FOSTERING GROWTH IN UGANDA'S INNOVATION SYSTEM

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Blekinge Institute of Technology

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Acronyms

AGT:	Agro Genetics Laboratories Ltd
AIDS:	Acquired Immune Deficiency Syndrome
ASARECA:	Association for Strengthening Agricultural Research in East and Central Africa
AU:	African Union
BIOEARN:	East African Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development
BST:	Bovine Somatotropin Hormone
BTH:	Blekinge Institute of Technology
CASTAFRICA:	Conference of Ministers responsible for the Application of Science and Technology to Development in Africa
CPA:	Africa's Science and Technology Consolidated Plan of Action
DNA:	Deoxyribonucleic Acid
EAC:	East African Community
EACSO:	East African Common Services Organization
EU:	European Union
FaVMU:	Faculty of Veterinary Medicine, Makerere University
FoAMU:	Faculty of Agriculture, Makerere University
FTO:	Freedom to Operate
GDP:	Gross Domestic Product
HIV:	Human Immunodeficiency Syndrome
IP:	Intellectual Property
IPR:	Intellectual Property Rights
IRCs:	Institutional Review Committees
JCRC:	Joint Clinical Research Centre
LPA:	Lagos Plan of Action
MAAIF:	Ministry of Agriculture, Animal Industry and Fisheries
MBL:	Med Biotech Laboratories
MFPED:	Ministry of Finance, Planning and Economic Development
MSI :	Millennium Science Initiative
NAADS:	National Agricultural Advisory Services
NARLI:	National Agricultural Research Laboratories Institute
NARO:	National Agricultural Research Organization
NARS:	National Agricultural Research System
NCHE:	National Council for Higher Education
NDP:	National Development Plan
NPA:	National Planning Authority
NRC:	National Research Council
OECD:	Organization for Economic Cooperation and Development
OFAB:	Open Forum for Agricultural Biotechnology
PEAP:	Poverty Eradication Action Plan
R&D:	Research and Development

R4D:	Research for Development
RUFORUM:	Regional Universities Forum
S&T:	Science and Technology
Sida:	Swedish International Development Agency
STI:	Science, Technology and Innovation
UIRI:	Uganda Industrial Research Institute
UK:	United Kingdom
UNAS:	Uganda National Academy of Sciences
UNCST:	Uganda National Council for Science and Technology
UNESCO:	United Nations Educational, Scientific and Cultural Organization
UNHRO:	Uganda National Health Research Organization
UoN:	University of Nairobi
USAID:	United States Agency for International Development
UVRI:	Uganda Virus Research Institute

Abstract

Research and innovation are key drivers for economic growth and competitiveness of countries. Of recent research and innovation-related initiatives have arisen in Uganda pointing to an evolving innovation system in the country and to the need to deepen understanding of the transformations taking place therein. This thesis provides evidence of this evolving innovation system in the country and makes recommendations to foster growth in it. A participatory research approach was employed using a combination of both qualitative and quantitative tools including key informant interviews and review of key policy documents, organizational reports and publications. Findings show that the role of research and innovation in driving economic growth and development was recognised in Uganda as early as the 1950s and 60s. But practical measures on how to integrate them into the national development planning process were lacking. It was not until the 1990s and 2000s that a realistic number of research and innovation initiatives started to emerge. These initiatives ranged from increased support to research, science policy development to supporting innovative business clusters. Arguably gains from these and other efforts would be enhanced, if government adopts a dual funding strategy for research and innovation, which on the one hand involves annual competitive grants and on the other hand increased core support to universities and research institutes. The public organizations create within them enabling conditions for creativity and enterprise development. The quality of education is improved at all levels to maintain a constant supply of a skilled scientific workforce. Ultimately, these efforts require inclusive innovation policies, which promote linkages and interactions between actors engaged in innovation processes both in country and abroad.

Preface

This thesis is based on my work in science policy, research and innovation development in Uganda and Eastern Africa. Research and innovation remain key drivers for national development, even more now with transition into knowledge-based economies and societies. Low income countries like Uganda can use their growing research and innovation potential to alleviate poverty, create jobs and improve livelihoods; and importantly also, prepare themselves to overcome global challenges such as climate change and its effects. Thus knowledge of how innovation systems of such countries as Uganda are evolving is necessary for decision making and design of effective interventions. This thesis makes a contribution towards that end.

The thesis is in three parts. Part 1 is an introductory chapter which provides rationale for the study, the study's aims, and key concepts that guided the work such as innovation systems, triple helix and mode 2 knowledge production. The methods used are also described in this part. Part 2 is a compilation of published papers. The papers have been slightly reformatted from their original publication to suit the requirements of this thesis. Paper I is about integration of science, technology and innovation into the national development planning process of Uganda. This paper was published in February 2011 in proceedings of the 2nd International Conference on Advances in Engineering and Technology. Paper II is about research in Uganda, and implications it has for public policy. This paper was published by the Uganda National Council for Science and Technology in 2009. Paper III shows how biotechnology is developing in Uganda and what is required to nurture its growth. This paper was published in the African Crop Science Journal in December 2010. Paper IV presents a challenge of managing intellectual property, as a cross cutting issue, in Eastern African universities and research institutes. It was published as a policy paper by the Inter-University Council for East Africa in late 2009. Part 3 are conclusions and way forward.

Secondary sources such as organizational reports, publications, policy documents and research databases were used to obtain data for this work. This was supplemented with interviews with scientists, policy makers, development experts, academicians, business managers and communities.

Part 1

Chapter 1 – INTRODUCTION

1.1 Background

Of recent developing countries have had a resurging interest to increase investment in research and innovation as the key drivers for economic growth and competitiveness (Juma, 2011; United Nations Educational Scientific and Cultural Organization (UNESCO), 2010). Most of these countries have either developed or are in the process of formulating innovation strategies and/or policies. Usually, however, translating these policies and strategies into actions is a challenge for most of the countries.

At a regional conference held in Bagamoyo Tanzania in 2004, consensus emerged that one way to speed up industrial and economic growth in Africa would be to build innovation systems and develop innovative business clusters (Mwamila, Trojer, Diyamett, & Temu, 2004). Participants at this conference observed that "the concept of innovation systems, if properly adapted and situated in the local context, could help overcome limitations in discussions of technology transfer by widening the spectrum to deliberations on generation, mutual flows and regeneration of knowledge". Interactions and learning, historical patterns, flows of knowledge and information across firms and organisations were regarded as more important considerations in further understanding the practices of innovation systems in the African context (Trojer, 2004).

Innovation systems in developing countries, particularly in Africa are regarded as "systems in construction", often reported to have weak patterns of interactions among the

different actors involved in the production of goods and services (Szogs, Cummings, & Chaminade, 2009; Larsen, Kim, & Theus, 2009). However, it has also been shown that firms, for example, in Uganda are likely to be more innovative where flows of knowledge and interactions are encouraged (Kiggundu, 2006); and that research and technical skills are also required by actors in the non formal sectors who play a critical role in innovation systems of low income countries (Hall & Dijkman, 2006).

Therefore, as countries in Africa and Uganda in particular, begin to lay new strategies for research and innovation-led growth, a re-examination of their innovation systems is essential. Understanding the existence (or lack thereof) of the interactive learning patterns among organizations and firms, and the institutions which influence such interactions, could provide useful insights for future innovation policy development.

1.2 Social and economic context

Uganda is landlocked. Its total surface area is 241,040 Sq.km, with 28% arable land. Being at the equator, Uganda is rich in biodiversity which, unfortunately is being rapidly degraded by human activities. Uganda's population in 2010 was estimated at 32 million people, with slightly over 50% under 15 years of age (World Bank, 2010). At an annual growth rate of 3.2%, the population would rise to approximately 90 million by 2050. The population is quite diverse with about 45 ethnic groups and over 32 different languages spoken. Over 80% of people in Uganda live in rural areas and engage substantially in subsistence agriculture. Uganda's major exports are coffee, tea, cotton and tobacco (exported mainly as raw materials). Other non-traditional exports include fish, assorted fruits, essential oils, vegetables, cereals and pulses, animal products and a few minerals. In 2006, oil was discovered in Uganda (in the Albertine Rift). Uganda is also a growing destination for wildlife and eco tourism. The present and future challenge for Uganda is to manage its natural resources sustainably, and to provide opportunities for the youthful population. Thus, Uganda's goal is to transform from a largely peasant society to a modern one in a sustainable way (Ministry of Finance Planning and Economic Development (MFPED), 2010); and more specifically to improve its competitiveness to levels associated with middle income countries. Inevitably, this requires scientific and technological interventions in all sectors of the economy. The five-year National Development Plan (NDP) launched in 2010 identifies the promotion of science, technology and innovation as one of the strategies for delivering Uganda's growth agenda.

Uganda's history is punctuated by political and social problems, especially after independence from Britain in 1962. Between 1962 and 1986, the country was mired in a series of political and civil unrest, which destroyed the economic and social fabric. This was exacerbated by the Lord's Resistance Army led by Joseph Kony and other rebel groups who continued atrocities in northern and eastern parts of the country displacing millions of people from their homes between 1986 and 2005. Worse still, the country suffered the scourge of HIV/AIDS epidemic which peaked adult prevalence of 18% in 1992. Aggressive and unified public campaign advocating behavior change

together with treatment options reduced the adult HIV prevalence to 6.4% in 2007 (Uganda AIDS Commission, 2007).

Amidst these upheavals, the National Resistance Movement which took governmental control in 1986 embarked on an economic recovery program and structural adjustments. These efforts led to a stable macro-economic environment, liberalization and peace. Real GDP growth rate averaged 5.3% p.a. between 2001 and 2011 and is projected to grow at an average of 7% p.a. by 2015 (MFPED, 2010). Uganda became the first country to be eligible for and to benefit from the Highly Indebted Poor Countries initiative in 1998, ensuring some US$ 700m (in nominal terms) in debt relief (World Bank, 2011). Poverty rate reduced from 56% in 1992 to 31% in 2006, and is expected to fall below 24% by 2015 (MFEPD, 2010). With this trend, Uganda could meet the Millennium Development Goal target of halving the proportion of the poor by 2015, and could be on course to achieve universal primary education and reduction in maternal and child mortality. However, to maintain this pace of economic development, closer attention has to be paid to building the country's innovation system; and research and innovation should be one of the top investment priorities.

1.3 Towards innovation policy and strategy development

The competitiveness of firms and countries largely rests on their scale and rate of innovation (World Bank, 2010; Gault, 2010). While substantial gains can be made by improving the business environment and ensuring macroeconomic stability, sustained increases in economic growth and improvement in the living standards in the long run can only be achieved through innovation (Schwab, 2010). The Pan African Competitiveness Forum, launched in 2008 in Addis Ababa, also stressed that poverty reduction and the sustainable development of Africa lies in strengthening innovation and creating innovative business clusters.

Innovations are new ideas or practices or new or improved goods and services introduced in a society (Lundvall, 2007; Rogers, 2003; Witt, 2002). They could be radically new, for example, introducing a malaria vaccine or they could be an existing phenomenon that finds a new application elsewhere, for example, a local bank introducing internet banking services which is already in use elsewhere. Innovation is a major mechanism for growth, employment and development, and usually firms take the lead in it (Edquist, 2009).

Recognising the role of innovation in creating value, several countries are transforming their innovation systems. The European Union, for example, laid new strategies to transform into an "innovation union" (European Commission, 2011); and Finland in 2009 re-evaluated its innovation system to prepare it for future growth challenges, while South Africa developed a ten (10) year innovation strategy 2008-2018 as its pathway to a knowledge-based economy and competitiveness (Ministry of Education and Ministry of Employment and the Economy, 2009; Department of Science and Technology, 2008). Many countries both developed and developing are doing the same

(Day & Muhammad, 2011). Some countries like Uganda and Tanzania have added "innovation" to their traditional science and technology policies (MFPED, 2009), while others like Zambia and Zimbabwe sought to review theirs (UNESCO, 2009).

In 2009 Uganda adopted a national science, technology and innovation (STI) policy, and has designated STI in its national development plan 2010-2015 as a sector that provides institutional and infrastructural support to the production of goods and services (MFPED, 2010). These and other initiatives by government, development partners, universities and industry could be precursors to more concrete and inclusive innovation policies and strategies in the country and the region.

1.4 Research problem statement

Innovation is an outcome of interactive learning between firms, other organizations and all economic agents in a particular setting. In Uganda, these interactions and how they influence the direction of innovation are less understood. Consequently, there is often lack of genuine consensus among policy makers and other actors on actions required to support the innovation process in the country. Essentially, firms and other organizations should actively innovate if they are to maintain a competitive edge. For this reason, the government of Uganda is reorienting its policies towards value addition, agro-processing and bio-product development by supporting programmes such as: the Millennium Science Initiative which provided grants for research, innovation and science curriculum development; the Presidential Support to Scientists for product development and commercialization of near market technologies; Innovation Systems and Clusters Program which is creating innovative business clusters; other cluster-related initiatives such as the One Village One Product which is intervening with technology at the sub-country level; the Competitiveness and Investment Climate Strategy of the MFPED which is supporting creation of clusters and improving value chains of key agricultural commodities; and other programs in universities and research organisations across the country. The rise of these initiatives manifests an evolving innovation system in the country. To understand the system better, it is necessary to identify the synergies, if any, between these efforts, and how they support innovation processes at different levels. It is also necessary to understand the transformations taking place within the institutional spheres so as to guide decisions on future innovation policies.

1.5 Objectives

1.5.1 Main objective:

To find out how the innovation system of Uganda is evolving and the potential for its growth.

1.5.2 Specific objectives:

a. To document the innovation system evolving in Uganda.

b. To analyse patterns of interactive learning which define the innovation system.

c. To establish how the patterns of interactive learning affect the innovation process in Uganda.

d. To establish an appropriate interactive learning model for Uganda.

1.6 Research questions

The key research questions are:

a. How is the innovation system in Uganda evolving?

b. What patterns of interactive learning exist in Uganda?

c. How do these patterns of interactive learning support innovation processes?

This licentiate thesis addresses the first and second specific objectives of the study, and in part answers research questions (a) and (b) above.

1.7 Significance

The study contributes to the understanding of the evolving innovation system in Uganda. Such knowledge is critical for the development of inclusive innovation policies and their effective implementation. Firms and other organizations, especially those who participate in the study may also use the study's findings to create and strengthen linkages and interactions with one another. Finally, the study also contributes to the body of knowledge on innovation systems in low income countries, particularly in Africa, where so little has so far been done in this field.

1.8 Ethical considerations

The informational resources used for the study are those already in the public domain such as published papers, institutional reports, policies and proceedings. No personal identifiable information was recorded nor was any information that could potentially be deemed derogative. Permission to use library resources was obtained where necessary from a responsible official within the organization such as head of the organization or department. Where interviews were necessary, these were conducted with adult male and female employees of the organizations or firms. The purpose of the study, risks and benefits were explained to the individuals. They were also told that they were free to decline to the interview anytime. Verbal consent was obtained from all the individuals interviewed.

Chapter 2 – CONCEPTUAL AND METHODOLOGICAL CONSIDERATIONS

2.1 Conceptual framework

This work is guided by three concepts viz: innovation systems, Triple Helix of university-industry-government relationship and Mode 2 knowledge production.

