

Higher Education Research, Science and Technology Transfer: A Look at the Policy Strides made in East Africa

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Abstract

Universities must continue to improve their relationships with enterprise. This is vital not only so that universities could provide work experience and job opportunities for their students, but also so that business principles would inform teaching; while enterprise, in turn, could benefit from research and excellent graduate employees. Recent significant changes in industry are raising the level of collaboration between the commercial public, private sectors and universities, bringing about a cultural shift in higher education. The world over, governments have enacted policies to promote university-industry technology transfer; and various universities have adopted formal intellectual-property policies, and have established technology transfer offices to manage their partnerships. This is, however, lacking in most African nations. In recent years, a key concern for policy-makers has been how to ensure that the wealth of knowledge generated within universities can be transferred to industry, so that society in general, and local businesses in particular, could benefit from universities' scientific and technological expertise. The time, therefore, seems ripe to embark on an analysis of the policies governing university-industry partnerships for technology transfer in East Africa – with a view to identifying some of the efforts made by the governments of the five countries forming the East African Community in facilitating such partnerships.

Key words: Higher Education, Policy, Science, Technology Transfer, East Africa

Background and Literature Review

Jofre and Andersen (2008) say that nurturing innovation through policies and actions has become a priority in both the public and private sectors, and that such policies and actions, according to Grimpe and Fier (2010), Camison and Fores (2010), Etzkowitz et al. (2008) focus broadly on facilitating and regulating the transfer of knowledge and technology among the multiple actors in the innovation system that includes the university, government, and industry. Industrial innovations provide the main driving force for economic growth, and thus bring about competition among countries. There are two principal theories behind this: The demand-pull theory, and the science-push theory. Whereas the demand-pull theory emphasizes market forces as the main determinants of technical innovations leading to economic growth, the science-push theory recognizes that science and technology are independently the determinants of industrial innovations (Mwamadzingo, 1995).

Researchers have, however, argued that the two are complementary to each other, given that a successful innovation needs both interaction between the market needs and the ever-dynamic science and technology.

To achieve meaningful innovations and development, the universities and governments must interact with industry (Jofre, 2008); and the kind of relationships they have would define the success and operations of the innovation system. The role of the university, industry and government, and their level of interaction, should be evaluated by the outcome of their innovations. The innovation-system theory has been applied to different organizational and spatial levels from firms, technologies, sectors, regions, to nations

whereby, as Freeman (1987), Lundvall (1992) and Nelson (1993) indicate, the innovation-system approach was initially developed at the national level, giving rise to the popular concept of a National Innovation System or (NIS). This view is reinforced by OECD (1997), noting that the concept of national innovation systems assumes that the flow of technology, knowledge and information among people, firms, and Research and Development (R&D) institutions is crucial to the innovative process, thus determining the innovation performance of the country.

The main innovation agents in a NIS have been identified to consist of private enterprises/industry, universities, public research institutes, and the people within them. And the interaction between agents produces a variety of formal and informal linkages.

When looked at from the National Innovation systems (NIS) perspective, the growth of any economy is to a great extent determined by the industry, rather than the government and university education (Etzkowitz & Leydesdorff, 2000). The Triple Helix model, however, looks at these interactions from a slightly different perspective. It emphasizes the role of university education in innovation systems, and recognises its co-dependence with and within government and industry. The model, according to Etzkowitz and Leydesdorff (2000), supports the hypothesis that universities, governments and industry play an equally important role in innovation, and that their interdependency is what defines the outcomes of the innovation system over time.

The triple-helix approach of University-governments-industry linkages has resulted in important organizational changes within universities. According to Jofre and Anderson (2008), the innovation systems are in a transition stage, and at different degrees of change. Such transitions are broadly motivated by the challenge of globalization and sustainable development, and are transforming the profile of the triple-helix relationships. This observation is even more relevant in the context of knowledge-based economies and emerging views on innovation – for example, the case of innovation as an open system or as an eco-system.

In the light of globalization, innovation has acquired strategic relevance in the quest to increase and sustain the economic growth of nations (Jofre & Andersen, 2008). In this context, governments from the developed and developing world see innovation as a strategy to increase their competitive advantage on the global stage.

As Justman and Teubal (1991), and Bell and Pavitt (1983) explain, technology is central to the development process, and long-term structural change is driven by technology; the growth of systems is an evolutionary process; and therefore, technological and organizational learning cannot be circumscribed; explicit efforts and investments are essential preconditions for learning and development.

Learning is not an automatic outcome of the accumulation of capital and investment. The new economies that are more complex can no longer be based on the simple production of goods for local markets and on the sole combination of labour and capital; since, as noted by Berkhout et al. (2006) and Von Hippel (1988), the conceptual development of innovation and its study as a field of theory and research have changed noticeably. Berkhout et al. (2006) explain such a conceptual transition through a sequence of three consecutive generations of innovation models.

