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Structure and Dynamics of Uganda's Technological Innovation System

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Abstract

This paper provides insight into Uganda's evolving innovation system. The framework used to gain this insight presents science, technology and innovation as a function of financing, governance, human capital and the strength of interactions within and across the functional spheres. From the framework, it appears universities and public research organizations are playing a major role in building Uganda's innovation system. Public research organizations should, however, collaborate more closely with universities, and be more pragmatic in technology dissemination. It seems that in Uganda the public sector will continue to play a leading role in fostering innovation in the foreseeable future as the private sector grows. A crucial element of the public sector support is to have in place stable merit-based system of science funding where competitive grants are awarded annually for research and innovation.

Keywords: Low Income Countries, Innovation, Innovation System, Research, Science, Technology, Uganda.

JEL Classification: O30, O31, O33, Q55.

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1. Introduction

In 2009 Uganda passed a national science, technology and innovation policy. The policy provides a broad framework for investment and capacity building in science and technology as well as regulation of scientific conduct. It lays out strategies intended to enable Uganda meet its aspiration for a science, technology and innovation-led growth and development. To this end, science, technology and innovation was for the first time designated in Uganda's National Development Plan for the period 2010-2015 as a sector that provides institutional and infrastructural support to the production of goods and services (MFPED, 2010; MFPED, 2009). A specific science, technology and innovation plan has been prepared.

These recent policy developments show that Uganda is making some effort to build its innovation system. Many countries around the world are building their innovation systems as a development and competitiveness strategy. The European Union, for example, wants to transform into an "innovation union" (European Commission, 2011). Finland in 2009 re-evaluated its innovation system to prepare it for future growth challenges, and South Africa has a ten-year innovation strategy (2008-2018) as its pathway to a knowledge-based economy. Following these examples, Uganda, indeed like other countries in the region such as Ethiopia, Kenya, Mozambique, Tanzania, and Zambia, to mention a few, has made "innovation" an integral part of its traditional science and technology policy (MFPED, 2009; UNESCO, 2009). Although this is a welcome move, it is not sufficient to foster innovation. Understanding how key organizations and firms in the innovation process interact and learn from each other, and the factors which influence such interactions, will be crucial for effective implementation of the science, technology and innovation policies.

Therefore, the aim of this paper is to provide insight into Uganda's evolving innovation system. The paper is limited to a discussion of the structure and functional elements of Uganda's innovation system. Key actors are identified and their relationship in the pursuit of science, technology and innovation is described. For purposes of this paper, science, technology and innovation are taken together to mean a dynamic process involving discovery and generation of new knowledge and the application of knowledge to develop new and/or improve goods and services. In this sense, science, technology and innovation is the means by which new products and new processes are developed and deployed to use.

The paper is organized as follows: A review of the relevant literature is in Section 2. Section 3 introduces a framework used to discuss the structure and functional elements of Uganda's evolving innovation system. This is followed by results and discussions of the functional elements in Section 4. Section 5 is concluding remarks.

2. Innovation System, What is it?

Innovation system is a concept first introduced in the 1980s and 1990s by Christopher Freeman, Bengt-Ake Lundvall and Richard Nelson (Lundvall *et al*., 2009; Godin, 2009; Lundvall, 2007; Archibugi *et al*., 1999). It refers essentially to interactions among diverse groups of actors involved in the production, diffusion and use of new and economically useful knowledge (Lundvall, 2010; Fischer, 2001). Lundvall recently described an innovation system as an 'open, evolving and complex system that encompasses relationships within and between organisations, institutions and socio-economic structures, which determine the rate and direction of innovation and competence building emanating from processes of science-based and experienced-based learning' (Lundvall *et al.*, 2009). For Lundvall learning is crucial in the innovation process. Such learning may be through formal educational and scientific organizations such as universities and research organizations; or it can be learning by doing, using and interacting such as is common in the workplace. Edquist & Johnson (1997) elaborate further that an innovation system has two components: organizations and institutions. Organizations are the actors or players, e.g. universities, research organizations or firms. Institutions are the common habits, rules, laws, and customs that influence the way the organizations relate. The patent law is an example of an 'institution'. It gives inventors the right to exclude others from exploiting their inventions over a prescribed period of time. Another example of an 'institution' could be the requirement to obtain informed consent from human participants in clinical trials. Institutions evolve with new values and organizations transform as a result. Therefore, innovation systems are dynamic; with people learning as they interact (Lundvall, 2010).