2.1.1 Innovation systems

Innovation systems concept first introduced in the 1980s and early 1990s by Christopher Freeman, Bengt-Ake Lundvall and Richard Nelson, refers essentially to the complex web of interactions and relationships among diverse actors (Lundvall, Joseph, Christina Chaminade, & Vang, 2009; Godin, 2009; Lundvall, 2007). It has gained wide recognition among scholars and policy makers (Lundvall, 2007; Balzat & Hanusch, 2004), becoming rhetoric to some, and to others, an analytical framework for understanding technological change and growth of countries (Sharif, 2009). The concept, however, is still evolving. There is debate as to whether it forms a theory or is simply a conceptual framework (Lundvall, 2007). Miettinen (2002) refers to it as "transdiscursive" term, i.e. loose and open, and cautions that it could potentially cause tensions because of divergent meanings and uses (Miettinen, 2002). Lundvall, however, recently indicated that it is better to consider 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 expe-*

rienced-based learning" (Lundvall et al., 2009). Despite the debate, many scholars still agree that the underlying notion of innovation systems is interaction and the learning that takes place within and between actors.

Innovation systems approach was chosen as the overall guiding framework for analysis. It was used inclusively taking into account research and innovation activities, the role of universities and firms, public policies and government agencies as well as incentive measures. With this framework, innovative activities could be analyzed in a broader context, not only focusing on outputs, but also on the processes and the actors involved in knowledge production and diffusion of innovations.

2.1.2 Mode 2 knowledge production

Mode 2 knowledge production describes the contemporary way knowledge is produced. Unlike in the traditional way (Mode 1) where knowledge is created in a disciplinary context, Mode 2 emphasizes knowledge production in a broader, trans-disciplinary, social and economic context (Gibbons et al., 1994). Mode 2 recognizes that diverse groups are involved in knowledge production, and that knowledge is widely distributed across sectors and in society. This phenomenon is quite evident in Uganda where many centres of knowledge have sprung up, and more actors (universities, research institutes, non-governmental organizations, private firms, and individuals) are emerging. In Mode 2, knowledge is produced in the context of its application, and in an inclusive manner, taking into account interests and values of the society at hand (Nowotny, Scott, & Gibbons, 2001).

2.1.3 Triple Helix

The Triple Helix of university-industry-government collaboration was found appropriate because it provides room for flexibility of institutional boundaries. Etzkowitz & Leydesdorff (2000) posit that in the Triple Helix, the "university has a more enhanced role in innovation in the evolving knowledge based societies" (Etzkowitz & Leydesdorff, 2000). Triple Helix stresses the need for mutual cooperation and collaboration between universities, government and industry. But such a collaboration may happen only when the functions of university, industry and government transform in such a way that enables each institutional sphere at specific and relevant situations to assume the role of the other (Leydesdorff & Etzkowitz, 2001). Setting up of a Business Incubation Facility at the School of Food Science and Technology in Makerere University and at Uganda Industrial Research Institute illustrates this point. The Triple Helix constellation is emerging in Uganda, and transformations within the individual institutional spheres of university, industry and government are beginning to happen. For example, in 2008 Makerere University passed an Institutional Research and Innovation Policy, and also transformed the School of Graduate Studies into a Directorate of Research and Graduate Training as a strategy to tap into the university's latent innovative potential, and engage in enterprise development.

Figure 1 shows the inter-relationships among institutional spheres in an innovation system operating in Mode 2 with Triple Helix constellations. In this diagram, knowledge producing organisations (K) comprise universities, research organisations, academies of sciences, and other science and technology related agencies (Nowotny et al., 2001). Lundvall (2007) referred to these entities as the "knowledge infrastructure". Government (G) includes science and technology policy, legal and regulatory organizations; and industry (I) includes manufacturing and services whether or not for profit. This classification is somewhat related to Fischer's (2001) building blocks of an innovation system comprising a group of actors with common interest: the manufacturing sector, the scientific sector (divided into training and research), sector of producer services (e.g. financial and marketing services, expertise) and the institutional sector (e.g. legal and regulatory frameworks, rules, norms and conventions, etc)(Fischer, 2001).

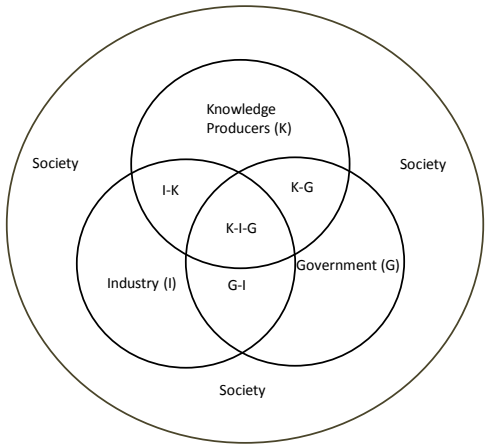

Figure 1: A Constellation of Actors

The region K-G, G-I and I-K indicate the transformation within the institutional spheres so that at specific and relevant situations each can take on the role of the other. But also, the region I-K, K-G and G-I, may represent intermediary organizations with specific missions, for example, technology brokerage or transfer agents, science advocacy groups, professional societies and so on. The interface K-I-G is crucial for innovation to occur. Here, all actors intensify interactions and promote learning in both formal and informal settings. The relationships at the interface K-I-G are complex, and manifest co-evolution processes. Influence from the society is important, and every innovative activity must take into account cultural and social sensitivities, and ensure that they are adequately addressed.

2.2 Methodology

2.2.1 Overall context

The study adopted a pragmatic worldview point, given the complex and evolving nature of transformations and relationships in an innovation system. Pragmatism as a worldview emphasizes understanding of the research problem, and working towards identifying possible solutions (Creswell, 2009). This view, therefore, offered the author flexibility to apply a variety of qualitative and quantitative tools to understand the actors and how they relate in the innovation process.

2.2.2 Target population

The study targeted organizations that were involved in or were expected to play a significant role in the research and innovation process. These were broadly categorised as: knowledge producing and associated organizations such as universities and research institutes/centres; industry comprising largely of manufacturing firms (mainly bioresource-based); government organs responsible for policy, financing, standards and regulation; and intermediary organizations such as professional and business associations.

2.2.3 Study design

Mixed methods were used, combining use of both quantitative and qualitative approaches in the study (Creswell, 2009). A mixed method was preferred because of the diversity of actors, and the context-specific nature of innovation systems.

2.2.4 Methods

A review of key policy documents was done. These documents included for example, science, technology and innovation policies, institutional reports, comprehensive national development frameworks, laws and regulations, research databases in Uganda, and journal articles, papers and related work on innovation systems globally, regionally and nationally. Some of the documents like institutional reports and government policies were solicited from the responsible agencies, or located from those agencies' libraries. Some of them were sourced online from web pages of the agencies or journal articles through the Blekinge Institute of Technology library. These documents were read. Review notes were made and summarized into key points and issues. In addition, semi-structured open ended key informant interviews were carried out with scientists, business leaders and administrators in the target organizations visited. These interviews were recorded on scripts and later summarized. Key issues and points emerging from the interviews were noted and discussed in the write up of the papers.

Part 2

Chapter 3 – PAPERS

3.1 Introduction to papers

This thesis is composed of four papers. Paper I discusses the integration of science, technology and innovation in Uganda's national development planning process. Paper II presents an overview of the research system in Uganda and associated policy issues. Paper III looks specifically at the emerging biotechnology (or broadly bioscience) enterprise in Uganda and analyses some of the challenges. Paper IV discusses a cross cutting issue of intellectual property management, and what universities and research institutes in Eastern Africa could do to promote innovation and business development.

Paper I

Ecuru, J., Lating, O. P., Ziraba, N.Y., and Trojer, L. (2011). *Integrating science, technology and innovation in national development planning process: the case of Uganda*. In proceedings of the 2nd International Conference on Advances in Engineering and Technology, pp 235-241, January 30th – February 1st, 2011, Entebbe- Uganda: ISBN: 978-9970-214-00-7

This paper analyzes how science, technology and innovation was (or was not) integrated in to the national development planning process of Uganda. Initially, in the 1960s, Uganda government had five-year development plans. However, political and civil unrest disrupted the continuity of these plans in the 1970s and early 1980s. Later in 1990s government adopted the poverty eradication action plan as its comprehensive development planning framework; and in 2010 reverted to the five-yearly plans. These plans guide government investments and expenditures. If science, technology and in-

novation were to benefit from public support, it would be crucial that it is included in the national planning framework. It was not until 2010 that science, technology and innovation featured vividly in the national development plan of Uganda.

Paper II

Ecuru, J., Nawegulo, N., Lutalo, R.B., Kasule, D., Tujunirwe, E., and Akampurira, I. (2008) *Research in Uganda: status and implications for public policy.* Published by Uganda National Council for Science and Technology, Kampala- Uganda

This paper provides an overview of the research system in Uganda. It considers broadly the types of research done, the financing mechanism, educational system, and associated science policies. Research is a major component of the innovation system. Traditionally, research in Uganda did not have strong links with industry, nor with decision making processes in government. This work provides a snapshot of the functioning of the research system and the implications it has on public policy.

Paper III

Ecuru, J., and Naluyima, H. (2010). *Biotechnology developments in Uganda and associated challenges*. African Crop Science Journal Vol. 18, No. 4, pp. 133 – 139; ISSN 1021-9730/2010.

This paper specifically analyzed the growth of biotechnology as an enterprise in Uganda. It showed that significant R&D work is taking place using biotechnology as a tool, especially in crop, fish and livestock improvement, value addition, waste management, and in medicine. However, it is observed that the continuing growth of biotechnology or more broadly, biosciences as an enterprise in Uganda will depend on the support given to science and technology generally.

Paper IV

Ecuru, J., Kingamkono, R. R., Omari, J., Shumu, T., and Ivar, V. (2008). *Managing intellectual property: Eastern African universities and research institutes can do more to help scientists. A policy brief published by the Inter-University Council for East Africa/ BIO-EARN Programme.*

This paper argues that universities and research institutes in Eastern Africa should have operational policies for managing intellectual property. This is critical in the rapidly evolving bioscience innovation system in the region. It argues that intellectual property legislation exists sufficiently, but instruments at the institutional level to utilize the regime are lacking. It argues further that such instruments are essential, not only for the scientist, but also for private sector involvement and sustenance of international collaboration in research and innovation.

3.2 Paper I

Integrating Science, Technology and Innovation in the National Development Planning Process: The Case of Uganda

Ecuru, J., Lating, P. O., Ziraba, N. Y., and Trojer, L

ABSTRACT

Science, technology and innovation plays a critical role in enhancing economic growth and contributing to national development. It is the means by which new products and services are developed or improved and brought to the market. However, to make this contribution, science, technology and innovation must be integrated in the national development planning process. Over the years, the integration of science, technology and innovation in Uganda's national development planning has been implicit. Intentions to use science, technology and innovation as the vehicle for economic growth were evident in the country's comprehensive development framework such as the Poverty Eradication Action Plan (1997 – 2008/09) and the National Development Plan (2010/11-2014/15). However, strategies of how to use it to bring about the desired outcomes of economic growth were lacking. The recent designation of science, technology and innovation in the National Development Plan of Uganda as a sector that provides institutional and infrastructural support to the production of goods and services demonstrates that integration of science, technology and innovation in development planning could be accomplished through endogenous efforts. But such inclusion of science, technology and innovation in the Plan should not be taken as an end in itself; rather it should be seen as a process. And implementation of the science, technology and innovation provisions of the National Development Plan ought to be undertaken within the context of the national innovation system.

Key words: Innovation, Innovation System, Science, Technology, Uganda.

INTRODUCTION

Science, technology and innovation (STI) plays a critical role in enhancing economic growth and contributing to national development. It is the means by which new products and services are developed or improved and brought to the market. Ideally, these new or value added products and services are intended for improvement of the standard of life. Economically they create new market opportunities, attract better prices and provide employment.

The importance of STI in economic growth and development of low income countries generally and of Uganda in particular has been echoed since the 1960s (East African Community (EAC), 2000). After independence in 1962, the country embarked on nation building with industrialization being at the centre of the development agenda.

STI was expected to play a key role in the industrialization process but it did not feature vividly in the development plans of the time. There was lack of clarity on how to promote STI for national development. This led some scholars to believe that STI was often given low priority in the development planning process (Senghor, 2000).

Only recently has STI been given more prominence in Uganda's National Development Plan 2010/11 – 2014/15. The NDP stipulates Uganda's medium term strategic direction and development priorities, focusing on growth, employment and socio-economic transformation for prosperity (Ministry of Finance, Planning and Economic Development (MFPED), 2010). The plan recognizes STI as a sector that provides institutional and infrastructural support to the production of goods and services. The promotion of STI is identified as one of the strategic objectives for achieving the goals of the NDP. Previously, also intentions to use STI as the vehicle for economic growth were evident in the country's comprehensive development framework, which was known as the Poverty Eradication Action Plan (MFPED, 2001). The Poverty Eradication Action Plan (PEAP) was a three-year planning framework for government. Programs and projects not aligned to the PEAP would not receive budgetary support. STI was not explicitly mentioned in the PEAP. The challenge, therefore, was to make STI projects PEAP compliant in order to qualify for public funding.

Thus, the development planning process in Uganda since independence until recently only implicitly considered STI. However, a clear strategy of how to translate the intentions to use STI for development into actions with tangible results was generally lacking. This challenge continues to date even with the deliberate inclusion of STI in the NDP. This paper examines the process of integrating STI in Uganda's national development planning process.

METHODOLOGY

The paper is based on a retrospective review of literature on STI in Uganda. A desk review of key STI documents was done. The focus was on the national development frameworks, for example, the National STI Policy (2009); National Industrialization Policy 2008; Poverty Eradication Action Plan 1997, 2001, and 2004; the National Development Plan 2010/11 – 2014/15. Other historical documents pertaining to Uganda's economic development since independence were also reviewed; as well as reports of STI regional and international meetings. The documents were read and summarized.

RESULTS AND DISCUSSION

Science, Technology and Innovation (STI) taken together may 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.* STI is not an end in itself; rather it is the means by which new products and new processes are developed and brought to the market. The process of integrating STI in Uganda's national development planning could be looked at from two dimensions: the exogenous and endogenous dimensions.

a) The exogenous dimension

Prior to Uganda's independence, STI was an integral part of the central government, which was the East African Common Services Organization (EACSO) with headquarters in Nairobi, Kenya (EAC, 2000). The three countries of Kenya, Uganda and Tanzania first cooperated in matters of STI through the EACSO. The latter body later became the East African Community. With this arrangement STI appeared to be quite well organized. However, STI was focused more on research aimed at improving productivity of cash crops such as cotton and coffee; and tackling tropical diseases such as malaria and trypanosomiasis (EAC, 2000).

This trend continued even after independence in 1962 through to the 1980s. Development planning during this period hardly incorporated STI. However, there was a growing global effort to help developing countries use STI as a tool for development (United Nations Educational, Scientific and Cultural Organization (UNESCO), 1987). Several African countries in the 1960s and 1970s established national research councils as coordination mechanisms for scientific research and development. In Uganda, a National Research Council was set up in 1970 to guide and coordinate research efforts (Uganda National Council for Science and Technology (UNCST), 2001). The predominant view at the time seemed to be that industrialization was preceded by research, then experimental development and later production and commercialization of products. This linear view of STI has been criticized because it fails to recognize other factors necessary in the innovation process (Godin, 2006). A systems approach to STI seems to be the more favoured view currently (Balzat & Hanusch, 2004). A systems approach recognizes the contribution of several actors in an interactive learning relationship, and the factors which influence such a relationship (Edquist 2009; Lundvall, 2009; Banji, 2006). Innovation is believed to be an outcome of these complex interactions between diverse actors (Lam & Lundvall, 2007).