These researchers explained that the initial and traditional model of innovation that is linear, from basic research to commercialization, is now being replaced by a second-generation model, in which the source of innovation is not science, but the market, in effect therefore, reversing the first-generation model. In a third-generation model, on the other hand, innovation is no longer based on a linear sequence of stages, but on an open process, which focuses on organizational research and development (R&D) collaboration efforts, to induce product and process innovations of a technical nature.

Berkhout et al. (2006) criticise these three models. Here, they point out: The first innovation model focuses excessively on the technology push and on the role of science generating ideas that are of reduced or of no value whatsoever; the second generation focuses on the market pull, emphasizing the role of innovation as a driver of performance improvement, but neglecting long-term research aiming at radical innovations; and the third generation, although balancing technology push and market pull, in order to increase the technological capabilities of the organization, tends to neglect the role of non-technological innovation.

The critique of Berkhout et al. (2006) has suggested a fourth generation model, in which innovation is embedded in a system of partnerships or “open innovation”. In this model, emphasis is given to the relationship between science and industry, the need to complement the knowledge of technologies with knowledge of markets, the need to create or adapt organizational capabilities, according to the networking requirements, and the role of entrepreneurship as a fundamental driver.

The university has undergone two major revolutions, according to Etzkowitz (1998). The first was an academic revolution, which made research a function of the university; while the second is the integration of economic function into the academic equation. Universities are now becoming more entrepreneurial and business-minded. Powell et al. (1996) notes that there is a complex web of relationships among academics – with universities originating business enterprises in which academics themselves are involved. This is well illustrated by Nobel-prize winner, Arthur Kornberg, in his book: ‘The Golden Helix’ (Kornberg, 1995). Here, he expressed bewilderment that a highly focused academic scientist, such as himself, had become an advocate of industry/academic intersection, finding it fruitful for both science and business (Blumenthal, 1986).

Latour and Woolgar, (1979) view an entrepreneurial scientist as one who is closing the gap between research and the utilization of the products, one who is encouraged to look at research results from a dual perspective: 1. A traditional research perspective in which publishable contributions to the literature are entered into the 'cycle of credibility'; and 2. An entrepreneurial perspective in which results are scanned for their commercial, as well as their intellectual potential. This is a dramatic shift from the traditional single mode.

As Etzkowitz (1998) puts it, seeking for funds has always been an important activity in the American research system, which demands a lot of entrepreneurial energy. The phantasy figures by a World Bank report of the year 1999 indicate an uneven distribution of science and technology effort worldwide (World Bank, 1999). There are a great deal of variations in the potential of various countries engaging in science and development (Michaela, 2000). According to Michaela, statistics show that the industrialized countries produce an average of 55.8 per cent of the world GNP, and they deploy about 84.5 per cent of the world's gross expenditure on research and development.

On the other hand, the developing countries produce an average of 2.2 per cent of GDP, deploying only about 0.5 per cent of the world's gross expenditure on research and development. There is, consequently, also a great disparity in the development of patents as a measure of technological output with the developed countries – including Western Europe, North America, Japan and the newly industrialised countries, accounting for more than 95 per cent of the patents registered between the years 1990-1995 (Michaela, 2000). It is not easy, however, to characterise an ideal technology transfer (Stankiewicz, 1985; Rothwell, 1985; Moe, 1983; Menon, 1987; Kenney, 1986; OECD, 1984). This transfer can take many forms including: academic consultancy faculties, contract research organizations, university spin-offs, and innovation brokers to research and science parks.

There is, consequently, the question of how accurately these interactions can be measured. Even though the innovation-system literature has grown and diversified steadily, Grimpe and Fier (2010) assert that the underlying dynamics of knowledge and technology transfer are not yet fully understood; nor are their definitions universally accepted. For instance: How are the informal interactions and knowledge transfer measured? It is easy to point out formal mechanisms for the transfer of knowledge and technology, since they are documented as either patents or licenses, notably in reference to collaboration frameworks linking university research and firms R&D activities (Motohashi, 2008). This cannot be the case with the informal transfer of knowledge. Consequently, there is little research on the context of informal transfer, although there is evidence suggesting that its occurrence and relevance in national innovation systems might well be considerable (Grimpe & Fier, 2010).

It is important to note that at the national level, the structure, functions, and performance of the innovation system are affected and shaped by the micro-economic and regulatory environment, as expressed by Gu and Lundvall (2006); and the view of innovation, as the result of a national system is seen to imply an

evolutionary approach to social and economic change. In this evolutionary approach, innovation and technological progress derive from a particular socio-economic path of development constructed by and shaped through history (Jofre, 2011). Research has shown that a country's ability to create and utilize new and innovative technologies for development is largely determined by the level of its research activities, as well as its policies and programmes that promote research and technology transfer. These abilities, as noted by Porter and Scott (2001), are also determined by the quality of linkages between these institutions and firms.