Innovation systems, however, differ across countries and communities. For example, the innovation system of South Africa may differ from that of Uganda. Countries structure and build their innovation systems differently according to their unique customs and traditions, political and socio-economic conditions. But regardless of the differences there might be, innovation systems usually have the same goal, which is, to 'support the development, diffusion and use of

innovations' (Chaminade and Edquist, 2006; Edquist, 2001). Here "innovations" refer to new ideas or practices or new or improved goods and services introduced in society (Lundvall, 2007;Rogers, 2003; Witt, 2002). These could be products, i.e. new or better goods and services, or processes, i.e. new ways of production which may be technological or changes in management style (Chaminade and Edquist, 2006). Innovations may be radically new, for example, when a new malaria vaccine is introduced; or they could be existing technology that finds new application elsewhere, for example, when a local bank introduces internet banking services which is already in use somewhere else.

Building blocks of an Innovation System

As of now, there is no single way of describing the structure of an innovation system. Of recent, however, a number of scholars have opted to study innovation systems in terms of their functions or building blocks. These scholars argue that besides identifying organizations (actors) and what they do, knowledge about the system's structure and the way it functions is important to foster innovation (Liu and White, 2001; Edquist, 2001). Consequently, many variants of functions or building blocks of an innovation system have been put forward. Chaminade & Edquist (2006) as well as Hekkert *et al*. (2007) did an extensive review of functions of innovation systems. Table 1 is adapted with modifications from (Chaminade and Edquist, 2006). It is a summary of some of the functions of innovation systems suggested in literature.

Describing an innovation system in terms of its functions has attracted interest of many scholars. It is a subject of ongoing discussions (See Table 1). This paper makes a contribution to the ongoing discourse by introducing another dimension of functions (or in this case, a framework) which could be used in deliberations on innovation systems particularly in low income countries. The framework is used to provide insight into Uganda's evolving innovation system. It uniquely recognizes the distributed and heavily decentralized way knowledge is currently produced and used in Uganda.

Table 1: Activities (functions) in Innovation Systems

Author(s)	Definition of function or activity	Main criteria for classification	Breakdown of functions, activities or building blocks
Edquist (2005)	Factors that influence the development and diffusion of innovation	Determinants of the innovation process	1. Knowledge inputs to the innovation process 2. Demand-side factors 3. Provision of constituents in system of innovation 4. Support services for innovating firms
Furman, Porter and Stern, (2002)	Building blocks required to produce and commercialize a flow of technologies new to the world over the long term	Determinants of national innovative capacity	1. Strong innovation infrastructure 2. Strong innovation environments (incl. input conditions, demand conditions, related and supporting industries and context for firm strategy and rivalry) 3. Linkages between 1 and 2.
Galli & Teubal, (1997)	Factors affecting the production and diffusion of innovations	Activities according to type of organization (hard or soft)	*Hard functions* 1. R&D 2. Supply of scientific and technical services to third parties *Soft functions* 3. Diffusion of information, knowledge and technology to bridging organizations. 4. Policy making by government offices 5. Design and implementation of institutions 6. Diffusion/divulgation of scientific cultures 7. Professional coordination through academies, professional associations.