Most of all the drive to integrate STI into national development planning was initiated by continental wide efforts notably by the United Nations Educational, Scientific and Cultural Organization (UNESCO) supported Conferences of Ministers responsible for the Application of Science and Technology in Development in Africa I and II (CASTAFRICA I and II) in 1974 and 1987 respectively; and the Lagos Plan of Action (LPA) in 1980 (UNESCO, 1987). For UNESCO, rapid scientific and technological progress could only be achieved through the indigenous efforts of developing countries (Mullin, 1987). This view became popular among developing countries because they found it consistent with their aspirations to liberate themselves from colonialism (Mullin, 1987). Consequently, in 1980 African leaders met in Lagos Nigeria and developed a masterpiece LPA. The LPA provided that each country should establish a center or body to "help the country in determining the origins and effects of alleviating the technological dependence and in approaching technological self-reliance by striking a socio-economically favoruable balance between foreign inputs and those inputs that are generated by the indigenous science and technology system and utilized by the national sectors of production and services". Such a centre was to be entrusted with the mandate for national science and technology policies and coordination of

all national research and development programmes. This centre in Uganda became in 1990, the Uganda National Council for Science and Technology (UNCST). The UNCST replaced the National Research Council. The ideals of the LPA were for member countries to attain self-sufficiency by becoming technologically independent. The LPA specifically called for member countries to develop short, medium and long term integrated development plans, with science and technology as an integral part.

Most recently, the Africa's Science and Technology Consolidated Plan of Action (CPA), 2005 prepared by the African Union/New Partnership for Africa's Development became an important regional framework for harmonization of STI development (African Union, 2005). The CPA evolved from a series of continental meetings. It is an instrument to implement the decisions of the African Ministerial Conference on Science and Technology that was held in Johannesburg in 2003. It is built on three pillars: capacity building, knowledge production and technological innovation; emphasizing the development of Africa through a system of research and innovation. The CPA lays down specific flagship programmes and projects including biodiversity, biotechnology and indigenous knowledge; energy, water and desertification; material sciences, manufacturing, laser and postharvest technologies; information and communication technologies and space science; as well as programmes to improve STI policy mechanisms. Implementation of CPA programmes is through centres of excellence; but requires determined and coherent actions by all member states. Undoubtedly, the CPA may have influenced STI planning in Uganda, but the extent of this influence is unknown.

These exogenous influences have to some extent shaped the process of integrating STI in the national development process of Uganda. Specifically, they helped to raise awareness among policy makers of the importance of STI in economic growth and development. Despite the efforts, however, regional or continental STI initiatives have been poorly domesticated in Uganda. There is often little room for consultations on these regional initiatives within country, and collective involvement of local actors in the STI system has remained weak. As a result, there is seldom sufficient local ownership for the programmes proposed by the regional or continental wide initiatives.

b) Endogenous dimension

Endogenously the integration of STI in Uganda's national development planning could have started in the 1990s. During the 1970s and early 1980s, development planning was interrupted by political instability and civil unrest; and further by the structural adjustment programmes of the 1980s and the early 1990s (MFPED, 2010). Between 1986-97 government implemented an economic recovery program aimed at stabilizing the economy and creating a conducive environment for rapid economic growth. These included among others interest rate reforms and fiscal measures to reduce Uganda's budget deficit, liberalization of trade policies and revitalization of the private sector (Kreimer, et al. 2000). From 1997 to 2008 development planning was guided by the PEAP. Significant reforms of the public sector happened during this period including the creation of dedicated research and development organizations

such as the National Agricultural Research Organization and the Uganda Industrial Research Institute. Government line ministries assumed a policy and regulatory function, leaving research to academic and research organizations.

It is at this stage that traces of STI integration into national development planning started to emerge. Though not explicitly stated, the need for STI was implied in most of the PEAP actions particularly those meant to increase ability of the poor to raise their incomes such as modernizing agriculture; as well as in actions to improve the quality of life of the poor, for example, in combating HIV, developing more efficient energy systems, designs for improved housing, and improving primary and secondary education (MFEPD, 2001; MFPED, 2004). The PEAP was Uganda's comprehensive development framework from 1997 to 2008/09. It was government's three-yearly planning document. All government expenditure had to be aligned to the PEAP. All the PEAPs, PEAP 1997, 2001 and 2004, had no specific actions to promote STI. But they all recognized the need for STI in some of the actions such as those aforementioned. It may have been possible to articulate STI within the context of the PEAP, but such a strategy would not be sufficient mechanism to promote STI primarily because results from STI are usually realized in the long term, though there could also be some short term outputs. PEAP neither provided a clear mechanism of how to use nor invest in STI to bring about the desired outcomes of economic growth. As such it appeared as if STI had been given low priority and no status in the planning process despite its potential central role in enhancing economic growth.

The PEAP was replaced by the 5-year National Development Plan (NDP) starting 2010. The plan is the first of six 5 –year development plans intended to transform Uganda from a peasant society to a middle income country. This time, STI has been included in the NDP as a sector that provides institutional and infrastructural support to the production of goods and services. It is the first time STI has been explicitly recognized in the national development planning process of Uganda. Unlike in the 1960s, 70s and 80s where exogenous influences shaped STI planning, the integration of STI into NDP was an outcome of endogenous efforts. The planning for STI within the NDP was done in a participatory manner involving a diverse group of actors. The success in according STI a sector status in the NDP demonstrates that home grown efforts in STI can be harnessed.

However, designation of STI as a sector within the NDP is not an end itself. It should be considered as a learning process of systematically integrating STI in national development planning. As the process evolves, it will be important to guard against the likely danger of promoting STI in isolation and the risk of backsliding to the linear view of STI of the 1960s to 80s. Implementation of the STI provisions of the NDP ought to be undertaken within the context of the national innovation system. Innovation system here refers to the complex web of interactions and relationships among diverse actors (Lam & Lundvall, 2007). It will be essential not only to focus on the expected outputs of the STI in the NDP, but also pay close attention to the multiplicity of actors involved in STI, how they relate and what policies, laws, behaviours, norms, routines and practices influence their interactions.

Political, cultural, social and behavioural factors notwithstanding, it may be worthwhile to consider the following pillars in support of the process of integrating STI in the development planning process of Uganda:

Human capital: Uganda's human capital base for STI, that is, the pool of knowledgeable, competent and skilled people, is still small. For example, active researchers in all fields were less than 2,000 in 2008 (Ecuru, et al. 2008). Increasing the human capital potential depends on the strength of the education system. Uganda's education system is quite well developed and positioned to produce the necessary human capital. However, challenges still exist of improving science and mathematics education as well as improving business and vocational education. Reforms such as universal primary education and universal secondary education and emphasis on science careers at the tertiary level, may increase the supply of scientists; but reforms are also necessary to improve the quality of education.

Governance: Governance, that is, organizing scientists to produce involves formulating policies, issuing guidelines, developing legislation, preparing strategies and plans for STI. Early on in 1990, it was proposed to have an explicit national policy on all fields of science and technology. A National Science and Technology Policy was first proposed at a National Workshop in 1991 and approved by Cabinet in 2009. The policy provides an overarching framework for investment, coordination and management of STI in Uganda. It aims to build and strengthen national capability to generate, access, select, transfer, disseminate and apply scientific knowledge, skills and technological innovations for the realization of Uganda's socio-economic and development objectives, and to ensure sustainable utilization of natural resources (MFPED, 2009). The UNCST and Parliamentary Committee on Science and Technology (2003) are the principal STI governance institutions in Uganda. UNCST is a semi-autonomous agency under the MFPED. The NDP proposes to establish a separate ministry for science and technology. The Parliamentary Committee on Science and Technology oversees matters of STI in Parliament, and advocates for desirable legislations for STI in the country. Complementary institutions which support STI governance exist, notable among which is Uganda National Academy of Sciences (UNAS). The Academy was established and nurtured by UNCST in 2000, and is supposed to provide independent, well researched opinions and recommendations on topical STI issues. It is important that these organizations talk to each other, particularly to lay strategies of how to integrate STI in development planning, mechanisms to translate STI policies into actions, and also chart a way of how to broker relationships among other actors in the innovation system.

Financing: STI is mainly in public research institutes and universities. Financing for STI is predominantly by government and development partners. For example, in 2007/08 financial year, government expenditure on research and development was estimated at 42%, development partners 51%, and other sources 7%. Government pays mainly for administrative costs such as utilities, maintenance and personnel. Contribution from the private sector is miniscule. Total annual national expenditure on R&D as percentage of GDP averaged 0.3% between 2003/04 and 2007/08 (UNCST,

2008). This is very low compared to say South Africa which spends between 0.8% and 1%, and Sweden, 4% annually (OECD, 2007). Scientists in Uganda have no option but to rely on grants from abroad. There is increasing need to have stable and more sustainable domestic funding arrangements for STI. Successful countries like South Africa and Sweden have dual schemes for public funding of STI. The first is direct STI funding to research organizations and universities. The second is a national competitive funding mechanism. It is possible for Uganda to adopt this same dual approach because it already has a National STI Fund established under section 20(3) of the UNCST Act (Cap 209). Besides, through the US$ 30 million Millennium Science Initiative Project (2006 -2012), reasonable capacity has been built within the UNCST to operate national competitive grants for STI. The consolidation of this competitive funding scheme would also open up possibilities for bilateral and multilateral cooperation in STI, much to the benefit of Ugandan scientists. This would also be a key marker of the process of integrating STI into national development planning. .

CONCLUSIONS

The integration of STI into national development planning processes is possible. This is demonstrated by the inclusion of STI in the NDP as a sector that provides institutional and infrastructural support to the production of goods and services. However, this should not be an end in itself. Integration of STI into national development planning is a process; not a single event. It will be important not only to focus on the likely tangible STI outputs in the NDP, but also on the process by which innovation takes place. This implies that the implementation of the STI provisions in the NDP ought to be undertaken within the context of the national innovation system, with due consideration to the relationships between the actors in the system. Further, the successful designation of STI in the NDP has demonstrated that home grown STI solutions are possible. Exogenous influences on national STI reforms are important, but by themselves may be inadequate to ensure effective integration of STI in the national development planning process.

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3.3 Paper II

Research in Uganda: Status and Implications for Public Policy

Ecuru, J., Nawegulo, L., Lutalo, R. B., Kasule, D., Tujunirwe, E., and Akampurira, I

ABSTRACT

Science and Technology is the engine for economic growth and social transformation. It is, therefore, important for government to invest in science and technology. A key element of such investment is to increase support to research and research capacity development. Research work in Uganda tripled over the last 10 years from about 100 new research projects registered with Uganda National Council for Science and Technology in 1997/98 to slightly over 300 new research projects registered in financial year 2006/07; and research and development spending also nearly tripled from Uganda Shillings 31 billion in 2003/04 to approximately Uganda Shillings 82 billion in 2007/08 (which accounts for about 0.4% of GDP in 2007/08). Government should sustain higher annual increases in research and development spending to reach at least 1% of GDP in the medium term. This spending could be directed more towards supporting research programmes aimed at increasing agricultural productivity, adding value to agricultural products and other bio-resources, understanding disease and developing new biopharmaceuticals supported by the rich indigenous knowledge base, developing new materials for construction and manufacturing, finding alternative methods of waste management and pollution control, using information and communication technologies to improve service delivery, enhancing nutrition of children, developing efficient and environmentally benign energy systems, and improving water quality and sanitation at the community and in the households. The most appropriate mode of delivering support for research and research capacity development appears to be through national competitive grants funding schemes administered transparently, focusing on the merit of proposals and strictly adhering to rules of competition. The Uganda Millennium Science Initiative funding facility and the National Agricultural Research Organization competitive grants are good starting points, and should be consolidated. To begin with, government could make Uganda Shillings 10 to 16 billion available annually to scientists and technologists through the funding facility already established at the Uganda National Council for Science and Technology. Also, actors within the research system should interact more and build synergies among themselves to promote innovation. Therefore, the creation of multidisciplinary research groups and/or strengthening local inter-institutional and regional and international collaborations and research partnerships is essential to propel Uganda's research enterprise forward.

Key words: Innovation, institution, policy, research, Uganda

INTRODUCTION

1.1 Background

Research plays an important role in sustainable development by helping find solutions to society's problems. Uganda's national development strategy recognises the need to use science, technology and innovation as the main drivers of economic growth and social transformation. This inevitably presents a formidable challenge of ensuring increased availability, access to and use of scientific knowledge and technology to increase productivity and profitability of firms and households. In this context, support to research becomes a key element for the continued supply of high quality technical information and more and better qualified human resources.

Research is "any systematic investigation, testing and evaluation, designed to develop or contribute to generalizable knowledge" (UNCST, 2007). The OECD defines research and development broadly as "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (OECD, 1993).

Research work in Uganda is steadily growing every year especially in the fields of health, social science, agriculture and the natural sciences (growth in the engineering and technology field is quite low). The impact of this growth on the economy is yet to be evaluated. This observed growth in the volume of research in Uganda may be attributed to the new universities and research institutions which have emerged in the recent past, reforms that occurred in a number of research institutions, new in-country research funding mechanisms set up, and an increasing number of active researchers in the country. There is need to periodically examine the research situation in Uganda to guide the design of continued research support.

This paper gives a snapshot of the status of research in Uganda as at December 2008, and its implications for public policy. It describes the research system, active research institutions, common research areas, financing structure and mechanism and the guiding policy framework for research in Uganda. The information provided in this paper may be useful in guiding the design of future support to research work in Uganda.

1.2 Objectives

This paper gives the status of research in Uganda, and examines its implications for public policy making.

More specifically, the paper:

a. Describes the research system;

b. Provides an overview of active research institutions;

c. Analyzes trends and distribution of research by fields;

d. Provides estimates of research spending; and

e. Describes the policy framework for research in Uganda.

1.3 Methodology

Much of the research information was obtained from the UNCST database. UNCST maintains a register/database of all types of research work undertaken in Uganda, dating back to 1970 (The database has over 5,000 research projects/programmes registered as new projects over the years). Additional information was obtained from government policy documents, government's annual budget estimates, and institutional documents/records of selected research institutions. Interviews with key informants were also conducted.

2.0 THE RESEARCH SYSTEM

Significant reforms in Uganda's research system occurred in the late 1980s and early 1990s. Prior to that period, research was integrated within government line ministries, e.g. Ministry of Agriculture, Ministry of Health, and in universities (basically Makerere University) with the exception of a few formerly East African regional bodies like the Uganda Virus Research Institute. Most of the ministries had Research Secretariats or departments with full time research personnel. Research was coordinated then by the National Research Council (NRC), established in 1970 by a cabinet decision. The NRC had responsibility for research oversight and advising on national research policy; and was also a research funding arm of government. The NRC was replaced in 1990 by the Uganda National Council for Science and Technology (UNCST).

During the structural adjustment processes in the late 1980s and early 1990s, specialized institutions were set up to undertake research. Thus was established, for example, the National Agricultural Research Organization in 1992. The reforms left government line ministries with a mandate for policy and regulation, while research was to be undertaken by academic and research institutions. In its early years, the UNCST proposed to establish also a National Health Research Council/Organization, Council for Scientific and Industrial Research and a National Social Sciences and Humanities Council, but these plans did not materialize.

Research in Uganda is liberalized, although it is still largely undertaken by public sector institutions, i.e. the research institutes and universities. Research in Uganda is, therefore, organized around universities, research organizations, private companies, local and international not-for-profit organizations, foreign scholars and nationals, and the indigenous peoples. There are also institutions such as the UNCST which are responsible for research policy and national level coordination, research oversight, standards and intellectual property management (see Annex 1 for key institutions in Uganda's research system). It suffices to say that much of the research in Uganda is undertaken through international collaborations and sponsorship. Creating new and maintaining existing research partnerships with foreign universities, firms and organizations would be the lifeline for research growth and progress in Uganda.

