia bug control?
HMW educa stakeholders on opportunities/ needs for nutrient research?
HMW determine resistance in coffee to antestia?
HMW identify ional/ bal partners specializing in coffee varietal resistance?
HMW screen for antestia bug resistance in existing varieties?
HMW use information regarding the efficacy of antestia bug's West Ugandan natural enemy in Rwanda research and management?
HMW identify funding for nutrient research?
HMW increase collaboration with stakeholders engaged in nutrient research?
HMW understand the efficacy of antestia bug's natural enemy from West Uganda?
HMW convince stakeholders for the need for varietal resistance research?
HMW identify equipment for nutrient research?
WHAT'S STOPPING US?

Exploring Pathways to Tackle the Challenge

The Potato Taste Defect Challenge Map, as executed by Daniel Rukazambuga and other experts at NUR, can be grouped into four clusters of sub-challenges as visualized below. These four sub-challenge domains point to distinct but related pathways for solving the potato taste defect challenge. These include research focused on the linkage between pests and the taste defect, control of pests through community outreach, quality control and export promotion of specialty coffee, and network creation and optimization to enhance coffee system management and performance. The challenge mapping exercise conducted at NUR revealed a number of key themes within each sub-challenge grouping, many of which are listed below. These sub-challenges and themes guided the analysis of ongoing efforts to address potato taste defect as follows and informed the identification of external partners poised to address specific issues related to these sub-challenges, as explored in Pillar 3.



Achieving a sustainable solution to the potato taste defect challenge requires concurrent action on these and other related sub-challenges. Without a systemic approach, we may achieve an *answer* to one aspect of the challenge without developing and implementing a long-term *solution.* What is the benefit of a key research finding if it is not integrated into on-farm management? What good is a transformative technology-based answer if the incentives for implementation are not properly aligned? What is achieved if a low-cost, community-based pest control approach is not scaled due to insufficient information sharing among stakeholders? Such choke-points are all too common in the application of science, technology, and innovation to address development challenges.

It is through an integrated, multi-pronged, and coordinated approach to addressing the potato defect that the Rwandan specialty coffee sector will be protected and strengthened. Some of the sub-challenges already garner attention from the Rwandan government, NGOs, and/or coffee companies. Others, however, remain without a clear champion and associated plan of action. In organizing a concerted effort to solve the potato taste defect challenge, we must appreciate what players are tackling those sub-components, and what outputs and outcomes we can expect from those stakeholders and the actions they take. The following analysis provides insight into these specific areas as derived from the initial challenge map.

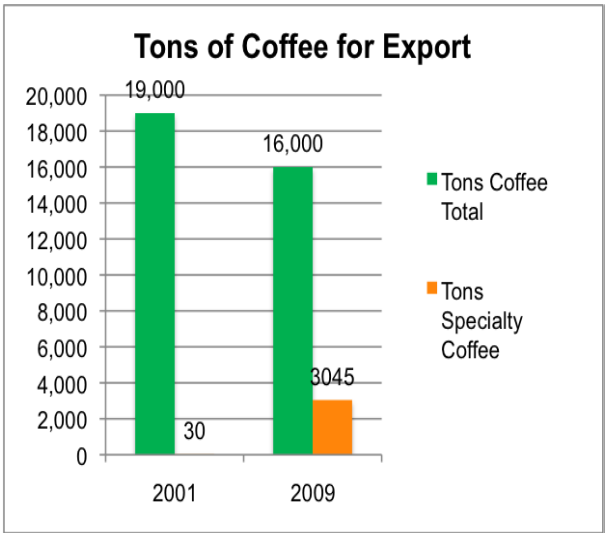
Pillar 1 Rwandan Specialty Coffee: Inputs & Framework Conditions

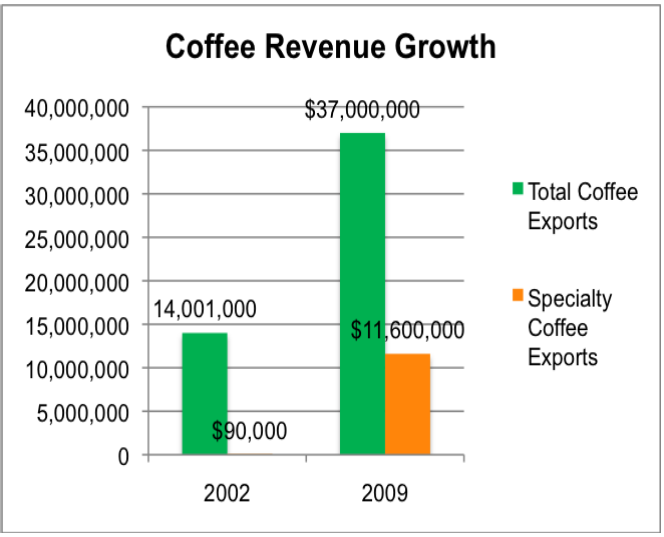
Specialty Coffee in Rwanda: Background

In many ways, Rwanda is an ideal country in which to grow specialty coffee, with its high altitude, volcanic soil, and heirloom Arabica bourbon coffee plants. Despite the conducive growing environment, high-quality specialty coffee production did not exist fifteen years ago in Rwanda. Historically, low-quality, inexpensive coffee meant for the mass-market (typically bringing a C price or below) characterized the industry (Rwanda Agricultural Research Institute [ISAR], n.d.; Coffeeresearch.org, n.d.).

Prior to the 1994 genocide, the governments of Presidents Kayibanda (1962 – 1973) and Habyarimana (1973 – 1994) purchased all coffee from farmers and then re-sold it internationally. Both regimes exerted heavy-handed control over the coffee sector and paid farmers set prices (K.C. Boudreaux, 2011). By the late 1980s, after a substantial drop in world coffee prices, the government could not afford to pay farmers even subsistence wages, and the industry crumbled (ibid). Rwanda's coffee sector plummeted to near nonexistence following the genocide, during which over 800,000 Rwandans were killed.

President Paul Kagame's government (2000 – present), liberalized the coffee industry in an effort to rejuvenate the fragile post-genocide economy. The government relinquished control of the industry, choosing instead to foster close relationships with international NGOs and coffee companies. The aim: to develop the more profitable, higher quality specialty coffee export sector that receives up to double the price of low-grade Rwandan coffee on the international market (Boudreaux, 2011).





These graphs combine data from a number of sources to approximate the growth in the specialty coffee sector relative to growth in coffee generally. Specialty coffee does not explain all of the coffee sector growth; some is simply a reflection of crop cycles. However, combined with an improvement in coffee generally – seen in the overall increase in coffee prices — it has contributed to a surge in coffee revenues despite an actual drop in tons exported between 2001 and 2009 (it should be noted that 2009 was a poor year for Rwandan coffee, and that because these graphs contain two to three data points rather than a full picture of production, growth should not be interpreted as linear). Sources: Boudreaux, 2011; Ngarambe, 2010; Ministry of Agriculture and Animal Husbandry & Ministry of Trade and Industry, 2008; UNCTAD & the Ministry of Trade and Industry, 2009.

Transforming Rwandan coffee from a low to high-quality export required cooperation

The outward-looking partnership approach taken by the Rwandan government proved beneficial. In 2000, 90% of Rwandan coffee earned an "ordinary" grade, the lowest mark. At that time, growers produced a negligible amount of high-grade coffee (Ministry of Agriculture and Animal Husbandry & Ministry of Trade and Industry, 2008). By 2009, however, Rwanda's exports soared to over 3,000 tons of specialty coffee, and revenues from coffee spiked. According to the US Agency for International Development (USAID), the explosion in specialty coffee production increased the incomes and household expenditures of approximately 500,000 rural coffee farmers in Rwanda (Chemonics International, 2006). From 2000-2010, annual incomes of coffee farming families rose from US $500 to US $3000, a six-fold increase (Schilling, ESRI International User Conference, 2011). Additionally, the development of coffee washing stations, which prepare specialty coffee for sale, added approximately 2000 jobs to the economy as of 2008 (Boudreaux, 2011). Overall, coffee exports earned Rwanda US $20 million in 2001, a figure jumped to US $56 million just nine years later (Ministry of Trade and Industry, 2011; Ministry of Agriculture and Animal Husbandry & Ministry of Trade and Industry, 2008).

Part of the explanation for this growth lies in a change in consumer behavior internationally. Specialty coffee consumption grew substantially in the past decades, outstripping the percentage growth of overall coffee consumption. Specialty coffee consumption currently grows by approximately 20% each year, with specialty coffee making up 8% of global coffee sales. In the United States, specifically, specialty coffee makes up a full one-third of the market (Boudreaux, 2011). Realizing the rising consumer demand, the Rwandan government, the donor community, and international non-governmental organizations looked to improvements in coffee production as a means of increasing smallholder farmers' incomes. The combination of the shift in consumer behavior, implementation of policies aimed at enhancing rural livelihoods, and focused international partnerships provided the foundation for a subsequent boom in Rwandan specialty coffee production.

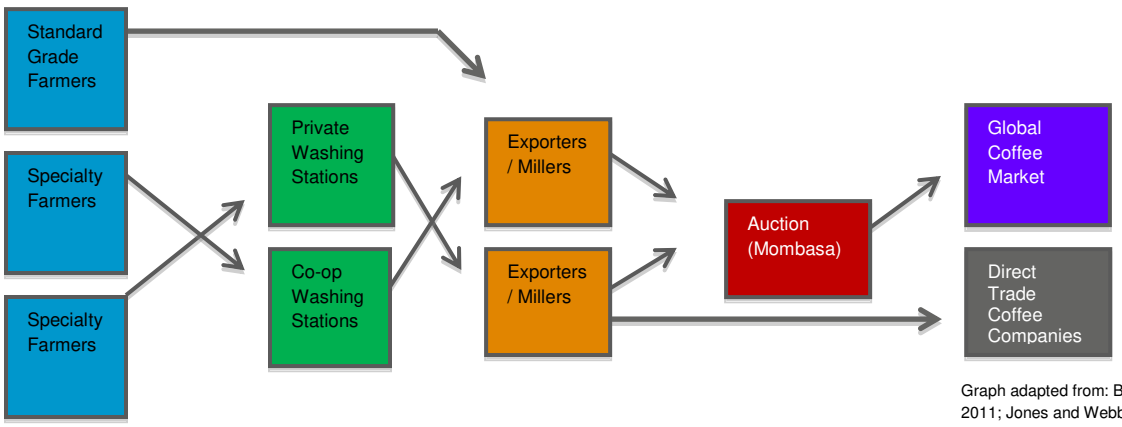
What makes specialty coffee special? Exploring the Rwandan coffee value chain

Rwanda produced "Standard, C-Grade" quality coffee for over 100 years. As noted previously, only in the last decade has specialty coffee become a major market force. The difference between standard and specialty coffee is more than a matter of price. The production processes differ substantially, as do their paths to the international coffee market.

Specialty and standard coffee are grown using similar methods in Rwanda, although some specialty coffee is organic or shade-grown. The differences become more apparent at the time of harvest. Farmers take great care with specialty coffee; washing stations will not process coffee cherries that are not red and ripe. Specialty coffee is then fully "washed," a process in which red coffee cherries are run through sluices, and dropped into fermentation tanks, a practice standard in Rwanda though not necessarily adopted everywhere. Fermentation softens the outside of the cherry, which is then removed once sufficiently soft (Sanneh, 2011).

Following coffee washing, the green, mucilage-stripped "beans" dry on racks, after which they are sorted. Agricultural workers sift through the beans by hand, removing those with noticeable defects. Once the coffee is dried and sorted, it is shipped from the coffee washing station to exporters in Kigali. Depending upon whether the coffee is purchased through "direct trade" by a coffee company or sold to an exporter, the coffee may be shipped to Mombasa for purchase, or purchased by a coffee company in, say, the United States to whom it is shipped directly. Many US specialty coffee companies purchase directly from cooperatives and are able to

advertise to consumers the specific cooperative and even the farm from which their beans hail. The image below illustrates the Rwandan coffee value chain.



Graph adapted from: Boudreaux, 2011; Jones and Webber, 2010

Rwandan coffee farmers sell their ripe cherries to both private and cooperative washing stations, although much of Rwanda's coffee is still unwashed. Cooperative washing stations pay a price that is set by the National Agricultural Export Board weekly, according to expected market prices. The cooperative or private washing station then sells the beans to exporters or, in some cases, directly to international coffee companies. Coffee that is sold to exporters is shipped to Mombasa, Kenya where it is sold at auction. From there the coffee is put on freighters bound for ports all over the world (K. C. Boudreaux 2011).

Rwanda's coffee strategy and key actors

Although by the late 1990s the coffee sector was very weak, the Rwandan government determined that the industry could be revived through value addition and quality improvements (Ministry of Agriculture and Animal Husbandry & Ministry of Trade and Industry, 2008). Rwanda's Ministry of Agriculture & Animal Husbandry and Ministry of Trade & Industry developed a foundational document — The Rwanda National Coffee Strategy — in 2002 with the help of a Boston-based consulting firm (2008). Revised in 2008, the strategy outlined the key priorities and benchmarks necessary to increase the output of specialty coffee, including decreasing production of ordinary coffee as a percent of total production and building the national coffee system on specialty and standard coffee (K.C. Boudreax, 2011). The 2002 strategy set the ambitious goal of achieving US $600 million in coffee export revenue by 2012; in 2008 this target was dropped to US $115 million by 2012 (Ministry of Agriculture & Animal Husbandry and Ministry of Trade & Industry, 2008). The strategy also predicted that by 2012, 63% of Rwandan coffee would be fully washed, specialty coffee. As of 2009, specialty coffee made up 19% of Rwandan coffee produced and 31% of coffee export revenue (Ministry of Agriculture & Animal Husbandry and Ministry of Trade & Industry, 2008). Although Rwanda will likely fall short of some targets, significant progress toward meeting the Coffee Strategy's goals has been made. In 2002, for example, the strategy projected that Rwanda would have 107 coffee washing stations by 2012; as of 2011, an estimated 200 coffee washing stations are operational (Ministry of Agriculture and Animal Husbandry & Ministry of Trade and Industry, 2008; Boudreaux, 2011; Ministry of Trade and Industry, 2011; Schilling, ESRI International User Conference, 2011).

A number of government agencies oversee, implement, and support the National Coffee Strategy. The National Agricultural Export Board (NAEB), Rwanda's coffee authority, works

closely with other governmental stakeholders, including the Rwanda Cooperative Agency (RCA) to create the enabling environment for growth in the specialty coffee sector (Ministry of Agriculture and Animal Resources, 2011). According to SPREAD Director Jean Claude Kayisinga, these two organizations are exceptionally influential and partner closely with the USAID-sponsored SPREAD project; for more information on SPREAD, see Pillar 2 (Kayisinga, 2011). Formerly known as OCIR-Café, NAEB serves as the central government body concerned with the coffee industry. It conducts outreach and extension services to farmers as well as developing and implementing coffee quality standards and expanding the number of coffee washing stations (Muhoho, 2011).

The Rwanda Cooperative Agency is a relatively young organization charged with organizing, building capacity in, and registering Rwanda's many cooperatives in coffee, tea, and other industries. Institutions such as NUR and the Rwanda Agricultural Research Institute (ISAR) invest in agricultural research in areas such as soil science, water management, pest control, and other areas that impact the health of specialty coffee in Rwanda. NUR, ISAR, and NAEB make up the Rwandan government's "Coffee Cluster," a nascent research collaboration of which LINK Challenger Daniel Rukazambuga is a founding member. These organizations work closely to build capacity and improve quality across the specialty coffee value chain. Perhaps the truest measure in the impact of these and other efforts lies in the benefits gained by Rwanda's smallholder farmers. This cohort is the subject of the next section.

Benefiting from Specialty Coffee: A Profile of Rwanda's Smallholder Farmer

The average Rwandan coffee farmer

One hundred and sixty five trees: that is the average stand size of a Rwandan coffee farmer (Goldstein, 2011). Land holdings in Rwanda are similarly small due to the country's high population density; two-thirds of Rwandan households own less than a quarter hectare of land. By comparison, the average Columbian smallholder coffee farmer works 1.2 hectares of land, and the average Nicaraguan small or medium-sized coffee farm owner works 2.4 hectares (New Agriculturalist, 2010; Gomez, n.d.). On that land, Rwandan smallholders grow more than just coffee. They commonly grow maize, sweet potatoes, cassava, tea, bananas, and other produce. With such constraints, it takes the harvest of approximately 500 Rwandan coffee farmers to produce one container load of exportable green coffee (Project Rwanda "The Coffee Bike", n.d.).

Coffee farmers represent only 10% of the 90% of Rwandans who work in agriculture, but the coffee they produce makes up a substantial portion of the country's exports (Rukazambuga, 2009; UNCTAD & the Ministry of Trade and Industry, 2010). The Rwandan small-holder farmer is the heart of the country's coffee sector: The day-to-day efforts, obstacles, and goals of the Rwandan small-holder coffee farmer define the industry's prospects for growth.

The Rwandan coffee farmer is not just an input on which a functioning coffee sector depends. Coffee farmers, like most Rwandan agricultural workers, make less than $2 per day, indicating poverty (USAID, 2009). A thriving specialty coffee industry does more than grow Rwanda's gross domestic product; it helps put more money into the pockets of some of Rwanda's poorest families. Despite their small land holdings, the income of Rwandan coffee farmers increases with the growth of the specialty coffee industry. In 2008, Rwandan coffee cherries sold for double the price they had five years earlier, improving the incomes of those farmers who produce more, higher quality coffee (Swanson and Bagaza, 2008). As a crop, specialty coffee has the potential to bring thousands of Rwandan farmers a better quality of life. Manifesting this outcome requires that stakeholders across the specialty coffee sector value chain work together to ensure the growth of the industry benefits the smallholder farmers on which productivity depends.

The Average Rwandan Coffee Farmer

Number of Farmers: The 500,000 Rwandan families that grow coffee are on average composed of five people, half of whom are at an actively employable age (K. C. Boudreaux 2011)

Age and health: Fifty-six percent of the agricultural population is under 20 years old in a country where average life expectancy is 50.6 years (World Bank, 2009; National Institute of Statistics of Rwanda 2008)

Education: Almost 22 percent of Rwandan farmers never attend primary school,; sixty-four percent of the agricultural population is literate. (National Institute of Statistics of Rwanda 2008)

Income: 90% of Rwandans, 71% of whom work in agriculture, live on less than $2 per day (Kitzantides 2011)

For example, farmers sometimes have to travel as much as five or ten kilometers to deliver their ripe coffee cherries to the washing stations. Traversing poor, hilly roads make these long treks very difficult (Project Rwanda, Impact, n.d.). Fresh cherries must arrive to the coffee washing station or buyer within 12 hours of their harvest to maintain their high quality, so access needs are heightened. To meet the time-delivery constraints, farmers often leave ripe cherries behind, thereby losing potential income (SPREAD, 2008). Ongoing infrastructure investments, such as increasing the number of coffee washing stations and making road improvements, lessen the transport constraints on these farmers. There also are creative solutions at work, such as specially designed coffee bikes that facilitate farmers' transport of ripe coffee cherries to the washing stations.

Clarifying farmer incentives to hasten quality improvements

Coffee washing stations use industry-wide guidelines to determine which cherries they should buy (e.g., cherries must be red and therefore ripe). Such regulations not only improved coffee quality over the last decade, but also provided important incentives to farmers for the production and timely delivery of acceptable cherries for purchase (Schilling, 2011). Determining whether a farmer delivered a *high-quality* product surpasses the standard guidelines. The bulk of ripe / acceptable cherries, not the quality grade, determine a farmer's pay. Thus, the incentives to produce high quality cherries remain opaque.

The quandary lies in the fact that coffee washing stations cannot readily tell which cherries are high or low quality until they are washed. Each farmer harvests a small volume of coffee cherries, usually not one that is large enough to wash in separate batches. Instead, cherries from many different farmers mix together and get washed as a single large batch.

Damage from antestia bug and other sources cannot be seen until the red "cherry" flesh is removed, thus mitigating a sorter's ability to distinguish from which farmer the cherry came.

Sorters analyze green coffee beans, inspecting them for black spots or other defects indicating inferior quality, and potentially potato taste. Because cherries cannot easily be tracked through the washing system, farmers receive the same price whether they deliver high, medium, or low quality beans. Cooperatives as a whole receive a dividend based on the market price for beans, which is in turn based on quality. Cooperatives typically distribute the dividend across its membership. Thus, farmers are not individually rewarded for producing especially high quality beans nor are they punished for producing low quality beans. The diffusion of responsibility and reward mitigates farmer incentives to protect their crops from pest damage (from the antestia bug, for example) and / or invest in quality-enhancing techniques (Maraba I Coffee Washing Station, 2011).

Cooperatives and Rwandan Specialty Coffee

One-third of coffee washing stations in Rwanda are owned by cooperatives. Cooperatives on average include between 1,000 and 2,000 farmers. Farmers pay dues, which guarantee farmers payment for cherries at the coffee washing station as well as a dividend based on the market sale price of the dried parchment coffee. Cooperatives use extra income from coffee sales to pay washing station staff, purchase fertilizer and seedlings for member farmers, and provide loans to members (Goldstein, 2011).

While coffee washing stations and cooperatives contributed to the transformation of Rwanda's coffee sector, a few persistent challenges stifle their effectiveness, including poor management, lack of resources to hire qualified staff, and limited communication between farmers and managers. Continuous efforts by the National Agricultural Export Board and international partners aim to address these capacity and resource bottlenecks (Rwanda Ministry of Trade and Industry, 2011; Swanson and Bagaza, 2008).

Linking increasing skills to sustainable progress

Slow uptake of modern farming techniques by Rwandan smallholder farmers in particular hinders the country's specialty coffee sector. A few oft-cited examples illustrate the point. Young trees and seedlings often do not grow and produce at their full potential due to insufficient care (Ministry of Agriculture and Animal Husbandry & Ministry of Trade and Industry, 2008; National Institute of Statistics of Rwanda, 2008). For example, though 83% of Rwandan farmland is located on hills where the downward slope and frequent cultivation encourages erosion, farmers often fail to implement modern and even traditional anti-erosion techniques (National Institute of Statistics of Rwanda, 2008). Similarly, farmers struggle with insects and plant diseases due to a lack of training in and access to more modern forms of pest management.