Johnson & Jacobsson (2003)	Factors that affect the knowledge production processes	Knowledge production processes that can be influenced by public policy	1. Creation of new knowledge 1. Guidance of the research process 2. Provision of resources 3. Generation of knowledge economies 4. Dissemination of market information
Xielin Liu and Steven White (2001)	Fundamental activities of innovation systems	Performance implications of a system's structure and dynamics	1.Education 2.R&D 3.Implementation (or manufacturing), 4.End-use (i.e. customers of the product) and 5. Linkage
OECD (2002)	Core blocks in the system of innovation to be considered in a comprehensive innovation policy	Innovation policy	1.Enhancing firm innovative capacities 2. Exploiting power of markets 3.Securing investment in knowledge 4.Promoting commercialization of publicly funded research 5. Promoting cluster development 6. Promoting internationally open networks
Fischer (2001)	Building blocks of an innovation system	Elements encompassing the innovation process	1. Manufacturing sector (manufacturing firms & their R&D labs) 2. Scientific sector (education & training; universities & research organizations) 3. Sector of producer services (support to industrial firms) 4. Institutional sector (regulations, financing,

			rules)
M Hekkert, Suurs, Negro, Kuhlmann and Smits (2007)	Functions of *technological* innovation systems	Processes which take place in an innovation systems	1. Entrepreneurial activities 2. Knowledge development 3. Knowledge diffusion through networks 4. Guidance of the search (i.e. long term goals set by gov't) 5. Market formation 6. Resources mobilization 7. Creation of legitimacy
M Hekkert, Suurs, Negro, Kuhlmann and Smits (2007); Bergek, Jacobsson, Carlsson, Lindmark and Rickne, (2008); Bergek, Marko Hekkert and Jacobsson, (2008)	Functions of *technological* innovation systems	Processes which take place in an innovation systems	1. Knowledge development and diffusion 2. Influence on the direction of search 3. Entrepreneurial experimentation 4. Market formation 5. Resource mobilization 6. Legitimation 7.Development of positive externalities or "free utilities"
Lundvall (2010)	Elements of a national system of innovation	Differences in structure of production systems and institutional set up of nation states	1. Internal organization of firms 2. Inter-firm relationships 3. Role of the public sector 4. Institutional set up of the financial sector 5. R&D-intensity and R&D-organization

Source: Adapted -with Modifications- from Chaminade and Edquist (2006).

3. The Framework

The framework consists of four functional elements. These are: Science, technology and innovation (Sti), Financing (F), Governance (G), and Human Capital (Hc) (see Figure 1). Assuming that the primary goal of any innovation system is to "support the development, diffusion and use of innovations" Chaminade and Edquist (2006), then:

$Sti = f(F, G, Hc, r)$,

where *r* denotes the strength and intensity of the interactions (and learning) both within and across the functional elements or spheres. Science, technology and innovation (Sti) in this case represents dynamic processes, such as discoveries, inventions, knowledge generation, product development, dissemination and diffusion of innovations. Governance (G) includes policies and plans, laws and regulations, standards and guidelines which directly or indirectly guide the Sti process. Financing (F) includes funding for Sti activities, e.g. grants for research and innovation, venture capital (e.g. the Youth Entrepreneurship Venture Capital Fund announced in Uganda's 2011/12 national budget speech), direct support from government treasury or private sector and development partners. Human capital (Hc) involves educational and training activities aimed at imparting knowledge and skills necessary for Sti. It also includes knowledge tacitly acquired in the course of work or through experience. Universities, firms and other organizations engaged in local skills development, as well as schools and business, technical and vocational education and training colleges are the primary actors that supply the necessary human capital.

Within each functional sphere (Sti, F, G and Hc) actors operate on a continuum oscillating between sole role (sr) player, e.g. a full time researcher, and dual role (dr) player e.g. a professor involved in both teaching and conducting research. Across functions an actor may perform multiple roles (mr), e.g. a professor who lectures at a university, does research, but also serves as a board member of a governmental agency. An actor may be an individual or an organization or a firm. Actors performing the same function may interact and learn from each other at specific times and situations within that functional sphere; but they may also interact and learn across functions (Figure 1).

4. Results and Discussion

Using the Framework: the Case of Uganda

The information used in the following section to illustrate the various functional elements of Uganda's innovation system were obtained by reviewing key science and technology related policy documents. These documents included the national science, technology and innovation and related policies, institutional reports, workshop proceedings, reports of scientific meetings, comprehensive national development frameworks, laws and regulations, research databases in Uganda, journal articles, papers and related work on innovation systems. These documents were read; key points were noted and summarized. Additional

information was gleaned from science and technology policy dialogues, meetings and events both within Uganda and abroad.