In order to ensure high quality and integrity of research, individual institutions, whether private or public, academic or non-academic, have their own established

institutional mechanisms of developing research proposals, undertaking some kind of scientific peer review and implementing research projects. In the academic circles, departmental and faculty research committees vet student's research proposals, in addition to higher degrees and research committees set up in some universities. These structures in public and private tertiary institutions which ensure high quality and relevant student's research must conform to the minimum standards and regulations for higher degrees programmes set by the National Council for Higher Education (NCHE) in Uganda. The extent to which faculty members and active research groups use the internal structures/mechanisms for scientific review is not clear. Usually, faculty members and research groups rely on the scientific and peer review by collaborating or research sponsoring agencies. There is insufficient evidence to suggest that local scientists substantially use their local counterparts as peer reviewers for their work, except when research proposals are submitted for ethical review as further discussed below.

Research matters in Uganda are coordinated nationally through the UNCST. The UNCST continued the work of the NRC, but with a much broader mandate to advance not only research but science and technology holistically. The establishment of the UNCST was to a very large extent influenced by the Lagos Plan of Action (LPA), 1980. The LPA provided that each country should establish a center or body to "help the country in determining the origins and effects of alleviating the technological dependence and in approaching technological self-reliance by striking a socio-economically favoruable balance between foreign inputs and those inputs that are generated by the indigenous science and technology system and utilized by the national sectors of production and services". Such a centre was to be entrusted with the mandate for national science and technology policies and coordination of all national research and development programmes.

The ideals of the LPA were for member countries to attain self-sufficiency by becoming technologically independent. However, the notion of technological independence and ultimate self-reliance is now difficult to match with the contemporary globalization trends. Development policies may instead have to increasingly focus on establishing partnerships, with goals of identifying and/or creating niche regional and international market opportunities for trade. Even though government of Uganda adopted most of the provisions of the LPA by establishing the UNCST, it has interpreted these provisions to address current challenges of advancing science and technology in a rapidly changing global economy.

The function of UNCST is broad, covering all aspects of science and technology, and could be summarized as follows: 1) to coordinate the formulation of explicit national science and technology policies; 2) to develop strategies and programmes for advancing science, technology and innovation, and 3) to facilitate the conduct of research and development. The mission of the UNCST is to, "provide effective and innovative leadership in the development, promotion and application of science and technology and its integration in sustainable development."

The UNCST is comprised of 32 members, eminent in diverse fields of science and technology. The members are appointed by the minister responsible for science and

technology matters in Uganda. There is not yet a standalone ministry for science and technology in Uganda. The Ministry of Finance, Planning and Economic Development (MFPED) is currently the parent Ministry to which the UNCST belongs. The placement of UNCST within the MFPED is not clear to many people, but the reasons are: 1) science and technology is crosscutting and would best be located within a crosscutting Ministry like the MFPED; 2) science and technology is or should be an integral part of socio-economic and development planning. These reasons notwithstanding, there has been a passionate plea from the scientific fraternity in Uganda to have a separate ministry for science and technology. It is argued this would enable better articulation and representation of science, technology and innovation matters at the highest political level, and also enhanced support to research and technology development.

The UNCST has specialized committees in the fields of agriculture, industry and engineering, natural sciences, physical sciences, health, information sciences, energy, and social sciences and humanities. These committees advise on policy matters in their specific fields. At the operational level, UNCST also uses task forces, standing committees (e.g. National Biosafety Committee and the National HIV/AIDS Research Committee), expert panels, and consultants to undertake more specialized assignments on its behalf.

UNCST offers a national coordination mechanism for research and development in Uganda. Section 3d of the UNCST Act 1990 (Cap 209), specifically designates the UNCST as the "clearing house for information on research and experimental development taking place in scientific institutions, centres and other enterprises and on the potential application of their results". By this, all persons and institutions carrying out research in Uganda are expected to register their research projects with the UNCST. As part of the registration process, UNCST evaluates every proposal submitted for their scientific soundness/integrity and for ethical appropriateness. The UNCST liaises with the Office of the President to evaluate national security implications of research applications. Involvement of the Office of the President in research registration and clearance is a tradition which dates back to the early 1970s, and has remained so to date primarily to guard against clandestine activities which may be carried out under the cover of research. Now that government has improved the management of national security affairs, the requirement for prior vetting of research applications by the Office of the President may need to be reviewed as part of a broader strategy to lessen bureaucracy in, and improve efficiency of research regulatory and support services in Uganda. This is particularly important because very many layers of research approval usually cause delays in obtaining research authorizations and is a big disincentive to research progress and a drawback to researchers who in most cases work within constrained timelines and budgets.

In research institutions, scientific committees, biosafety committees, and institutional review committees (IRCs) have been or are expected to be set up. The latter have a responsibility to review both the science and ethics of research protocols submitted to them before the protocols are registered with the UNCST (for clinical trials, investiga-

tors must have also obtained a National Drug Authority certificate in respect of a drug to be tested; for research in game parks-protected areas- approval must have also been obtained from the Uganda Wildlife Authority; and the National Forestry Authority, where applicable). Some of the IRCs are functioning well and ensure high quality review of scientific proposals, but some are not due to inadequate capacity. The UNCST is continuing to strengthen the ethical review capacity in Uganda, and several partners, e.g. the National Institutes of Health, International AIDS Vaccine initiative, Makerere University-Walter Reed Project, the European Union and Developing Countries Clinical Trials Partnership, have assisted in this endevour.

Key challenges of Uganda's research system are: to ensure effective coordination and linkages among actors within and outside the system, to ensure that research results are used in public policy decision making at all levels, to train and retain more and better qualified scientists and researchers, to make research relevant to problems of national interest, and to minimize duplication of efforts. The system also needs to be flexible in order to support innovation, especially through cooperation with the private sector.

3.0 KEY RESEARCH INSTITUTIONS

Research institutions in Uganda may be categorized into: i) institutions mandated to formulate and implement research policy and national level coordination; ii) regulatory institutions including those for standards and intellectual property management, iii) research institutions – which carry out research; iv) training institutions which produce the human resources for research, as well as carrying out research and v) research support institutions – these plan and manage research activities as well as the financing and dissemination of research results.

Research in Uganda is largely carried out in the public research institutes and universities. There are a few private enterprises and international research organizations which also undertake research. Majority of the research institutions in Uganda undertake research to generate knowledge which does not have immediate application, and also carry out research to improve organizational, programme or project performances. Fewer institutions engage in applied research and product development for commercial or industrial enterprise.

3.1 Research training institutions

Traditionally, the universities' role is training, doing research and outreach. In Uganda, like in many other countries, research is a component of all graduate training programmes which also aim at developing research skills in students. Makerere University, until about 10 years ago was the sole local provider of graduate training in Uganda. However, a number of other universities have since been established, which offer graduate training especially at Masters level. Tables 1 and 2 below show the number of graduate training programmes in 10 key universities in 2007.

Table 1: Graduate Training Programmes in 5 Public Universities

Field	Makerere (TSP*=33,488)		Mbarara (TSP = 3,000)		Kyambogo (TSP = 10,193)		Gulu (TSP = 3,347)		Busitema (TSP = 350)	
	Masters	**PhD**	**Masters**	**PhD**	**Masters**	**PhD**	**Masters**	**PhD**	**Masters**	**PhD**
Food & Agriculture	17	7	Nil	Nil	-	-	-	-	-	-
Engineering	16	8	Nil	Nil	-	-	-	-	-	-
Health Sciences	15	15	9	2	-	-	-	-	-	-
Natural Sciences	11	9	6	-	1	-		-	-	-
Education	40	2	1	-	-	-	1	-	-	-
Social Sciences	27	3	1	1	2	-	2	-	-	-
Total	**126**	**44**	**17**	**3**	**3**	**0**	**3**	**0**	**0**	**0**

Table 2: Graduate Training Programmes in 5 Private Universities

Field	Nkumba (TSP = 4,260)		Nkozi (TSP = 3,397)		Mukono (TSP = 6,000)		Islamic (TSP = 5,000)		Ndejje (TSP = 2,164)	
	Masters	**PhD**	**Masters**	**PhD**	**Masters**	**PhD**	**Masters**	**PhD**	**Masters**	**PhD**
Food & Agriculture	Nil	Nil	-	-	Nil	Nil	Nil	Nil	Nil	Nil
Engineering	Nil	Nil	2	1	-	-	-	-	Nil	Nil
Health Sciences	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Natural Sciences	1	-	-	-	-	-	3	-	-	-
Education	10	-	-	-	3	-	1	-	1	-
Social Sciences	25	1	10	2	10	-	9	-	7	-
Total	**36**	**1**	**12**	**3**	**13**	**-**	**13**	**-**	**8**	**-**

Nil implies that the university does not offer programme in those fields even at undergraduate level
**TSP refers to Total Student Population in 2008*

With the exception of Makerere University, the private universities have more graduate training programmes than public universities in the field of social sciences, business administration and education. The public universities, on the other hand, dominate most the science and technology (S&T) graduate training. Private universities also make a contribution in S&T graduate training especially in the fields of computing and information technology, botany, zoology and environmental management studies.

Graduate training in the health sciences is predominantly in Makerere University College of Health Sciences and Mbarara University of Science and Technology Faculty of Medicine. Makerere University has doubled the number of masters programmes from about 72 in 1998 to approximately 170 in 2008 (UNCST, 2008). Graduates with Masters and Doctorate degrees at Makerere University have also doubled over the last 8 years, although the actual numbers are still comparatively low (Table 3). Administrative records indicate an estimate of between 20 and 24 doctorates annually.

Table 3: Makerere University Postgraduate Students in 2000 and 2007

Programmes	**Year**					
	2000			**2007**		
	M	**F**	**Total**	**M**	**F**	**Total**
Doctorates	8	3	**11**	18	5	**23**
Masters	220	112	**332**	425	232	**657**

3.2 Collaborative arrangements for research

Research institutions in Uganda tend to collaborate rather informally, e.g. when individual researchers form groups to work together on particular projects; or engage in joint consultancies and training. These collaborations are usually on individual basis, and do not involve the institutions as entities.

Formal collaborations (i.e. where there are written memoranda of understanding or research agreements) among local research institutions in Uganda are rare, but there is growing interest among researchers and research administrators to start formalizing their collaborations. In a few cases, formal research agreements exist where foreign, international or donor institutions are involved. However, in most cases, the local institutions have limited capacity to engage in a fair negotiation of terms for the research cooperation because of the absence of enabling institutional policies/frameworks. For example, most, if not all, of the local research institutions do not have Institutional Intellectual Property/Technology Management policies. Makerere University senate passed the university's intellectual property policy in early 2008 (School of Graduate Studies Bulletin, July 2008). The absence of such supportive policies weakens regional and international collaborations, and also limits the participation of private sector in product development partnerships with the universities or research institutes.

4.0 RESEARCH FIELDS

The UNCST facilitates research and development (R&D) activities in Uganda in accordance with Section 3d of the UNCST Act (Cap 209) which mandates the UNCST to act as a clearinghouse for information on research and experimental development taking place in scientific institutions, centres and other enterprises and on the potential application of their results. In exercise of this function, the UNCST maintains a

register of R&D activities in Uganda, which dates back to 1970. For purposes of this study, fields of research were categorized into: Medical and Health Sciences, Natural Sciences, Engineering and Technology, Agricultural Sciences and Social Sciences and Humanities in accordance with the international standardization of statistics on science and technology (UNESCO, 1978). The sections below present R&D trends[1] in Uganda from July 1997 to June 2007.

4.1 Research trend: July 1997 to June 2007

The number of new research projects registered at the UNCST almost tripled, from 109 in 1997/1998 to 335 in 2006/2007. Figure 1 shows the number of new projects in each research field between 1997/98 to 2006/07. There was a steady increase in the number of new projects registered in the fields of Social Sciences and Humanities, Medical and Health Sciences and the Natural sciences. Fewer projects were registered annually in the fields of Engineering and Technology and the Agricultural Sciences.

Generally, the UNCST database registers fewer projects in the field of Agriculture and Engineering compared to other fields. Research projects in health and social sciences involve humans and communities and therefore, have ethical implications which compel investigators to seek scientific and ethical approval from the UNCST; many social sciences projects also involve working with communities and access to these communities or information is facilitated by the UNCST. Most of the natural sciences studies are carried out in protected areas (game parks, forest reserves, and wetlands) and in communities. Again access to these places is facilitated through the UNCST. The aforementioned reasons account for UNCST's registration of over 80% of studies conducted in Uganda in the fields of health, social sciences and natural sciences.

As for agriculture, an arrangement between UNCST and the old National Agricultural Research Organization (NARO)[2] for the latter to register agriculture studies on behalf of UNCST, and provide periodic reports on the same to UNCST did not work well, resulting in fewer numbers of agriculture studies registered by UNCST. The UNCST and the new NARO should work out new modalities for enhancing UNCST's registration of research projects in the field of agriculture.

There were generally fewer studies registered in the engineering and technology fields. It has been difficult for UNCST to register these studies because most of them are conducted in laboratories and workshops and few involve interaction with people or communities. There appears to be no compelling factor (other than enforcing compliance with the UNCST's research registration requirement) for investigators of these studies to register their projects with the UNCST. There will be need in the foreseeable future to formulate/issue new guidelines (or regulations) and to design a mechanism to enable institutions register their projects both at institutional level and with the UNCST.

1 Additional R&D information was obtained from other centres to compliment information in the UNCST register

2 The National Agricultural Research Act 2005 established a new NARO.

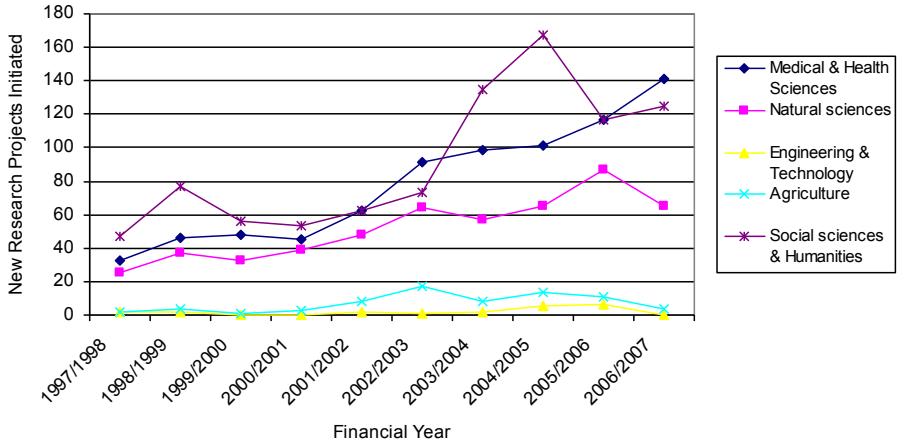

Figure 1: Number of new research projects registered annually by the UNCST between 1997 and 2007[3]

Most research institutions and university departments do not yet adequately document their R&D information. There are no well designed and functional databases within the institutions to register research activities done or being done. Where such databases exist, the information recorded about research projects is too scanty and insufficient to be meaningfully used in national planning. A national research information management system may help solve this problem. The system could be designed in such a way that it enables UNCST to register and track research progress country wide. It should also assist to establish within institutions, policies and mechanisms for capturing and recording all research work undertaken in a given institution, and have the information linked to a national node at the UNCST.