Various arguments have been put forward regarding the relationship between university and industry interactions (Stenkiewicz, 1985). One is that university industry linkages have been fuelled by economic factors. Due to the global economic recession many countries are finding it important to strengthen their technological innovations to stay at the cutting edge of competition. Many academic and research institutions are now getting increased funding for science and technology activities keen on innovations. There is, however, a fear that these institutions are being underutilised, and therefore require strong policies to incorporate them in the development process. Secondly, it is argued that the current interest in the university-industry relationship is caused by the interdependence of many new technologies, like information technology and new material and products.

These new technologies require high degrees of academic interaction in basic research and co-operation among people with diverse specialities and advanced science and technology environments.

Blackman and Segal (1993) list some of the benefits of strong collaborations between enterprises and universities as being: The opportunity to attract more funds for teaching and research; collaborative research with enterprises pulling in more public funds when governments are involved; acquisition and/or access to modern equipment; opportunities for staff and students to familiarise themselves with state-of-the-art industrial science and technology management systems; improved interaction between university departments and employers; supplementary incomes from consulting; and enhancement of the higher educational image as a contributor to the economy. The most important driving force is the necessity for higher education institutions to generate supplementary income.

Many countries, especially developing countries, are experiencing the pressure of quantitative expansion with declining public resources. Funds set aside for research are shrinking; and thus, the need to diversify the resource-based contracts with industry.

It has been demonstrated that centres of commercial innovation generally profit from links with universities (OECD, 1984); and this is corroborated by Jaffe (1989) in his article, pointing to the positive effect of university research on local industrial research and development spending, and on the local rate

of innovation. Michaela (2000) explains that most developed countries, like those in North America, have achieved long-standing relations between universities and industry, a domain that higher learning institutions are now encouraged by their governments to explore. These linkages have been intensified by resource constraints, especially in developing countries, and the need for relevance of the institutional activities.

Most institutions are, consequently, having some form of collaboration with industry; and it is worth noting that these collaborations are receiving a lot of attention in institutions' policies and structures (Lee, 2000).

Notably, there were no policies on technology at the beginning of industrialisation in these countries, but many implicit policies were adopted as part of the restructuring process of industrial society (Mudenda, 1995). These included policies that had a direct bearing on industrial and economic development. In Britain for instance, the introduction of a stratified education system, based on the public and comprehensive schools, ensured the stability of the class system that would lead to economic development. The public schools trained those who were meant to become industries' managers, while the comprehensive schools trained those with skills to work in the industry.

Mudenda (1995) noted that the United States of America, on the other hand, adopted a liberal education policy that was instrumental in producing a modern industrial labour force. The technical colleges in Germany had very strong links with industry, and were used in the preparing of a labour force suitable for the development of scientific industry. The newly industrialized countries, like Japan, according to Mudenda (1995), however, had explicit technology policies, which were advocated as an integral part of industrial and economic development. Their policies spelt out scientific research and experimental-design work, the introduction of scientific and technological achievements into the national economy, the enhancement of material and technological aspects of scientific work – to ensure that such advances achieved mechanisation and automation of production, financing science and technology research, capital investment in the development of science and technology, and the training of science and technology personnel.

Nicholas (2011) notes that the economic success of the Japanese innovation system in the past was supported by the development of domestic capabilities rather than by any inflow of foreign knowledge; but now universities in Japan are moving from national to global collaborations (Lee et al., 2010). Sun and Negishi (2010) also point to the weakening collaboration between university, industry, and government in Japan – in favour of the increasingly foreign-centred nature of the knowledge creation and diffusion networks.

Technology developed within a research institution gives it a competitive edge. In this era, when public funding for research is either dwindling or non-existent, research-industry linkages, which facilitate commercialisation may be a partial route out for the sustenance of research in institutions of higher learning (Wolson, 1999). While public and international research institutions in developing countries were established to produce for the public good, the changing times demand that these institutions move in tandem. In view of this, there is an ever-increasing need for the review of government and institutional policies to facilitate increased and sustained research-industry linkages, in order to tap into the financial and infrastructural strengths of the private sector.

Unfortunately, according to Ogbu, Oyeyinka and Mlawa (1995) institutions in Africa have not been effective in stimulating innovation and industrial growth, because they have only limited co-operation with industry. Research institutions are normally concerned with their own internal, urgent problems of staffing, structuring proposals to attract donor funding, and expansion. On the other hand, industry is preoccupied with its own problems (Sheikhupura Chamber of Commerce and Industry 2010), such as the lack of adequate markets, institutional rigidities, inefficient and inadequate infrastructures; and it is usually unaware that the researchers might have plausible solutions to such problems. The contacts that exist between institutions of research and industry are mainly limited to contracts and consultancies, which more often than not serve to supplement individual salaries and retain staff (Mwamadzingo 1995).

It is possible that many remain unreported and may happen at the expense of the concerned research institutions. In academic institutions, the members of the faculty often take up partnerships in the form of contracts, in order to raise funds, rather than to follow their research interests; and, according to Mwamadzingo (1995), this is partly due to the limited funding they receive from the exchequer towards research.