Science, Technology and Innovation

Science, technology and innovation in Uganda can be traced back to the pre-industrial iron ore discoveries around Lake Turkana in Kenya, and carbon steel industry around the shores of Lake Victoria (Teng-Zeng, 2006). But later during the colonial era (1894-1962), science, technology and innovation was predominantly in health and agriculture; specifically, research on tropical diseases (malaria and sleeping sickness), cash crops (cotton, coffee, and tea) and fisheries (Teng-Zeng, 2006; EAC, 2000). Tsetse control and fisheries research were conducted in eastern Uganda (i.e. National Livestock Resources Research Institute), while tropical diseases research was done in central Uganda (i.e. Uganda Virus Research Institute at Entebbe). Interest in studying the African way of life led to the establishment of an East African Institute of Social Research at Makerere in 1948 (now Makerere Institute of Social Research). To date humanities, health, agriculture and natural sciences continue to dominate the fields of research in Uganda. In 2008, for example, social sciences and humanities accounted for 36 per cent of the research conducted in Uganda followed by health (31 per cent), natural sciences (21 per cent), and agriculture (ten per cent) and engineering and technology two per cent (Ecuru *et al*., 2008). Uganda needs to do more to promote research and innovation in the engineering and physical sciences fields as well as the foundation for value addition and manufacturing. Also latent potential of the informal sector engaged in metal fabrication, wood works, food and farm produce and herbal medicines is largely untapped.

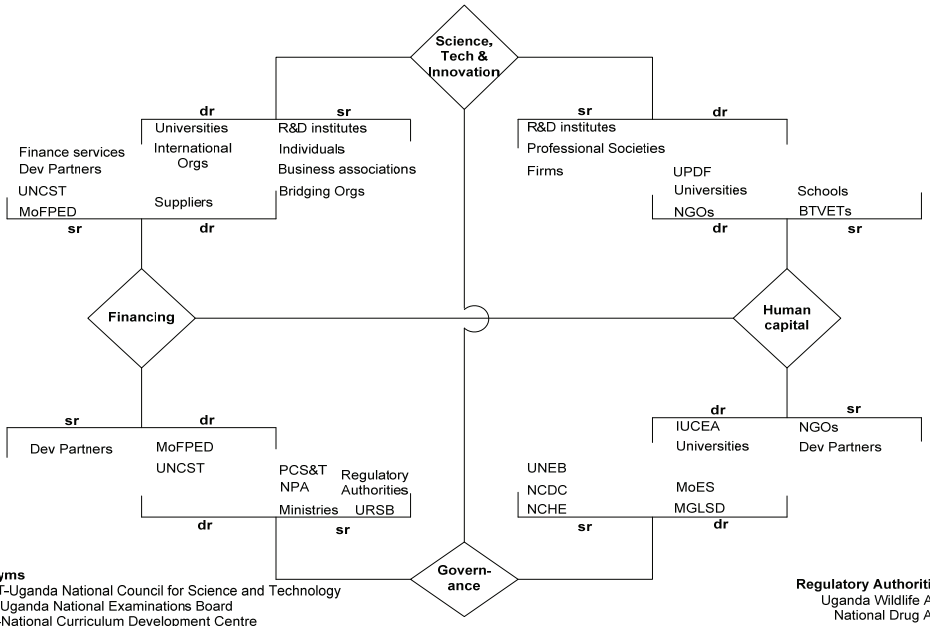
Public universities and research organizations account for the bulk of scientific and technological activities in the country. Unlike in South Africa, where private companies account for almost half of the research and innovation investment, the contribution from private companies in Uganda is still very small. If Uganda is to achieve its goal of becoming a middle income country as soon as possible, public universities and research organizations have to be more proactive in translating their research products into commercial ventures and enterprises.