4.2 R&D distribution by field

Figure 2 below shows the distribution by field of new research projects between 1997/1998 and 2006/2007 in Uganda. The largest proportion of research projects were in the fields of Social Sciences and Humanities (36%), Medical and Health Sciences (31%), and Natural Sciences (21%). The fields of agriculture and engineering had fewer projects compared to other fields.

3 Additional research information collected from Faculties of Technology and Science in Makerere University and NARO have not been included in Figure 1 because they lacked start dates; but even if they were included, the numbers of new research projects in engineering and agriculture still remained much lower than the other fields of health, social sciences and natural sciences

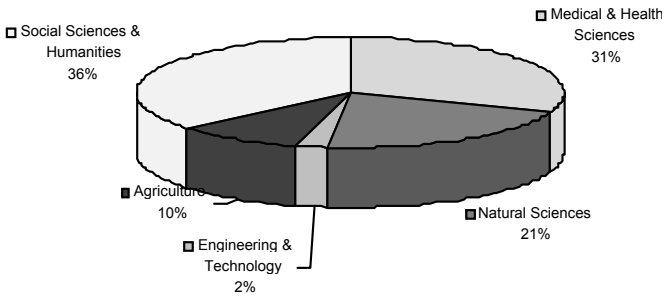

Figure 2: Research distribution by field between 1997 and 2007

Research capacity in the social sciences field is fairly well developed compared to other fields. The Faculty of Social Sciences and School of Education in Makerere University, the Makerere Institute of Social Research, Centre for Basic Research, the Refugee Law Project and a number of non-governmental organizations and initiatives contributed to the large number of research projects in the social science and humanities field.

In the Medical and Health Sciences, the global prioritization of HIV/AIDS, malaria and tuberculosis largely contributed to the many numbers of research projects in this area. A number of institutions, notable among which include the Joint Clinical Research Centre, Makerere University College of Health Sciences, and the Uganda Virus Research Institute (having most of the research conducted by Centres for Disease Control, Medical Research Council and the International AIDS Vaccine Initiative), were instrumental in building research capacities in the medical and health sciences fields.

Many of the research projects in the Natural Sciences were undertaken by foreign nationals whose interests were mainly in wildlife conservation and management issues. Most of these researchers came usually as individuals and worked in collaboration with local institutions, e.g. Makerere University Biological Field Station in Kabarole, Faculty of Forestry and Nature Conservation (Budongo Forest Research and Conservation Initiative) and the Uganda Wildlife Authority.

Agricultural research has been predominantly undertaken by the National Agricultural Research Organization (NARO) and Makerere University's Faculty of Agriculture. The review of the National Agricultural Research System which took in 2005/2006 reformed NARO and brought on board other actors (known as agricultural research service providers) from the academia, private sector, non-governmental organizations and civil society.

The field of Engineering and Technology had the smallest number of research projects compared to other fields. Research capacity in this field has been lacking for several years. Much of the research work was undertaken by the Faculty of Technology and the Faculty of Computing and Information Technology at Makerere University.

Table 4 below shows the proportion of new projects by area of research in a particular research field. This is based on a cumulative number of projects over 10 years.

Table 4: Proportion of new projects by area of research between 1997 and 2007

Research Field	Research Area	%
Social Science and Humanities	Anthropology	40
	Governance	18
	Education and sports	11
	Women and gender	10
	Trade and commerce	10
	Law, ethics and human rights	8
	Media and communication	3
Medical and Health Sciences	Communicable diseases	44
	Health policy, education & management	16
	Reproductive health, child & maternal health and nutrition	15
	Drug/substance use	9
	Non-communicable diseases	6
	Diagnostics	6
	Veterinary	3
	Environmental health	1
Natural Sciences	Biological sciences and ecology	57
	Conservation & management	19
	Earth & related environmental sciences	8
	Computer & information sciences	8
	Chemical sciences	6
	Mathematics	1
	Physical sciences	1
Agriculture	Animal and diary science	28
	Plant breeding and production	25
	Forestry	16
	Agricultural economics	16
	Fisheries	8
	Agricultural engineering	7
Engineering and Technology	Civil engineering	33
	Construction and management	22
	Mechanical engineering	21
	Electrical engineering and Information Technology	16
	Survey	5
	Architecture	3

In the field of *Social Sciences and Humanities*, most research projects were in the areas of anthropology (40%) and Governance (18%). The other areas had a fairly equal

distribution of research projects. In the *Medical and Health Sciences* field, majority of research projects were in the area of Communicable diseases (44%), of which 39% were HIV/AIDS related research projects, 23% malaria, 10% Tuberculosis and 28% in other areas. Other significant areas included Health Policy, Education and Management (16%) and Reproductive Health, Child and Maternal Health and Nutrition (15%). In *Natural Sciences*, major areas were in the Biological Sciences and Ecology (57%) and Conservation and Management (19%). There was almost equal distribution of research projects among the various areas in the agricultural and the technology and engineering fields.

5.0 R&D SPENDING

Investing in R&D would help the Ugandan economy transition into a science-based and knowledge-driven economy. The Government of Uganda currently invests in a wide range of R&D programmes, e.g. funding research, curriculum improvement and science training through the Uganda Millennium Science Initiative; direct support to R&D programmes in public research agencies e.g. Uganda Industrial Research Institute, National Agricultural Research Organization, Uganda Virus Research Institute, Economic Policy Research Centre, and more others; support to innovations to assist businesses develop and increase R&D capabilities e.g. support to scientists to add value to their research products administered by the UNCST; and support for R&D infrastructure across all sectors of the economy.

5.1 R&D Funding Structure and Mechanisms

The financing of R&D in Uganda is mainly by government and foreign or international agencies. Very little financing is from individuals and private firms. The only individuals who finance their research projects would be postgraduate students. Given that the private sector in Uganda is still too weak to make substantial investments in R&D, and development partners may have their own priorities, government bears the biggest responsibility of ensuring that funds are available for R&D. Though small, it is possible for government to finance a significant portion of its local research needs. The challenge is how to efficiently allocate and utilize the would be available financing. Apparently, there is no clear national policy on R&D financing in Uganda. Under Section 20(3) of the UNCST Act 1990 (Cap 209), government established a National Science and Technology Fund for the purpose of promoting research, but the fund has never been formally operationalised. Nevertheless, current funding mechanisms for R&D in Uganda may be categorized as follows:

a) *Budgetary support (or direct government support)* for research in government institutions. That is, core support to R&D in government institutions such as the National Agricultural Research Organization, Uganda Industrial Research Institute and public universities. This type of support mainly goes towards physical infrastructure development, administrative and personnel costs.

b) *Project support* for the purchase of scientific and technological inputs in government departments as part of institutional capacity strengthening and support to special projects. This type of financing mechanism is also used by donors and private multinational companies to support R&D projects in institutions.

c) *Grant support* for research allocated on a competitive basis. This kind of competitive award of grants for research is practiced on a very small scale in academic institutions such as Makerere University for the beneficiaries within that particular institution. However, over the last 5 years, greater attention has been put in developing competitive grants schemes to support for research. Competitive grants schemes are preferred mechanisms of financing research especially where resources are limited, provided that they are administered with transparency, and is merit-based and rule-bound. The recent reform in agricultural research financing established a competitive grants scheme for agricultural research under the National Agricultural Research Organization.

The Uganda Millennium Science Initiative (MSI) Project co-financed by the government of Uganda (US$ 3.35 million) and the International Development Association (US$ 30 million) starting initially from 2006/2007 to 2010/2011, is a good example of financing research on a competitive basis. The goal of the Uganda MSI is for universities and research institutions to train more and better qualified scientists and engineers, to conduct high quality and relevant research, and for firms to utilize the research and training outputs to increase their profitability, all for the sake on enhancing a science and technology-led economic growth. The MSI has established a Competitive Grants Funding Facility at the UNCST, with an estimated annual commitment of about US$ 4.2 million in research grants. The MSI grants are fairly sizeable, the largest single grant for research being US$ 800,000 and the smallest US$100,000 for a period of three years. The grants are awarded to multidisciplinary teams who should also have postgraduate students at Masters and PhD levels. There are no particular priority areas for the Uganda MSI. The project supports innovative ideas in all fields of science and technology provided they meet the selection criteria. An associated scheme is "Support to Scientists" which government set up in financial year 2006/2007. This scheme was initiated at the request of H.E. President Y.K. Museveni to support scientists who would have innovative near-market ideas/products/technologies. Such innovations must be capable of adding value to local (bio)resources and potentially commercializable. This scheme contributes about US$ 4.8 million annually, and is administrated through the UNCST. Technically, the Uganda MSI and the Support to Scientist schemes would be considered steps towards operationalising the National S&T Fund established under Section 20 (3) of the UNCST Act (Cap 209). In all, they are good efforts by government to support R&D, which other partners could build on by contributing directly to the fund or otherwise so as to develop within Uganda a strong national science (research) funding mechanism.

5.2 National Expenditure on R&D

In Uganda, total estimated R&D spending from all sources combined increased from Ushs. 31,870 million in 2003/2004 to Ushs. 82,249 million in 2007/2008. Between

2006/2007 and 2007/2008, R&D spending rose by 56% from Ushs. 54,689 million to Ushs. 82,249 million. Excluding expenditure by the private non-profit sector[4], spending rose by 62% from Ushs. 38,017 million to Ushs. 61,717 million in the same period (see Figure 3 below).

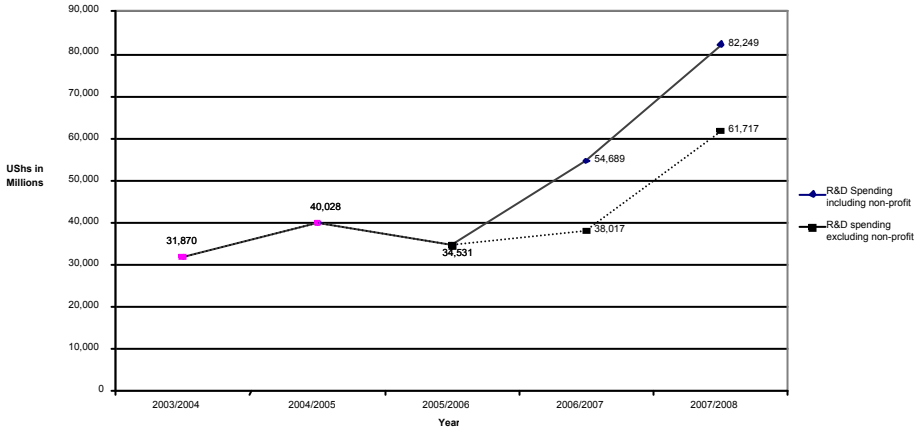

Figure 3: R&D spending from 2003/04 to 2007/08, Ushs. Millions

In general government funding for R&D activities has continued to rise since 2003/2004, with the exception of 2005/2006 which showed a considerable decline of 16% in nominal terms over the previous year. This increase in government funding for research could be attributed to the increasing recognition of science and technology as an important element in helping achieve higher economic growth rates in the medium and long term. It is also consistent with the increasing proportion of government financing of its budget, as the donor contribution as a percentage of total public spending decreases. As the economy continues to perform well, government will progressively fund a larger portion of its national budget (and R&D) from local resources.

5.3 Sources of Public Funding for R&D

The main sources of public R&D funding over the last five years have been government treasury and the donor community. The contribution from Government treasury rose by 25% (i.e. from Ushs. 27,396 million to Ushs. 34,327 million) between 2006/2007 and 2007/2008, while the donor contribution or 'funds from abroad' increased by 53% from Ushs. 27,288 million to Ushs. 41,717 million in the same period. In 2007/2008, Government committed about 42% of estimated total R&D expenditure, and donors committed about 51%. Figure 4 shows the total expenditure on R&D by source of funds for the period 2003/2004 to 2007/2008. All expenditure on R&D in the higher education sector was from abroad; whereas funding from the local private non-profit organizations was not significant.

4 Private non-profit includes: Non-market, private non-profit institutions serving households and communities (i.e. the general public); private individuals or households.

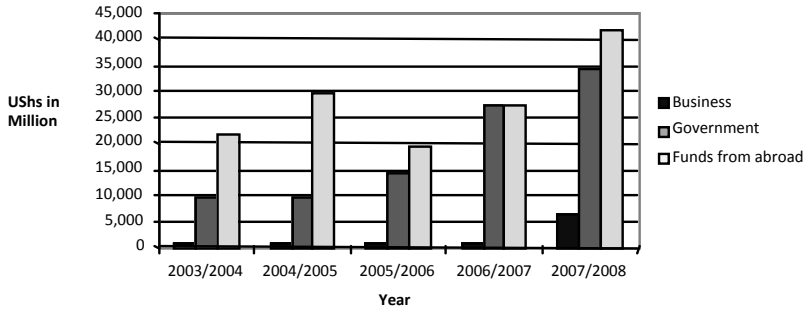

Figure 4: R&D spending by source and funds

5.4 Spending by Field of Research

Table 5 below shows national R&D expenditure by fields of research. The greatest concentration of R&D funds was in the fields of Agricultural Sciences and Medical/Health sciences, and the least in the fields of Natural Sciences and Engineering and Technology. R&D spending for agricultural sciences almost doubled from Ushs 25,674 million in 2006/2007 to Ushs 50,688 million in 2007/2008, while in the medical sciences spending increased by 45% in the same period. The remarkable increase in funding of R&D in the Agricultural Sciences field was probably brought about by the implementation of the National Agricultural Research System and in particular, the operationalization of the new NARO.

Table 5: R&D spending by field of research in Ushs/millions

Field	**FY 2006/2007**			**FY 2007/2008**		
	Recurrent[1]	**Dev't**[2]	**Total**	**Recurrent**	**Dev't**	**Total**
Natural Sciences	-	365	365	-	109	109
Agricultural Sciences	2,840	22,834	25,674	5,536	45,152	50,688
Engineering and Technology	3,030	235	3,265	3,026	1,805	4,831
Medical and Health Sciences	1,268	12,027	13,295	1,268	17,964	19,232
Social Sciences and Humanities	1,382	10,708	12,090	5,134	2,255	7,389
Total	8,520	46,169	**54,689**	14,964	67,285	**82,249**

[1] Recurrent expenditure: expenses that occur repeatedly, e.g. payment of research personnel & administrative expenses

[2] Development expenditure: capital expenses incurred to acquire or upgrade physical assets such as buildings, machinery and equipment

5.5 Performance of R&D as Percentage of GDP

Figure 5 shows the performance of R&D as a percentage of Gross Domestic Product (GDP) and total government expenditure since 2003/2004. In the past five years, Uganda's R&D performance as a percentage of GDP fluctuated between 0.2% and 0.5%. This is far below the recommended spending of at least 1% of GDP on R&D for African states. The African Union Summit in early 2007 recommended that African States should spend at least 1% of their GDP on R&D in order to foster growth and economic development in Africa (AU, 2007). In contrast, developed and emerging industrialized countries spend at least 2% to 4% of their GDP on R&D.