Farmers' lack of access to training poses a challenge perpetuating some of these problems. The ratio of farmers to extension agents in Rwanda is 13,000 to one, rendering training in optimized approaches rare in both rate and content covered (World Bank, 2009). Existing programs include those of the National Agriculture Export Board and the Rwanda Cooperative Agency that oversee outreach to farmers and cooperatives, working closely with international donors and NGOs to facilitate training. NAEB's staff of agronomists and other coffee experts interacts directly with farmers, and provide inputs such as fertilizer. USAID's SPREAD project, a partner of NAEB and RCA, focuses on quality improvements and capacity building throughout the coffee value chain. The US-based non-governmental organization TechnoServe also works directly with farmers and coffee washing station workers. For example, it implements the Bill and Melinda Gates Foundation-sponsored Coffee Initiative, a US $47 million project active in Rwanda, Kenya, Ethiopia, and Tanzania, that works with approximately 180,000 farmers

(TechnoServe, 2010). Addressing these bottlenecks requires innovative approaches to outreach, training, and research. Ensuring the smallholder farmer remains central to the strategies aimed at addressing the potato taste defect constitutes an important first step in addressing these bottlenecks.

Pillar 2 Rwandan Specialty Coffee: Knowledge Networks & Interactions

Revitalizing and Reorienting the Rwandan Coffee Sector Through Partnership

Cross-sectoral partnerships vital but intermittent

Partnership with strategic allies enabled the Rwandan government to restore and transform its country's coffee industry. The Rwandan government and a host of stakeholders – such as NGOs, coffee companies, development partners, and universities – used a diverse array of mechanisms to increase specialty coffee production through the early to mid 2000s. Many of these interventions focused on sub-challenges 1 (How might we build effective networks throughout the coffee system?) and 4 (How might we expand the specialty coffee sector?), though these challenges were tackled in the broader context of developing the coffee sector, not addressing the potato taste defect challenge explicitly. These earlier efforts included improvements to coffee quality, the development of coffee cooperatives, and improvements in Rwandan coffee branding and marketing.

The list below outlines a few of the most noteworthy collaborations aimed at improving Rwandan coffee quality and expanding its market share. It is by understanding such past and ongoing partnerships that new entrants appreciate what sub-challenges are sufficiently addressed and where holes exist in collaborative efforts that merit action to improve sector performance.

- **Partnership for Enhancing Agriculture in Rwanda through Linkages project (PEARL):** One of strongest and most successful partnerships in specialty coffee expansion, PEARL combined the efforts of the Rwandan government, the US government, and academia in Rwanda and the US. In 2000, USAID, Michigan State University, and Texas A&M University initiated collaboration with NUR and the NAEB, formerly OCIR-Café. PEARL supported quality coffee production in Rwanda by assisting Rwandan coffee farmers in forming cooperatives, building coffee washing stations, and helping cooperatives start their own stations (Swanson and Bagaza, 2008). The project also brought international coffee experts to Rwanda to train cuppers (coffee tasters who describe the taste characteristics of roasted beans), washing station managers, and co-op leaders. PEARL ended in 2006, but was immediately followed by the SPREAD project.
- **SPREAD (Sustaining Partnerships to Enhance Rural Enterprise and Agribusiness Development):** Started in 2006 as an extension of PEARL, SPREAD is funded by USAID, and implemented by Texas A&M, NUR, and NAEB, and, starting in 2011, the Global Coffee Quality Research Initiative (Managa, 2011). In addition to improving coffee quality in Rwanda and organizing cooperatives, SPREAD reached out to international coffee companies such as Green Mountain Coffee, Intelligentsia Coffee & Tea, Stumptown Coffee Roasters, and others to train coffee washers, cuppers, and managers in Rwanda (SPREAD, 2011). PEARL and SPREAD both prioritized educating international coffee companies about Rwanda's potential as a global leader in specialty coffee production. In 2012, a second round of the SPREAD project begins. Although priorities are not yet public, there will likely be continued support for marketing and capacity building, as well as investments in research (Managa, 2011).
- **The Coffee Initiative:** A similar project called the Coffee Initiative, implemented by TechnoServe and funded by the Bill and Melinda Gates Foundation, works on quality improvements at the farm level in Rwanda, as well as in Tanzania, Kenya, and Ethiopia.

The Coffee Initiative has reached 67,000 smallholder farmers to date (TechnoServe, 2010). As a result of these projects and others like them, the number of coffee washing stations in Rwanda grew from two in 2002 to 112 in 2009 (Ministry of Agriculture and Animal Husbandry & Ministry of Trade and Industry, 2008; Boudreaux, 2011).

Due in large part to these collaborations coffee connoisseurs have come to view Rwandan coffee as a premier supplier in just ten years. The following textbox details other efforts to enhance the international standing of Rwandan specialty coffee.

Cup of Excellence: One way that Rwanda overcame its initial low-quality coffee image is through The Cup of Excellence, a coffee-taste competition sponsored by the Rwandan government's National Agricultural Export Board. The competition is organized by the Cup of Excellence organization, a non-profit that holds coffee competitions to encourage high-end buyers to invest in developing countries. Tasters from international coffee companies, including US roasters Green Mountain Coffee, Counter Culture Coffee, and Intelligentsia Coffee & Tea travel to Rwanda to sniff and sample roasted beans picked from cooperatives throughout the country. Begun in 2008, Rwanda's Cup of Excellence is now the annual showcase for the best of Rwandan coffee. The winners – cooperatives producing and washing exceptional coffee – receive the prestigious Cup of Excellence award. They also are eligible for an even bigger benefit: coffee companies compete to outbid each other for the finest beans. In 2010, Hiro Coffee Co. Ltd bought the winning coffee for $23.61 per pound (Cup of Excellence, n.d.). By comparison, in 2011, coffee prices hit a 14-year peak at the New York Mercantile during which roasters paid up to $2.65 per pound (Smith, 2011).

Government of Rwanda spearheaded initial and ongoing networking activities

As noted previously, even early coffee sector interventions prioritized sub-challenge 1: How might we build effective networks throughout the coffee system? While these efforts were not necessarily focused on pest management, a relatively robust number of organizations interact regularly with the shared goal of growing the quality coffee sector in Rwanda. The Government of Rwanda deserves much credit for this active partnership landscape, as it guides the specialty coffee industry's development through a number of agencies and institutions. Important government stakeholders already discussed in this analysis include the NAEB, ISAR, and NUR. As well, high level champions, most notably President Paul Kagame, played an active role in enhancing the international reputation of the country's specialty coffee varietals through advocacy with international partners. According to Fast Company Magazine, President Kagame personally courted executives at Costco and Starbucks, now the two biggest buyers of Rwandan coffee. He also won the support of former US President Bill Clinton whose foundation subsequently partnered with the Rwandan government and the Hunter Foundation to build a coffee processing plant in Kigali to help buy fertilizer and train farmers (Chu, 2009; William J. Clinton Foundation, n.d.; Clinton Global Initiative, 2009).

Collective action that balances relevant sub-challenges still needed

Despite the rapid growth experienced in the sector and the dedication of the Rwandan government and international stakeholders, challenges persist. Some of these, such as the potato taste defect, are serious enough to dampen specialty coffee growth. The emergence of the potato defect reveals that these partnerships may have overemphasized market growth and enhanced coffee quality in lieu of other sub-challenges such as on-farm management (sub-challenge 2) and pest research (sub-challenge 3). Specific veins of research and outreach

invisible in past collaborations are now of critical importance. What is needed is a balanced approach that takes into account past successes, ongoing activities, and currently orphaned or underemphasized issues.

Collaboration Key to Sustainability

Collaboration has proved to be a successful mechanism for revitalizing and sustaining the Rwandan coffee sector. Indeed, examples from the past reveal what can be accomplished when organizations and institutions work in concert rather than in isolation. Yet, some organizations, because of their mandate, leadership, organization, or other factors, are more amenable to partnership than others. It is important to understand a potential partner's proclivity to collaborate when considering whether and how to combine efforts. The following scorecards offer a preliminary assessment of the collaboration tendencies of key coffee sector organizations in Rwanda.

The Global Knowledge Initiative developed the following Collaboration Scorecards using primary and secondary research. The scorecards strive to give potential collaborators basic information on the ease or difficulty of partnering with the organizations and institutions featured. Rather than offering a definitive appraisal of an institution's capacity, the Collaboration Scorecards provoke consideration of an institution's partnership track record. Although we undertook extensive research in creating this tool, we recognize that the addition of relevant facts and perspectives will only improve upon these initial assessments. If a greater number stakeholders and readers refine these evaluations and add to this initial cataloguing by creating scorecards for other relevant institutions, a more complete picture can emerge. With more detail, the scorecards become even more valuable tools with which to forge and optimize new and existing collaborations.

The authors selected the organizations highlighted on the scorecards below and in Annex I because of their importance to the coffee sector in Rwanda generally. These are organizations that likely offer resources essential to addressing one or more of the potato taste defect sub-challenges identified in Pillar I.

Cross-cutting insights from the collaboration scorecards

The list of featured collaborators represents substantial diversity in terms of the level of collaboration (e.g., highly active in Rwanda, active in other geographies but not yet Rwanda) and type of collaboration (e.g., laboratory research, grass-roots farmer education) of in the coffee sector. Despite the differences, a few strong themes emerge.

(1) The prominent organizations working in Rwanda, with some exceptions, are highly networked, and collaborate extensively. Many of these organizations collaborate with each other, and with other organizations not listed here.

(2) Too often research appears disconnected from farmer outreach activities. In the case of research undertaken under SPREAD, by NUR, and ISAR, it is unclear the extent to which the majority of research efforts substantially extend to the farmer. For institutions like international NGOs CABI and CIRAD, France's agricultural development agency, little or no connection to Rwandan coffee farmers occurs as neither institution works actively in Rwanda. Organizations with strong connections to farmers, such as NAEB, TechnoServe, and the coffee companies often do not undertake their own research. This indicates a potentially precarious knowledge gap between researchers, agriculture-based trainers, and

farmers, all of whom must collaborate to eliminate the potato taste defect in Rwandan specialty coffee.

(3) The SPREAD project appears to be effective at leveraging resources and partners. Every potential collaborator on the list with the exception of CIRAD and CABI connect in one way or another to SPREAD. Such analysis points to the SPREAD project as a "super-connector," one that is likely a necessary partner in developing a solution to the potato taste defect challenge.

(4) A systematic lack of funding and research characterize efforts to address the potato taste defect. SPREAD expends substantial resources on research to improve coffee quality, and recently began working with Dr. Timothy Schilling at the Global Coffee Quality Research Initiative to research potato taste in dried coffee. However, CIRAD is the only organization that has conducted significant research on potato taste defect at the farm level, and generally does not work in Rwanda (Cilas et al, 1998; Bouyjou B., 1999). These scorecards reveal a lack of funding for potato taste research at the farm level. The good news is – fighting the potato taste defect could easily fit into the mission of many of these organizations.

Full List of Collaboration Scorecards

In the analysis body:

1. SPREAD
2. Cup of Excellence
3. ISAR
4. Michigan State University

In Annex I:

5. Transfair USA
6. TechnoServe
7. Green Mountain Coffee
8. Rwanda Development Board
9. CABI
10. Rwanda Cooperative Agency
11. Roger's Family Coffee
12. Starbucks Coffee Company
13. RWASHOSCCO
14. Texas A&M University
15. CIRAD
16. National Agricultural Export Board

A number of other organizations could and should be analyzed through Collaboration Scorecards. These include the Rwanda Cooperative Agency, coffee companies such as Counter Culture Coffee, Intelligentsia Coffee & Tea, Stumptown Coffee, and the Global Coffee Quality Research Initiative. We hope to expand our list of Collaboration Scorecards, and again encourage any stakeholders or collaborators to create their own scorecards and add to our collective knowledge of the collaboration landscape in Rwandan specialty coffee. Finally, the scorecards are not meant to deter partnership with any of these organizations. Instead, they aim to inform potential partners of cases in which additional time and resources may be required to render collaborative activity demonstrable of sector-wide outcomes and outputs.

Collaboration Scorecards help potential partners identify the super-collaborators (green), those on their way to becoming collaboration pros (yellow), and those that are not yet active in the collaborative innovation game (red).

SPREAD

Key facts

SPREAD (Sustaining Partnerships to Enhance Rural Enterprise and Agribusiness Development) is a project aimed at increasing incomes for Rwandan coffee farmers and cooperatives. SPREAD provides them technical assistance in areas such as coffee production, processing, management, packaging, and sales. Funded by USAID and led by Texas A&M University, SPREAD is composed of Texas A&M, NUR, NAEB, and works closely with many NGOs and specialty coffee companies. SPREAD is also a sponsor of the Rwandan Cup of Excellence and undertakes research on Rwandan quality coffee and appellation.

Strengths

- Substantial funding from USAID
- SPREAD has a history of research, and research-focused partners such as with Texas A&M
- Strong relationships with international coffee companies and Rwandan government

Weaknesses

- Priorities for SPREAD II unclear
- Potato defect research has largely been focused on improving post-harvest coffee quality not causes of the defect

Cup of Excellence

Key facts

The first Cup of Excellence was held in Rwanda in 2008 and has continued since. This event has helped improve the quality of Rwandan coffee, market specialty coffee to international buyers, and reward coffee washing stations for performance. Cup of Excellence is well connected; the same coffee companies who work with SPREAD on farm or cooperative-level quality improvements help judge coffee at the event. This bodes well for collaboration; however, because Cup of Excellence is essentially an event-planning organization, it may be difficult for the organization to expand their mission to combat pests causing potato defect. In terms of detecting the defect, though, they may be among the best positioned to do so.

Strengths

- Well connected in Rwandan Specialty Coffee
- Well-placed to identify coffee potato defect
- May have ability to leverage interest of coffee companies in potato taste research
- Could be used to gather baseline data on potato taste regionally

Weaknesses

- Mission does not have explicit research/outreach component
- Largely an event organizing entity

ISAR

Key facts

The Rwanda Agriculture Research Institute (ISAR) stands as a major research institute in Rwanda tasked to help in the transformation of subsistence to commercial agriculture. Its coffee program currently investigates various aspects of high quality coffee production, including screening, identifying, and preventing coffee diseases such as coffee leaf rust. Researchers at ISAR also develop high-yielding, pest-resistant varieties of coffee that are distributed by the National Agriculture Export Board.

Strengths

- Familiar with on-farm and on-station evaluation techniques due to prior research with coffee leaf rust
- Already collaborating with NAEB and NUR
- Has previously collaborated with CABI

Weaknesses

- Low level of funding
- Lack of fully trained staff

Michigan State University

Key facts

In 2001 Michigan State University (MSU) partnered with USAID and, with Texas A&M University's assistance, led the PEARL project, which substantially improved the quality of Rwandan coffee and doubled many coffee farmers' incomes. In 2006 when PEARL was renewed as SPREAD, MSU did not take a leadership role in the program. According to MSU's website, they are still involved in Cup of Excellence and other SPREAD-sponsored projects, however, Rwandan coffee experts have downplayed MSU's role. PEARL's former head, MSU's Dr. Dan Clay, is currently helping to lead a USAID-sponsored coffee project in Burundi. It is unclear how involved MSU is in Rwandan coffee, and whether they will be involved in future projects.

Strengths

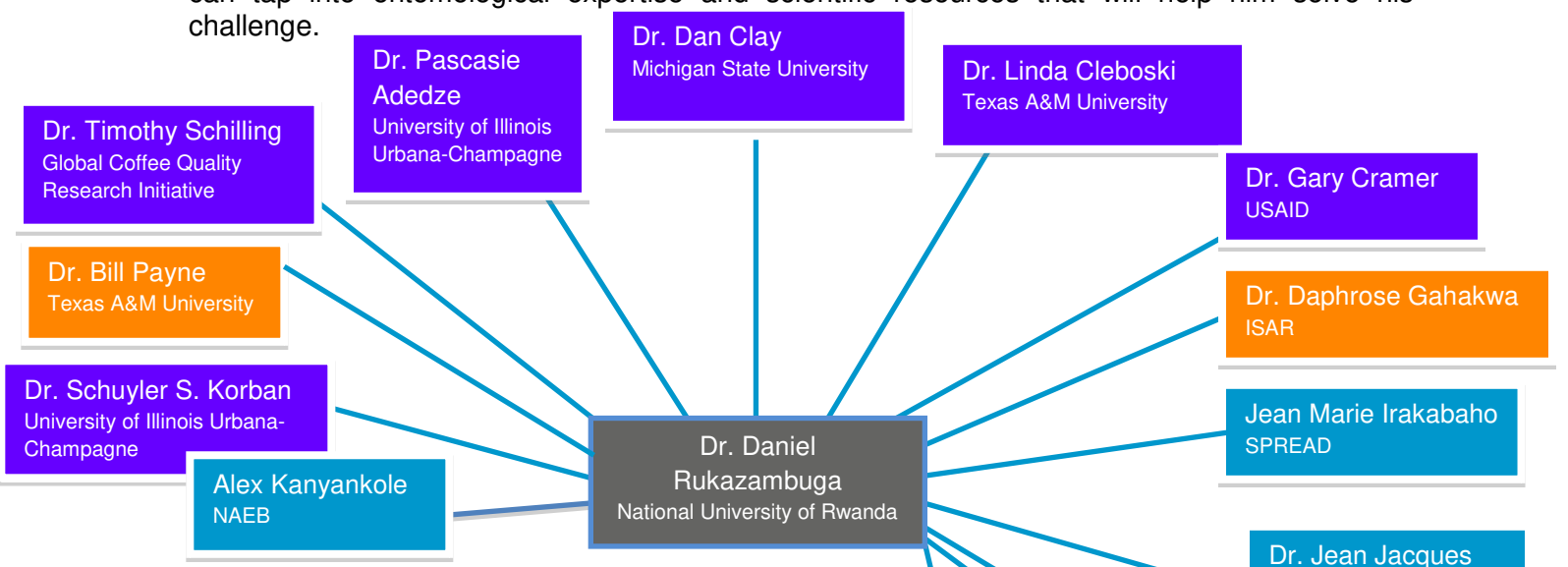
- Exceptional history of work on specialty coffee in Rwanda
- Connections to organizations and individuals currently working in Rwanda
- University has strong agricultural research record

Weaknesses

- No longer working substantially in Rwanda. After five years in Rwanda, focusing on Burundian coffee today
- No record of work specifically on potato defect

From Institutional to Personal Collaborations

While institutional partnerships prove vital for sectoral transformation, scientists' networks look much more personal. With Daniel Rukazambuga as the Principal Investigator of the LINK challenge, the authors sought to explore his network to ascertain what resources exist and where opportunities for new partnerships are most attractive. Though not exhaustive, this visual illustrates Daniel Rukazambuga's network. The diagram includes potential collaborators whom Daniel identified and those who work in organizations and institutes partnering with NUR. Daniel's partners range from scientists to coffee exporters to farmer outreach experts. The strength of Daniel's network is its diversity, yet he lacks partnerships specifically with entomologists who have worked with coffee pests. By connecting with other networks, Daniel can tap into entomological expertise and scientific resources that will help him solve his challenge.

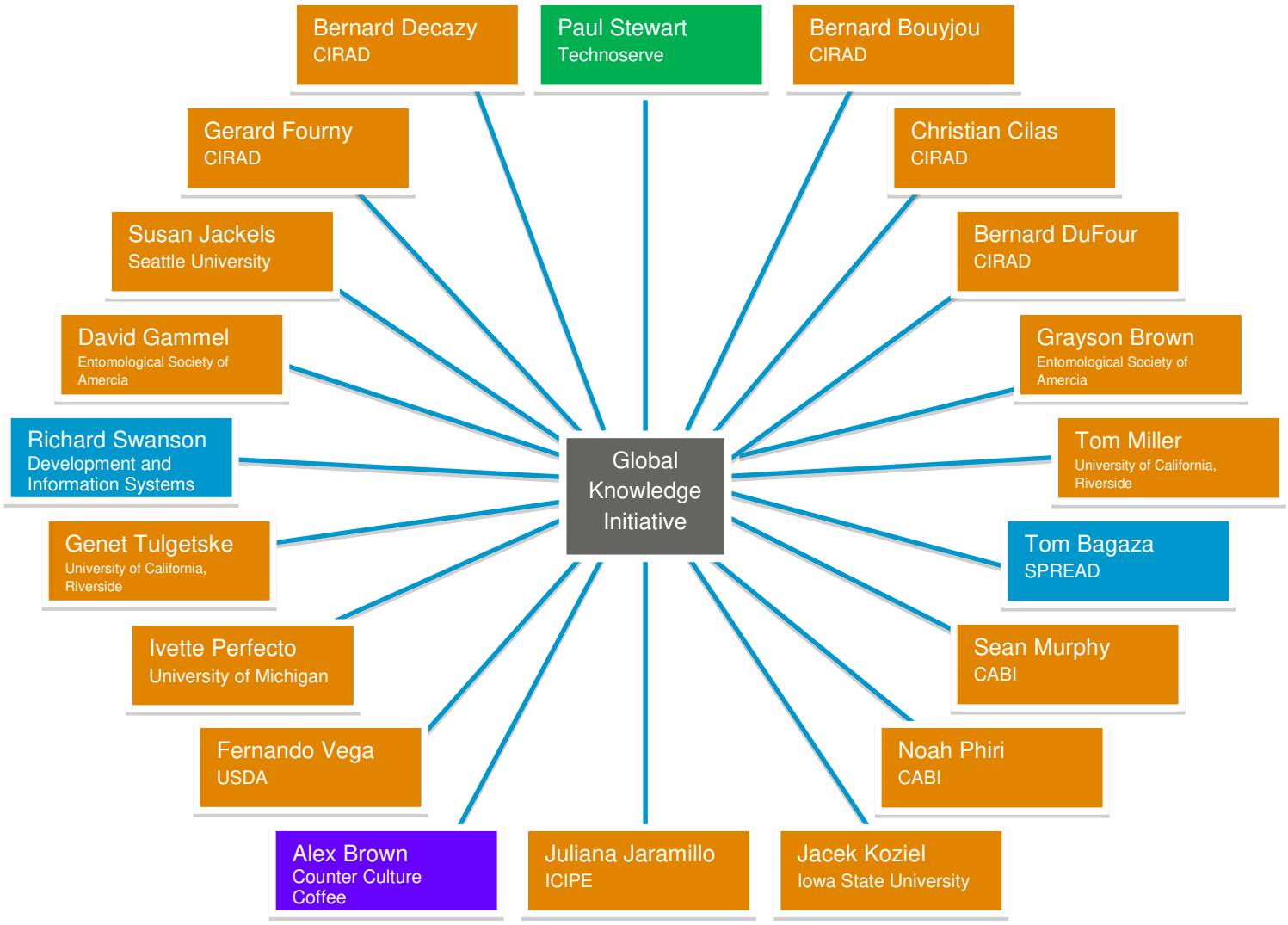


Sub-challenge Key	
HMW improve the export rate and productivity of specialty coffee - grow the industry?	HMW expand the specialty coffee market?
HMW improve and increase utilization of coffee?	
HMW improve quality/ensure quality of coffee for export?	
HMW research and combat the antestia bug/pests?	HMW use research to reduce / eliminate potato taste challenge?
HMW research and eliminate potato taste?	
HMW use IPM to solve challenge/eliminate antestia bug/coffee pests?	HMW empower farmers to manage pests on a grassroots level?
HMW work with coffee farmers to solve challenge?	
System: HMW work together/bring groups together to solve challenge?	HMW build effective networks throughout the coffee system to combat potato taste?
HMW improve the coffee production infrastructure and inputs?	