In East Africa, as in other developing countries, the relationship between research institutions and industries is weak. While the research institutions do little to establish working relationships with local companies (Mwamadzingo, 1995), the firms think poorly of institutes' abilities, and expect little from them. As a result, research institutions do little or no industrial research, and are used by a few companies that usually want to access testing facilities. Industries, in most cases, seek new technologies from the developed world, or from the emerging economies. Given a choice, the industry would prefer a foreign technology over one that is developed locally.

The role of universities in the innovation process is natural (Mwamadzingo, 1995), because of their multidisciplinary nature, their competence in undertaking basic research, their reservoirs of knowledge and information, and their ability to recruit young talent. The role of universities in bringing about technological innovations, and therefore national development, has been underscored; but, unfortunately this is not the case in developing countries. Universities in developing countries are pre-occupied with their own internal problems, such as inadequate resources (Mwamadzingo, 1995). Lall (1992) observed

that the structural weakness of industry in sub-Saharan Africa is central to the explanation of Africa's deindustrialisation. He identified incentives, institutions' capabilities and the right mix of policies as the means through which industrialization could be revived.

Developing countries have always been passive recipients of technology. They have, however, started to review their policies on science and technology application for development. One of the efforts is through the Regional Impact of Information Society Technologies in Africa (IST-Africa), a multi-stakeholder initiative that is focused on reducing the digital divide in Sub-Saharan Africa. The former United Nations Secretary-General, Kofi Annan said in November 2002 that: "While ICT cannot address all of [Africa's] problems, it can do much to place Africa on a firmer industrial footing... and [to] strengthen the continent's human resources, with training that leads to sustainable livelihoods".

Supported by the European Commission, under the Framework Programme 7 (FP7), IST-Africa (2009 - 2011) is a multi-stakeholder Initiative focused on: Skills Transfer to Support Research-Capacity Building and Science and Technology Development in Africa, and on community building to support European Union-African Research Co-operation. This is a collaborative initiative between International Information Management Corporation (IIMC), Ireland as Coordinator, the Department of Science and Technology (South Africa), the Ministry of Communications, Science and Technology (Botswana), the Ministry of Communications, Science and Technology (Lesotho), the Ministry of Education (Namibia), the ICT Policy Implementation Technical Unit (Mozambique), the National Computer Board (Mauritius), the Tanzania Commission for Science and Technology, the Uganda National Council for Science and Technology, the Ministry of Higher Education, Science and Technology (Kenya), Ministère de l'Enseignement Supérieur et de la Recherche Scientifique (Burundi), the Ministry in the President's Office in charge of Information and Communication Technology (Rwanda), the Agence Nationale des Technologies de l'Information et de la Communication (Cameroon), the Ministère de la Recherche Scientifique (Senegal), and the Ministry of Communications and Information Technology (Egypt).

During 2009 - 2011, IST-Africa focused on supporting the Implementation of the 8th Africa-European Union Partnership on Science, Information Society and Space, thereby strengthening the research dimension of Information Society policy dialogues between the European Commission and African countries and key regional organizations; it also focused on the analysis of African ICT policy and research priorities, including long-term perspectives aligned with European Union priorities and recommendations for future Africa-European Union co-operation initiatives, including the identification of matching counterpart funding, and the raising of the awareness of African research capacity, promoting the participation of African organisations in the ICT Theme of FP7 (FP7-ICT), and identifying co-operation opportunities in fields of mutual interest.

The goal was to increase the visibility of mutual research technology, development potential, and network-relevant African and European stakeholders. The opportunity to showcase relevant research capacity was provided through an annual IST-Africa Conference.

The policy initiatives described in this paper point to the efforts made by countries in East Africa – who are evidently recognising the need for science and technology in economic development. The mechanism linking universities and research institutions with the production sector in East Africa appears to have failed to bear much fruit; and there is widespread concern that research at the universities and research institutions is not focused on the needs of the industry. A bulk of the research results remains unused, thus limiting the effectiveness of science and technology.

Higher Education Research, Science and Technology-Policy Initiatives in Kenya

Since Kenya attained its independence in 1963, various efforts have been made – with the emphasis on science and technology – intended to bring about the country's development. At independence, Kenya adopted the British system of education of 7 years' primary schooling, 4 years of secondary schooling, and 2 years of high school, followed by 3 years of university education. In 1985, there was a shift from the British 7-4-2-3 system to a new system of education, the 8-4-4 system: with eight years of primary education, 4 years of secondary education, and 4 years of university education (Republic of Kenya, 1981).

This change was prompted primarily by growing unemployment; and the 8-4-4 system was intended to nurture self-sufficiency. The curriculum proposed under the 8.4.4 system of education included vocational subjects, besides the general knowledge subjects. These were introduced to equip students with skills that match the needs of industry, as well as entrepreneurial skills. This objective has, however, not been fully addressed, as the challenges remain – with the curriculum undergoing several changes since its introduction – in an effort to respond to the expectations.