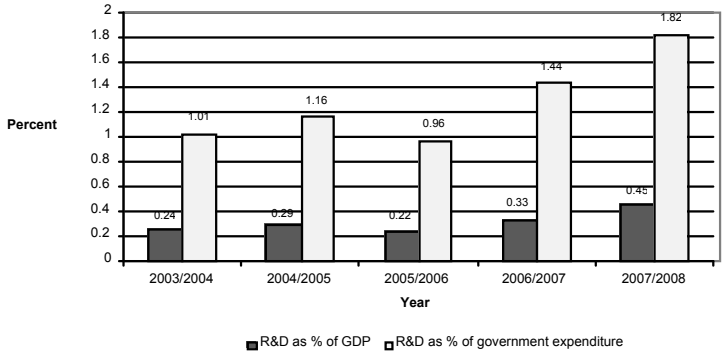

Figure 5: R&D as percentage of GDP and total government expediture

6.0 POLICY FRAMEWORK

Science and Technology is the foundation upon which many nations build and attain higher levels of economic growth and development. Countries which have deliberately planned for and invested in science and technology are the leading competitors in the global economy today. Both public and private enterprises in these countries have developed high-level capabilities to effectively create, distribute and utilize scientific and technological knowledge and skills in the production of goods and services. In Uganda, the government recognizes the importance of science and technology in accelerating economic growth and social transformation. This recognition is reflected in various key national planning documents including the Poverty Eradication Action Plan (which is to be replaced by the National Development Plan), Uganda National Council for Science and Technology Act, Draft National Science, Technology and Innovation Policy, Draft Vision 2035, and the Plan for Modernization of Agriculture.

6.1 Key National Policies

a) Constitution of the Republic of Uganda, 1995 (as amended)

The Constitution is the supreme law in Uganda. All policies and laws are derived from the Constitution. The Constitution clearly stipulates that the State shall stimulate agricultural, industrial, technological and scientific development by adopting appropriate policies and the enactment of enabling legislation.

b) Poverty Eradication Action Plan (PEAP)

The PEAP is Uganda's comprehensive development framework and medium term planning tool, with a particular focus on poverty reduction. It also guides the formulation of government policy and their implementation. The PEAP is currently being revised, and will from 2009 be replaced by a 5-year National Development Plan (MFPED, 2007). The PEAP is structured around 5 pillars viz: 1) Economic Management; 2) Enhancing Production, Competitiveness and Incomes; 3) Security, Conflict Resolution and Disaster Management; 4) Good Governance; and 5) Human Development. Matters of science and technology, research and training are addressed more prominently under pillars 2 and 5. Government financing is usually tied to the PEAP. In a number of cases, agencies' programmes have been evaluated for their conformity with the PEAP as a precondition for public funding. The continuing challenge is for research and academic institutions to align their research projects with the PEAP objectives.

c) Draft National Science, Technology and Innovation Policy

The formulation of this policy was one of the activities UNCST embarked on in 1993/1994. The goal of the policy is to strengthen Uganda's capability to generate, transfer, and apply technologies ensuring sustainable utilization of natural resources for the development of the country (MFPED, 2007). This policy is still in draft form, but likely to be adopted soon. The policy outlines some of the strategies to overcome key issues affecting research in Uganda such as low level of coordination among stakeholders, duplication of efforts, low capital base, inadequate infrastructure and limited funding; weak research capacity and challenges of commercializing research products. Some critical areas that the policy emphasizes are R&D in traditional, conventional and emerging technologies, including, among others, indigenous knowledge, biotechnology, nano technology, information and communication technology, and micro electronics. These areas are also in line with UNCST priorities of increasing agricultural productivity and food security; improving human health; information and communications technology development; sustainable use of natural resources and protection of the environment; biotechnology development; materials development and construction technologies; and energy systems development. Just like other policies, the successful implementation of this policy requires practical involvement of many actors including government (both central and local governments), the private sector, civil society and other stakeholders.

6.2 Sectoral Research Policies

There are a few sectoral policies specifically for research. Notable among these is the National Agricultural Research Policy, 2003 (MAAIF, 2003). This policy provided for the enactment of the National Agricultural Research Act, 2005 which reformed the national agricultural research system (NARS). The NARS is a new concept that gave semi-autonomy status to former institutes of the National Agricultural Research Organization (NARO), and brought on board other entities engaged in agricultural research service provision such as universities, civil society, farmers groups, private sector, etc. Under the NARS, agricultural services providers must register with NARO, which

is the coordinating body for agricultural research in Uganda. The former NARO institutions became public agricultural research institutes and zonal agricultural research institutes. The NARS objectives include:

a. Transform agricultural production into a modern science-based market oriented agriculture capable of greater efficiency, profitability and of sustaining growth in the agricultural sector while contributing to poverty eradication;

b. Promote agriculture and related industry for the purposes of contributing to the improvement of the quality of life and livelihoods of the people, having regard to the protection of the environment; and

c. Support the development and implementation of national policy with relevant information and knowledge.

An arrangement similar to the NARS is being discussed for the health sector. A national health research policy has been drafted and is undergoing stakeholder consultations. A body to coordinate health research is being proposed: The Uganda National Health Research Organization (UNHRO). However, unlike the new NARS, the proposed UNHRO follows the old NARO model which failed. It is hoped that lessons learnt in the reformation of the NARS will be used in designing the National Health Research System.

As for industry, there is no specific policy proposed, except the current National Industrialization Policy. The policy provides broadly for utilization of scientific research in industrial innovations. The Uganda Industrial Research Institute (UIRI) is the lead institution to undertake and facilitate applied industrial research for the development of optimal production processes for Uganda's nascent industry. The UIRI is strengthening further its collaborations with the academia (especially Makerere University and Kyambogo University), research institutions and firms in a range of its programmes including incubation services, pilot industrial plants, and technology internships.

Government also approved a National Biotechnology and Biosafety Policy in April 2008 to ensure safe application of biotechnology in Uganda. The policy paves way for use of genetic engineering and related techniques in agriculture, medicine, industry, and environment protection. The specific aims of the policy are to build and strengthen Uganda's biotechnology R&D capacity, promote use of biotechnology in production, provide a sound regulatory framework for bioengineered organisms, and promote the ethical and responsible use of biotechnology for national development purposes.

Overall, national policies for research in Uganda are sector based. They are found in pieces of legislation and sectoral policies. The closest harmonization of these policies is provided under the proposed National Science, Technology and Innovation Policy.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Government recognizes that investing in R&D is an important strategy to achieve higher rates of economic growth and social transformation; the challenge is how to make this investment. In making this investment, government ought to emphasize synergies, cooperation and interaction among the many actors in the research system. Therefore, the creation of multidisciplinary research groups and/or strengthening local inter-institutional and regional and international collaborations is essential to propel Uganda's research enterprise forward.

As a central coordinating institution, UNCST's role becomes paramount in brokering relationships and partnerships among various actors in the research system. This implies, inter alia, increased sharing of research policy related information with actors and partners in the research system, leveraging more resources and support for research, and improving standards of research practice and quality assurance. This also calls for the strengthening of UNCST's capacity to generate and disseminate relevant research information to guide public policy in science and technology. In this connection, setting up a more robust national research information management system will be desirable in the medium term.

R&D spending in Uganda is increasing but still far below the recommended levels (at least 1% of GDP annually) to make economic impact. Government should make progressive annual increases in its allocations for R&D spending in a bid to increase national R&D spending to reach at least 1% of GDP in the medium term. This spending could be directed more towards supporting research programmes aimed at increasing agricultural productivity, adding value to agricultural products and other bio-resources, understanding disease and developing new biopharmaceuticals tapping into the rich indigenous knowledge base, developing new materials for construction and manufacturing, finding alternative methods of waste management and pollution control, using information and communication technologies to improve service delivery, enhancing nutrition of children, developing efficient and environmentally benign energy systems, and improving water quality and sanitation at the community and in the households.

Recent reforms in the NARS and the Uganda MSI have shown that national competitive grants schemes could be a viable mechanism of funding research in Uganda, given the limited resource base. This allows the concentration of resources to highly productive groups working on the most innovative and relevant projects. The Competitive Grants Funding Facility established by the Uganda MSI at the UNCST should be consolidated. For a start, an annual Government allocation of Uganda Shillings 10 to 16 billion to the national competitive science funding/grants scheme at UNCST would be reasonable in the short and medium term. Development partners should be invited to contribute to this scheme to support R&D in Uganda in more sustainable way.

The policy framework for research in Uganda is found in different pieces of legislation and sectoral policies. It is believed, however, that the Draft National Science, Technology and Innovation Policy would provide a better coordinated framework for support not only to research, but also to all aspects of science and technology. Government should, therefore, accelerate the adoption of this policy.

7.2 Recommendations

a. Improve the efficiency of research regulatory and support services in Uganda;

b. Local research institutions and universities should set up institutional intellectual property/technology management and innovation policies;

c. Design a mechanism or strategy (such as a national research information management system) to enable institutions register (document) their projects both at institutional level and with the UNCST; have the information linked to a national node at the UNCST;

d. Build more research capacity in the fields of engineering, technology and physical sciences;

e. Have a clear national policy on R&D financing in Uganda;

f. Accelerate the adoption of the national science, technology and innovation policy;

g. Consolidate the competitive grants funding facility established by the Uganda MSI at the UNCST. For a start, an annual Government allocation of Uganda Shillings 10 to 16 billion to the national competitive science funding/grants scheme at UNCST should be made; and development partners should be invited to contribute to this scheme to support R&D in Uganda in more sustainable way.

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3.4 Paper III

Biotechnology Developments in Uganda and Associated Challenges

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ABSTRACT

Biotechnology is an important tool whose application Ugandan scientists are exploring in crop, fish and livestock improvement, value addition, waste management, and in medicine. However, the continuing growth of biotechnology or more broadly, biosciences as an enterprise in Uganda will depend on the support given to science and technology generally. To accelerate this growth, Government must ensure supportive science and technology structures such as: a national science funding facility for research and technology development; institutional governance systems which promote innovativeness, and high quality education at all levels to maintain a constant supply of a skilled bioscience workforce. Specific measures at institutional level could include: establishing more synergies between biotechnology programmes and strengthening interactions among the actors both locally and internationally; integrating biotechnology into institutional programmes and regulatory instruments; putting in place technology management policies and developing capacities for their implementation; encouraging private sector participation in commercialization of bioscience innovations, supporting spin-off bioscience-based companies through a national innovation and commercialization fund; and eliminating administrative bottlenecks in procurement and financial management through early and more coordinated planning. This paper gives highlights of biotechnology developments and the associated challenges in Uganda.

Key Words: Bioscience, biotechnology, policies, science and technology

INTRODUCTION

Uganda has embraced science, technology and innovation as the cornerstone for economic growth and development (Ministry of Finance, Planning and Economic Development, 2010). Priority appears to be in promoting science education, research in and value addition to bio and agro-based products. The country could have a competitive edge in developing a bio-resource economy given its rich natural resource potential. For this reason, biotechnology is rapidly advancing within the country as a tool to improve crop, livestock and fish production, manage toxic wastes, and develop new materials and improve medical diagnostics and therapeutics. However, the continued growth of biotechnology as an enterprise will depend a lot on how the multiplicity of actors in the field relate with each other, and the foundational support given to science and technology generally. This paper presents key achievements and challenges in biotechnology in Uganda.

Historical perspective

Avramovic (1996) described biotechnology as "a variety of techniques involving living organisms or their parts as a means of production". Traditionally, baking bread, brewing beer and making cheese and yoghurt employ biotechnology. In this paper, however, biotechnology is closely associated with transgenic organisms or use of recombinant DNA techniques. Biotechnology became prominent in Uganda around 1993 when the Department of Animal Science in the Faculty of Agriculture at Makerere University proposed to test a transgenically derived bovine somatotropin (BST) hormone for growth and milk production in Ugandan cattle. The BST hormone which was to be imported was produced through the genetic engineering of agrobacteria. At the time, the United States of America and the European Union (EU) were deeply engaged in debate over trade on genetically modified organisms. Later that year, in November 1993, the EU placed a moratorium on the sale of BST. In 1995, another proposal was made to conduct a Phase 1 clinical trial of a candidate HIV-1 vaccine (ALVAC vCP 205). The vaccine construct was a live recombinant canary pox vector expressing HIV-1 glycoproteins 120 and 41. It was the first preventative HIV-1 vaccine study in Uganda and in Africa (Cao, et al., 2002). The BST and ALVAC vCP 205 vaccine proposals made to Uganda National Council for Science and Technology (UNCST) to a large extent formed the basis for the formulation of national biosafety guidelines, leading to the establishment of a National Biosafety Committee in 1996 (Ssebuwufu, 1998). Later, in April 2008, government passed a national biotechnology and biosafety policy for Uganda. To date, research into biotechnology continues and remains strategic for Uganda. This research ranges from laboratory-based investigations of novel genes conferring resistance to pathogens, drought and other biotic and abiotic stresses, to field trials of transgenic crops, for example, banana, cotton, maize, potato and cassava. Any prospects of moving promising transgenic products to the market require a proper understanding of the constraints and opportunities within the biotechnology innovation system as a whole.

Biotechnology research and development in Uganda

Biotechnology research and development related work in Uganda is growing (Baguma & Sengooba, 2007; Juma & Serageldin, 2007; Clark, Mugabe & Smith, 2007). The following are highlights of some of the work:

In agriculture, molecular markers are being used to characterize crop pathogens (e.g. the fungus cercospora zeae-maydis which causes gray leaf spot disease in maize and the sweetpotato feathery mottle virus). Genetic diversity of crops, and marker assisted selection for viral and disease resistance (e.g. resistance to cassava mosaic disease, cassava brown streak virus and coffee wild disease) are also being studied. Research is being done to genetically improve East African highland bananas for resistance to banana bacterial wilt, nematodes and weevils as well as to enhance its nutritional value. Confined field trials of bio-engineered bananas which begun in 2007 to confer resistance against black Sigatoka disease caused by the fungus Mycosphaerella fijiensis continue at the National Crop Resources Research Institute (NACRRI) near Kampala City.

Further, confined field trials of herbicide tolerant and insect resistant transgenic Bacillus thuringiensis (Bt) cotton and transgenic cassava resistant to cassava brown streak virus begun at National Semi-Arid Resources Research Institute and NACRRI, respectively. Micropropagation of bananas and pineapples using tissue culture for commercial purposes is being done at Agro-Genetic Technologies Ltd (AGT). The latter is also exploring new protocols for coffee multiplication. In the livestock subsector, identification of drug resistant trypanosome genes is ongoing. Other work include development of animal vaccines and improved diagnostic tools for Bovine pleuropneumonia, Newcastle disease, and east cost fever.

In the health sector, molecular markers are being used to study the pharmacokinetics and characterization of drug resistance, especially resistance to anti-malarial drugs, anti tuberculosis drugs (multi-drug and extremely drug resistant tuberculosis), and antiretroviral drugs for HIV/AIDS. Phase 1 clinical trials of DNA based vaccines developed elsewhere using recombinant adeno 5 virus vector are also ongoing.

In the field of environment, genetic markers are being developed to characterize various species of wildlife including elephants, hippopotamus, buffalo and fish. The results of these studies would be used for conservation planning. A search for and bioengineering of microorganisms to optimize nitrogen removal from heavily contaminated sites is ongoing. Over the years, organizations in Uganda have developed capabilities for bio-engineering work. Table 1 shows capabilities in 8 leading organizations in Uganda that carry out biotechnology related work.