A Next Generation of Collaborators for the Potato Taste Team

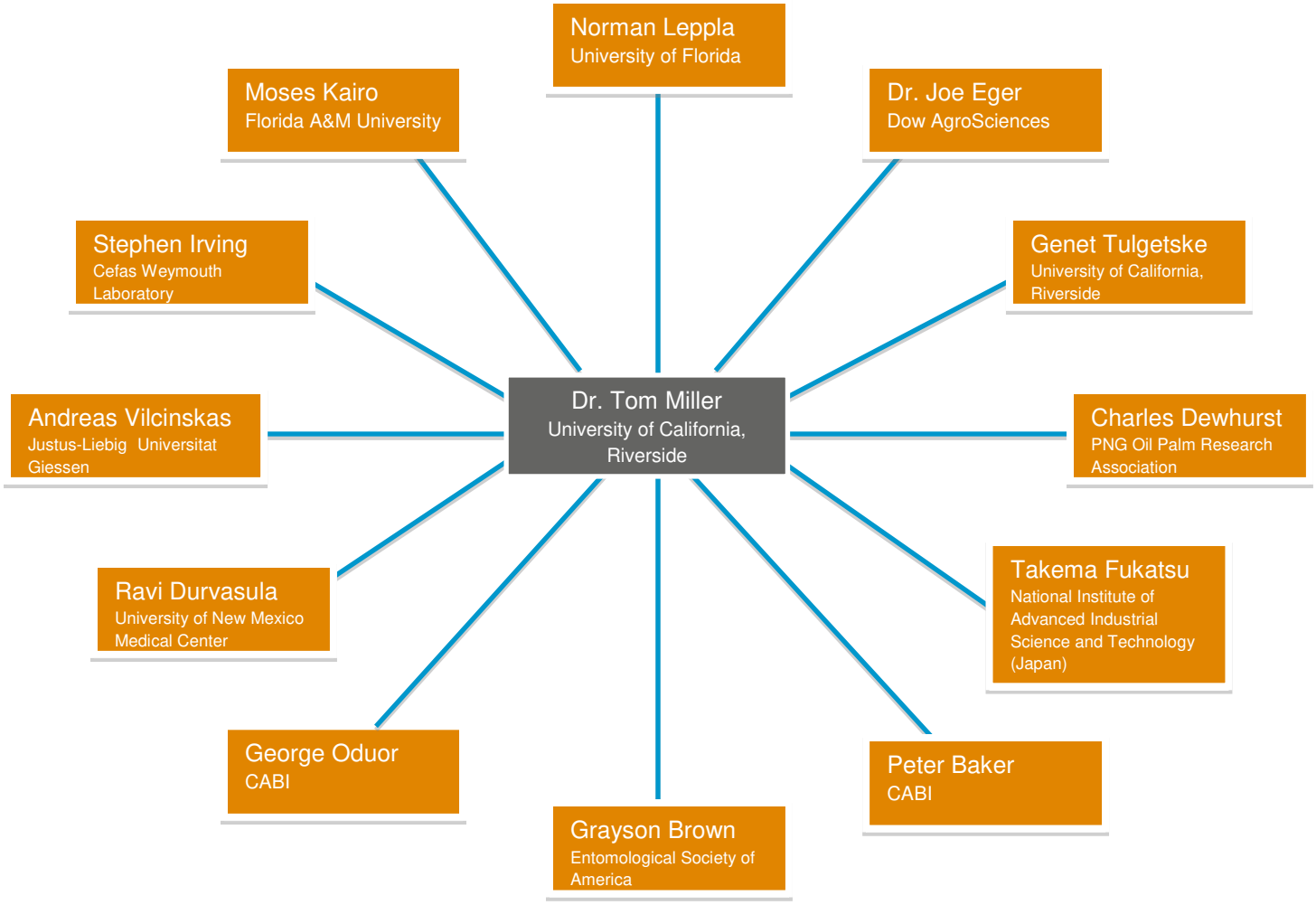
This visual illustrates a sampling of the individuals the Global Knowledge Initiative identified who may be able to help Daniel, his team, and others solve the potato taste challenge. Some of these individuals may know of the National University of Rwanda's work in coffee already. Others may have never heard of the potato taste defect but because of their stake in research, outreach, or coffee quality, may offer needed resources. The Global Knowledge Initiative's network includes a substantial number of entomologists who have worked on coffee pests; researchers poised to help Daniel solve his scientific challenge.

This microcosm of the available solvers world-wide relevant to the potato taste challenge serves as a call to the Rwandan community to engage in an even more thorough landscape analysis to identify the individuals needed to devise and implement a durable solution to the challenge.



How Might We Tap Into Research Networks?

Finding the right group of people to collaborate on solving a scientific challenge involves exploring networks of researchers and practitioners to identify the right mix of specialties, talents, and interests. Below is an example of one researcher's network, stretching across disciplines and around the globe. Dr. Tom Miller, an Entomologist at the University of California, Riverside, is already using his network to help Daniel and his team leverage resources toward solving the potato taste defect challenge. Though primarily a research network, Miller's largely entomological network numerous potential human and knowledge resources necessary for solving the potato taste defect challenge.



Pillar 3 Potential Outputs & Outcomes of Solving the Potato Defect Challenge

What Does Success Look Like?

Defining success in terms of solving the potato taste defect challenge can take many forms. For some, success may be developing a technology that detects the defect before it can be passed along to buyers and consumers. For others, it may involve developing an effective way to capture the antestia bug before it can puncture the coffee cherries. For Daniel Rukazambuga, success means understanding the relationship between the antestia bug and potato taste such that effective technologies and control strategies appropriate for smallholder farmers are developed and implemented. None of these definitions of success are necessarily "right" or "wrong." Rather, it is likely a combination of these definitions will contribute to a long-term, comprehensive approach to eliminating potato taste in Rwandan specialty coffee. Consider the following hypothetical scenario as an example of how a number of individuals and institutions, working collaboratively, might contribute to a shared vision of the future: an increasing supply of Rwandan specialty coffee free of the potato taste defect.

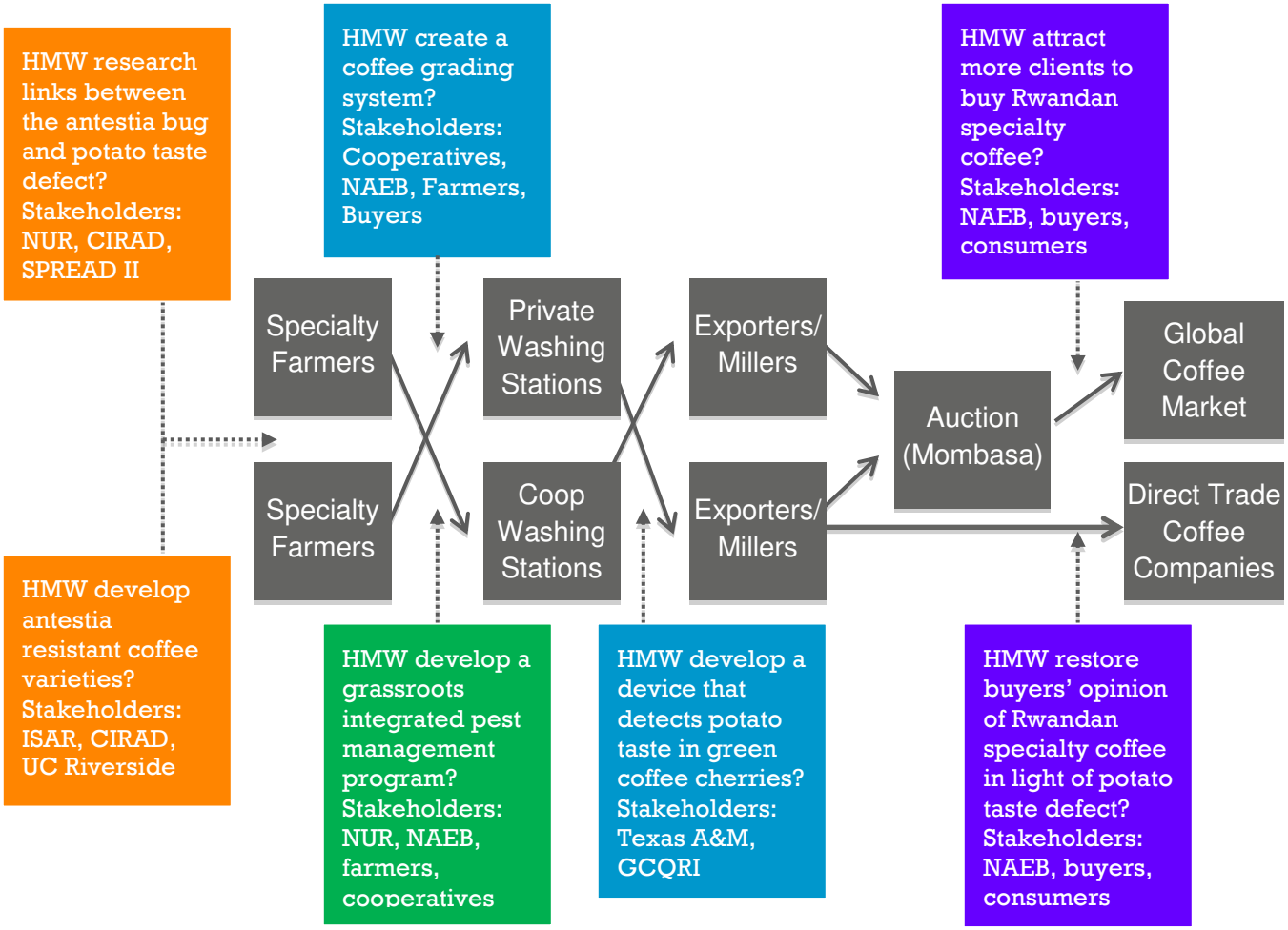
Possible Scenario: Eliminating potato taste defect through collective action

Armed with surveys and laptops, teams of NUR graduate students and faculty members walk into the fields of Huye District. Their job: to collect baseline data on potato taste defect and antestia bug incidence. Once collected, they upload their findings to a master database, which is shared among a group of scientists, policymakers, and business leaders working to rid Rwandan specialty coffee of potato taste. A researcher at CIRAD integrates this data into her latest inquiry analyzing the hypothesis that antestia's bites leave a coffee cherry susceptible to a fungus causing potato taste. At the same time, the SPREAD Director adds the names of farmers surveyed to the list of potential trainees. Next week, a coffee cooperative in Huye affiliated with the SPREAD II Project will train local coffee farmers on antestia bug mitigation strategies. Far away from the fields of Huye, researchers at the University of California, Riverside explore methods to prevent the antestia bug from attacking coffee cherries in the first place, while researchers at the Global Coffee Quality Research Initiative investigate how to detect potato defect in green coffee. All along the specialty coffee value chain, actors following distinct but complementary pathways work to achieve a common goal: eliminating potato taste defect in Rwandan specialty coffee.

Eliminating Potato Taste Through Collective Action

Achieving the above scenario does not require a fundamental shift in the missions or ongoing activities of any of these individual actors. Rather, it necessitates (1) understanding the stakeholders critical for such a comprehensive approach and (2) a more integrated knowledge network that facilitates strategic planning, communication, and resource sharing among these necessary partners. Opportunities for collective action emerge when the initial challenge map developed by the expert team at NUR is married with the specialty coffee value chain and the network maps. The following diagram gives one example of how a collective action system might be organized to address the potato taste defect challenge through such integration.

Opportunities to address potato taste defect throughout the Specialty Coffee Value Chain in Rwanda



Graph adapted from: Boudreaux, 2011; Jones & Martin, 2010

This diagram offers one example of a collaborative action scheme that can be adopted to solve the potato taste challenge. Many of the efforts noted in the scheme are underway currently, some of which have been highlighted in this analysis. Other interventions, as discussed in Pillar 2, have received less attention from Rwandan coffee stakeholders than others, such as researching the cause of potato taste and its links to antestia bug. However, even current potato taste detection and mitigation efforts remain largely ad hoc and removed from a broader systemic approach to developing a long-term solution to the challenge. Many pieces of the puzzle are there; now is the time to bring them together into a cohesive approach toward purpose-driven collaboration.

Beyond laying bare the context in which the potato taste challenge will be solved, defining the roles specific partners can play in this effort constitutes a next step. The National University of Rwanda's Knowledge Partnership Landscape Analysis offers unique insight into that institution's

collaboration potential, and provides a case study of how the many stakeholders engaged in the Rwandan coffee sector might be aligned to realize a sustainable solution to potato taste.

Efforts are underway to initiate this collective action system. In January 2012, Tom Miller of University of California Riverside, Christian Cilas of CIRAD, and experts from the Global Knowledge Initiative will join Dr. Daniel Rukzambuga, members of the LINK Rwanda coffee research team, and more than 100 key stakeholders within the broader science, technology, and innovation ecosystem within Rwanda for a series of planning meetings. The aim of these efforts is to develop a whole-of-system research and action strategy for addressing the potato taste defect. The broad constituency of specialty coffee sector stakeholders to discuss system-wide action will include representatives from the Government of Rwanda, SPREAD, and the private sector. The Global Knowledge Initiative will release this initial analysis at the stakeholder consultation. The goal of doing so is to spur action within these constituencies, grow the network of potential solvers, and refine these inputs so that they may fuel the construction of a purpose-driven knowledge network capable of tackling Rwanda's, and Daniel's, potato taste challenge.

Transfair USA

Key facts

Transfair USA helps Rwandan coffee cooperatives produce and certify Fair Trade coffee. They have worked with SPREAD, and with the William J. Clinton Foundation, the Cordes Foundation, and Green Mountain Coffee on developing Fair Trade blends. A $250,000 initiative with Clinton, Cordes, and Green Mountain currently benefits two Rwandan cooperatives. Transfair is an important collaborator because it is well connected and can broker relationships between cooperatives and coffee companies. In terms of the potato taste challenge, with a focus on increasing farmer income rather than training for improved coffee quality, their contribution to solving potato taste may feature a solution at later stages of development.

Strengths

- Maintains several international partnership; cooperates with NUR
- Uses a farmer-centered model that could be helpful for outreach and co-design of solutions

Weaknesses

- Although interested in coffee quality at the farmer level, they do not have an explicit research component to their mission
- Because a small fraction of Rwandan coffee is Fair Trade Certified, few Rwandan farmers are likely connected to Transfair

TechnoServe

Key facts

TechnoServe is implementing a $47 million Bill and Melinda Gates Foundation-sponsored coffee quality and farmer support project in East Africa. TechnoServe's biggest weakness in the context of NUR's challenge is the lack of direct connections with NUR and many of the coffee companies working to improve Rwandan coffee. Because of their farmer-centric model, though, and substantial track record of grassroots technology transfer, TechnoServe could be a valuable partner. Although not closely connected with SPREAD's network of coffee companies, TechnoServe is linked to Peet's Coffee and Tea, and produces its Uzuri African Blend. If TechnoServe can link with other Rwandan coffee projects, this could be an excellent collaborator.

Strengths

- One of East Africa's best funded coffee projects
- Farmer-centric model is ideal for pre-harvest handling/pest management
- History of working closely with coffee companies and donors
- Previously collaborated with SPREAD

Weaknesses

- Coffee Initiative is not Rwanda-specific
- Not directly connected with NUR's coffee research team

Green Mountain Coffee

Key facts

This US-based coffee roaster is well connected in the international NGO, donor, coffee company, and coffee quality arenas. Green Mountain has been involved in Rwandan coffee since the early 2000s. They have partnered with the Clinton Foundation, the Cordes Foundation, and Transfair in producing Rwandan fair trade coffee blends, have also worked with SPREAD, and roasted Costco's signature Rwandan blend. Green Mountain is an extremely fast-growing company; according to Forbes Magazine, in 2010 Green Mountain was the second fastest growing company in the world.

Strengths

- Well connected in multiple sectors
- Relationships with NUR-connected NGOs
- Invested in coffee quality through GCQRI
- Invested in smallholder wellbeing through Fair Trade relationships
- Donates 5% of pre-tax profits to charity

Weaknesses

- Have not engaged directly in Rwandan coffee quality research

Rwanda Development Board

Key facts

A government agency, the Rwanda Development Board (RDB) focuses on the economic growth of Rwanda and works to promote Rwandan business, entrepreneurship, investment, human capacity, and ICTs.
In agriculture, RDB identifies and proposes growth and investment opportunities, develops agri-business projects, strengthens production chains, and supports private companies. In coffee, RDB identifies market opportunities for coffee cooperatives and businesses. In conjunction with the NAEB, RDB is responsible for the development of roasting operations within the country, the expansion of Rwanda's coffee brand, and development of new financing tools for coffee washing stations.

Strengths

- Since coffee is a national priority, the RDB places the crop as a top focus for development
- Contextualizes coffee in a business context rather than a scientific or agricultural one
- Offers free business plan analysis and marketing and logistics advice

Weaknesses

- No direct support of scientific research
- Focused strictly on macro-level business development rather than day-to-day farmer and coffee washing station technical challenges

CABI

Key facts

Cabi is an international NGO that specializes in addressing agriculture and environmental challenges through information dissemination and research. Cabi works with farmers and extension agents around the world to promote plant health and implement pest prevention, identification, and management. Cabi has maintained partnerships with organizations relevant to agricultural research in Rwanda, including ISAR, NAEB, and the International Coffee Organization. Cabi's current project in Rwanda involves investigating coffee leaf rust and training farmers to prevent and control the disease.

Strengths

- Cabi has a history with Rwandan coffee, including research on coffee wilt disease and a project to increase post-harvest coffee production quality
- Cabi publishes a large amount of scientific research concerning food security and the environment

Weaknesses

- Cabi doesn't have a center in Rwanda and Rwanda is not the key focus of its efforts. It often works in a more sectoral or regional direction
- No history of working with the potato taste

Rwanda Cooperative Agency

Key facts

The Rwanda Cooperative Agency (RCA) is a government agency founded in 2008 to build capacity in, regulate, and inspect Rwandan cooperatives. These cooperatives work in coffee, as well as in other agricultural industries. According to SPREAD, the RCA has been an effective partner in the past three years and has successfully improved the quality of coffee and management of cooperatives. In a 2011 GKI interview, SPREAD director Jean Claude Kayisinga noted that the RCA was one of SPREAD's most effective collaborators. The RCA collaborated with NUR's Center for Environment, Entrepreneurship and Sustainable Development in producing a training manual for farming cooperatives.

Strengths

- Works closely with Rwandan cooperatives
- Collaborates with numerous Rwandan government agencies, international governments, and NGOs such as SPREAD

Weaknesses

- No direct involvement in research
- Recent entrant into Rwandan coffee quality efforts

Roger's Family Coffee

Key facts

Roger's Family Coffee is a wholesale coffee importer based in the United States. They work closely with SPREAD, whose director noted Roger's Family as one of the best coffee companies with which to work. Roger's Family agronomist Dr. Mario Serracin spends much of his time in Rwanda and knows Daniel Rukazambuga's team at NUR. Roger's Family works on the ground, but is also a charitable company; they donated $4.3 million over the last few years to charitable causes, including over $300,000 to Rwanda. This funding has supported education, water purification, and girls' programs in Rwanda, though not farmer capacity building or development as such.

Strengths

- Well connected in Rwanda and internationally
- Directly connected to NUR's team
- Substantial emphasis on philanthropy

Weaknesses

- Charitable work not often explicitly connected to farmer capacity building or research

Starbucks Coffee Company

Key facts

This coffee giant constantly scours the globe for high quality coffee and invests where it finds fertile markets. Starbucks frequently sells Rwandan coffee in its shops around the world. In 2007, in cooperation with USAID, Starbucks provided assistance and expertise to teach techniques to farmers to improve their coffee quality. Two years later, Starbucks established Farmer Support Centers to increase high quality coffee production, improve overall coffee quality, and decrease production costs to farmers. In addition, Starbucks often provides loans to Rwandan coffee farmers through non-profit lender Root Capital.

Strengths

- Substantial funding available
- Stated commitment to Rwandan coffee
- Some of the most experience with specialty coffee of any coffee company in the world

Weaknesses

- Potentially less nimble than smaller roasters
- As of yet, has not funded coffee research in Rwanda

RWASHOSCCO

This SPREAD-sponsored coffee cooperative is large, well connected, and capable of producing high quality coffee. It is, however, plagued by poor management and inefficiency. RWASHOSCCO coffee washing stations regularly produce at a fraction of their potential output. A 2007 SPREAD report noted that RWASHOSCCO farmers did not often realize that they were members of a cooperative rather than employees, and did not know they had the right to question management. In improving Rwandan specialty coffee at the farm level, however, RWASHOSCCO may approve an important partner due to their extensive network and ability to reach directly into farms.