Human Capital

Human capital constitutes the pool of knowledgeable and skilled people capable of generating new ideas, and transforming ideas into socially valuable and economically viable goods and services. In Uganda this pool is still small. Human capital potential is shaped by the educational system of a country and by the learning environment in firms and other organizations.

Uganda's education system comprises two to three years of pre-primary schooling, seven years of primary, four years of lower secondary, two years of upper secondary, and three to five years of undergraduate study. Technical and vocational colleges offer one to three year diploma and certificate courses providing technical skills in a variety of scientific and technological fields. Sustained efforts are needed to attract students into science and engineering career programmes, especially at universities. At the moment less than 25% of students enrolled in universities are for science and engineering programmes, which are about half the international average (Barugahara and Lutalo, 2011).

Figure 1: Actors and Functions in Uganda's Innovation System



Acronyms
UNCST-Uganda National Council for Science and Technology
UNEB-Uganda National Examinations Board
NCDC-National Curriculum Development Centre
NCHE-National Council for Higher Education
URSB-Uganda Registration Services Bureau
NPA-National Planning Authority
MoFPED-Ministry of Finance, Planning & Economic Development
MoES-Ministry of Education & Sports
MGLSD-Ministry of Gender, Labor & Social Development
IUCEA-Inter-University Council for East Africa
PCS&T-Parliamentary Committee on Science & Technology
BTVETS-Business, Technical, Vocational Education & Training Sch.
UPDF- Uganda Peoples' Defense Forces
NGOs-Non-Governmental Organizations

Regulatory Authorities, e.g.
Uganda Wildlife Authority
National Drug Authority
National Forestry Authority
Uganda National Bureau of Standards
Public Procurement and Disposal Authority
National Environment Management Authority

Public R&D Institutes, e.g.
National Agricultural Research Org (with its 17 institutes
Uganda National Health Research Org (with its 4 institutes)
Uganda Industrial Research Institute
Joint Clinical Research Centre

International Organizations, e.g.
International Potato Centre
Centres for Disease Control, USA
International AIDS Vaccine Initiative
Medical Research Council, UK
Makerere Univ-Johns Hopkins University Collaborations
Epicentre, Mbarara
Uganda-Case Western Research University
National Institutes of Health, USA
Makerere Univ-Univ of New Jersey Research Collaboration
Malaria Consortium

Bridging Organizations, e.g.
National Agricultural Advisory Services
Coffee Development Authority
Uganda Export Promotions Board
Cotton Development Organization
Program for Biosafety Systems
Science Foundation for Livelihoods and Development
Advocates Coalition for Development and Environment

Private R&D Institutes, e.g.
Med Biotech Laboratories LtD
Centre for Basic Research
Rakai Health Research Institute

Business Associations, e.g.
Private Sector Foundation
Uganda Manufacturers Association
Uganda National Farmers Federation

Development Partners, e.g.
World Bank
Swedish International Development Agency
United States Agency for International Development
European Union
Royal Dutch Embassy
Belgium Development Cooperation
German Development Cooperation
Government of Norway

NGOs, e.g.
Gatsby Trust-Uganda
Appropriate Technology-Uganda
SNV-Netherlands Dev. Org-Uganda
Prolinnova-Uganda
Swisscontact International
African Innovations Institute-Uganda
World Vision-Uganda

Universities, e.g.
Makerere University
Mbarara University of Science & Technology
Busitema University
Gulu University
Kyambogo University
Uganda Christian University
Uganda Martyrs University
Islamic University in Uganda
Bugema University
Ndejje University
Nkumba University
Kampala International University

Professional Societies, e.g.
Uganda National Academy of Sciences
Institute of Professional Engineers
Uganda Society for Health Scientists

Ministries, e.g.
Ministry of Trade & Industry
Ministry of Water & Environment
Ministry of Agriculture, Animal Industry & Fisheries
Ministry of Energy & Mineral Development
Ministry of Works and Transport
Office of the President
Ministry of Defense
Ministry of ICT

For a long time, Uganda had only one university, i.e. Makerere University, which started as a technical college in 1922 and was accorded a university status in 1949. Higher education reforms which took place in the early 1990s paved way for emergence of private universities. By the end of 2011 there were five recognized public universities and over 22 private ones. The Universities and Tertiary Education Act of 2005 further gave autonomy to universities and created the National Council for Higher Education to ensure good standards (high quality) in higher education.