Table 1: Key biotechnology capabilities in 8 institutions

Common Techniques	**Institution**							
	FoAMU	NARLI	NACCRI	MBL	AGT	JCRC	UVRI	FaVMU
DNA finger printing	X	X	X	X		X	X	X
Transformation		X						X
Marker Assisted Selection	X		X					
Tissue culture-micro-propagation	X	X	X		X			
Tissue culture- disease elimination	X							
Tissue culture -germplasm conservation								
Tissue culture-somatic embryogenesis	X	X						
Diagnostics-PCR	X	X	X	X		X	X	X
Diagnostics-ELISA	X	X	X	X		X	X	X
Gene cloning		X				X	X	X
Microarrays/Real time PCR	X		X			X	X	
Nucleic acid hybridization		X		X		X	X	X
DNA Sequencing						X	X	
Proteomics						X	X	X

Key

FoAMU- Faculty of Agriculture, Makerere University

NARLI- National Agricultural Research Laboratories Institute

MBL- Med Biotech Laboratories

JCRC- Joint Clinical Research Centre

UVRI- Uganda Virus Research Institute

FaVMU- Faculty of Veterinary Medicine, Makerere University

Human capital in biotechnology

Systematic efforts to build a critical mass of biotechnology experts in Uganda started in the late 1990s. The East African Research Network for Biotechnology, Biosafety and Biotechnology Policy Development (BIO-EARN) Programme which started in 1998 was one of the pioneer programmes to provide targeted training in biotechnology. The programme initially trained four Ugandans at doctoral (Ph.D.) level in biotechnology related areas through a sandwich between Makerere University and Universities in Sweden. The programme continued to train twelve students at masters (M.Sc.) and two more students at Ph.D. level using the capacity it had developed. Other initiatives such as the Rockefeller Foundation, USAID, and Association for Strengthening Agricultural Research in East and Central Africa (ASARECA) have also made significant contributions in training more human resources in biotechnology. Consequently, modest capacity now exists within the country to supervise biotechnology training at postgraduate levels, provided students can occasionally access more advanced facilities abroad, such as the state-of-the-art scientific facilities at Biosciences East and Central Africa in the International Livestock Research Institute in Nairobi, Kenya. Already, this arrangement for biotechnology training is being implemented by a number of programmes including Agricultural Biotechnology Support Programme of the USAID, BIO-EARN, BiosafeTrain, ASARECA, Regional Universities Forum (RUFORUM), and the Uganda Millennium Science Initiative of the UNCST. Together, these programmes will train locally up to 70 M.Sc. and 20 Ph.D. students in biotechnology related areas by 2012. Biotechnology related work was by end of 2009 being undertaken by a total core scientific workforce of about 200 scientists only, 30% of whom had Ph.D. and about the same number with M.Sc. Technicians and related support personnel comprised the remaining 40% of the workforce. To increase this human capacity, RUFORUM initiated in 2008/09 a new regional postgraduate programme which offers taught Ph.D. and M.Sc. in Plant Breeding and Biotechnology. The postgraduate programme is hosted by Makerere University (in the Faculty of Agriculture).

Biotechnology governance and regulatory issues

Government approved a National Biotechnology and Biosafety Policy for Uganda in April 2008. The policy aims to ensure safe application of biotechnology in Uganda. The policy paves way for use of genetic engineering and related techniques in all fields of science and technology. The specific aims of the policy are to build and strengthen Uganda's biotechnology research and development capacity, promote use of biotech-

nology in production, provide a sound regulatory framework for bioengineered organisms and promote the ethical and responsible use of biotechnology for national development purposes. There were no specific policies which appeared to hinder biotechnology in Uganda. However, plans are underway to enact a National Biosafety Bill, which is hoped would create a much stronger legal framework for biotechnology in Uganda.

UNCST is the national agency for coordination of biotechnology and biosafety in Uganda. It has over the years developed functional systems for biosafety management of research protocols on bioengineered organisms, and is coordinating the regulation of biotechnology in the country. These efforts resulted in the adoption of the aforementioned National Biotechnology and Biosafety Policy (2008) and the drafting of a Biosafety Bill. Nevertheless, given the cross cutting nature of biotechnology, other regulatory agencies such as the National Drug Authority, the Phytosanitary Inspection Division of the Ministry of Agriculture, Animal Industry and Fisheries, Uganda National Bureau of Standards, and National Environment Management Authority also need to integrate biotechnology and biosafety into their existing regulatory regimes and institutional programmes. These agencies are, by virtue of their mandates, partners in the regulation of bioengineered products and services in the country. It is important, therefore, that they revise and update their regulatory instruments to cover bioengineered products and services as well, and develop specific capabilities for their implementation in this regard.

Public research organizations and universities need institutional intellectual property or technology management policies to protect proprietary knowledge and information, and to allow easy licensing and/or transfer of technology. Such institutional policies facilitate regional and international collaboration and exchange of research materials and information; and the development of partnerships for product development, especially with the private sector. So far, only Makerere University, has an institutional intellectual property and innovation policy which was approved in early 2008. Other universities and research organizations including, for example, the National Agricultural Research Organization, the Uganda Industrial Research Institute, need to establish theirs too.

Administrative inefficiencies in financial and procurement management are emerging challenges public research organizations and universities must address. In 2003, Government enacted the Public Procurement and Disposal of Public Assets Act which prescribes rules and procedures of how public funds ought to be used to acquire goods, works and services. The law aims, inter alia, at ensuring the application of fair, competitive, transparent, nondiscriminatory and value for money procurement and disposal standards and practices by public agencies. This procurement law is not, however, well understood by most scientists, and many public organizations still struggle with its implementation. As a result, there have been inefficiencies in procurement, leading either to delays in acquiring goods, works and services or scientists not getting items with the right specifications for their work. In so far as most research is externally funded, and even when locally financed, proper accountability for funds and more ef-

ficient procurement management are paramount in sustaining research collaborations, and ensuring timely and high quality scientific work. Therefore, early procurement planning and timely procurement are necessary, and the scientists themselves as users must be involved in the procurement process.

Interactions among biotechnology actors

In Uganda, key actors in biotechnology research and innovation are in the public research organizations and universities, mainly Makerere University and the National Agricultural Research Institutes. The actors somehow know each other, but not so much about what each one is doing. Interactions among them are generally weak and very informal, as it depends on the initiative of an individual scientist. Interactions with the private sector are even much weaker, although it is common to find active scientists/ researchers in the public sector who make reasonable effort to collaborate with private organizations -firms, farmers and non-Governmental organizations. Firms are often reluctant to reciprocate because they tend to focus more on immediate results and short term financial gains (salary and allowances). It is, therefore, difficult to trace a true symbiotic relationship between public sector scientists and entrepreneurs in the private sector. However, collaborations between local scientists and their counterparts abroad appears to be stronger, perhaps because foreign partners have more advanced scientific facilities which the local scientists can access periodically. Partners abroad also provide training opportunities for local scientists to enhance their skills, and are also seen as a gateway to international research funding sources. In this regard, it is important that Ugandan scientists develop and nurture strategic international science and technology partnerships to support growth of the biotechnology enterprise in Uganda. In all, interactions among local biotechnology actors in Uganda as well as with their counterparts abroad need to be strengthened. One way would be to have more "bio-2biz" type of fora focusing on enterprise development opportunities arising from bio-science innovations in the public research organizations. The aim of such fora would be to seek collaboration with partners at the outset of research and to identify partners in product development and dissemination. These would be complimentary forums to ongoing initiatives such as the Open Forum for Agricultural Biotechnology (OFAB) which was established in December 2007 through partnership between UNCST, International Food Policy Research Institute's Program for Biosafety Systems, and the African Agricultural Technology Foundation headquartered in Nairobi, Kenya. The OFAB is a monthly luncheon organized by UNCST which brings together scientists, policy makers, media and the public to discuss topical agricultural biotechnology related issues globally and nationally.

Financing of biotechnology

A larger proportion of biotechnology work in Uganda is funded from abroad. Most of the financing comes through research collaborations, and draw from competitive grants in the international community. The major sponsors of biotechnology work by 2009 were: Swedish International Development Agency (Sida) through the BIO-EARN Programme and the bilateral research collaboration program between Makerere

University and Swedish universities, USAID, Rockefeller Foundation, Bill and Melinda Gates Foundation through the Alliance for a Green Revolution in Africa (AGRA), ASARECA, Monsanto and Government of Uganda through the Uganda Millennium Science Initiative (MSI) project. A sustainable national funding mechanism for research and technology development is required in Uganda. Government should establish a national science funding mechanism which is predictable, transparent and merit based, and which makes grants for research and technology development available annually both directly and on a competitive basis. This dual financing arrangement for research and innovation is not new. Countries with a true commitment to advancing science and technology as an engine for economic growth and development have established their own national science funding agencies. South Africa, for example, has the National Research Foundation and United States of America has the National Science Foundation. Countries like these compete favourably in the international market, because their industry and commerce is backed by science and technology strategically financed from domestic sources. In Uganda, an emerging good example would be the MSI which in 2007, 2008 and 2009 awarded several large grants on a competitive basis to support research, innovation, and science curriculum development. This type of funding allows for training of more scientists, equipping research facilities, and can sustain longer term research and innovation programs in organizations, including enlarging employment opportunities for scientists. Government can build on the success of its MSI, and allocate more resources to it so that grants are awarded annually to productive research groups. It is estimated that Government contribution of approximately US$ 5 to 8 million annually to the MSI type of funding in the medium term would support implementation of more than 50 large research programmes with at least 250 scientists participating in any given year. In this way, scientists would be motivated to think creatively and innovatively all the time, because they would be assured, somehow, of a possibility of getting funding for their projects. It is also an incentive to retain highly skilled scientists in the country and to attract those in the Diaspora. Further, it is arguably the most appropriate way to support and sustain bilateral cooperation in science and technology and joint research activities. By adopting such dual financing for research and innovation, government tap the real potential of Ugandan scientists to contribute to economic growth and national prosperity. Additionally, some type of "bridging finance" would be needed. That is, small amounts of money which would facilitate the crucial product development phase of an innovation, moving the innovation sufficiently along the product development pathway for it to become of interest to potential private partners. Such funding would be provided through a microcredit scheme or as alluded to above through an innovation fund such as the existing Presidential Support to Scientists fund, and the Uganda MSI grants for technology platforms.

Private sector involvement

Private bioscience-based enterprises in Uganda are yet to evolve. Public research organizations will for some long time be the major players in biotechnology research, product development and dissemination. However, government can encourage private

commercialization of bioscience innovations by supporting spin-off bioscience-based companies. Spinoffs would have an added advantage of attracting more technically skilled workforce into private sector. However, for a start, Government could provide venture capital for innovation and commercialization of research products independently or through the Uganda Development Corporation, to interested scientists who would like to start a bioscience based enterprise. Government has to intervene because there are no private venture capitalists in the country as yet for bioscience-based innovations. Furthermore, private sector could be deliberately supported to exploit business opportunities that arise from innovations in public research organizations. Public research organizations should not only focus on directly commercializing their innovations; but they may also, through well established technology management policies, license these innovations to the private sector.

CONCLUSION

The biotechnology or more broadly, biosciences enterprise in Uganda is growing, but this growth is dependent on the foundational support given to science and technology generally within the country. Strong supportive science and technology structures are needed. These include: a national science funding facility for research and technology development; institutional governance systems which promote innovativeness; and high quality education at all levels to maintain a constant supply of a skilled scientific workforce. In addition, public research organizations in Uganda need play a more active role in forging the links which are essential for innovation.

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3.5 Paper IV

Managing Intellectual Property: Eastern African Universities and Research Institutes can do more to help Scientists

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ABSTRACT

Universities and research institutes in Eastern Africa do not have sufficient and functional policies, structures or mechanisms for managing intellectual property. Proper management of intellectual property requires an organization at the minimum to have an intellectual property policy or rules. With the exception of Moi University and the University of Nairobi, none of the participating organizations in the BIOEARN Programme between 2006 and 2009 had a functional institutional mechanism for managing intellectual property. In all the organizations, the scientists' awareness and appreciation of intellectual property protection was very low, and no well defined intellectual property management programs could be traced. This notwithstanding, however, intellectual property legislation exists in Eastern Africa, but the instruments to utilize the regime at the organizational level is lacking. It is therefore crucial for universities and research institutes in Eastern Africa to have in place operational policies for managing intellectual property, not only for the scientist, but also for attracting private sector participation and sustenance of international research collaboration.

Keywords: East Africa, intellectual property, policy, research, university.

INTRODUCTION

In 2000, the media in Kenya reported a controversy between University of Nairobi (UoN) and Oxford University scientists over a patent filed by the latter in the United Kingdom (UK) covering sequences used in an HIV in vaccine product (Wachira Kigotho, 2000). The product was developed as a result of a collaborative research project in which some commercial sex workers in Nairobi were found to have developed immunity to HIV due to their repeated exposure to the virus. The controversy arose because the patent did not include the UoN scientists as co-inventors. The UoN scientists got concerned and complained about their exclusion from the patent. In response, the UK scientists argued that their Kenyan counterparts did not provide "intellectual" input into the design of the vaccine product, and therefore, could not be named as co-inventors. At the time, the UoN did not have a functional institutional intellectual property (IP) management policy. After a series of talks, however, the controversy was resolved through an agreement whereby the Kenyan scientists, their UK counterparts and the research sponsors would jointly own the patent and proportionately share royalties should the product be commercialized (Levings, 2001).

This case illustrates the IP related challenges which scientists working in Eastern African universities and research institutes face due to lack of functional systems within their institutes to manage IP. Between October 2006 and June 2007 the BIO-EARN Programme conducted an assessment of IP assets and the freedom to operate (FTO) in its partner institutes in Ethiopia, Kenya, Tanzania and Uganda; and found that a significant number of IP assets exist in the institutes. However, institutional policies for managing the IP did not exist; or where they existed, they were very weak. It was evident that IP matters were given low priority within the institutions. Scientists had limited awareness and lacked appreciation of IP protection, despite the fact that relevant national IP laws exist in all the countries (Asiimwe, 2008).

This policy paper is based on the IP and FTO assessment carried out in BIO-EARN partner institutions. It presents an argument for universities and research institutes in Eastern Africa to develop institutional IP management policies and structures in order to encourage innovation, facilitate international collaboration, assure scientists of a reward system, and attract private sector investment in science-based enterprises.

Definition of IP and the Freedom to Operate

Intellectual Property is used here to mean the creative ideas and expressions of persons which have been fixed in some material form (Jacob, Alexander & Lane, 2004). In practice this translates into, for example, a written document, or a new song, or a new computer program, or a new plant variety or a new machine, or a new molecule and so on and so forth. The government can protect these creative works and ideas by granting the owners of the works and ideas legal rights to prevent anyone from using the IP for a given period of time. Such rights are called Intellectual Property Rights (IPR), and they include mainly patents, copyright, and trademarks. If a scientist is able to undertake research or commercial development of a product without infringing on these rights, then the scientist is said to have the "freedom to operate" (FTO).

RATIONALE

Currently there are about 50 scientists and 40 postgraduate students in Ethiopia, Kenya, Tanzania and Uganda working collaboratively on BIO-EARN research for development (R4D) projects. The BIO-EARN contributes to regional economic growth by developing biotechnologies for use in enhancing agricultural productivity, adding value to industrial products and processes and environmental management.

The R4D projects, the details of which can be obtained from www.bio-earn.org, involve: 1) developing new sorghum varieties with multiple tolerance to disease, drought and poor soil conditions; 2) developing new methods for breeding virus free sweet potatoes and cassava; 3) developing innovative technologies for treating highly toxic waste water from abattoirs and leather tanning industries; 4) developing new technologies for producing biogas from sisal and fish wastes. The fifth project provides policy related support to facilitate the development of the anticipated R4D products and their eventual uptake by the private sector.

Each of the scientists and the partner institutes has some IP they are bringing into the collaboration; and they would also be working with proprietary technologies developed elsewhere. Each project has prospects of developing innovative products or processes with potential for industrial application or commercialization. It was thus necessary to understand, right at the beginning, the existing IP asset base at each of the partner institutes, the potential IP arising from each project, the FTO for each project, and the institutional structures/mechanisms of managing the expected IP.