Strengths

- Well connected to farmers
- Improved coffee quality substantially
- Capable of working directly with cooperative members/farmers

Weaknesses

- Poorly managed
- Suffered from challenges with the board of directors
- Poor communication with stakeholders
- Coffee washing stations produce under capacity

Texas A&M University

Key facts

Texas A&M University has been involved in Rwandan coffee through the Norman Borlaug Institute since 2001, when Dr. Timothy Schilling collaborated with Michigan State University on their USAID funded PEARL project. Since 2006, when they became the lead on the USAID SPREAD project, they have collaborated with NUR, the Rwanda National Agricultural Export Board (formerly OCIR-Café), Rwandan coffee cooperatives, and various international coffee companies. Texas A&M helps with the administration of SPREAD, and Norman Borlaug Institute researchers have studied Rwandan coffee, including the potato taste defect.

Strengths

- Strong legacy in Rwanda (Since 2001)
- Newly formed collaboration with GCQRI
- As of 2011, approximately $125,000 per year allocated for research
- With collaborators, increased smallholder incomes substantially

Weaknesses

- Works within somewhat strict USAID funding guidelines
- It is unclear exactly what SPREAD II (starting January, 2011) will fund

National Agriculture Export Board

Key facts

The government institution charged with supervising all coffee-related activities, The National Agriculture Export Board (NAEB, formerly OCIR-Café), is involved in coffee sector development and organizes implementation of most government policies related to coffee, including production, processing, marketing research, and farmer training and extension. The National Agriculture Export Board works closely with NUR, SPREAD, and nearly all other coffee organizations working in Rwanda. Because of its prominence, and influence within the specialty coffee industry, the NAEB will necessarily be involved in any large scale, farm level solution to the potato defect.

Strengths

- Close connection to SPREAD, NUR, and most other organizations working in Rwandan coffee
- Employs agronomists who provide technical assistance and technology transfer directly to farmers, coffee washing stations, and cooperatives

Weaknesses

- Currently difficult to connect with – for a substantial period of time did not have working website
- Funding availability unclear

CIRAD

Key facts

This French agricultural research NGO is one of the few research organizations to have published academic papers on potato taste in East African coffee. In the early 1990s, a team of CIRAD researchers worked on identifying the relationship between potato taste and the antestia bug. They published two papers on the subject before the Burundian civil war cut short their work. CIRAD has not researched potato taste in Rwanda, however it did engage in an environmentally sustainable coffee production project in Rwanda and Uganda from 2007-2010.

Strengths

- Legacy of quality coffee research
- Carried out some of the most important potato defect research

Weaknesses

- Not well connected in Rwanda – neither NUR nor SPREAD have close contact with CIRAD

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Defining success in terms of solving the potato taste defect challenge can take many forms. For some, success may be developing a technology that detects the defect before it can be passed along to buyers and consumers. For others, it may involve developing an effective way to capture the antestia bug before it can puncture the coffee cherries. For Daniel Rukazambuga, success means understanding the relationship between the antestia bug and potato taste such that effective technologies and control strategies appropriate for smallholder farmers are developed and implemented.

GLOBAL KNOWLEDGE INITIATIVE

The National University of Rwanda's Knowledge Partnership Landscape Analysis

January 2012

Table of Contents

Executive Summary

The dawning of the Collaboration Era

At no point in human history has the world seen more collaboration between individuals working jointly to push forward the knowledge frontier. According to the Royal Society's 2011 report "Knowledge, Networks and Nations," the scientific world "is becoming increasingly interconnected, with international collaboration on the rise." A few of the causes of increasing collaboration cited by the report include faster and easier communications capabilities; the overwhelming scale of research budgets and technological equipment needs that outstrips what a single research team, and in some cases, whole countries' research enterprises can shoulder; and increasing evidence that collaboration expedites results and enhances research effectiveness.

However, the Royal Society report concludes that despite these contributors to the rise of collaboration rise, it is scientists themselves who are the primary drivers of most collaboration:

> In developing their research and finding answers, scientists are seeking to work with the best people, institutions and equipment which complement their research, wherever they may be" (Royal Society, 2011). The web of person-to-person connections through formal and informal channels, diaspora communities, virtual global networks, and professional communities of shared interests serve as critical drivers of international collaboration. While the Royal Society acknowledges that these networks span the globe and are largely "motivated by the bottom-up exchange of scientific insight, knowledge and skills," the authors assert that "little is understood about the dynamics of networking and the mobility of scientists, how these affect global science, and how best to harness these networks to catalyze international collaboration" (ibid.).

Designing the Knowledge Partnership Landscape Analysis (KPLA)

The Global Knowledge Initiative devised the Knowledge Partnership Landscape Analysis as a replicable tool with which to examine the breadth, utility, and growth potential of individuals' scientific networks. Three design criteria informed the construction of the Knowledge Partnership Landscape Analysis methodology. First, a fundamental design criterion used in developing the Knowledge Partnership Landscape Analysis was that the tool be capable of illuminating some of the poorly understood dimensions of collaboration at the level of the researcher and her or his institution, as alluded to in the Royal Society report. Specifically, the Global Knowledge Initiative asked: *How might we reveal available/needed resources within key institutions to catalyze international collaborative problem solving on specific challenges?* This question echoed throughout the design process.

A second criterion related to the applicability of the tool to complex problems that exceed the boundaries of any one area of science. The multi-sectoral, trans-disciplinary, and international nature of the development challenges that the Global Knowledge Initiative seeks to help its partners tackle demands construction of tools that enable simplicity and clarity. The tool must be as comprehensible to researchers in anthropology as in agronomy. Further, collaborative innovation requires that partnerships be established on an "even-playing field." This entails balancing numerous perspectives and interests, whether they arise from donors, developed country partners, or stakeholders from the developing world. Establishing this balanced approach to collaboration demands that would-be collaborators adopt a common vernacular across resource categories to convey needs to distinct constituencies.

Finally, the tool needed to contextualize the full spectrum of resources available to and needed by actors germane to a particular challenge context (i.e., the potato taste defect challenge

plaguing Rwandan specialty coffee as detailed in The Global Knowledge Initiative's *Promoting Agricultural Knowledge and Innovation Systems, Ridding Specialty Coffee of Potato Taste: A Collaborative Innovation Case Study*). Too often questions related to boosting collaborative potential in developing countries are answered with calls for increased financing. While meager research budgets unequivocally hamper science and technology capacity building, money alone will not transform systems. Distinguishing what resources — technological, institutional, knowledge-based, human, etc. — are available through partners and what resources are lacking and therefore candidates for financing is an essential first step in STI finance strategy-setting and linkage strategy articulation. Too much of the academic work on science collaboration has failed to incorporate a rigorous assessment of individuals' or institutions' collaboration baselines. The need for a tool that helps to establish such a baseline against which additional resources, secured through collaboration, may be layered, measured, and assessed, further informed the Global Knowledge Initiative's design thinking with the KPLA.

Constructed to uphold these three design criteria, the following Knowledge Partnership Landscape Analysis takes stock of the critical science, technology, and innovation resources available at the National University of Rwanda (NUR) and several of the key research faculty already engaged in solution generation there. The KPLA is the third in the Global Knowledge Initiative's LINK analyses. The KPLA was devised to support the NUR Faculty of Agriculture and their peers across other disciplinary faculties in their effort to rid Rwandan specialty coffee of the potato taste defect.

The KPLA employs the "THICK methodology" to analyze the availability of and need for resources and functions required for collaborative innovation and problem solving. Devised to dissect an innovation systems perspective into critical resource domains, THICK is an acronym that stands for the first letter of each of the five resource categories noted below:

Technology Resources	Tools and the knowledge to use them
Human Resources	Trained people who can put science and technology to work for problem solving in industry, the public sector, civil society and the informal sector
Institutional and Financial Resources	Organizations or functions that provide the structure and collective knowledge needed to innovate, whether in a fixed place or as a networked composite
Collaboration and Communication Resources:	Connections among the parts of the system that diffuse knowledge and enable learning, includes information and communication technologies and skills
Knowledge Resources	Information embedded in research and indigenous knowledge, written guidelines and procedural documents, regulatory and legislative code, and intellectual property that adds value and enables solution generation and application

Through World Bank support, the Global Knowledge Initiative's Sara Farley, together with experts from the Stanford Research Institute International, the World Bank Institute, and the World Bank Uganda Office devised the THICK framework as a way to help researchers and

non-scientists take stock of the science, technology, and innovation-based resources required to address challenges in key sectors like health, agriculture, transport, logistics, and energy.

Research approach

The Global Knowledge Initiative applied the THICK framework to answer the question of how best to boost NUR's collaborative potential to tackle the potato taste challenge. A seven month-long primary research effort unfolded during which 25 NUR professors, students, and researchers described their resource needs and existing partnerships along each of the five THICK pillars. In a series of extensive interviews, the respondents also identified key bottlenecks for which optimized and/or new partnerships might prove successful in overcoming them. In 10 of the 25 cases, interviewees also completed a complementary survey protocol that enabled quantitative, though statistically insignificant, analysis of NUR's STI resource base.

The NUR Faculty of Agriculture began this mapping exercise in 2011 with the initiation of the LINK (Learning and Innovation Network for Knowledge and Solutions) program sponsored by the Global Knowledge Initiative. Through LINK, the Dean of NUR's Faculty of Agriculture Daniel Rukazambuga and his team of development and agriculture experts aim to rid Rwanda's specialty coffee sector of a potato taste defect, possibly caused by the pest known as antestia bug.

Report highlights

Conclusions and key observations pertinent to each of the THICK pillars are highlighted below.

I. Technology Resources

- A majority of interviewed respondents expressed a "deep need" for technological resources such as laboratory equipment, field equipment, and consumables.
- Some partnerships designed to address technology needs through sharing of equipment and laboratory space exist. However, most partnerships designed to address equipment and other technology needs have closed, leaving a dearth of collaborative activity in this area.

II. Human Resources

- Most existing and past partnerships described by NUR faculty, staff, and students emphasize training and capacity building. However, insufficient retention incentives mean difficulty keeping highly qualified personnel at the university following exposure to such opportunities. Further, a lack of trained technicians to support research efforts hinders research productivity and research collaboration potential.
- Respondents expressed interest in enhancing management and information and communication technology (ICT) skills as a way to improve their research and partnership potential.

III. Institutional and Financial Resources

- NUR's Research Commission, which helps NUR faculty organize and fund research, elicited mention as a common institutional asset for stakeholders across the university community.
- Interviewee responses were ambiguous regarding what institutional resources (e.g., policies) are available at the university, and how they might benefit individual faculty, staff, and students seeking to forge new collaborations.

IV. Collaboration and Communication Resources

- Respondents generally characterized NUR by its strong linkages with international universities, development organizations, and domestic public institutions. However, connections with private sector and communities appear nascent.
- NUR researchers' perception of the availability and quality of information and communication technology/connectivity varies depending upon one's position at university. While high-level administrators benefit from personal Internet access, the experience of lower-level staff and students is typically that of few "connected" computers and slow Internet connectivity.

V. Knowledge Resources

- Enhancing access to knowledge resources constitutes a major thrust of partnership opportunities pursued by NUR.
- Ongoing collaborations with UNESCO (the United Nations Educational, Scientific, and Cultural Organization), SIDA (the Swedish International Development Agency), AGORA (Access to Global Online Research in Agriculture), and INASP (International Network for the Availability of Scientific Publications) facilitate access to online academic journals, though fee constraints and connectivity issues hinder full utilization of online knowledge resources.

The interviews conducted offer a rare opportunity to peel back the layers of the National University of Rwanda — a complex, multi-dimensional institution that serves as Rwanda's largest manufacturer of highly trained human resources. The analysis affords the reader access to what some of the most dynamic collaborators think about their resource needs and partnership opportunities. Many of these insights are not necessarily unique to NUR, as many developing and even developed country universities face similar constraints and opportunities. What is unique is how NUR is beginning to use this information to optimize its partnership arrangements, both within the scope of the potato taste challenge and beyond it. Thus, the KPLA interviews constitute valuable insights that can inform and propel progress toward deepened capacity for collaborative innovation.

Applying the Insights of the Knowledge Partnership Landscape Analysis

In sum, those interviewed expressed a high degree of enthusiasm for collaboration as a means to overcome many of the resource needs faced. With a quick glance at *Annex 1: Full List of Partnerships* one recognizes that many of the individuals working inside NUR serve as active and productive collaborators. However, neither this analysis nor the Annex should be construed as finished products. By taking this initial inquiry, growing the number of respondents, building further the catalogue of available/needed resources, and mapping those to existing partnerships, the picture will become more fine-grained and more accurate. The more detail and precision the KPLA offers, the more valuable it becomes in building inclusive, effective, and efficient knowledge networks. Thus, the insights of this KPLA should be viewed as preliminary and stand to be greatly enhanced in value as more NUR interviewees and their colleagues in other institutions participate in the KPLA process. Equipped with an expanding information base on collaborative innovation and science, technology, and innovation (STI) resource needs/availability, the National University of Rwanda faculty, staff, and students will be poised to inform potential partners of exactly what they seek to gain through collaborations, and what they are able to bring to them in return.

Introduction

The Knowledge Partnership Landscape Analysis: Background and Structure

As people and institutions grapple with evermore complex, integrated challenges across a spectrum of domains — agriculture, water, climate, economic development, security — collaboration reveals itself as a necessary strategy for maximizing resources (Royal Society 2011). Tackling integrated challenges through collaboration requires that partnerships be established on an "even-playing field" that balances numerous perspectives and interests, whether they arise from donors, developed country partners, or stakeholders from the developing world. Establishing the "even playing field" from which long-term, mutually beneficial interaction springs demands would-be collaborators understand and be able to communicate their resource availability and needs. Clear are the merits of establishing science, technology and innovation (STI) resource baselines with sufficient detail that potential collaborators see where they can plug in.

First, by cataloguing resource availability/need, potential partners can better understand the resource gaps they may fill as well as the resource endowments they may leverage. Second, such effort affords both partners with the clarity required to establish a two-way street between collaborators as opposed to a uni-directional flow of resources, as has tended to be the case in many "North-South science partnerships." For partners from developing countries whose institutional contexts may be less well understood by potential collaborators in middle-income and high-income countries, clarifying the institutional "context for partnership" constitutes an essential first step toward building knowledge partnerships that deliver solutions as opposed to outputs, such as scientific papers or technology prototypes that far too often fail to reach the scale required to trigger social impact. Equipped with a more fine-grained picture of their STI resource needs and availability, researchers from the National University of Rwanda (NUR), for example, will be positioned to communicate in specific terms what they seek from existing and future partners, and how they will contribute to the teams they join.

Designed to achieve these insights, the following Knowledge Partnership Landscape Analysis (KPLA) takes stock of the critical science, technology, and innovation resources available at NUR and to the partners already engaged in solution generation there. The KPLA is the third in the Global Knowledge Initiative's series of analyses devised to support the NUR Faculty of Agriculture in their effort to rid Rwandan specialty coffee of the potato taste defect. As such, the NUR Faculty of Agriculture and the resources relevant to solving the potato taste challenge feature heavily in the analysis. The analysis extends beyond the Faculty of Agriculture to include other parts of the university relevant to science, technology, and innovation-based problem solving, including high-level representatives of the Faculty of Science, Faculty of Medicine, and Faculty of Economics and Management.[1] The expert perspectives offered deliver a multi-disciplinary look into the resource and partnership assets and needs at play within NUR germane to solving challenges in agriculture and with respect to the potato taste challenge in specific. Unique to the analysis used with other products, the Knowledge Partnership Landscape Analysis features first-person accounts. The words written are transcripts from oral interviews.

[1] The creation of a "Potato Taste Challenge Map" informed the selection of those disciplinary areas in which expert interviews were sought (see *Promoting agricultural knowledge and innovation systems: Ridding specialty coffee of potato taste* for further detail on the Challenge Mapping process and results).

The KPLA uses the "THICK methodology" to analyze the availability of and need for resources and functions required for collaborative innovation and problem solving. THICK is an acronym that stands for the first letter of each of the five resource categories noted below:

Technology Resources	Tools and the knowledge to use them
Human Resources	Trained people who can put science and technology to work for problem solving in industry, the public sector, civil society and the informal sector
Institutional and Financial Resources	Organizations or functions that provide the structure and collective knowledge needed to innovate, whether in a fixed place or as a networked composite
Collaboration and Communication Resources:	Connections among the parts of the system that diffuse knowledge and enable learning, includes information and communication technologies and skills
Knowledge Resources	Information embedded in research and indigenous knowledge, written guidelines and procedural documents, regulatory and legislative code, and intellectual property that adds value and enables solution generation and application

The Global Knowledge Initiative applied the THICK framework to answer the question of how best to boost NUR's collaborative potential to tackle the potato taste challenge. In a series of interviews with 25 NUR faculty, researchers, and students over seven months, respondents described their resource needs and existing partnerships along each of the five THICK pillars. They also identified key bottlenecks that new or improved partnerships might overcome. In 10 of the 25 cases, interviewees completed a complementary survey protocol that enabled quantitative, though statistically insignificant, analysis of the resource base.

The NUR Faculty of Agriculture began this mapping exercise in 2011 with the initiation of the LINK (Learning and Innovation Network for Knowledge and Solutions) program sponsored by the Global Knowledge Initiative. Through LINK, the Dean of NUR's Faculty of Agriculture Daniel Rukazambuga and his team of development and agriculture experts aim to rid Rwanda's specialty coffee sector of a potato taste defect, possibly caused by the pest known as antestia bug. Dr. Rukazambuga's team received training in the THICK research protocol during an on-site LINK training in Butare, Rwanda in June 2011. During this training, a first group of researchers participated in a full THICK interview and learned how to conduct the interview protocol themselves. Between July and December 2011, subsequent interviews occurred via phone. Decisions about who should participate were made as a function of whether a person's expertise related in some way to the understanding and solving of the potato taste challenge as indicated by LINK team members from NUR (see *Promoting Agricultural Knowledge and Innovation Systems; Ridding Specialty Coffee of Potato Taste: A Collaborative Innovation Case Study* for further details).

The resulting synthetic analysis provides a preliminary overview of NUR's existing resource base and its partners poised to contribute to solving integrated science, technology, and innovation-based challenges.

Structure of the report

This National University of Rwanda Knowledge Partnership Landscape Analysis presents a preliminary investigation of available and needed STI resources in chapters devoted to each respective THICK resource pillar, beginning with Technology Resources. The chapters open with a synthesis derived from the full 25 interviews combined. Following the synthesis, chapters provide selected expert quotes specific to each critical resource area, allowing the reader to absorb the contents of the interviews verbatim. These quotes follow the guiding questions as they were phrased to the interviewees. The final chapter presents conclusions derived from analysis within and across the pillars. An annex lists a number of the existing partnerships noted by the participating experts involved in the manufacturing of the report.

The Experts

Meet the Experts

The biographies below highlight some of the relevant professional experiences of the sources interviewed for the NUR Knowledge Partnership Landscape Analysis.

Source 1

DR. FELIX AKORLI, COORDINATOR M.SC. IN ICTS, FACULTY OF COMPUTER SCIENCE

Felix is an expert in mobile and wireless computing and received his Ph.D. at the Catholic University of Rio de Janeiro. He is the head of NUR's recently founded Master's degree in ICTs, and says that many of the program's 30 graduates have gone on to undertake high-level work, helping to build Rwanda's ICT infrastructure.

Source 2

DR. PIERRE MAMBANI BANDA, HEAD OF THE SOIL AND ENVIRONMENTAL MANAGEMENT DEPARTMENT, FACULTY OF AGRICULTURE

Pierre is a soil scientist who specializes in soil physics and soil chemistry. He studies methods of soil improvements for larger crop yields. Prior to coming to NUR, Pierre taught at the University of Kisangani in the Democratic Republic of Congo

Source 3

DR. CHARLES KARANGWA, SENIOR LECTURER, FACULTY OF MEDICINE

Charles holds a Ph.D. in Toxicology, and is currently working with the Rwandan Government to determine baseline levels of chemicals in Rwanda's agricultural water system. His research also extends to toxins resulting from agricultural runoff.

Source 4

DR. CALLIXTE KAREGE, LECTURER, ANIMAL PRODUCTION, FACULTY OF AGRICULTURE

The consummate scholar, Callixte has studied all over the world, and received degrees in Rwanda, Senegal, Morocco, Scotland, and France. He studies Animal Production, specializing in food technology for ruminants. Callixte participated in the Global Knowledge Initiative-UNESCO science policy training intensive in June 2011 in Dar Es Salaam, Tanzania.

Source 5

JEAN CLAUDE KAYISINGA, DIRECTOR, SPREAD

Jean Claude is the Director of USAID and NUR's SPREAD coffee development project, which is managed by Texas A&M University. Jean Claude also teaches in the Department of Agricultural Economics and Agribusiness at NUR, and works closely with Dr. Daniel Rukazambuga and the National Agriculture Export Board on the future of Rwandan coffee.

Source 6
ALPHONSINE KENYANGI, ASSISTANT LECTURER, FACULTY OF AGRICULTURE

Alphonsine is a member of the Faculty of Agriculture's coffee research team, contributing her expertise in Crop Science and Horticulture. She received a Bachelor's degree from NUR and her Master's degree at Wageningen University in the Netherlands.

Source 7
DR. ELIE MUHINDA MUGUNGA , SENIOR LECTURER, FACULTY OF AGRICULTURE & FORMER HEAD OF ISAR, RWANDA'S AGRICULTURAL RESEARCH INSTITUTE

Elie is a specialist in Entomology and Parasitology who studied at what is now the University of Kinshasa, and received a Ph.D. from Rivers State University of Science and Technology in Nigeria. This self-proclaimed "Pest Man" has experience addressing disease-carrying insects such as mosquitoes and sandflies, but now has turned his attention to coffee threats. He has trained farmers to identify and prevent coffee rust disease, researched the coffee borer, and is now tackling the antestia bug.