Most of the reforms taking place in Uganda's education sector are geared towards supply of the much needed scientific workforce. Since 1996, every child of school going age (i.e. six to 12 years) must attend primary school free of charge under the universal primary education program. Starting 2006 government further adopted a phased introduction of universal secondary education. The study of science subjects is compulsory in lower secondary education; and since 2005, 75 per cent of all government sponsorship (currently 4,000 students annually) for undergraduate student enrolment in public universities is towards science based courses. As a government policy, all public universities established after Makerere University are supposed to emphasize science disciplines. However, they often end up with more humanities and arts students. By recruiting more students into humanities and arts courses, public universities can generate income internally to meet shortfalls in government funding. Unless government intervenes with more sustained funding to the higher education sector, public universities may fail to achieve the policy goal of producing more science and engineering graduates. A continuing challenge cutting across the entire education sector in Uganda is ensuring higher quality of learning at all levels and reforming curricula to meet the changing skills demand in the economy.

Capacity for postgraduate training at Ugandan universities, other than Makerere University is still very low. Owing to the limited facilities, a significant number of Ugandan students seek graduate studies abroad. Over the years, Makerere University has built considerable capacity to offer science-based postgraduate (PhD and MSc) training. Makerere University could, therefore, take advantage of its unique position and capabilities to expand its graduate school. This opportunity is somewhat identified in the University's strategic plan for the period 2008/09-2018/19 which aims to transform the university into a research-led university, essentially producing Masters and PhDs for other universities. To achieve this goal, however, would require the university to substantially reduce enrolment for undergraduate students. It would also mean losing revenue from

undergraduate private students. Therefore, realizing the goal of a research-led university may take some time.

Governance

From independence in 1962 until the early 1990s policy for science, technology and innovation was such that research and technology dissemination were carried out within government's line ministries and departments. In 1970 a National Research Council was created by a Cabinet decision to guide and coordinate research in Uganda. This body became the Uganda National Council for Science and Technology (UNCST) duly established by Act of Parliament (Chapter 209) in 1990. Public Sector Reforms in the 1990s detached research from government ministries and line departments and created autonomous research organizations such as the National Agricultural Research Organization (established in 1992 but restructured in 2005 by the National Agricultural Research System Act of 2005). Granting autonomy to research organizations was aimed at reducing red tape, improving accountability and overall efficiency. However, it tended to alienate government from research and academia and vice versa. Interactions between research organizations and universities and government and industry became more difficult to achieve in practice.

Earlier on in 1990 need was felt for an explicit national policy on all fields of science and technology, hoping that it would provide a coordinated framework for science and technology development in the country. The first attempt to formulate this policy was at a National Workshop held toward the end of 1991. A draft of the national science and technology policy was prepared in 1993. The draft policy underwent several revisions until it was finally passed by government in August 2009. The goal of the policy is to strengthen Uganda's capability to generate, transfer and apply technologies, ensuring sustainable utilization of natural resources for development. Besides this framework policy, sectoral science and technology policies also exist including, for example, the National Agricultural Research Policy 2005 and the National Biotechnology and Biosafety Policy 2008.

Uganda has no stand alone ministry for science and technology unlike its neighbours Kenya and Tanzania or South Africa for that matter. The Ministry responsible for science and technology is that of Finance, Planning and Economic Development, which is also the parent ministry to which UNCST belongs. Coordination of science and technology matters is, therefore, the responsibility of the UNCST. The UNCST was established in 1990 to advise on and coordinate the

formulation of an explicit national policy on all fields of science and technology; and also to coordinate research and development, and facilitate science and technology integration into all sectors of the economy, among other functions. Over the years, UNCST has grown tremendously and evolved into an organization with three major clusters of roles. First, it functions as a national research and innovation funding agency. In some countries separate organizations are created and dedicated to play this role. In South Africa, for example, such a role is played by the National Research Foundation and other Research Councils. Second, UNCST plays the role of a science and technology policy think tank and advisory body to government. Such a function entails guiding the direction, setting goals and determining priorities for strategic investments in science, technology and innovation. Juma (2011) argues that such a function should be positioned at the highest possible level in government such as at presidential or cabinet level. Third, UNCST acts as a regulatory body in some situations e.g. for biosafety, human subjects research and access to genetic resources. Because these are crosscutting themes and sometimes involve new and emerging technologies, it is difficult to place them in any one single organization, other than the UNCST.