With regard to skills training, the country has four national polytechnics, 17 institutes of technology, one technical teachers' training college, and 21 technical training institutes. In addition, there are over 600 youth polytechnics distributed throughout the country. However, only 350 of the youth polytechnics receive Government assistance. The private sector operates close to 1 000 commercial colleges that offer courses in computers and non-technical areas of training.

In addition to the institutions above that fall under the auspices of the Ministry of Higher Education, Science and Technology (MOES&T), other Government Ministries operate institutions that provide specialised technical training. These include institutions run by the Ministries of Home Affairs, the Office of the President, Agriculture, Health, Water-Resource Management and Development, Roads and Public

Works, and Labour and Human-Resource Development, among others. Overall, the management of Technical, Industrial, Vocational and Entrepreneurial Training (TIVET) institutions is spread across 10 ministries. This makes co-ordination of their activities and the maintenance of training standards difficult, as the supervision of most of these institutions is left to individual ministries and the private sector, which often lacks the capacity to ensure quality and high standards of training.

Due to the limited places available in TIVET institutions, only a small proportion of eligible school leavers are admitted. Every year, less than a half of those graduating from the primary schools either join the Youth Polytechnics for artisan training; or they enroll directly for apprenticeship training in the 'Jua Kali' sector (Jua Kali is a Swahili term referring to Kenya's informal sector of the economy). For many trainees, TIVET programmes are terminal – with few options for further training. The existing education and training structure, therefore, needs to be reviewed, in order to establish opportunities that link TIVET programmes with those of higher institutions of learning, as this strategy has the potential to enhance skills training and to play a vital role in industrial transformation, economic growth, and poverty reduction.

Quality research requires sufficient funding, the availability of highly trained research staff, adequate and appropriate facilities and equipment. Kenya needs to give R&D the priority in national development, in order to achieve this objective.

Currently, the overall responsibility for the management of R&D lies within the MOES&T. The ministry provides the overall national policy guidelines on science and technology, whereas the National Council for Science and Technology (NCST) undertakes the advisory and co-ordination functions. At the sectoral level, the management of R&D remains the responsibility of individual Government ministries and departments, since they implement R&D programmes and activities in their respective sectors.

Despite the critical role R&D plays in the national development, it faces various challenges that include: ineffective co-ordination between the various actors, the poor harmonization of research policies, and limited research funding (0.6 per cent allocation of GDP – although what is disbursed is much less). Other challenges include a de-linked R&D from development, limited appreciation for the role of R&D, limited research and especially applied research, inadequate mechanisms and arrangements for dissemination and utilization of research findings, the absence of any up-to-date research bank of inventories and directories of what has been done or is being done.

In addition, there is only limited demand-driven and collaborative research between universities/research institutions and private sector/industries, weak institutional capacity in terms of human resources and

equipment, inadequate prioritisation of research vis-à-vis goals, aspirations and commitments (Republic of Kenya, 2005).

As expressed in the Sessional paper no. 1 of 2005, the current policy framework for education, training and research, the Government of Kenya has committed itself to working with tertiary and university managements, to deliberately target the mobilization of more financial resources from the private sector, industry, grants, and fee payments to students. Government grants to these institutions are to be earmarked for financing the basic and critical capacity and skills needed for national development. The private sector and students are, therefore, required to contribute more towards the financing of quality tertiary and university education and training.

In its Vision 2030, a road map to economic development, Kenya recognises the role of education and training as one of the key social sectors in the transformation of society; the rest being: Health; Water and Sanitation; the Environment; Housing and Urbanization; Gender, Youth, Sports and Culture; as well as Equity and Poverty eradication. Under education and training, Kenya has committed itself to provide globally competitive quality education, training and research to the citizens – for their development and enhanced individual wellbeing. The overall goal for 2012 is to reduce illiteracy by increasing access to education, improving the transition rate from primary to secondary schools, and raising the quality and relevance of education.

Other goals include the integration of all special-needs education into learning and training institutions, achieving an 80% adult literacy rate, increasing the school enrolment rate to 95%, and increasing the transition rates to technical institutions and universities from 3% to 8% by 2012. Public and private universities are encouraged to expand their enrolment, with an emphasis on science and technology courses and the achievement of competitive international ranking for Kenyan students in mathematics, science and technology.

The specific strategies involve; a revision of the curricula of university and technical institutes by including more science and technology subjects. In partnership with the private sector, the Government also recognises the need to increase funding – to enable institutions of higher learning to support those activities envisaged under the economic pillar, and to be a regional centre of research and development in new technologies.

Kenya has also established the National Council for Science and Technology (NCST) under the ministry of Higher Education Science and Technology (MOHEST), whose mandate includes the development and implementation of Science and Technology Innovation (STI) Policy, research development, research authorization, and the co-ordination of Technical Education (TE). Besides the NCST, The ministry

operates with three technical directorates, namely: The Directorate of Research Development (DRD), the Directorate of Technical Education (DTE), and the Directorate of Higher Education (DHE). Policy priorities include:

- Strengthening the National STI standing and its competitiveness;
- Improving the quality, relevance, equity and access to higher education and technical training;
- Promoting evidence-based policy-making and national development;
- Encourage private sector participation in STI and technical education;
- Enhancing the capacity of the national STI system towards demand-driven STI, quality higher education and technical education services, as well as the effective use of existing talents and facilities; and
- Promoting excellence, creativity, innovation and investment in STI, higher education and technical education.