Source 8
DR. ESRON MUNYANZIZA, COORDINATOR, M.SC. IN AGROFORESTRY

Esron is new to NUR's coffee research team. He has a Ph.D. in Forest Ecology and Agroforestry, and prior to joining NUR conducted research in Tanzania and at the Rwanda Agricultural Research Institute. Esron studies the socioeconomic and ecological value of Rwanda's forests; his understanding of agroforestry will be integral to NUR's efforts to improve the taste of coffee, Rwanda's most important tree crop.

Source 9
MARK MWUNGGRA, STUDENT, SOIL AND ENVIRONMENTAL MANAGEMENT

Mark is a student at NUR, completing the fourth year of his Bachelor's degree in Soil and Environmental Management.

Source 10
DR. FRANCOIS NARAMABUYE, ASSOCIATE PROFESSOR, FACULTY OF AGRICULTURE

Francois is an associate professor of Soil Science and Environmental Science, and received a Ph.D. in Engineering and Soil Science at the University of Kwa-Zulu Natal in South Africa. He focuses on socioeconomic, agricultural, and water management issues, and works collaboratively with students and other professors, locally and internationally.

Source 11
JOSEPH NDAGIJIMANA, HEAD OF ENTREPRENEURSHIP DEPARTMENT, CENTER FOR THE ENVIRONMENT, ENTREPRENEURSHIP AND SUSTAINABLE DEVELOPMENT

Joseph is one of the first department heads at NUR's Center of Environment, Entrepreneurship, and Sustainable Development (CEESD), and is also a lecturer in the Faculty of Economics and Management, in the Department of Economics. He holds a Master's degree in Applied Economics, and his current research focuses on the effects of Rwandan land reform.

Source 12
Dr. Fidele Ndahayo, Dean, Faculty of Sciences

Fidele obtained his B.Sc. and M.Sc. in theoretical physics, and holds a Ph.D. in Physics and Mathematics from the Russian Peoples' Friendship University in Moscow. He is a Senior Lecturer in the Department of Physics at NUR. Fidele was recently elected as the Chairperson of the Rwanda National Commission for the UNESCO General Subcommittee.

Source 13
Jean Chrystotome Ngabitsinge, Head of Agricultural Economics Department, Faculty of Agriculture

An agricultural economist, Jean has a B.Sc. in Business Economics from Venice University, a M.Sc. in Economics from Catholic University of Milan, and a Ph.D. in Agricultural Economics from the University of Milan. He has been an associate researcher at Leuven University and Bonn University. Jean is on the Faculty of Agriculture's coffee research team, and works on coffee sector value-chain analysis and development.

Source 14
Adronis Niyonkuru, Senior Lecturer, Computer Science Department, Faculty of Applied Science

Adronis is head of the Computer Science Department, and is also currently the acting Dean of the Faculty of Applied Sciences, as well as teaching classes. Adronis received his Ph.D. in Computer Engineering, and his research focuses on security programs for small computer systems.

Source 15
Issa Nkurunziza, Assistant Teacher, Agricultural Economics, Faculty of Agriculture

A current Master's degree student at Kenyatta University in Kenya, and member of the NUR Faculty of Agriculture coffee research team, Issa works in agribusiness management and trade. While finishing his studies, he is also teaching at NUR in the Department of Agricultural Economics and Agribusiness.

Source 16
Dr. Donat Nsabimana, Head, Department of Biology, Faculty of Science

Donat received a Ph.D. from Sweden's University of Gothenburg in Sweden, focusing on forest carbon emissions. Donat's work largely centers upon understanding the impacts of climate change and how different species of plants, specifically trees, are affected by the phenomenon.

Source 17
Laetitia Nyina-wamwiza, Head of Department of Animal Production, Faculty of Agriculture

Laetitia is an expert on Aquatic Resources Management, and has undertaken much of her research on aquaculture and the chemical composition of water in Lake Kivu, one of East Africa's Great Lakes. She completed her Ph.D. in Belgium at the University of Notre-Dame de la Paix.

Source 18
ISAAC OLADUNJOYE, SENIOR LECTURER, DEPARTMENT OF ANIMAL PRODUCTION, FACULTY OF AGRICULTURE

Isaac received his Bachelor's degree in Agriculture, and holds a Ph.D. in Animal Science, specializing in gastric nutrition. He studies alternate feeds for livestock, such as poultry, and hopes to help develop a local poultry industry in Rwanda, where large-scale poultry farming has not successfully taken place.

Source 19
RAMA RAO, PROFESSOR, FACULTY OF ECONOMICS AND MANAGEMENT

Rama is a management expert and an experienced international collaborator with a Ph.D. in Agribusiness, who works with researchers throughout Africa, as well as in North America and Europe. He is particularly interested in expanding and encouraging entrepreneurship in Rwanda. Rama has worked on range of projects including the UNDP Human Development Report and designing entrepreneurship models for local communities.

Source 20
DR. HAMUDU RUKANGANTAMBARA, LECTURER, DEPARTMENT OF SOIL AND ENVIRONMENTAL SCIENCE

Hamudu undertook his graduate work in Russia, receiving a Master's degree in Chemistry in Kiev and a Ph.D. at Moscow University in Science, with work in both Biology and Chemistry. He has taught in the Department of Soil and the Environmental Management at NUR since 2008 and researches fertilizers that are appropriate for local ecological conditions in Rwanda.

Source 21
DR. DANIEL RUKAZAMBUGA, DEAN, FACULTY OF AGRICULTURE

Daniel is an entomologist who has worked for over 20 years to improve the livelihoods of East African farmers. He received a Bachelor's degree in Agriculture from Sokoine University of Agriculture in Tanzania, a Masters in London at Imperial College, and a Ph.D. at the University of Reading, also in the UK. Since finishing his Ph.D., Daniel has worked in Tanzania and Rwanda, both in the laboratory, and in the field working with smallholder farmers. He is passionate about both entomology and alleviating poverty, and is GKI's LINK Round I winner and the leader of the Faculty of Agriculture's coffee research team.

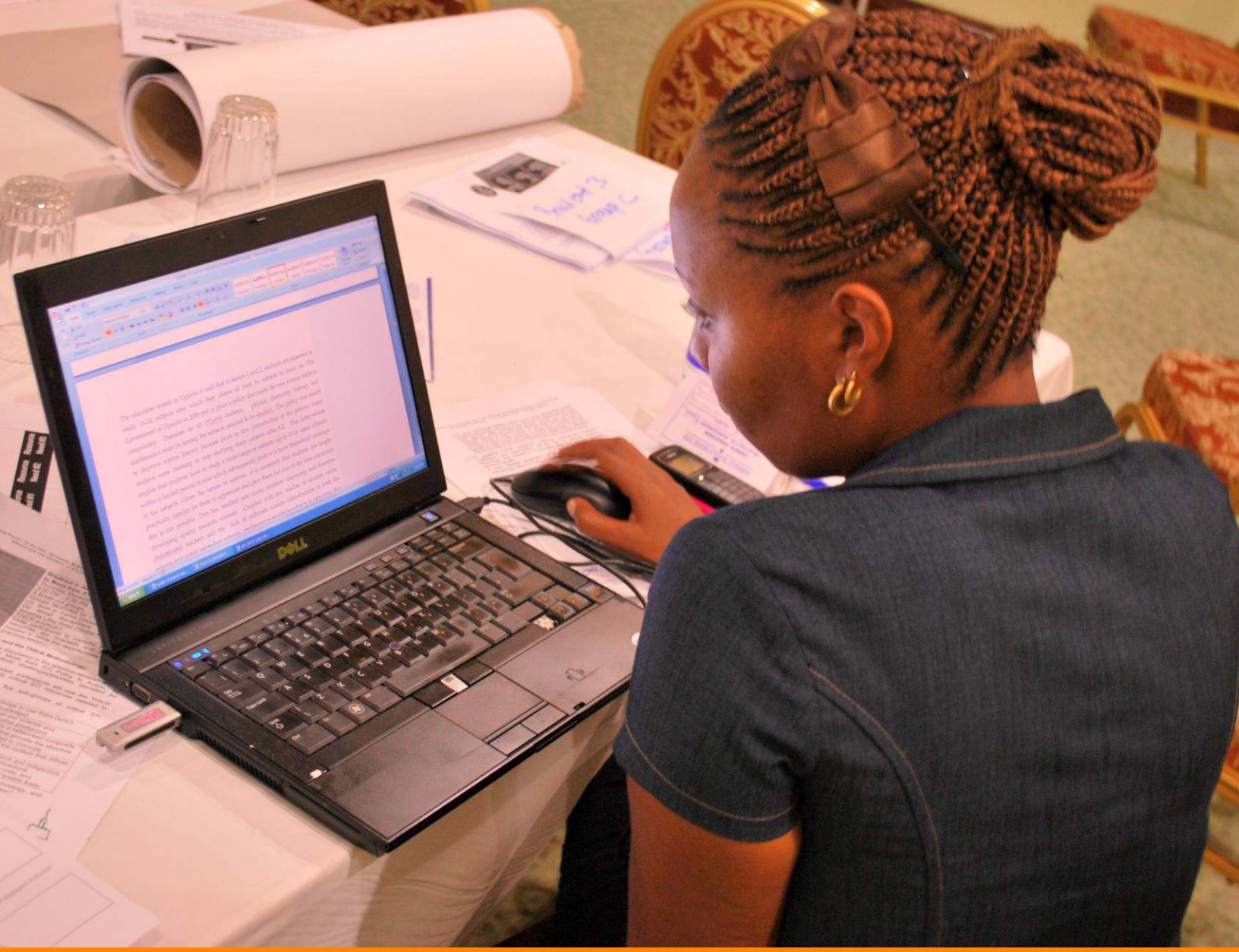
Source 22
DR. PETER SALLAH, VICE-DEAN & PROFESSOR, FACULTY OF AGRICULTURE

A geneticist, plant breeder, and member of the Faculty of Agriculture's coffee research team, Peter received his Bachelor's degree from the University of Ghana and both his M.Sc. and Ph.D. from the University of Minnesota in the US. Peter's research focuses on the development of plant varieties for African farmers. In addition to research, he mentors young scientists, encouraging them to pursue careers in science and gain research experience.

Source 23
DIEUDONNE UWIZEYE, HEAD OF SUSTAINABLE

Dieudonne's background is in education and development studies, and he focuses on female empowerment in rural areas as well as farming cooperative sustainability. His work involves

DEVELOPMENT, CEESD	coordinating interdisciplinary research activities throughout NUR and internationally, aimed at sustainable economic and social development. Dieudonne is currently undertaking a Ph.D. in demography at the University of Dar-es-Salaam in Tanzania.
Source 24 EMMANUEL UWIZEYE, RESEARCH ASSISTANT, SOIL SCIENCE, FACULTY OF AGRICULTURE	Emmanuel completed a Masters degree in Agroforestry and Soil Management at NUR. He is currently conducting research with Dr. Francois Naramabuye in "riming" material used in Rwandan agriculture.
Source 25 UMARU GARBA WALI, HEAD OF FACULTY OF CIVIL ENGINEERING	Umaru studies water resources engineering, and holds a Ph.D. in Hydraulics and Engineering Hydrology from Moscow State University of Environmental Engineering in Russia. He teaches courses ranging from Fluid Mechanics to Sanitary Engineering.



Technology Resources

Synthesis of Findings

The KPLA defines Technology Resources as *tools and the knowledge to use them*. Examples of technology resources include laboratory equipment, consumables and reagents, computers, printers, office technology, and technical knowledge for maintaining equipment. Across the 25 respondents, interviewees noted the relatively low degree to which their technology resource needs are being met and a paucity of partnerships designed for that purpose. Interviewees primarily named the lack of high-quality laboratory equipment as a bottleneck to delivering high-quality academic research and training.

In many cases, respondents stated the equipment needed to conduct specific veins of research is not available to NUR faculty and staff. Specific to the challenge of potato taste in coffee, technologies are needed to "establish the current pest status [of the antestia bug so that we might better understand] the agro-ecological distribution of the antestia bug, the interaction with agronomic or cultural practices, and [determine] antestia's natural enemies" (Dean, Faculty of Agriculture, NUR).

> *I think that NUR is trying to improve [its technology base], but still we have a long way to go because of our infrastructure. It is still not sufficient.*
>
> *- Senior Lecturer, NUR, Faculty of Medicine*

Interviewed respondents also noted the aged and out-of-service character of much of the available laboratory equipment. Insufficient reagents with which to conduct research also elicited mention. In one case, an interviewee spoke of having to cut analysis short because his lab did not have the needed reagents. Respondents also made clear that human resource gaps — such as the dearth of trained technicians — compound technology needs (*The KPLA Human Resources section provides further detail on this topic).* The KPLA Survey results corroborate the interview findings, namely that NUR faculty and students perceive that less than half of their technology needs are being met.

Survey Results: Technology Availability & Access

(*Based upon 8 survey respondents from NUR's Faculty of Agriculture*)

Q1: On a scale of 0-5, how well are your technological needs (e.g., scientific equipment, processing technologies, design technologies) being met? (5 = needs are completely met)

Average rating: 2.1

Q2: On a scale of 0-5, how do you rate your ability to access needed technology? (5 = excellent)

Average rating: 2.6

What does this information reveal? While survey respondents are slightly more positive than those interviewed about their ability to access needed technology, such needs largely go unmet, hindering the rate, quality, relevance, and application of research.

Overall, the KPLA data reveals that there are a limited number of partnerships active at NUR to address technology resource needs specifically. The few that garnered mention in this area include the Ministry of Agriculture and Animal Resources, the Ministry of Health, and the

Rwanda Agricultural Research Institute (ISAR). Past partnerships referenced, which have now concluded, include those with Wageningen University in the Netherlands and the University of Liege in Belgium. Some interviewees noted that partnership-planning discussions are underway with universities such as Michigan State and Texas A&M through the SPREAD program, a component of which may address equipment needs for antestia research. However, the majority of respondents stated they were not part of and/or did not know of partnerships that address the technology resource needs they face.

Voices of the Experts

Guiding Questions

Q1: How would you rate the degree to which your technology needs are being met? Do you have any ongoing partnerships to address your technology needs (e.g., technology acquisition or sharing)? With whom and for what?

Q2: What technology resources (e.g., equipment) do you need that a partner might help you access?

Selected responses to the above questions from some of the 25 interviewees follow.

Source 21
DEAN, FACULTY OF AGRICULTURE, NUR

At the moment, [our technology resource needs] are being met very little. The focus of previous collaboration was in different fields. So, none of the equipment we'd need for antestia bug was provided. … We don't have an external partnership [in antestia bug research]. We are starting to look for one with the Global Knowledge Initiative.

We need [technologies] to establish the current pest status … [explore the] taxonomic element … equipment to help with collection and identification … rearing technologies to feed the insects, keep them in the laboratory so that we can then do the testing on them.

Source 7
SENIOR LECTURER, FACULTY OF AGRICULTURE

[The degree to which our technology resource needs are being met] is not beyond 50%. [In the] entomology lab, we need proper microscopes … [we also] need big equipment [like] deep freezers to keep a lot of specimens. For pathology, we have another set of needs. We need to do cultures, which requires having specific culture media, equipment … This is not a blind need … The faculty is on this challenge.

Source 10
ASSOCIATE PROFESSOR, FACULTY OF

If I take the section of laboratories — there is a deep need. I am not satisfied at all with our laboratories, first of all because we have little equipment and the need is huge, and also because we need them for teaching, for research, for consultancies. So, there is a big gap on that side. If we had, for instance, the X-ray, [it] would let us minimize the work

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[in collecting soil samples], minimize the use of energy, speed up the work, and help us get accurate graphs.

Source 24
STUDENT, SOIL SCIENCE, FACULTY OF AGRICULTURE

It is half [of what we need, in terms of technological resources]. We need so much. We were talking about materials for labs. Many things you cannot do with available materials. We need more materials so we can do everything we need to do. Some that we have is old and not updated. We need especially electronics for laboratory analysis recording, so the information is very precise. Some old materials mess up lab results.

Source 22
VICE-DEAN & PROFESSOR, FACULTY OF AGRICULTURE

I think it is good, but we need some more laboratory equipment because the labs are not particularly resourced to do plant breeding research. Because we collaborate with ISAR, they have some labs that we can use for research and teaching … It would be good to have some of that equipment on campus.

I think [we need] statistical software like SAS. We can access GenSTAT free of charge. But, we need to acquire a license to SAS. That is something a collaborator can assist us with.

[Partners in this area include] the Belgian government, the Netherlands. We have good collaboration with MINAGRI [Ministry of Agriculture and Animal Resources].

Source 2
HEAD, DEPARTMENT OF SOIL AND ENVIRONMENTAL MANAGEMENT, FACULTY OF AGRICULTURE

For laboratories, for instance, we are weak in that area. Our equipment is aging, and we find it difficult to replace. We are facing a lot of problems [replacing consumables]. We sometimes have to cut off the analysis because we don't have reagents. If some of our partners can help us in that area it would be very, very helpful. We particularly need equipment [for] soil analysis in the lab, as well as some field equipment.

In the past, yes [we have had partnerships to address technology needs]. For now, I would say that we are not receiving anything. There are some negotiations but we don't know yet the results. Not very long ago we got some equipment from Holland [through] Wageningen University.

Source 15
STUDENT, AGRICULTURAL ECONOMICS, FACULTY OF AGRICULTURE

Right now, I have only my laptop. But, I would use GPS in my work to find fields. I would want a digital camera to take pictures too. Printers would be useful too. Photocopiers would be essential tool also.

I have found a GPS. I will go to the Rwanda Gateway to access it — that's a unit at NUR that focuses on Geographic Information Systems (GIS). Then I need to find someone who can help me use the GPS. I can learn skills that way. I think I will try to go there by borrowing the GPS.

Source 3
SENIOR LECTURER, FACULTY OF MEDICINE

I think that NUR is trying to improve, but still we have a long way to go because of our infrastructure. It is still not sufficient. In our laboratory, we need staff to manage easily the whole unit in our laboratory … We have a specific problem with heavy equipment and technicians in our region. We need equipment [like gas chromatography mass spectrometers], but we can't get it because equipment needs regular maintenance.

[In terms of partnership to address these needs] we are in contact with a project with SPREAD; we have collaborations with University of Michigan and Texas A&M. They would like to support our unit that works on water

quality. The University of Liege provided some heavy equipment, and the Ministry of Health has also provided equipment to us.

Source 12

DEAN, FACULTY OF SCIENCES

We do have some equipment, and we try to use modern equipment. The problem [is] once we get them, we do not get technicians to maintain them. When they are working, they are used … 50% by researchers and maybe 30% by students doing their projects.

Currently, no we don't have any partnership [to address this need]. We have a partnership with a Belgium Cooperative [a consortium of universities based in Belgium]. We have gotten some equipment through them and they have renovated some of our chemistry & biology labs.

Human Resources

Synthesis of Findings

The KPLA describes Human Resources as *the trained people who can put science and technology to work for problem solving in industry, the public sector, civil society, and the informal sector, including technicians, technical experts, and access to training*. Interviewees were clear: human resource limitations hinder their ability to tackle challenges. While many revealed a sense of optimism regarding training opportunities being seized and becoming available, respondents declared a nearly universal need for technicians, more numerous and diverse training opportunities, and redoubled efforts toward staff retention.

In terms of priorities, trained technicians constitute respondents' primary human resource need. Professors repeatedly pointed to the scarcity of technicians to assist with lab work, data collection, and analysis, as a key reason behind low productivity at the laboratory level. This constraint limits their research potential and capacity for collaboration. Similarly, the lack of trained technicians to maintain equipment poses a bottleneck in terms of properly utilizing and accessing technology resources. One scientist in the Soil and Environment Management Department raised the point that often times when lab equipment breaks, no one is available to repair it.

> *Trained technicians are most important now, because they can ensure the sustainability of research programs. But also we need teaching staff … the few staff available are overloaded with teaching activities and don't have time to do research.*
>
> *-Dean, Faculty of Science*

Training constitutes the focus of most of the National University of Rwanda's partnerships to address human resource needs. SIDA, the Swedish International Cooperation Development Agency, and SAREC, its former research-focused division, support training initiatives with NUR, as do a host of university partners from the Netherlands, Belgium, Germany, India, Kenya, South Africa, Tanzania, and Uganda. While these partnerships offer potential boons, KPLA respondents noted that the NUR struggles to retain the personnel that receive training from these international partners. For example, one researcher of the Soil Science and Environmental Management Department stated: "Sometimes people are sent abroad for training and for some reason they find it difficult to come back. Maybe they don't like the working conditions here." Those interviewed point to providing in-country training opportunities and assistance with staff retention as key concerns in terms of human resource needs. Interviewees also affirmed their interest in augmenting their skills germane to project management, lab management, and utilization of technical software — skill areas that would improve research capacity and collaboration potential.

With regard to the potato taste challenge being tackled by the Faculty of Agriculture, interviewees highlighted the need for identifying and recruiting experts with specialties relevant to the potato taste defect and its potential cause — the antestia bug. One researcher of the Crop Production and Horticulture Department pointed to CIRAD, the French agricultural research for development center, as a potential collaborator. Another scientist, also of the Crop Production and Horticulture Department, defined the cadre of experts his teams seeks as partners to rid Rwandan specialty coffee of potato taste. His list includes taxonomists, plant nutritionists, crop management experts, post-harvest technologists, biological-control experts, integrated pest management (IPM) experts, plant breeders who have substantial experience working with coffee, and insect-rearing experts.

Survey Results: Skills Availability & Training

(*as provided by 10 survey respondents from the NUR Faculty of Agriculture*)

Q1: On a scale of 0-5, how would you rate the availability of scientific and technical training at your institution? (5 = very available)

Average rating: 2.7

Q2: On a scale of 0-5, how would you rate the quality of scientific and technical training at your institution? (5 = excellent)

Average rating: 2.5

Q3: On a scale of 0-5, how would you rate the availability of professional skills training at your institution (these include information and communication skills, skills to collaborate with partners outside of your university such as in industry, grant writing skills, etc)?