The challenge, however, is that the three major clusters of roles currently played by the UNCST are huge mandates in themselves, and may with time overwhelm the capacity of UNCST as an organization. This is probably why a dedicated ministry for science and technology has been proposed (MFPED, 2010). The other challenge is that as the trends of research and innovation keep rising and knowledge production becomes increasingly diversified and distributed, the three clusters of roles could potentially conflict under one roof. If these clusters of roles are to be played more effectively in future, then having them executed in separate houses might be a prudent strategy as long as the resource envelope is able to sustain them as such.

As for legislation, there are different pieces of it which regulate various aspects of scientific conduct. For example, the National Environment Management Authority Act 1995 provides for environmental impact assessment of major scientific projects. The National Drug Authority Act of 1993 regulates clinical trials. The Uganda Wildlife Authority Act of 1996 regulates research in wildlife protected areas. There are other laws, regulations and guidelines, e.g. for quality of commercial and consumer products, intellectual property protection, plant quarantine, human research protection, biosafety, and radiation safety.

Therefore, it appears Uganda is not short of the basic policies, laws and regulations to guide science, technology and innovation. The key issue is the

extent to which these policies and laws are harmonized to promote research and innovation in the country. Although new policies and laws may be justifiable in some situations, more effort should be devoted to implementing, reviewing and consolidating the existing ones. Responsible agencies should have the means to quickly adjust their policy and legal regimes to accommodate significantly new and emerging areas of science, technology and innovation.

Financing

Financing for science, technology and innovation in Uganda is predominantly by government and development partners. In 2007/08 financial year, government's share of expenditure on research and development was about 42 per cent, development partners 51 per cent and other sources seven per cent. Government support was mainly for administrative costs such as utilities, maintenance and personnel. Contribution from private sector was miniscule. In middle income countries, private sector usually spends more on research and development. For example, in 2004/05 the business sector in South Africa financed 45% of research and development and performed 58% of total research and development, while international sources amounted to only 15% (OECD, 2007). Scientists in Uganda rely on grants from abroad, which are very competitive to win, and which sometimes may not be properly aligned to the country's development needs. For many Ugandan scientists, having good grants proposal writing skills is paramount and forging links with other scientists abroad is absolutely essential. In addition, having a supportive local research environment, e.g. efficient administrative processes, less cumbersome regulatory systems for research and less burdensome tax regimes for scientific equipment, would be necessary to attract more foreign research investment.

Between 2003/04 and 2007/08, total annual national expenditure on R&D as percentage of GDP averaged 0.3 per cent (Ecuru *et al*., 2008). This is very low compared to South Africa, which spent between 0.8 per cent and one per cent of its GDP on research and development during the same period (OECD, 2007). Uganda should work towards spending at least one per cent of its GDP per annum on research and development in the medium term as recommended by the African Union Summit of 2007 in Addis Ababa, Ethiopia.

A key missing link in the financing of science, technology and innovation in Uganda is the absence of a stable merit-based competitive funding scheme coupled with weak contribution from the private sector. The Uganda Millennium Science Initiative (MSI) launched in February 2007 by President Y.K Museveni

was the closest to having a national competitive/merit-based system for science funding. The MSI was a project worth US$ 33.35 million over 5 years co-financed by the government of Uganda (US$ 3.35 million) and the World Bank (US$ 30 million), and implemented by the UNCST. By the end of 2009 UNCST had awarded competitively a total of 39 grants each ranging between US$ 0.25 million to US$ 1.25 million for three to four years. Impressive results have so far been reported, including strengthening tertiary science and engineering curricula, potentially commercializable research products, outreach events, more skilled science and engineering graduates, etc. Building on the MSI model of financing research and innovation could be one way the Uganda government would operationalize the National Science and Technology Fund established in 1990 under Section 20 (3) of the UNCST Act 1990 (Chapter 209). The MSI project in Uganda appears to have been a step towards building a merit-based system for science funding in the country.