The Ministry hopes to achieve its goals by bringing and working with research institutions at both national and international levels; higher education institutions, including the technical institutions; public and private universities. Among the International Research organisations that are currently working in Kenya are: The International Livestock Research Institute (ILRI); World Agro-forestry Centre (ICRAF); International Centre of Insect Physiology and Ecology (ICIPE); International Potato Centre (CIP); International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); Centre for Agriculture and Biosciences International (CABI). While the Public Research Bodies include: The Kenya Agricultural Research Institute (KARI); the Kenya Medical Research Institute (KEMRI); the Kenya Forestry Research Institute (KEFRI); the Kenya Industrial Research Development Institute (KIRDI); the Kenya Fisheries Research Institute (KMFRI); the Kenya Institute for Public Policy Research and Analysis (KIPPRA); the Kenya Trypanosomiasis Research Institute (KETRI); the Kenya Sugar Research Foundation (KESREF); Coffee Research Foundation (CRF); Tea Research Foundation (TRF); Institute of Primate Research (IPR); Institute of Policy Analysis and Research (IPAR); the Tegemeo Institute of Agricultural Policy and Development; National Museums of Kenya (NMK); the Kenya Plant Health Inspectorate Service (KEPHIS); National Environmental Management Authority (NEMA); and the Kenya Wildlife Service (KWS).

There are seven public universities, on the other hand, which have constituent colleges and campuses across the country, and about 26 private universities at various levels of recognition. Most of these research institutions get into partnership with the universities and other institutions of higher learning – primarily for the purpose of students' placements. The ministry has so far played a rather minimal role in linking up the university and research institutions – let alone spearheading ties between universities and industry – for key research activities, innovations and technology transfer.

A study sponsored by the Commission for Higher Education (CHE) confirmed that there is some collaboration between industry and universities in Kenya (Gichaga et al., 2005). Internship and industrial attachments are a requirement in professional degree programmes, such as business, law, engineering and

ICT in Kenyan universities. Some private universities, such as Strathmore University and USIU have an attachment requirement for all their degree programmes. These attachments result in some level of collaboration between the universities and industry. There are, however, weaknesses – as most of the links with international universities are not well structured. They are particularly weak in the area of Intellectual Property Rights (IPR), because most Kenyan universities do not yet have operational IPR policies. Consequently, it is possible for a university to lose IPR to a foreign university.

In fact, most universities have not yet developed guidelines for faculty collaboration with researchers at other universities. Collaboration beyond student exchange is normally based on common research interests. This assumes that faculty in both universities are equally active in research. The limited research output of Kenyan lecturers reduces the opportunities for collaboration with industry and foreign universities. The study commissioned by CHE, according to Gichaga et al. (2005), found that there is limited collaboration between Kenyan universities and industry. This is partly due to the lack of awareness of local industry of the potential for research contributions from Kenyan universities, or to the lack of awareness of university researchers of industry's needs.

The situation is exacerbated by the fact that the multinational manufacturing companies undertake their own research in the countries of their origin.

Higher Education Research, Science and Technology Policy Initiatives in Tanzania

The Tanzania Commission for Science and Technology (COSTECH) is a parastatal organization with the responsibility of co-ordinating and promoting research and technology development activities in the country. It is the chief advisor to the Government on all matters pertaining to science and technology, and their application to the socio-economic development of the country. Established by an Act of Parliament No. 7 of 1986 as a successor to the Tanzania National Scientific Research Council, COSTECH became operational in 1988. The Act provides for a structural framework of the Commission, which brings together, the top leadership of the scientific and technological institutions in the country under one forum.

Thus, the Commission maintains a system of collaboration, consultation and co-operation with parties within Tanzania, whose functions relate to the development and application of science and technology. In view of this, all major national research and development institutes are affiliated to COSTECH. The roles of the Commission could be summarised as follows:

- To advise the Government on all matters relating to science and technology, including the formulation of science and technology policy; priority setting for research and development; the allocation and utilisation of resources.

- To promote, co-ordinate, monitor and evaluate scientific research and technology development and technology transfer activities in the country.
- To facilitate national, regional and international co-operation in scientific research and technology development and transfer.
- To acquire, store, and disseminate scientific and technological information, and to popularise science and technology.

COSTECH involves itself with a number of activities, which ensure that the research priorities identified at national level are carried out effectively and efficiently – in order to achieve the expected results. Through nine technical Research and Development Advisory Committees, research policies and research agendas are worked out by experts for the effective management of research and development activities. The Government of Tanzania recognises that it is essential to have a strong linkage among the research and development institutions, the donor community, policy-makers and end-users of the research results. Through COSTECH, the Government aims at: linking the research and development activities to national industrial requirements and those of end-users; improving the quality of research and development output through the effective utilisation of the resources; sensitizing the scientific and donor community on national research priorities.