Average rating: 2.2

Q4: On a scale of 0-5, how would you rate the quality of professional skills training at your institution? *(5 = excellent)*

Average rating: 2.6

What does this information reveal? Survey results reveal that NUR stakeholders feel a need for both increased access and improved quality in terms of professional and scientific/technical training. Although scientific and technical training — as made available through Bachelor's, Master's, and Ph.D. programs — may be slightly more available than professional skills training (such as through short-courses or intensives on technical writing, software, information communication technologies, etc.), both are lacking at NUR. Increasing the quality and relevance of the existing opportunities available is also crucial.

Voices of the Experts

Guiding Questions

Q1: How would you rate the degree to which your human resource needs are being met? Do you have any ongoing partnerships to address human resource needs (e.g., to deliver enhanced training opportunities)? With whom and for what? What human resources (e.g., trained technicians, lab assistants, post-doctoral fellows, etc.) do you need that a partner might help you access?

Selected responses to the above questions from some of the 25 interviewees follow.

Source 5
DIRECTOR, SPREAD

[The degree to which NUR's human resource needs are met] is still low. This is the case because most of the time you go to NUR and you find you don't have many Ph.D.s. They go to work for the government or for bigger salaries … We still have that problem of capacity building. We need to tackle that, and make sure the university is really helping them to stay at NUR. It is looking for motivation to help people to stay.

Source 16
HEAD, DEPARTMENT OF BIOLOGY, FACULTY OF SCIENCE

[We need] short trainings, [that] experts [would] come and give to us. And then we may be able to have technicians. Because as you know, technicians are those you send into the field to regularly collect data. As a lecturer you don't have time to go every day in the field. They could [get] training and then they go regularly to collect data. So we need expert trainers shortly and we need technicians who could go in the field on a regular basis.

Source 23
HEAD OF SUSTAINABLE DEVELOPMENT, CEESD

Maybe we can [further develop the] capacity of the staff we have already, like offering training in the areas of big project management, or big research project management, raising funds, [identifying] international funds for research, etc. If we can have a partner who can help us to train staff in these areas, it would be fine.

Source 1
COORDINATOR OF MASTER IN ICT PROGRAM

A lot of people who are being trained have not come back to beef up the staff, so it is difficult to carry out research. Because of that, SIDA is trying to start a local training program in 2013. It is to help, not only with information and communication technologies training, but in all the fields that have been sponsored by SIDA historically. We partner with universities in Sweden and elsewhere, and then we can do research together and supervise together theses and Ph.D. students' work. This helps transfer that knowledge to the staff in our university. It is not only for ICTs but it is for all faculties.

Source 3
SENIOR LECTURER, FACULTY OF MEDICINE

We have an urgent need [for people who can maintain heavy equipment]. It is not enough to buy heavy equipment. We need to think about maintenance … I have a big project to increase the capacity because we are facing problems. [We have only] one laboratory doing food, drug, and water quality control because we are lacking skills.

Source 10
ASSOCIATE PROFESSOR, FACULTY OF AGRICULTURE

We need to train people to work in the laboratory, people to maintain equipment, but we also need, very importantly, some equipment and skills to manage our laboratory. We need lots of support because some projects are not very keen to work with us because we don't have proper lab management. That is an area that needs a lot of support.

Source 15
STUDENT, AGRICULTURAL ECONOMICS AND AGRIBUSINESS

The agricultural experts, coffee processing experts, these are [the] human resources needs. [As I] need an economic model to analyze my data, having access to a specialist in economics is important for me too. An expert in the coffee value chain too is someone I need. An expert in geography too is someone whom I need. Those who understand best how a cooperative operates: these are the people I need.

Institutional & Financial Resources

Synthesis of Findings

The KPLA describes Institutions as *organizations or functions that provide the structure and collective knowledge needed to innovate, whether in a fixed place or as a networked composite.* Examples of institutional and financial resources include university or national policies such as those that deal with intellectual property rights, research, or collaboration with industry; office space; laboratory infrastructure (such as running water, electricity); access to metrology or standards testing services; university support for research; and research and study grant opportunities. Compared to other resource areas, questions regarding Institutional and Financial Resources elicited diverse responses. For example, some researchers conveyed the need for increased and sustained funding for research, including funding for NUR's Research Commission. Others noted the sufficiency of institutional resources at NUR, including the research policy framework and the NUR policy on intellectual property rights. Other responses indicate that some researchers feel uninformed regarding the details of how policies that guide the allocation of institutional and financial resources are developed at NUR.

> *In terms of policy, I would say that we have good policies. But the gap is that people don't know about them, so it would be better if there is a framework — if people know that there are policies so they can take advantage of them.*
>
> *- Associate Professor, Faculty of Agriculture*

Regarding institutional and financial support for research, multiple interviewees noted the contribution made to the knowledge partnership landscape by NUR's Research Commission, which helps to organize and fund research for NUR professors. Researchers value the Research Commission's work in helping professors prioritize their research plans, organize consultancies, and access trainings. Nine researchers noted NUR's assistance in these areas. Despite the Commission's success, respondents also commented that insufficient funding for research cripples their work, and some specifically noted that the Research Commission needs greater financial support if it is to make a more demonstrable impact. Eight NUR respondents spoke to their need to secure funding for longer-term, more in-depth research projects and scholarships for students.

Respondents overwhelmingly pointed to Sweden's SIDA as an important partner for NUR in the area of institutional and financial resources. Those interviewed also mentioned the Korean Government, the Netherlands, and South Africa as partners, though the most common responses after SIDA were, "I don't know" or "No partners."

Strikingly, interview responses indicate a disconnect between the day-to-day activities and needs of NUR personnel and the policies that largely influence their professional lives. Of 25 respondents, four said they did not know if they had any partnerships to address institutional needs; another four asserted that they did not have any partnerships, though their colleagues indicated otherwise. When asked what institutional needs they had that a partner might be able to assist with, five respondents stated that they did not know, or needed more information on institutional issues, further indicating the lack of the faculty's knowledge of NUR's institutional assets and needs. As one professor from the Faculty of Water and Environmental Management stated, though he knows the university has policies on a range of topics, he does not necessarily know what they are and how they might be of use to him and his colleagues.

SURVEY RESULTS: INSTITUTIONAL AVAILABILITY & ACCESS

(*as provided by 10 survey respondents from the NUR Faculty of Agriculture*)

Q1: On a scale of 0-5, how well are your institutional resource needs being met (these may include access to laboratory and office infrastructure, university support for research, etc.)? (5 = needs are completely met)

Average rating: 2.2

Q2: On a scale of 0-5, how interested are you in partnerships that address your institutional resource needs? (5 = extremely interested)

Average rating: 4.1

What does this information reveal? Survey results support KPLA interview findings that NUR faculty and students perceive a high need for additional institutional resources and view partnerships as a highly attractive (4.1/5) means to access them.

Voices of the Experts

Guiding Questions

Q1: How would you rate the degree to which your institutional resource needs are being met? What about your financial needs? Do you have any ongoing partnerships to address institutional needs (e.g., university policies on intellectual property)? With whom and for what? What institutional resources (e.g., structuring joint research/collaboration agreements) do you need that a partner might help you access?

Selected responses to the above questions from some of the 25 interviewees follow.

Source 19
PROFESSOR, FACULTY OF ECONOMICS AND MANAGEMENT

Policymaking and institution building [at NUR] have taken shape during the last five years since Rector Silas Lwakabamba initiated huge reforms in the campus. The transformation process is going on. Now, we have financial management policies, research, human resources, procurement policies. In each component we use our resources with some external guidance. This is really for the purpose of modernizing the university.

As a management expert, our structure is not very efficient. [According to] one institutional analysis from the government, our economic side is OK and our administration is OK. Infrastructure is very poor, however. So how do you create a really smart organization that is able to respond

to the change? That's the challenge.

Source 2
HEAD, DEPARTMENT OF SOIL AND ENVIRONMENTAL MANAGEMENT, FACULTY OF AGRICULTURE

We have what we call a Research Commission [that] is receiving funds from some external partners. Our university is a public university so most of the funds are coming from the government, with all the limitations you can imagine for a developing country … I think the (financial) needs are quite high, looking at the mission we have. Because, as I said, our mission is training people, setting research in communities, and all this requires some means to do it, if we are going to do it properly. So, I would say our needs are high.

Source 8
COORDINATOR, M.SC. IN AGROFORESTRY

I would say the way the results of research are shared in terms of publication … For example, somebody would come and carry out research in the country in collaboration with local people and he goes back home, writes a book which [he] is offering himself alone, and that is when I find it very bad. That area needs to be very much improved. They need to make a partnership, which is really a partnership, not just an instrument and a partnership by definition … I think the aim of partnership is to bring about changes in the local community. So that at the end of the project someone can say "We are very proud, we have been very good partners. Here are the changes."

Source 12
DEAN, FACULTY OF SCIENCES

Some tools are already [there], like policies [and] programs. Strategic plans are already in place. What is [needed is] the implementation of these policies. Sometimes what we have is not enough to fund the research activities [that] are needed.

We have very weak link[s] between industry and higher learning institutions because most research institutions are commissioned [in developed countries] by governments or public institutions. We have not gotten that framework where a public institution can ask a public institution to get funding from them. So research activities are not funded in a sustainable manner. One year we have money, the next year we don't.

Source 1
COORDINATOR M.SC. IN ICTS, FACULTY OF COMPUTER SCIENCE

We have a very good and elaborate research policy in our university. This is being headed by a unit/department called the Research Commission. [Also] they are now putting in place policies for internships and working with outside industries. We have a good policy on consultancy. This is what we have.

Now there is a need for us to have a strong "University-Industry Collaboration Policy," which is being developed. Already the National Policy or ICT Strategic policy is developing the concept of research parks. So we are going along with national policy in order to fulfill the vision of the country, *Vision 2020* … Presently, our funding is through an NUR collaboration with SIDA. There is that worry on my part, that [if] SIDA/SAREC removes [funding or] does not support us, we could be in trouble. In order to mitigate this, for the program we are running, we are establishing good contacts with industries.

Source 3
SENIOR LECTURER, FACULTY OF MEDICINE

We are suffering from lack of policies. We are setting up laboratory capacity. There are some basic steps we are making but we need policies regarding research, regarding laboratories, in order to operate properly. There is also a need to set up capacity for bigger government laboratories … At NUR we have a Research Commission and last year they provided the institution with a research policy. We now have a research policy at the whole institution. We need to extend to faculty research units, to departments.

Collaboration & Communication Resources

Synthesis of Findings

The Global Knowledge Initiative's KPLA interview describes Collaboration and Communication Resources as *connections among the parts of the system that diffuse knowledge and enable learning*. Examples of these resources include access to information and communication technologies (ICTs) such as mobile phones, professional societies, university consortiums aimed at promoting collaboration, and the availability of extension services to connect university research to communities and/or the private sector.

Based on the responses of interviewed respondents, NUR maintains relationships with several other universities, development organizations, and non-governmental organizations in Europe, North America, Sub-Saharan Africa, and, to a lesser extent, Asia. These connections tend to focus on developing infrastructure, purchasing equipment and ICTs, and increasing capacity in university faculty and staff through training. In the Netherlands, Sweden, and Belgium, partnerships often form or gain strength when NUR hires faculty who have completed graduate degree programs in these countries, or when NUR students and/or staff are sent to universities in these countries to complete graduate school. In Europe, NUR faculty members have particularly numerous connections to Wageningen University (Netherlands), Gothenburg University (Sweden), and the University of Leuven (Belgium).

> *Without [Internet] the world is dead! Internet, mobile phone … I have a modem if I need to use it at home, it is always available.*
>
> *-Professor, Crop Protection and Horticulture*

Although relatively well connected among academic institutions and non-governmental organizations, NUR does not boast strong relationships with private sector firms, either internationally or domestically. Out of 25 respondents, seven collaborated with private sector firms in the past. Of these seven, only two individuals partnered with the same firm — IBM. By contrast, 16 out of 25 respondents partner with public institutions such as the donor organizations SIDA (Sweden), DFID (the UK's Department of International Development), and USAID (the US Agency for International Development). In fact, SIDA/SAREC (the former research agency of SIDA) was the most frequently named external partner.

SURVEY RESULTS: ICT AVAILABILITY

(*as provided by 10 survey respondents from NUR)*

Q1: On a scale of 0-5, how would you rate the following information and communication technology tools that enable collaboration in terms of their availability for your work? (5 = very available)

a. *Cell phones—traditional cell phones without a data plan*

Average rating: 3.3

b. *Internet*

Average rating: 3.9

What does this information reveal? Respondents at NUR express a relatively high degree of satisfaction with the availability of the Internet. In fact, according to this survey, some respondents find the Internet more available than mobile phones.

As Rwanda's largest public university, NUR also maintains close connections with many of the country's government ministries and public research organizations. Connections to the Rwanda Agricultural Research Institute (ISAR), the Ministry of Agriculture, the Rwanda Development Board, and the National Agricultural Export Board, which oversees the coffee industry, earned the most frequent mention.

Overall, those interviewed value the benefits of collaboration. Respondents particularly appreciate the opportunities collaboration brings, such as increased knowledge, technology transfer, funding, capacity building, and prospects to undertake research and publish. They noted, however, that partnerships to address these resources are still too few, especially in the areas of technology and funding resources. Ironically, these two bottlenecks constrain interviewees' efforts to develop broader networks insofar as researchers' main methods of meeting collaborators (workshops and on the Internet) require travel support and ICTs.

In terms of ICT availability and utility, the National University of Rwanda's ICT profile is mixed. Many researchers expressed optimism about the current state of ICT infrastructure at NUR, specifically the university's degree of Internet connectivity. It is important to note that the KPLA respondents tend to hold higher-level research, faculty, and/or administrative positions at the university. Such positions tend to afford access to personal computers with Internet connections, while lower-level staff may share computers with Internet connections. Respondents noted Internet connectivity has improved in the past years, but persistent bottlenecks include power outages, national Internet outages, and network overuse at NUR.

SURVEY RESULTS: NATIONAL & INTERNATIONAL COLLABORATION

(*as provided by 10 survey respondents from NUR)*

Q1: On a scale of 0-5, how easily can you find national partners (in universities, firms, public sector) to meet your resource needs? (5 = very easily)

Average rating: 2.7

Q2: On a scale of 0-5, how easily can you find regional/global partners to meet your needs? (5 = very easily)

Average rating: 2.4

Q3: On a scale of 0-5, how high is your interest in increasing the number and quality of your knowledge partnerships nationally? (5 = very high)

Average rating: 4.4

Q4: On a scale of 0-5, how high is your interest in increasing the number and quality of your knowledge partnerships regionally and globally? (5 = very high)

Average rating: 4.8

What does this information reveal? With a near perfect 5 out of 5 score, respondents share an exceedingly high appreciation for the value wrought through regional and global knowledge partnerships. However, a gap between NUR professors' desire for collaboration and their ability to partner with individuals outside their institutional walls means this appreciation does not regularly catalyze action. Survey responses suggest that collaborators at NUR find identifying partners nationally and internationally difficult.

According to respondents, NUR's progress toward improved collaboration and communication resources owes much to partnerships with SIDA, the Korean government, and through Rwandan government initiatives. NUR still has room to improve, though, if its faculty and staff are to collaborate effectively with international partners. Although many members of NUR's staff think the campus Internet is sufficient or good, interviewees acknowledge that improvements in Internet availability and bandwidth speed would enhance their collaborative capacity, improvements that beckon for more technicians able to maintain computers and equipment.

Voices of the Experts

Guiding Questions

Q1: Are you engaged in any (research, teaching, entrepreneurship, etc.) partnerships with individuals outside of your institution to address any aspect of the challenge(s) you seek to solve through your work? If yes, are you currently partnering with individuals from:

(a) Other universities? If yes, who?
(b) Firms? If yes, who?
(c) Public research institutions? If yes, who?
(d) Non-profit organizations? If yes, who?
(e) Government entities (provincial or national)? If yes, who?

FOR A FULL LIST OF NATIONAL UNIVERSITY OF RWANDA'S PARTNERSHIPS AS GLEANED FROM THE 25 KPLA INTERVIEWEES, SEE ANNEX I: FULL LIST OF PARTNERSHIPS FROM KPLA INTERVIEWS.

Selected responses to the above questions from some of the 25 interviewees follow.

Source 16
HEAD, DEPARTMENT OF BIOLOGY, FACULTY OF SCIENCE

[We partner with] Gothenburg University (Sweden), the one [where] I did my Ph.D., and at which [another] student is studying. We collaborate with Antioch University (US) on [a] biodiversity conservation project…Also on biodiversity, we collaborate with [the] University of Burundi, Makerere University (Uganda), and University of Dar Es Salaam (Tanzania).

Source 19
PROFESSOR, FACULTY OF ECONOMICS AND MANAGEMENT

Sometimes with IBM we have some sort of projects related to information communication technologies (ICT) and poverty reduction. My faculty members were associated with that, [as well as] the companies in Rwanda. We worked with local companies, not very big companies … There is one big company, that is UNILEVER. And small enterprises for cosmetics … Companies in Rwanda are very small, but we work with them too.

Source 12
DEAN, FACULTY OF SCIENCES

[We work with] IIRST (Institute of Scientific and Technological Research, Rwanda), that is a public institution. And the second is ISAR. We are working with these two institutions mainly by sharing human resources. Some of our staff are involved in research projects funded by those institutions, some [partner] to conduct teaching… Even our students are doing internships at the end of undergrad at these research institutions. And in some areas we even share laboratory equipment. And we use their equipment: we take samples from the lab to analyze them and sometimes they bring equipment to our lab.

Source 8
COORDINATOR, M.SC. IN AGROFORESTRY

For some time SIDA was paying for the Internet for the whole university. Again, SIDA is offering the payment for international journals. We have very good e-resource[s], very good e-journals from our university. And our university is linking to other universities to access their e-journals.

Source 17
SENIOR LECTURER, FACULTY OF FACULTY OF AGRICULTURE

I work in collaboration with one project in [the] Ministry of Agriculture called PAIGELAC. It is a project financed by African [Development] Bank to improve and implement aquaculture and fisheries in Rwanda, to protect lakes and farms for production of fish. Secondly, I am working with Ministry of Infrastructure on a project of Lake Kivu monitoring. It is looking at doing [chemical] extraction. I am looking at effects…I am working with them because they give me a laboratory on the lake. For my side, we share the data I have.

Guiding Questions

Q2: What are the greatest benefits you have received through your current or past partnerships? What partner has made the biggest difference for you in terms of moving you toward the outcome you seek to your challenge? What did this partner provide for you?

Source 19
PROFESSOR, FACULTY OF ECONOMICS AND MANAGEMENT

[The greatest benefits of partnership include] mutual learning and continuing with collaborative skills. And at the end we get a lot of satisfaction by saying we did something good for society. And it is definitely [the case that] we get a lot out of the experience with those whom we interact with. And students learn capacity building skills and gain confidence.

Source 7
SENIOR LECTURER, FACULTY OF AGRICULTURE

Partnership is always better than working in a vacuum. Sharing experience with others, your peers or with the farmers. It is a great benefit. It improves the process.

Source 25
HEAD OF FACULTY OF CIVIL ENGINEERING

What I consider most is the publications. I was lucky to publish with different people from different institutions … I know a lot of people within and outside Africa to collaborate with and talk to inside and out of Africa. [Also], the learning: I learn from collaboration. We learn some other issues and techniques and we show them what we are doing. These are the greatest benefits.

Source 8
COORDINATOR, M.SC. IN AGROFORESTRY

The knowledge has expanded. The range of partners has also expanded. And also it is nice to say that I won international prizes … And of course I made scientific publication[s], and from them I was promoted ... And of course another gain I can say … to realize that there are challenges and to solve the problem — that is a kind of benefit, although it is a challenge.

Source 12
DEAN, FACULTY OF SCIENCES

The greatest benefit that I can think of is the role of science in some activities is being better understood. And more of us are getting requests from public institutions.

Source 16
HEAD, DEPARTMENT OF BIOLOGY, FACULTY OF SCIENCE

I share knowledge that I gained from my studies. When I [am] invited to discuss aspects of climate change … we share the info and I can teach what I know so that they can be involved in climate change issues. Otherwise I was not involved mainly for salary … Nowadays as an academic institution there is a need for research funds that is missing. … But those institutions that themselves do not have much in the way of funds, I did not gain much from them; I helped them to organize themselves by understanding the principles of climate change. Organizations like the Rockefeller Foundation are providing funding, and the MacArthur Foundation too has also provided funding. Those are the only two sources of funds we had so far.

Guiding Questions

Q3: What unmet needs or specific problems do you seek to address through partnership? What are the three biggest resource needs you face as you work to address the development challenge you described at the beginning of our interview?

Q4: Generally, how do you meet collaborators (e.g., at workshops, online, through professional societies)?

Source 19
PROFESSOR, FACULTY OF ECONOMICS AND MANAGEMENT

Still [the] capacity building of junior staff is a challenge. We need for them to do more Ph.Ds. On [the] institutional side, I am really lacking software; in most of the disciplines we have a procurement problem. I would like to have in-kind support for installation. That is one. And finally this place … it is not simply teaching. We need help in benchmarking our institutions in my faculty with others…This happens through students/staff and addressing local needs and creating sellable

projects we can develop. It is not just simply to ask for a computer or money — it is necessary to have collaboration and cooperation.

Source 21
Dean, Faculty of Agriculture

[In] pest management, mainly we want to evaluate the current status of the pest in the country. Then we want to adapt and develop new technologies to address key pests, such as antestia bug. We also want help taking what we find and working with farmers. Really, we want to work with farmers right from the beginning.

Source 20
lecturer, Department of Soil and Environmental Science

Exchange … skills. Yes, I want to say that we need collaborations to exchange [insights into] how we work, how we do experiments. For example what we do in our facility, we don't know what we are doing in our work. We need help with experiments … how to do experiments.

Source 16
Head, Department of Biology, Faculty of Science

[Partnership is attractive] mainly [as a mechanism] to have research funds. To have a fund that we can use to continue our research, it would be my first interest. And sometimes research tools are needed.

Source 2
Professor, Soil Science and Environmental Management

[I meet collaborators] sometimes during a meeting or during a seminar. You can get contact with those people. Sometimes if someone at the Ministry of Agriculture is aware of a problem, he can contact you and see what to do. But as I was saying, there are no official channels. Those things are still to be done.