International collaboration is essential for research institutes in Africa to be part of the bioscience revolution. Management of IP is for that reason an increasingly important part of research collaboration, technology transfer, and commercialization of research. Research institutes in Africa, therefore, need to increase their capacity to manage IP.

METHODOLOGY

Relevant national policies, policy documents, legislation and institute reports were reviewed in each country. This was followed by interviews with the scientists involved in the BIO-EARN R4D projects. An IP assessment form was also designed and given to institute officials and/or BIO-EARN scientists to complete. Lastly, a preliminary search was made to determine the FTO for each project.

Nine institutes were involved in the assessment. These were: in Ethiopia - Addis Ababa University; in Kenya - Moi University, University of Nairobi, Kenya Agricultural Research Institute, and Kenyatta University; in Tanzania - Mikocheni Agricultural Research Institute and University of Dar es Salaam; and in Uganda - Makerere University and the National Crop Resources Research Institute.

FINDINGS

With the exception of Moi University and the University of Nairobi, none of the participating institutes had a functional institutional policy/mechanism for managing IP. In the majority of the institutes, IP matters are conveniently assigned to the legal office, which is more often preoccupied with more pressing and somewhat urgent central administrative and non-IP related issues.

In all the institutes, the scientists' awareness and appreciation of IP protection was rated very low. There was no evidence of a well defined IP program at the institutes. In very rare circumstances individual scientists proactively tried on their own to identify and seek outside support to protect their IP, but often with less success.

The lack of sound IP management at the institutes has also kept the private sector at bay. Because of lack of a system (IP management) that inculcates trust, private companies prefer to have informal "gentleman's" agreements with individual scientists to undertake specific tasks, usually for a small fee. Unfortunately, these informal arrangements are risky and difficult to sustain and do not comparatively add much value to the institute's long term research and innovation agenda.

Within the BIO-EARN R4D projects, the prospects of generating attractive IP are good. A preliminary FTO analysis found no restrictions on the use of acquired research materials (which are mainly germplasm).

For each of the projects, the expected IP would be:

Project 1: *Developing biotechnologies to ameliorate biotic and abiotic stresses in sorghum*: new techniques for speeding-up breeding for resistance to drought, aluminium toxicity and low phosphorus availability in the soil and plant disease stresses through the use of marker-assisted selection; and new sorghum varieties which confer multiple tolerance to the above stresses.

Project 2: *Toward sustainable cassava and sweet potato production in East Africa*: new diagnostic tools based on micro-array technology for viral diseases of cassava and sweet potato; marker assisted breeding techniques for virus-resistant sweet potato and cassava; and an innovative seed delivery system for clean sweet potato and cassava planting materials.

Project 3: *Development of efficient technologies for the sustainable treatment of high strength waste water in Eastern Africa*: a process of treating high strength waste water from abattoirs and tanneries using locally isolated microorganisms, and a process of enhancing microbial community structures in bioreactors.

Project 4: *Development of improved technologies to utilize industrial and agricultural waste for bio-energy and value added chemical production:* a process of recovering polyunsaturated fatty acids from fish waste; a process of producing biogas from fish-processing waste water and fish waste; and an integrated process of converting sisal waste into biogas.

The mode of protection (i.e. patents, plant variety protection, trademarks, copyright, etc) of the above potential IP may be appropriately determined at filing.

KEY ISSUES

Based on the above observations, there are issues to consider at the institute and the national level:

Institute level issues

Universities and research institutes in Eastern Africa do not have functional policies, structures or mechanisms of managing IP in their respective institutes. In order to properly manage IP, an institute must at the minimum, have an IP policy or rules. Such a policy would provide guidance to everyone in the institute on how to handle IP. The policy would spell out the relationship between the scientist and the institute and how to deal with third parties outside the institute; it would outline the process of how a scientist in the institute would go about protecting an IP, and how both the scientist and institute would share revenues when the IP becomes commercially viable. These provisions would also be reflected in the employment contracts of scientists within the institute and in all contractual arrangements with other parties.

National level issues

Although IP legislation exists in all BIO-EARN participating countries, their effectiveness has not been sufficiently tested because scientists are not actively filing for IP protection. This notwithstanding, with the current advancements of biotechnology research and product development in the region, some critical issues need to be clarified in the national laws. These issues relate to: plant variety protection vis–a-vis the popular tradition of farmers saving seeds; access to genetic resources and the sharing of benefits thereof; and restrictions on patenting "life forms" - plants and animals. It is equally important for countries to arrive at some degree of harmonization of positions on the above issues in order to foster regional collaboration in research and technology development.

BIO-EARN'S RESPONSE

The BIO-EARN marks its 10th anniversary in 2008. In this decade of service to the science community and people of Eastern Africa, the BIO-EARN has contributed in training highly skilled scientists in biotechnology and biosafety, generated scientific knowledge, equipped laboratories with state-of-the-art scientific and information and communication technology infrastructure; and catalyzed the formulation of national biotechnology policies in the partner countries.

In the next 3 years, the BIO-EARN will support its partner institutions to develop and/or strengthen their IP management capacities, with emphasis on institutional IP policy formulation, setting up IP offices, training IP personnel and sensitizing scientists. In April 2007, the BIO-EARN established a 10-person Intellectual Property Management Committee (IPMC) comprising representatives from each BIO-EARN partner institute. In 2008, BIO-EARN will commit significant funding for IP capacity building in partner institutes. The goal is to have systems within BIO-EARN institutions not only for managing IP, but also for promoting product development partnerships with the private sector, and uptake pathways for innovative products expected from the R4D projects.

In conclusion, IP management starts at the institute where innovation takes place. Scientists should, however, guard against the temptation of making IP an end in itself when planning or executing projects. The goal should rather be the challenge which the project seeks to address; and IP matters automatically becomes a component of the project ensuring ownership and technology dissemination

RECOMMENDATIONS

Universities and research institutes in Eastern Africa should develop institutional policies and build capacity to manage IP. Without an institutional IP policy, and the capacity required to implement such policies, it is impossible to manage IP regardless of the sufficiency of existing national IP laws.

Scientists within the institutes need to be sensitized about the importance of IP protection. As a start, practices such as maintaining laboratory note books should be encouraged. The institute could also designate a staff member to liaise with other colleagues on IP matters, including arranging for occasional internal IP seminars.

Governments in the region need to progressively expand their research funding portfolios - work towards allocating at least 1% of GDP to research and development within the next decade. Investing more in research and technology development would inevitably increase the chances of generating more IP and more opportunities for creating science-based business enterprises.

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PART 3

Chapter 4 – CONCLUSIONS AND WAY FORWARD

4.1 Summary of the papers

Paper I presented how science, technology and innovation was (or was not) integrated in the national development planning framework of Uganda. From the 1960s until the 1990s, the push to integrate science and technology into the national planning framework was more by exogenous influences, notably the UNESCO ministerial conferences on science and technology for the development of Africa. Over the years, there has been an awareness of the need to use science, technology and innovation as the vehicle for economic growth and development. But this need was not systematically provided for within the national development planning framework. Moreover strategies on how to use science, technology and innovation to bring about desired outcomes of economic growth seemed to be lacking. Therefore, while exogenous influences such as continental or regional initiatives were important in raising awareness of the importance of science, technology and innovation among policy makers and political leaders, they were not sufficient in themselves to achieve the integration of science, technology and innovation into national development planning process. It was not until 2010 that science, technology and innovation featured vividly in the national development plan of Uganda. Arguably, successful integration of science, technology and innovation into the national development planning framework may be realized more when approached endogenously.

Paper II provided an overview of the research system in Uganda. For quite a long time, research in Uganda was disconnected from industry, and had little influence on decision making processes. However, transformations appear to be taking place within the

system with renewed interests to invest more in research and innovation. This paper provided a succinct overview of research in Uganda, and identified key policy issues that needed to be addressed. It showed that government spending on R&D was on average 0.3% of GDP p.a. between 2003 and 2008, which was far below the 1% recommended for African Union member states. It identified the need to establish a competitive funding model (merit-based system) for research in Uganda. The paper also highlighted priority areas where research investment could be targeted such as, increasing agricultural productivity, adding value to agricultural products and other bioresources, understanding disease and developing new biopharmaceuticals supported by the rich indigenous knowledge base, developing new materials for construction and manufacturing, finding alternative methods of waste management and pollution control, using information and communication technologies to improve service delivery, enhancing nutrition of children, developing efficient and environmentally benign energy systems, and improving water quality and sanitation at the community and in the households. Finally, the paper identified the need for increased synergies within the research system and more interactions between actors to promote innovation.

Paper III specifically looked at the growth of biotechnology as an enterprise in Uganda. Significant R&D work is taking place using biotechnology as a tool, especially in crop, fish and livestock improvement, value addition, waste management, and in medicine. However, the continuing growth of biotechnology or more broadly, biosciences as an enterprise in Uganda will depend on the support given to science and technology generally. This paper makes important recommendations which include: the need to set up a national science funding facility for research and technology development; having in place institutional governance systems which promote innovativeness, and ensuring high quality education at all levels to maintain a constant supply of a skilled bioscience workforce. Specific measures at institutional level should be made, among which are: the need for more synergies between biotechnology programmes and strengthening interactions among the actors both locally and internationally; integrating biotechnology into institutional programmes and regulatory instruments; putting in place technology management policies and developing capacities for their implementation; encouraging private sector participation in commercialization of bioscience innovations, supporting spin-off bioscience-based companies through a national innovation and commercialization fund; and eliminating administrative bottlenecks in procurement and financial management through early and more coordinated planning; and universities and research institutes have to play a greater role in supporting creation of bioscience business enterprises through spinoffs or cooperation with existing firms and clusters.

Paper IV argues specifically that universities and research institutes in Eastern Africa need to have operational policies for managing intellectual property. This is critical in fostering bioscience innovation in the region. The paper argues that intellectual property legislation exists sufficiently, but instruments at the institutional level to utilize the regime are generally lacking. Such instruments are essential, not only for the scientist, but also for private sector involvement and sustenance of international research collab-

oration. Practical suggestions on how universities and research institutes may go about managing their intellectual property are made. Some of these include, for example, outlining the process through which a scientist in the institute would go about protecting his/her intellectual property, and how both the scientist and institute would share benefits when the intellectual property becomes commercially viable. Some national level policy issues were also identified. These issues relate to plant variety protection vis–a-vis the popular tradition of farmers saving seeds; access to genetic resources and the sharing of benefits thereof; and restrictions on patenting "life forms" - plants and animals. Countries in the region may need to harmonize their positions on these issues in order to foster regional collaboration in research and innovation.

4.2 Conclusions

When trying to identify an emerging[1] innovation system in Uganda it seems that universities and public research organizations were playing a leading role. Less attention was paid to developing innovative capacities of the business and informal sectors. Therefore the gap between academia and industry appeared not to be closing. This scenario may gradually be changing, however, as more people begin to appreciate the need to establish connections between academia, government and industry. Anecdotal evidence suggests a growing interest among academia and industry actors to collaborate, and some successful cases can be traced. An observable fact is a growing pool of entrepreneurial-minded people in universities who are creating or joining businesses, and government officials getting into academic programs and participating in enterprise development. This cross fertilization of interests may signal the beginning of transformations within academia, government and industry that allows these institutional spheres to have overlapping but complementary roles- a phenomenon associated with Mode 2 knowledge production and Triple-Helix processes.

This notwithstanding, some specific actions could be taken to foster growth in Uganda's innovation system. First, it is important that research and innovation priorities are aligned with the aspirations of the national development plan which are: growth, employment and socio-economic transformation for prosperity. Whereas the country continues to register more research in health, social sciences, natural and agricultural sciences, a deliberate effort is required to promote research and innovation in the engineering and physical sciences fields as well. The low number of research (and innovation) in engineering and physical sciences (e.g. –accounting for only 2% of research in 2008) does not reflect the country's commitment to modernize agriculture, add value to natural resources and expand manufacturing.

Second, national funding modalities for research and innovation should be streamlined and institutionalized. A dual funding mechanism is required, which on the one part involves increasing core funding to universities and research institutes, and on the

1 Uganda's innovation system has not yet attained the full functionality of a stable innovation system such as the ones seen in developed western economies.

other, awarding competitive grants annually for research and innovation, i.e. through a merit-based system. The grants should be sufficiently large in size to employ research staff and support students training at postgraduate level.

Third, there is need to focus on the innovator, and to create enabling conditions for productivity enhancement at the work place. Quite often, policy makers in Uganda tend to concentrate on anticipated outputs from research and innovation investments, but overlook and downplay the essential needs of the scientist or innovator which include, inter alia, access to financing for innovative projects, business incubation services, efficient procurement and financial management, favorable employment terms, access to information and freedom to operate. Most of these needs can be met through innovative administrative and institutional reforms, particularly in public organizations and universities.

In conclusion, there is an evolving innovation system in Uganda. The recent designation of science, technology and innovation in the National Development Plan, and a growing number of research and innovation-related initiatives in the country manifest this evolving innovation system.

4.3 Scientific contribution and originality

This work is a contribution towards a deeper understanding of Uganda's evolving innovation system. The study adds to knowledge on the application of concepts such as innovation systems, triple helix and mode 2 in low income countries like Uganda. Importantly, it also contributes to the ongoing discourse on how research and innovation processes occur and innovation systems evolve in low income countries. Furthermore, it may be a useful reference resource for policy makers and all partners engaged in innovation processes, especially to guide investments in research, technology and innovation competence building.

4.4 Way forward

Noting the constantly changing research and innovation landscape, and the increasing emphasis on building innovation systems, it is important for Uganda's innovation policies to support linkages and interactions between knowledge producers (academia), government and industry within country and abroad, and develop mechanisms to foster collaboration. This research will make contributions towards this end.

The next step in the study is to investigate further co-evolution processes taking place both at the macro and micro level in Uganda's innovation system. Specific emphasis will be made on interactive learning patterns and how they influence the direction of research and innovation in Uganda. This will be achieved through a number of activities including a cross-sectional survey of manufacturing firms in the subsectors of food and beverages, chemicals and pharmaceuticals. In addition, micro or sub innovation systems will be analyzed using the Technological Innovation Systems analytical frame-

work proposed by Hekkert, Suurs, Negro, Kuhlmann, & Smits, (2007), and social network analysis tools. These subsystems include among others: shear butter innovation system in northern Uganda; bio-energy innovation system in central Uganda, and tropical fruit processing innovation system also in central Uganda. These activities will hopefully be completed within eighteen months.

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ABSTRACT

Research and innovation are key drivers for economic growth and competitiveness of countries. Of recent research and innovation-related initiatives have arisen in Uganda pointing to an evolving innovation system in the country and to the need to deepen understanding of the transformations taking place therein. This thesis provides evidence of this evolving innovation system in the country and makes recommendations to foster growth in it. A participatory research approach was employed using a combination of both qualitative and quantitative tools including key informant interviews and review of key policy documents, organizational reports and publications. Findings show that the role of research and innovation in driving economic growth and development was recognised in Uganda as early as the 1950s and 60s. But practical measures on how to integrate them into the national development planning process were lacking. It was not until the 1990s and 2000s that a realistic number of research and innovation initiatives started to emerge. These initiatives ranged from increased support to research, science policy development to supporting innovative business clusters. Arguably gains from these and other efforts would be enhanced, if government adopts a dual funding strategy for research and innovation, which on the one hand involves annual competitive grants and on the other hand increased core support to universities and research institutes. The public organizations create within them enabling conditions for creativity and enterprise development. The quality of education is improved at all levels to maintain a constant supply of a skilled scientific workforce. Ultimately, these efforts require inclusive innovation policies, which promote linkages and interactions between actors engaged in innovation processes both in country and abroad.

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