This would be in addition to sensitizing entrepreneurs and other research beneficiaries on the importance of supporting research and development activities, the utilisation of research results in the anticipation of building strong and effective linkages between research and development institutions and their clientele, as well as improving the setting up of research and development priority areas.

COSTECH has co-ordinated the formulation of research priority areas, which are in seven major economic sectors. These priority areas, which have been given more emphasis include: agriculture to ensure food security; the better use of energy, including renewable energy; the better utilisation of natural resources, public health, manufacturing industry, as well as new and emerging technologies, such as biotechnology and information and communications technology (ICT). COSTECH has also forged a linkage between institutions, which deal with technology development. These are seen as sister institutions; and their collaboration is vital to the national economy. The institutions involved include: the Tanzania Industrial Research and Development Organization (TIRDO); the Institute for Policy Innovation (IPI); Tanzania Engineering and Manufacturing Design Organization (TEMDO); the Centre for Agricultural Mechanization and Rural Technology (CAMARTEC); the National Housing and Building Research Agency (NHBRA), Small Industries Development Organization (SIDO), Tanzania Traditional Energy Development and Environment Organization (TaTEDO).

Another major function of the Commission is to promote research and the spirit of invention and innovation at all levels. Under research promotion, COSTECH supports research through providing grants, commissioning specific studies and projects, as well as identifying individuals with talents who can contribute significantly to scientific and technological development. Part V of the COSTECH

enabling Act provides for the establishment of the National Fund for the Advancement of Science and Technology (NFAST). The Act stipulates that: The Fund shall be managed and administered by the Commission for the purpose of: financing, by way of loan or grant, any research or study carried out by, or for the benefit, of persons or organizations engaged in research in matters related to the development of science and technology; financing by way of loan or grant, the training of citizens of the United Republic of Tanzania, by or for the benefit of organisations engaged in research in the development of science and technology; making an award or awards to a person or body of persons qualifying; providing support for scientific research and technology development and the application of the results in compliance with the national priorities determined by the Government on the advice of the Commission; and commissioning the carrying out of research and development by an individual, group of individuals, institutions or groups of institutions.

Research activities in the country have benefited from this Fund in many ways, including the provision of grants to scientists to conduct research; financial support for conducting scientific meetings, workshops and seminars; funds for publishing and disseminating scientific and technological information. It is worth noting that the Tanzanian S&T Policy (1986) stipulated the use of about 3.5% of the GDP for the advancement of S&T in the country. Realizing that spending 3.5% of the GDP had been impractical since the policy was promulgated, in the reviewed version, the Tanzania S&T Policy (1995) revised the recommendation to be at least 1% of the GDP; but the actual expenditure is still far below 1% of GDP (United Republic of Tanzania, 2010).

Notwithstanding the above achievements, a number of challenges still remain. These include inadequate use of a multi-disciplinary approach to researchers among R&D institutions; inadequate appreciation of socio-economic aspects in research and development; a poor emphasis on socio-economic research into the national research agenda. Furthermore, there is an inadequate supportive environment for private sector involvement in research; inadequate mechanisms for technology transfer and the commercialization of research results. Also, there has been inadequate funding for research activities; and where funds have been available, research has not been focused on addressing any societal problems.

Higher Education Research, Science and Technology-Policy Initiatives in Uganda

Science- and technology-based courses at higher education level, are largely offered at the public universities, notably: Makerere and Kyambogo Universities in Central Uganda, Mbarara University of Science and Technology in Western Uganda, Gulu University in Northern Uganda and the Busitema University in Eastern Uganda. The courses offered at these public universities include: pure sciences, such as: biology, chemistry, physics, mathematics, geology and environmental science; applied sciences, such as engineering, information-and-communication technology; and agriculture, forestry and food sciences.

The expansion of access and equity to university education is intended to widen the opportunities of accessing university education to a considerable number of the Ugandan community; and this has so far registered an increase in the enrolment number, with more than 100,000 students registered currently. This expansion has enabled the production of a great number of graduates in the areas of the Humanities, the Arts and Social Sciences, in the face of the limited available outlets for employment that require science- and technology-based graduates; and this, the Government of Uganda considers, to be a big challenge. There is a notable imbalance between science- and technology-based programmes vis-à-vis the arts and humanities-based programmes, thereby affecting the development of the production and manufacturing industrial sector.

The performance of the manufacturing and industrial sector has, therefore, been affected by the production of inadequate human resources in the area of science and technology (Bilali, 2009). Bilali (2009) further notes that ICT-Teaching and Learning-Mediated techniques are still lacking in the Ugandan tertiary institutions. This has affected the performance of the higher education in ICT-related functionalities.