Source 25
Head of Faculty of Civil Engineering

[To collaborate with specific individuals] we look for their contacts, contact them, and try to invite them here. Then from them we know others. [Attending] some other training courses…and making presentations at conferences…I meet people from different countries, exchange contacts and tell them what we are doing and what we have…Then we link up and try to make a network.

Source 8
Coordinator, M.Sc. in Agroforestry

[Regarding my collaborators,] we meet in a workshop, mostly, or a conference — it is where we meet generally speaking. And visits, for example, a partner can come for a visit, but usually I don't have the occasion. Visits are also very nice for strengthening the bonds. And of course Internet. Once you have established contact, we can remain in contact through the Internet. But [for the] first contact we meet in workshops, and after some visits, through telephone calls like this one, or email.

Guiding Questions

Q5: Do you use information and communication technologies (ICTs) in your work, for example, to interact with partners outside of your organization? What kinds of ICTs do you use (e.g., mobile phones, personal digital assistants (like a Blackberry or smart-phone), pager, web-enabled computer, etc.)? How would you describe your ability to connect to the Internet? Is there is a bottleneck, and if so, what is it?

Source 12
DEAN, FACULTY OF SCIENCES

For my work, ICTs are very important … even in teaching. ICTs are very important in research … But the issue of acquiring expensive ICTs with an unstable power supply system [is a problem]. Sometimes we [are not able to] use some very expensive equipment because we have an unstable power supply or because we don't have people to do basic maintenance of equipment.

Source 11
HEAD OF ENTREPRENEURSHIP DEPARTMENT, CEESD

When we are organizing ourselves sometimes we need to invite people from outside. We (don't) have any problem [with communication], because everywhere we have Internet. Even at (the) District level it is very easy — we send an email and then people respond directly … By phone as well. But we [don't] meet any problem when we're organizing.

Source 16
HEAD, DEPARTMENT OF BIOLOGY, FACULTY OF SCIENCE

Nowadays we have very good connectivity for phone, mobile phone, for Internet. Everywhere nowadays. All the staff at the university are connected. Offices are connected. Every office is connected. But we are also able to buy modems, mobile Internet. When I'm at home I use mobile Internet. But when I'm in the office I use a wireless connection. So…NUR is well connected.

Source 25
HEAD OF FACULTY OF CIVIL ENGINEERING

Most of all [we connect via] email communication — that is what is readily available here. Every time in the night I can use the direct connection or mobile. Second is cell phone. Third is website(s).

Source 4
LECTURER, ANIMAL PRODUCTION, FACULTY OF AGRICULTURE

When I came, I had problems with connections. But it is hard to compare because I came from a country with high-speed Internet all day. I might say it is not good, but someone else will say it is good.

Source 2
PROFESSOR, SOIL SCIENCE AND ENVIRONMENTAL MANAGEMENT,

It is quite difficult, because sometimes it works and sometimes it doesn't. I might say that it is not very reliable. OK, it is not related to the equipment, but it is a matter of the network. For instance, in my office we have only one desktop and all the staff have to use that desktop and if everyone has to use that desktop. It is really a problem. And for now the whole facility is using just one computer. In that sense, it is difficult.

FACULTY OF AGRICULTURE

I can say that there is some insufficiency of this equipment.

Source 3
SENIOR LECTURER, FACULTY OF MEDICINE

We are using Internet, which is the main means of communication. I think that now we have a better connection, and each year we are improving the Internet connection. … Sometimes you have a power cut, but we are in a good way to solve problems of communication through Internet. Academic staff have a closed user group so they can communicate.

Guiding Questions

Q6: How would you rate the degree to which your collaboration and communication resource needs are being met? Do you have any ongoing partnerships to address your collaboration and communication resource needs (e.g., partnerships to enhance your access to information and communication technologies)? With whom and for what? What collaboration and communication resources (e.g., improved access to the Internet) do you need that a partner might help you access?

Source 16
HEAD, DEPARTMENT OF BIOLOGY, FACULTY OF SCIENCE

Mainly the weakness that we have, and that I am feeling need to be approached, are [with] villagers. Because whatever we do without involving villagers is not sustainable. As scientists, we can do many things, but the villagers need to be sensitized. We find that we don't have workshops for villagers.

Source 21
DEAN, FACULTY OF AGRICULTURE

We think through partnership, we have had good resources — from Wageningen [University] and from Texas A&M [University]. For graduate [level training], we also got books from ICRAF [The World Agroforestry Centre] and from Wageningen. We also got books from ICIPE [The International Centre of Insect Physiology and Ecology] for entomology. From the SIDA/SAREC project, which pays for electronic journals, we have access to those across the whole spectrum of journal. We have 32,000 journals paid for through this support. For antestia bug, collaboration needs are not yet being met.

Source 19
PROFESSOR, FACULTY OF ECONOMICS AND MANAGEMENT

It is SIDA/SAREC that has been working in that area of ICTs … USAID gave us the research system and computers were given by SIDA. They (SIDA) are a long-term partner for us and we are going to make it for another five years to come.

Source 21
DEAN, FACULTY OF AGRICULTURE

[We do not have any partners to address potato taste defect] yet, except the current one with GKI, which just started!

Source 24

[In terms of communication and collaboration resource needs], even if I

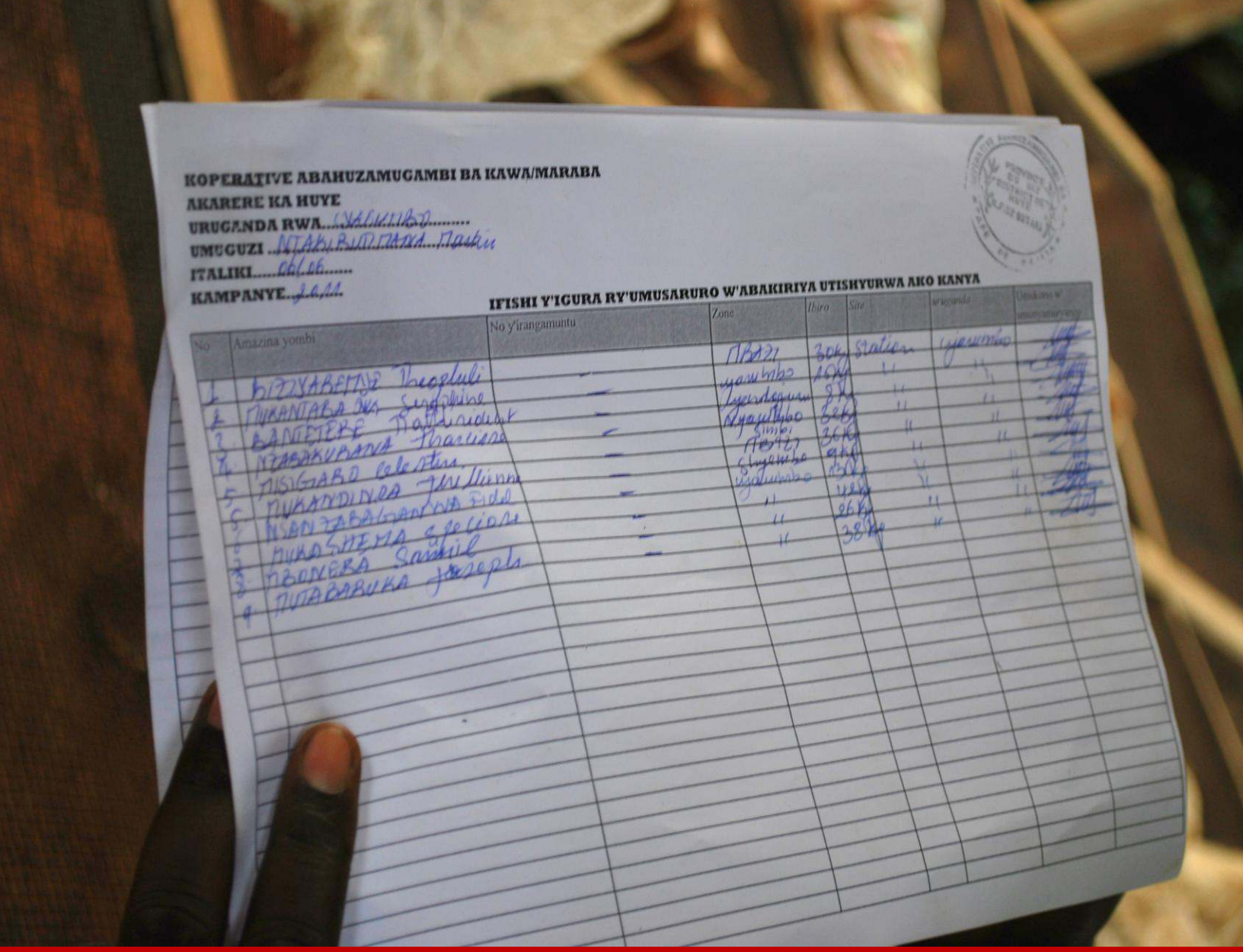
MASTERS STUDENT, AGROFORESTRY AND SOIL MGMT

am happy with the connection, if I want to download an article, you need a lot of time to get the file. So we need the high-speed Internet connection. As the wireless is all around here, it would be good to have a laptop to access everywhere you are.

Source 23

HEAD OF SUSTAINABLE DEVELOPMENT, CEESD

Public connectivity — what we need most is connectivity to websites to give us information and knowledge … And also partnership with people who are working the same area in which we are working. Because you know sometimes membership is not free and you need to pay for partnership.



Knowledge Resources

Synthesis of Findings

The KPLA defines *Knowledge Resources as information embedded in research and indigenous knowledge, written guidelines and procedural documents, regulatory and legislative code, and intellectual property that adds value and enables solution generation and application.* This includes technical reports and surveys, professional journals, and databases of research findings. Interviewees spoke of NUR's scarce library resources, books and print journals. One Faculty of Economics source noted that, not only does library content require updating, their resident librarian complains of insufficient space to house new materials. Enhancing access to knowledge resources is one of the main goals NUR pursues in its collaborative relationships with universities; however, respondent explained that access garnered usually is not spread evenly across NUR.

> *We have access to e-journals. The students are familiar with computers and we visit websites to find resources.*
>
> *- Student, Soil and Environmental Management*

Interviewees expressed a pressing need for improved access to academic journals. While almost all respondents report some access to online journals, whether through Google Scholar, AGORA (Access to Global Online Research in Agriculture), or INASP (International Network for the Availability of Scientific Publications), many struggle with poor Internet connections or journal fees that pose limitations. To be effective teachers and researchers, university faculty demand access to specialized journals. Some stated that SIDA supports NUR's access to online journals, though additional partners are needed to bridge the gap between those available and needed. Respondents also hoped to find partners to provide statistical software for data analysis.

Professors interviewed spend anywhere from 20% to 70% of their time teaching, though most allocate approximately 50%. Professors ensure their course content is updated and current through NUR's annual review process and also through personal research. Some who allocate a greater percent of their work hours to teaching worry that time spent in the classroom detracts from their academic research. Even with heavy teaching loads, interviewees publish in journals including *Aquaculture Nutrition*, *Bioscience*, and *The International Journal of Computation Math*.

SURVEY RESULTS: KNOWLEDGE RESOURCE AVAILABILITY & ACCESS

(*as provided by 10 survey respondents from the NUR Faculty of Agriculture*)

Q1: On a scale of 0-5, how well are your knowledge resource needs (these may include access to online journals, research data sets, etc.) being met? (5 = needs are completely met)

Average rating: 3.1

Q2: On a scale of 0-5, how do you rate your ability to access needed knowledge resources?

Average rating: 3.2

Q3: On a scale of 0-5, how interested are you in partnerships that address your knowledge resource needs? (5 = extremely interested)

Average rating: 4.75

What does this information reveal? Results reveal a strong desire on behalf of NUR faculty and students to increase their partnerships to address knowledge resource needs.

Voices of the Experts

Guiding Questions

Q1: Do you access existing knowledge relevant to the challenge you are working to address (e.g., through academic journals)?

a. If so, how (e.g., online subscriptions, the library)?

b. If you find these resources online, what have been the most helpful websites?

Selected responses to the above questions from some of the 25 interviewees follow.

Source 24
Masters Student, Agroforestry and Soil Management

With the [Internet] connection, we can get access to many journals. [There are] many channels that we can [use to] get access to journals related to agriculture, INASP, and others … about five to six journals in all. Of course, [there are] libraries [we can use] to get access to many books to improve our knowledge, [but] some you cannot access without paying.

Source 10
Student, Soil and Environmental Management

We have access to e-journals. The students are familiar with computers and we visit websites to find resources. NUR provides some e-journals, others are not paid by NUR so [they are] difficult to receive.

Source 7
Senior Lecturer, Department of Crop Production and Horticulture

I can do searches electronically. We have INASP, UNESCO, then AGORA [for which we have an institutional] code to those resources. And then you have the main library, which has increasing volumes of scientific books.

Source 22
Vice Dean and Professor, Department of Crop Production and Horticulture

These days, hard copies are not easy to come by. Online through AGORA, through The Essential Electronic Agricultural Library, [we can get access]. You go to Google — you can access things for free too.

Source 8
Coordinator of Ms.C. in Agroforestry

We have many electronic journals. We have access to many scientific journals. So through the Internet connection we have access, but the problem is that the connection is not a good one. So in principle, one can access international journals, but in reality, due to the poor connection, access then becomes poor. In our library we have journals, books…but they are poorly equipped. So I would say then that access to journals and books is moderate.

Source 18
Senior Lecturer, Department of Animal Production

We use the popular search engine Google. And we also have — I think the university has — the AGORA journals and we are able to access most of the publications.

Guiding Questions

Q2: In the last five years, have you published an academic paper?
  a. If so, how many articles? In what publications?

Q3: *For teachers/professors only: What percentage of time do you spend teaching?*
  a. How do you ensure your curriculum is up to date?

Source 21
Dean, Faculty of Agriculture

Fifty percent of my time is spent teaching. We do a curriculum review and involve stakeholders, mainly the government stakeholders. Also, private sector and farmers are used for curriculum updating.

Source 12
Dean, Faculty of Science

I just compare my lecture notes with other existing lecture notes from distant scholars and compare to the curriculum, which is available here. But normally I try to keep to a standard. I compare and make sure it is not distant from what is being taught [by others elsewhere].

Source 25
Head of Faculty of Civil Engineering

If you talk about teaching, I would say more than 60% of my time. Sometimes I do research in the night. But general working time, maybe 60% of the time, is teaching. That includes field activities, teaching, practicals.

On Updating Curriculum: One, we have programs. We work according to programs. But usually when we feel that there is an additional thing that we need – we need to come to students. We bring this idea forward, we add this indirectly, bring this in through other examples, so students will have this knowledge.

Source 10
Associate Professor, Faculty of Agriculture

Directly related with soil science I have published four articles — four in international journals and one research report. Locally I have published many papers related to rural agriculture development and environment, [including] *The Australian Journal of Soil Science, Edite Rwandais*.

Source 18
Senior Lecturer, Department of Animal Production,

Because of the shortage of staff in some areas we spend most of our time teaching. So you know that is not actually helpful for research [productivity] because teaching is a full time job. But, the university is trying to recruit more staff and with that you'll have more time for research activities. Of the official hours [I spend], maybe 70% is for teaching and 30% on research.

FACULTY OF AGRICULTURE

Source 19
PROFESSOR, FACULTY OF ECONOMICS AND MANAGEMENT

Yes, our Human Development Report is one [publication]. And I did a small work on Rwanda … it came out in a Conference Proceeding. And then some were published at NUR Rwandan Studies … And there is one on the role of ICTs in maintaining health policies in Rwanda. And I have publish[ed] one or two that are coming up shortly.

Guiding Questions

Q4: How would you rate the degree to which your knowledge resource needs are being met? Do you have any ongoing partnerships to address knowledge needs (e.g., access to academic journals provided through a consortium)? With whom and for what? What knowledge resources (e.g., data sets pertinent to your research) do you need that a partner might help you access?

Source 15
ASSISTANT TEACHER, AGRICULTURAL ECONOMICS, FACULTY OF AGRICULTURE

I need journals about coffee and coffee value chains. Journals talking about socioeconomic factors would be important to access too. Data and articles on the importance of cooperatives would be great too, especially in terms of helping farmers to reduce poverty and increase their income to improve their livelihoods.

Source 3
SENIOR LECTURER, FACULTY OF MEDICINE

I cannot say that I am fully satisfied, but there is a [sense] that we can improve our resources. As I told you, there are big American journals that we don't have free access to. We don't have enough books in my domain. So we need to procure books. We need to choose some items because we have a limited budget.

Source 1
COORDINATOR M.SC. IN ICTS, FACULTY OF COMPUTER SCIENCE

As I mentioned to you, I would like my students to have access to some virtual laboratories outside that they could use to understand the theory and do a lot of thinking to be equal to anybody, even at MIT [US]. And if you could get that, we have a link with universities we can visit. Among the students and lecturers, it could help us become one [of] the top in Africa.

Source 19
PROFESSOR, FACULTY OF ECONOMICS AND MANAGEMENT

We have access to electronic journals supported by INASP, and also by SIDA. Our library resources are being developed by funding from SIDA. Sometimes we used to get books as a gift by partners, such as Rotary International and we buy some out of our funds.

Source 2
HEAD, DEPARTMENT OF SOIL SCIENCE AND ENV MGMT

Well, yes I have some colleagues working around the world and whenever there is a resource I want that I can't get here, I ask them to help me find it. So I might say that that is on the personal level. If possible, I would be happy to have some sort of subscription for some of the scientific journals on a regular basis.

Source 12
DEAN, FACULTY OF SCIENCE

Yes … in every partnership we try to get access to their libraries. But most of the time, only the staff on these programs can access the libraries of these institutions. But in every partnership we have, we try to address this issue.

Conclusions

The National University of Rwanda Knowledge Partnership Landscape Analysis interviews offer a rare opportunity to peel back the layers of the National University of Rwanda — a complex, multi-dimensional institution — to hear what some of the most dynamic collaborators think about their resource needs and partnership opportunities. NUR represents a driving force of Rwanda's knowledge infrastructure and a dominant producer of Rwanda's highly skilled professionals. Opened in 1963 as the country's first institution of higher learning, NUR currently offers 39 undergraduate programs and 24 postgraduate programs of which STEM (science, technology, engineering, and math) degrees constitute the majority. The university boasts a student population of more than 12,000 students–approximately one-third of the total public higher education population in Rwanda. Almost half of these students pursue science-based subjects, such as applied sciences, agriculture, medicine, and public health (NUR Annual Report, 2009). As Dr Rutagwentda Théogène, Chairperson of the NUR Board of Directors states:

> *The National University of Rwanda is the only higher education institution in Rwanda that covers the full range of disciplines. It continues to train the scientists and the engineers who act as the home and facilitator for much of Rwanda's applied scientific research. It trains the agriculturalists and those who will bring business and enterprise to agriculture while conserving the environment for future generations…It [also] trains the professions essential for a stable and sustainable civil society—the doctors, lawyers, academicians, political scientists, sociologists, social workers, psychologists, and many more* (ibid).

As this statement asserts, NUR faculty, staff, current students, and alumni constitute a considerable brain trust that drive Rwanda's development. Combined with other elements of the Rwandan knowledge infrastructure such as the Kigali Institute of Science and Technology, these individuals have the potential to solve some of Rwanda's most pressing challenges — even if that potential is not yet fully tapped.

The KPLA offers a number of insights into how NUR's collective problem-solving potential might be enhanced through better understanding of the institution's collaboration baseline. Such information can then be used to construct smarter partnerships.

It is clear from the KPLA survey results that respondents share an exceedingly high appreciation for the value of regional and global knowledge partnerships. Interest in increasing their partnerships to address resource gaps is especially high in the areas of knowledge and technology resources, and, to a lesser extent, institutional resources. In terms of human resources, respondents indicated a high level of interest in partnerships that augment professional skills such as technical writing and laboratory management, as these opportunities tend to be less available than traditional scientific/technical training. Hindering NUR's collaborative potential is the gap that exists between NUR professors' desire for collaboration and their ability to partner with individuals outside their institutional walls: identifying the right partner at the right time remains a challenge. This means that while appreciation for collaboration is high, this understood value does not necessarily catalyze action.

So what needs to be done to reduce this gap? The Global Knowledge Initiative suggests a few near-term actions that NUR should consider to boost its collaborative potential. This list is not exhaustive, but offers a starting point for reflection and discussion.

(1) **Analyze resource bottlenecks and partnership opportunities that cut across multiple THICK dimensions.** The 25 interviews conducted for the KPLA elicited dozens of resource needs and partnership opportunities; multiplied over an entire campus, the list of needs and opportunities will only grow. Identifying cross-cutting resource bottlenecks and partnership opportunities offers a way to prioritize among

innumerable, critical needs. A few specific examples arose in this initial KPLA analysis. First, the issue of insufficient availability of trained laboratory technicians surfaced in inquiries regarding technology resources and human resources. Indeed, one respondent noted that without trained technicians, investment in certain types of "heavy equipment" is moot. Without addressing this specific human resource gap, progress on other fronts will be stymied. Access to information and communication technologies constitutes another cross-cutting issue raised by interviewees. Efforts to enhance the availability of "connected" computers and improve bandwidth across campus would have far-reaching implications for improving person-to-person networking, efficiency, and knowledge acquisition. Designing partnerships specifically attuned to address these needs constitutes a next step for the NUR community.

(2) Get specific about the resources sought through partnership. Training on technical writing, access to journals on the coffee value chain, statistical software like SAS — these are just a few of the many specific resource needs NUR faculty and students interviewed seek to address through partnership. Such detail empowers action, as potential partners can clearly assess whether they are poised to help address that need or not. Using information derived from the KPLA specific to potato taste and the antestia bug challenge, the Global Knowledge Initiative crafted a "Challenger Profile" for the NUR LINK coffee research team. The "Challenger Profile" paints an even more nuanced picture of available versus needed resources to address the potato taste challenge, providing a concise overview for potential partners. Similar profiles can be crafted for a range of challenges addressed by the NUR community. Such efforts will only strengthen NUR's success rate of partner identification required to help university stakeholders solve current and future challenges.