A merit-based system for research and innovation funding is desirable for harnessing ideas and knowledge, and nurturing local talent. It would also encourage creativity and a culture of innovation in Ugandan universities, research organizations and firms. However, developing and sustaining such a system might also depend on the extent to which it is consistent with and supported by the current national budgeting regime.

Uganda's annual national budget is arrived at through a consultative process involving Sector Working Groups (SWGs). A SWG is a forum for negotiation, policy dialogue and agreement on priority plans as well as budget allocations within the sector. Presently designated SWGs are: Agriculture; Lands, Housing and Urban Development; Energy and Mineral Development; Works and Transport; Information and Communication Technology; Tourism, Trade and Industry; Education; Health; Water and Environment; Social Development; Security; Justice, Law and Order; Public Sector Management; Accountability; Legislature; and Public Administration (MFPED, 2011). Ideally, any government ministry or agency should fit in one of these SWGs. Universities, for example, belong to the Education SWG, the National Agricultural Research Organization is in the Agriculture SWG, and UNCST belongs to the Accountability SWG, where its parent Ministry of Finance, Planning and Economic Development falls. In principle, therefore, each agency with significant science, technology and innovation activities should vie for financial resources within their respective SWGs. Since science, technology and innovation cuts across all the SWGs, it seems logical and plausible to have it rationalized within each SWG. However, this approach may not be welcomed by some members of the scientific

community who strongly believe that science, technology and innovation deserves a sector status and, therefore, should also be designated a SWG. The SWGs, notwithstanding, it is important that agencies with significant science, technology and innovation activities have opportunities for joint cooperation in research and innovation with universities, research organizations and firms. This would be possible if government encouraged dual funding systems for research and innovation which, on the one hand, involves direct funding to universities and research organizations, and on the other, having in place a stable merit-based system where grants are competitively awarded annually to individuals and research groups. Countries with remarkable progress in research and innovation use multiple streams of merit-based as well as direct funding support to research organizations and universities. South Africa, for example, runs a merit-based system for funding scientific projects through the National Research Foundation, Technology Innovation Agency, Medical Research Council, among others. Uganda needs to do the same to bolster its innovation system.

5. Conclusion

In trying to understand the structure and dynamics of Uganda's innovation system, universities appear to be playing a more active role (Figure 1). They are active in human capital development, and are the centre for most scientific and technological activities in the country. Universities in Uganda participate quite significantly in policy making processes (governance). University staff are often hired as consultants or are appointed to serve as members of advisory boards and technical committees of government agencies. Some public universities have started engaging in business enterprise development. Makerere University, for example, has an upcoming business incubator for innovations in foods and beverages, and is also active in creating and supporting business clusters. In Uganda, where the private sector is still weak, universities can play an important role in creating new enterprises or enhancing the competitiveness of the existing ones. Ugandan universities can harness their intellectual property assets in a pragmatic way to encourage private sector growth. Public research and development organizations can also do the same, particularly if they overcome rigid institutional boundaries which appear to confine them to research only.

Using the four functional spheres Sti, G, Hc, and F, therefore, may be an alternative way of understanding the structure and dynamics of an innovation system, particularly in a low income country like Uganda. The framework, with its inherent limitations, recognizes the diversity of actors and their contribution

to building Uganda's innovation system. However, to foster innovation, it is absolutely essential to create conditions for the actors to cooperate, collaborate and interact more intensely across each of the functional spheres. Further work is needed to assess the framework in other settings and to understand how it can be used to create enabling conditions for interaction both within firms and organizations and among different actors in the innovation process.

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