(3) Leverage existing assets to grow the picture of needed/available resources required to tackle specific challenges (e.g., potato taste in Rwandan specialty coffee). With a quick glance at *Annex 1: Full List of Partnerships* one recognizes that many of the individuals working inside NUR serve as active and productive collaborators. However, neither this analysis nor the Annex should be construed as finished products. By taking this initial inquiry, growing the number of respondents, building further the catalogue of available/needed resources, and mapping those to existing partnerships, the picture will become more fine-grained and more accurate. The more detail and precision the KPLA offers, the more valuable it becomes in building inclusive, effective, and efficient knowledge networks. Thus, the insights of this KPLA should be viewed as preliminary and stand to be greatly enhanced in value as more NUR interviewees and their colleagues in other institutions participate in the KPLA process. Equipped with an expanding information base on collaborative innovation and STI resource needs/availability, the National University of Rwanda faculty, staff, and students will be poised to inform potential partners of exactly what they seek to gain through collaborations, and what they are able to bring to them in return.

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Annex I: Full List of Partnerships from KPLA Interviews

Type of Institution	Partnering Institution	NUR Connections
Universities	Antioch University (United States)	Donat Nsabimana
	Blekinge Institute of Technology (Sweden)	Felix Akorli
	Boston College (United States)	Joseph Ndagijimana
	Braunschweig Technical University (Germany)	Francois Naramabuye
	Center for Conflict Management, National University of Rwanda	Joseph Ndagijimana
	Cooper Union for Advancement of Arts and Science (United States)	Felix Akorli
	Egerton University (Kenya)	Umaru Garba Wali
	Gothenburg University (Sweden)	Fidele Ndahayo, Donat Nsabimana, Charles Karangwa
	Institute of Agricultural Research and Training (Nigeria)	Isaac Oladunjoye
	Institute of Agriculture, Technology, and Education of Kibungo (Rwanda)	Pierre Mambani Banda
	Iowa State University (United States)	Jean Claude Kayisinga
	Kigali College of Environment and Conservation (Rwanda)	Laetitia Nyina-wamwiza
	Kigali Institute of Science and Technology (Rwanda)	Umaru Garba Wali
	Korean University of Technology and Education (Korea)	Felix Akorli
	Kwame Nkrumah University Of Science and Technology (Ghana)	Umaru Garba Wali, Felix Akorli
	Linkoping University (Sweden)	Fidele Ndahayo
	Makerere University (Uganda)	Donat Nsabimana, Joseph Ndagijimana, Francois Naramabuye
	Moor Plantation Ibadan (Nigeria)	Isaac Oladunjoye
	Sokoine University of Agriculture (Tanzania)	Esron Munyanziza, Umaru Garba Wali, Francois Naramabuye
	South Africa Institute of Management (South Africa)	Joseph Ndagijimana
	Technical University of Clausthal (Germany)	Francois Naramabuye
	Texas A&M University (United States)	Rama Rao, Jean Claude Kayisinga,
	Trinity College (Ireland)	Rama Rao

	Umutara Polytechnic University (Rwanda)	Laetitia Nyina-wamwiza
	United Nations Education, Science and Cultural Organization–IHE (International Institute for Hydraulic and Environmental Engineering) Institute of Water Education (Netherlands)	Umaru Garba Wali, Fidele Ndahayo
	University of Botswana	Umaru Garba Wali
	University of Burundi	Francois Naramabuye, Donat Nsabimana
	University of Dar Es Salaam (Tanzania)	Donat Nsabimana
	University of Democratic Republic of Congo	Francois Naramabuye
	University of Dublin (Ireland)	Rama Rao
	University of Kibungo (Rwanda)	Laetitia Nyina-wamwiza
	University of KwaZulu Natal (South Africa)	Felix Akorli, Joseph Ndagijimana
	University of Leuven (Belgium)	Jean Chrystotome Ngabitsinge, Charles Karangwa
	University of Liege (Belgium)	Charles Karangwa
	University of Maryland (United States)	Rama Rao
	University of Missouri (United States)	Joseph Ndagijimana
	University of Nairobi (Kenya)	Felix Akorli
	University of Tanzania	Umaru Garba Wali
	University of Western Cape (Ghana)	Felix Akorli
	University of Western Ontario (Canada)	Rama Rao
	University of Zimbabwe	Umaru Garba Wali
	Wageningan University (Netherlands)	Alphonsine Kenyangi, Esron Munyanziza, Fidele Ndahayo (not personally)
Firms	ConAgra Foods	Jean Claude Kayisinga
	Costco	Jean Claude Kayisinga
	European Pharmacopoeia	Charles Karangwa
	Green Mountain Coffee,	Jean Claude Kayisinga
	Horizon (Pyrethrum)	Jean Claude Kayisinga
	IBM	Rama Rao, Felix Akorli
	Intelligentsia Coffee & Tea	Jean Claude Kayisinga
	Kenyanye	Charles Karangwa
	LTS International	Esron Munyanziza
	MDF Training and Consultancy	Esron Munyanziza
	The MTN Group	Felix Akorli
	NIRAS (Consultancy)	Francois Naramabuye
	Organic Solutions	Pierre Mambani Banda
	Promelec	Felix Akorli
	Rock Global Consultancy	Felix Akorli
	Rogers Family Company	Jean Claude Kayisinga
	RUMA Certified Public Accountants	Esron Munyanziza
	Rwandatel	Felix Akorli
	Rwashoscco (Coffee Cooperative)	Rama Rao
	SC Johnson	Jean Claude Kayisinga
	Sustainable Harvest	Jean Claude Kayisinga

	UNILEVER	Rama Rao
	Union Hand Roasted Coffee	Jean Claude Kayisinga
	US Pharmacopeia	Charles Karangwa
Public Research Organizations (Rwanda)	Institute of Policy Analysis and Research	Rama Rao
	Institute of Scientific and Technological Research	Fidele Ndahayo, Rama Rao
	Rwanda Agricultural Research Institute (ISAR)	Rama Rao, Emmanuel Uwizeye, Elie Muhinda Mugunga, Alphonsine Kenyangi, Daniel Rukazambuga, Jean Chrystotome Ngabitsinge, Peter Sallah, Pierre Mambani Banda, Fidele Ndahayo, Donat Nsabimana, Jean Claude Kayisinga, Umaru Garba Wali,
	National Institute of Statistics of Rwanda	Rama Rao
Non-Profit Organizations / International Development Organizations	Association pour la Conservation de la Nature au Rwanda (ACNR)	Donat Nsabimana
	African Forest Network	Esron Munyanziza
	African Population and Health Research Center	Rama Rao
	Alliance for a Green Revolution in Africa (AGRA)	Emmanuel Uwizeye, Peter Sallah, Francois Naramabuye
	Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)	Elie Muhinda Mugunga
	Belgium Technical Cooperation	Rama Rao
	Bill and Melinda Gates Foundation	Francois Naramabuye
	CABI (Centre for Agriculture and Biosciences International)	Elie Muhinda Mugunga
	Consultative Group on International Agricultural Research (CGIAR)	Peter Sallah
	Canadian International Development Agency (CIDA)	Felix Akorli
	Department for International Development (DFID)	Rama Rao, Jean Chrystotome Ngabitsinge, Esron Munyanziza
	East Africa Plant Genetic Resources	Esron Munyanziza
	Family Health International	Esron Munyanziza
	ICRAF World Agroforestry Center	Umaru Garba Wali
	International Fund for Agricultural Development	Jean Chrystotome Ngabitsinge
	International Center for Research in Agroforestry	Esron Munyanziza
	International Development Research Centre	Francois Naramabuye
	International Institute of Tropical Agriculture	Pierre Mambani Banda
	International Institution of Environment and Development	Jean Chrystotome Ngabitsinge
	International Monetary Fund (IMF)	Joseph Ndagijimana
	Junior Chamber International	Rama Rao
	Karisoke Research Center	Donat Nsabimana
	Kenya National Museum	Esron Munyanziza
	Korean International Cooperation Agency (Korean Government)	Felix Akorli, Peter Sallah,

	Lake Victoria Research Initiative	Francois Naramabuye
	Mabawa Empowerment Organization	Rama Rao
	Maize and Wheat Foundation of Central Asia	Peter Sallah
	Management Sciences for Health (MSH)	Charles Karangwa
	Nigeria Society of Engineers	Umaru Garba Wali
	Nile Basin Discourse Forum	Dieudonne Uwizeye, Joseph Ndagijimana
	Nile River Basin Initiative	Hamudu Rukangantambara, Francois Naramabuye
	Rwanda Environmental Conservation Organization	Dieudonne Uwizeye, Joseph Ndagijimana
	Rwanda Environmental NGO Forum	Dieudonne Uwizeye, Joseph Ndagijimana
	Rwanda Horticulture Interprofessional Organisation	Alphonsine Kenyangi
	Rockefeller Foundation	Peter Sallah
	Rwanda Rainwater Harvesting Association	Umaru Garba Wali
	Seanet International	Umaru Garba Wali
	Swedish International Development Cooperation Agency (Sida)	Rama Rao, Esron Munyanziza, Felix Akorli, Joseph Ndagijimana, Umaru Garba Wali, Dieudonne Uwizeye, Charles Karangwa, Jean Claude Kayisinga, Donat Nsabimana, Fidele Ndahayo, Isaac Oladunjoye, Daniel Rukazambuga, Alphonsine Kenyangi, Elie Muhinda Mugunga, Emmanuel Uwizeye, Francois Naramabuye
	Netherlands Development Organisation (SNV)	Jean Claude Kayisinga, Joseph Ndagijimana
	SPREAD (Sustaining Partnerships to Enhance Rural Enterprise And Agribusiness Development)	Rama Rao, Daniel Rukazambuga
	TechnoServe	Jean Claude Kayisinga
	The Global Fund	Charles Karangwa
	United Nations Economic Commission for Africa (UNECA)	Rama Rao
	United States Agency for International Development (USAID)	Rama Rao, Donat Nsabinamana, Felix Akorli
	Waternet	Umaru Garba Wali
	World Wildlife Preservation Society	Donat Nsabimana
	Youth Employment Service Rwanda,	Rama Rao
Public Entities	Federal Ministry of Science and Technology (Nigeria)	Isaac Oladunjoye
	National Bank of Rwanda	Joseph Ndagijimana
	Radio Rwanda	Joseph Ndagijimana
	Rwanda Utilities Regulatory Agency	Umaru Garba Wali
	Rwanda Agriculture Board	Francois Naramabuye
	Rwanda Agriculture Development Authority	Alphonsine Kenyangi
	Rwanda Bureau of Standards	Joseph Ndagijimana
	Rwanda Cooperative Agency	Jean Claude Kayisinga, Dieudonne Uwizeye

	Rwanda Development Board	Jean Claude Kayisinga, Donat Nsabimana, Felix Akorli
	Rwanda Environmental Management Agency	Umaru Garba Wali, Dieudonne Uwizeye, Joseph Ndagijimana
	Rwanda Horticulture Development Authority	Alphonsine Kenyangi
	Rwanda Ministry of Agriculture	Laetitia Nyina-wamwiza, Jean Chrystotome Ngabitsinge, Pierre Mambani Banda, Donat Nsabimana, Charles Karangwa
	Rwanda Ministry of Finance and Economic Planning	Rama Rao
	Rwanda Ministry of Health	Charles Karangwa
	Rwanda Ministry of Infrastructure	Laetitia Nyina-wamwiza, Fidele Ndahayo
	Rwanda Ministry of Local Government	Rama Rao, Joseph Ndagijimana
	Rwanda Ministry of Trade and Industry (MINICOM)	Joseph Ndagijimana, Charles Karangwa
	Rwanda National Agriculture Export Board	Elie Muhinda Mugunga, Daniel Rukazambuga, Jean Claude Kayisinga
	Rwanda National Land Commission	Jean Chrystotome Ngabitsinge
	Rwanda Private Sector Federation	Joseph Ndagijimana
	Rwanda Revenue Authority	Rama Rao
	US Embassy (United States)	Joseph Ndagijimana

GLOBAL KNOWLEDGE INITIATIVE

CHALLENGE: TACKLING POTATO TASTE IN RWANDAN SPECIALTY COFFEE

CHALLENGER: Dr. Daniel Rukazambuga

Program: Learning and Innovation Network for Knowledge and Solutions (LINK)

ROUND 1 East Africa

GLOBAL KNOWLEDGE INITIATIVE

LOCATE. ENABLE. CONNECT. SOLVE.

Challenger: Dr. Daniel Rukazambuga
Title: Dean
Host Institution: Faculty of Agriculture, National University of Rwanda (NUR)
Location: Butare, Rwanda
Email: drukazambuga@nur.ac.rw

Introducing Daniel Rukazambuga:

Our principal investigator for the East Africa LINK team, Daniel, hails from a family dedicated to education – and it shows. Originally from Rwanda, as a child his family relocated to Burundi, then Tanzania, to ensure his education progressed despite the hostilities mounting in Rwanda. Demonstrating this commitment, Daniel's father, a farmer, walked him 11 kilometers to school and back every day for three years. Now an Entomologist, Daniel has worked for the past 23 years to improve the livelihoods of banana, maize and coffee farmers. In addition to collaborating with international universities and the US Agency for International Development, Daniel works side-by-side with Rwandan farmers, students, and researchers. He understands their needs and resource constraints, as well as the potential benefits rendered to them through capacity building initiatives and new technologies.

My Challenge:

Coffee plays a central role in the Rwandan economy. Along with tea, it is the primary agricultural export in my country, and over half a million of my fellow citizens are coffee farmers. Indeed, Rwandans turned to coffee to help spur recovery as our country emerged from the painful 1994 genocide. Small-holder farmers, many of whom live on less than $2 per day and depend on coffee as their main source of income, are coffee's primary producers. In recent years, Rwanda has become famous for specialty coffee. Today, buyers in the US, Europe, and Japan seek out Rwanda's quality coffee. However, buyers of high-grade beans have begun to report a potato taste in roasted coffee. Due to this taste defect, buyers are getting leery, and the market viability of Rwandan specialty coffee is under question. Many scientists and coffee specialists suspect the antestia bug as one of the primary culprits. The current control strategies of antestia bug have not succeeded in reducing the potato taste; hence there is an urgent need for alternative strategies appropriate for Rwandan farmers. My research includes the study of the antestia bug profile and its distribution, population dynamics, natural enemies, interaction with crop systems, pesticides, bio-pesticides, and other integrated pest management options. I seek to encourage the use of modern pest management techniques among Rwandan coffee farmers while also developing technologies to curb the devastating effects of this insect.

Why I am seeking partners:

I am looking for specialists fields related to pest management to develop appropriate technology for farmers who work in a densely populated area with small, scatted plots on hilly terrain. To address this complex challenge, I hope to find specialists in biological control, integrated pest management, pesticide applications, cropping systems, plant nutrition, plant resistance mechanisms, and agricultural economics, among others relevant areas. In addition, past studies of the antestia bug did not include research across diverse agro-ecological zones. Partners outside of Rwanda, but with similar ecological conditions, can extend their research and, in doing so, increase our knowledge of the problem and help us identify potential solutions.

My vision for solving this challenge:

Through partnerships with entomologists, coffee experts, farmers, pesticide specialists, and entrepreneurs, we can develop and promote integrated pest management to fight the antestia bug and stave off the potato taste defect.
We can:

- Reduce the occurrence of potato taste that threatens the Rwandan specialty coffee market
- Diminish the negative effects of the antestia bug
- Protect and increase the income of small-holder coffee farmers
- Promote the use of good pest management techniques for all crops in the Rwandan agriculture-led economy

Daniel identifies an unmet challenge

Daniel secures resources to tackle it

Daniel seeks specific resources to get him across the finish line

Through partnership, Daniel solves his challenge!

Resources Daniel and his team have available:

- Partnership with the National Agriculture Export Board, the government-sponsored organization tasked with coffee promotion, assistance, and monitoring
- Large student involvement in research
- Membership in a "coffee industry cluster" responsible for developing pest management techniques
- Access to some online journals
- Consistent internet access
- Entomologists to aid in research
- Supportive intellectual property rights (IPR) policy
- Dedicated team of researchers (see below)

Resources Daniel and his team need:

- Advanced Statistical Software (SAS or STATA)
- Taxonomists, seed scientists, and biotechnologists
- Insect collection, identification, and rearing technology
- Lab equipment, including microscopes and a freezer
- Crop management and/or biological control experts
- Integrated pest management (IPM) experts
- GPS equipment
- Experts in applied economics and agriculture
- Digital camera

Daniel's commitment to solving the challenge:

Daniel's team has a partnership and memorandum of understanding with Rwanda's major coffee organization, the National Agriculture Export Board. In addition, Daniel serves as an active member of the "coffee cluster" that includes the Rwanda Agriculture Research Institute, the USAID coffee program SPREAD (Sustaining Partnerships to enhance Rural Enterprise and Agribusiness Development), and others committed to safeguarding the coffee sector.

GLOBAL KNOWLEDGE INITIATIVE

MEMBERS OF THE NUR COFFEE RESEARCH TEAM

Dr. Elie Muhinda Mugunga: Senior Lecturer of Crop Production and Horticulture and Former head of ISAR

Elie is a specialist in entomology and parasitology who loves his work and the challenges it brings. A graduate of what is now the University of Kinshasa, he prepared his Ph.D. at the International Center of Insect Physiology and Ecology, received his degree from Rivers State University of Science and Technology in Nigeria, and performed a fellowship at the Hebrew University of Jerusalem. The self-proclaimed "Pest Man" has performed research on malaria-carrying mosquitoes and disease-spreading sandflies. As the previous head of Rwanda's main agricultural research institute, he has trained farmers to identify and prevent coffee rust disease, researched the coffee borer, and is now tackling the antestia bug.

Alphonsine Kenyangi: Assistant Lecturer of Crop Production and Horticulture

Alphonsine attended the National University of Rwanda for her undergraduate degree and received her Master's degree in plant sciences from Wageningen University in the Netherlands. While her original concentration was in vermicompost as a component in mixes for ornamental plants, she now works on coffee "because it is such an important cash crop in Rwanda." On the team, Alphonsine spends much of her time with students in the field, collecting data and surveying coffee farmers to discover the specific challenges they face. She personally works to discover the most cost effective ways to increase crop yields for farmers to boost their incomes.

Dr. Jean Chrystotome Ngabitsinze: Lecturer and Head of the Department of Agricultural Economics

An agricultural economist, Jean has a B.Sc. in Business Economics from Venice University, a M.Sc. in Economics from Catholic University of Milan, and a Ph.D. in Agricultural Economics from the University of Milan. He has been an associate researcher at Leuven University and Bonn University. Since so much of Rwanda's economy depends on agriculture, he felt that the best way to help his country was to become an agricultural economist. On the team, Jean works on coffee sector value-chain analysis and development. He researches coffee production as the beans move from farmer to international market and tries to increase connections between producers and buyers.

Dr. Peter Sallah: Professor and Vice Dean of the Faculty of Agriculture

A geneticist and plant breeder, Peter graduated from the University of Ghana and then went on to receive both his M.Sc. and Ph.D. from the University of Minnesota. Originally from Ghana, he left his home because he wanted to share his experiences with fellow African scientists. His career has focused on the development and improvement of varieties mainly for small-holder farmers in Africa, especially in Ghana and in Rwanda. In addition to his research, he also enjoys mentoring young scientists, encouraging them to pursue careers in science and to gain research experience. On Daniel's team, he looks at different varieties of coffee plants to discover how the differences can be exploited to control the antestia bug.

Dr. Esron Munyanziza: Professor of Forest Ecology and Agroforestry

Prior to joining NUR in 2008, Esron conducted research in Tanzania and at the Rwanda Agricultural Research Institute. With a Ph.D. in Forest Ecology and Agroforestry, Esron studies the socioeconomic and ecological value of Rwandan acacia trees. He recently conducted a study in which he identified all sub-species of acacia native to Rwanda. Beyond publications, Esron's research will aid in the conservation of vulnerable ecosystems and increased understanding of how preserving Rwanda's forests and savannah can benefit Rwandans. Esron's understanding of agroforestry will be integral to NUR's efforts to improve the taste of coffee, Rwanda's most important tree crop.

Dr. Pierre Mambani Banda: Professor of Soil and Environmental Management

Pierre Mambani Banda is a new addition to Daniel's coffee research team, but is no newcomer to collaborative research. He is an experienced soil scientist, and head of NUR's Department of Soil and Environmental Management. Prior to coming to NUR, Pierre taught at the University of Kisangani in the Democratic Republic of Congo. His research focuses on identifying solutions to soil deficiencies, better use of lowland agricultural areas, and improved water use and irrigation. Banda hopes that by giving farmers means to more efficiently use water and soil, they can produce more and varied crops, increasing their incomes while protecting the environment. Banda's background in soil science and irrigation will no doubt add substantial value to the Faculty of Agriculture's coffee research. In a sector where improved irrigation and modern farming methods are rare, researchers with Banda's expertise are valuable.

Issa Nkurunziza: Master's Candidate in Agribusiness Management and Trade

A current Master's degree student at Kenyatta University in Kenya, Issa works in agribusiness management and trade. Not only is he completing his studies, he also teaches at NUR in the department of agricultural economics and agribusiness. His thesis analyzes the socioeconomic factors affecting farmer participation in the vertical integration of the coffee value chain, particularly those factors that hinder participation, and he uses his work to inform Daniel's research. He decided to work in agriculture because he wants to encourage his countrymen to keep the market in mind when deciding what to grow.

Dr. Alfred Bizoza: Lecturer in Agricultural Economics

An NUR graduate and recent Ph.D. in Agriculture Economics from Wageningen University, Alfred wrote his dissertation on the economics of soil and water conservation in Rwanda. Since Rwanda suffers from high land degradation because of its hilly terrain, he wanted to discover the most effective and beneficial measures against soil erosion for farmers. Using his specialty in agricultural economics, he works with local-level institutions to create strong relationships with coffee farmers and nurture environments conducive to successful coffee businesses. Alfred pursues his goal of contributing to knowledge transfer as a means to boost Rwanda's competitive edge in the export market.

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