Due to the competing priorities within the education sector, the higher education sub-sector is not adequately funded. This scenario affects the effective and efficient implementation of programmes intended to improve the performance of the sub-sector. As Bilali (2009) notes, the inability to afford higher education by students hoping to study science- and technology-based courses on private sponsorship arrangement, limits equitable access to higher education in science and technology. This limits the performance of the universities in terms of enrolling adequate numbers of students to study science- and technology-based courses.

In its effort to enhance science and technology activities, the Government of Uganda has established a Uganda National Council for Science and Technology (UNCST). This is a Government Agency, established by CAP 209, under the Ministry of Finance Planning and Economic Development. The Council is mandated to facilitate and to co-ordinate the development and implementation of policies and strategies for integrating Science and Technology (S&T) into the national development process. When rolling out the country's Science, Technology and Innovation Policy developed in the year 2009, the Minister of State for Finance, Planning and Economic Development noted that the progress of research and development activities had been constrained by a number of challenges, which included: The low level of co-ordination among stakeholders, leading to the duplication of efforts; the low capital base; inadequate infrastructure; and most importantly, the lack of a coherent and overarching National Science, Technology and Innovation (STI) Policy to guide the activities and the distribution of resources for science, technology and innovation.

These challenges, coupled with the shortage of skilled human resources, the over-dependence on foreign technology, and an inadequate social consciousness of the role of STI in national development, all combined to keep Uganda underdeveloped.

Uganda recognises that – given the limitations of her production factor endowments – the mounting pressures of providing for the basic needs of the growing population, and accelerating the pace of economic development cannot be tackled without an enhanced capacity in science, technology and innovation. It is, therefore, essential that STI be prioritised in the overall development strategy of the country. In order to address the challenges and the urgent need for economic growth and transformation, the Government of Uganda, through an extensive consultative process, formulated a comprehensive and overarching Science, Technology and Innovation (STI) Policy. This policy sets out a vision for the STI sector, and highlights the strategic frameworks for its attainment. The STI Policy provides a mechanism for an increased capacity in STI that is expected to result in significant improvements in national productivity, leading to competitiveness and better standards of living for the people of Uganda – in line with the National Development Plan for the period 2010/11 - 2014/15, and beyond.

This STI policy is consistent with the national development objectives, which are: poverty eradication, industrialisation, agricultural modernisation, increased productivity, employment creation, value addition and gender mainstreaming. The policy provides a framework for supporting local innovation and scientific excellence by funding national research priorities, providing an infrastructure for technology-generation and incubation, supporting local innovations and rewarding scientific excellence. The goal of this policy is to strengthen the national capability to generate, transfer, and apply scientific knowledge, skills and technologies that ensure sustainable utilisation of the natural resources for the realisation of Uganda's development objectives. The objectives of the policy are to:

- Create an enabling policy environment to foster STI and augment the contribution to national development.
- Build the STI sector capacity to generate and transfer technology.
- Establish and strengthen the legal and regulatory framework, to ensure the ethics and safety in STI development and application.
- Strengthen the STI co-ordination framework, to enhance the sector's performance and contribution to national development.

The Government of the Republic of Uganda has also initiated deliberate efforts to encourage the universities to incorporate the ICT-component into the teaching and learning, as well as the managerial activities of the universities. Makerere and Kyambogo universities are already implementing this strategy. The Universities and other Tertiary Institutions Act 2001, as amended, and the Budget Act of 2001, permit public universities to collect and utilise at source, appropriation-in-aid funds to improve their funding levels. This strategy has yielded fruits, as the public universities and other tertiary institutions have developed corporate arrangements to supplement government funding. Improvement in the funding levels has enabled the universities to serve as vehicles that drive the country into achieving excellence in science and technology (Republic of Uganda, 2009).

There are, however, only a few, instances of the deliberate linkage of Government, university and industry for sustainable development (Republic of Uganda, 2009). This has been blamed on the education system, which fails to encourage connection – not only between the sciences (social science, natural science and the humanities) – but also between theory and practice.

Higher Education Research, Science and Technology-Policy Initiatives in Rwanda

The Government of Rwanda recognises the fact that the provision of higher education is a primary tool for the country's development. The Government intends to build a strong, vibrant, higher education system that is internationally competitive, that meets the demands of the Rwandan and regional economy for skilled and educated workers, and delivers research, innovation, and knowledge transfer to support social and economic development. It is recognised in the current higher education policy that higher education is fundamental and indispensable to the social and economic transformation of the country, and that the successful implementation of all development policies are dependent on higher education playing its key roles of human-capital development, and providing research and innovation to support the transformation process.

Rwanda's National Higher Education Policy gives higher education its due importance in social and economic development; and it gives recognition to the importance of human capital in the transformation process. The Government has bold ambitions for the development of higher education and the role it must play in the realisation of the country's Vision 2020.

Through its Vision 2020, the Government of Rwanda is committed to ensuring that it takes advantage of the development process and recognises that for this development process to be a success, it must embrace the future, and exploit the innovations in Science and technology, in order to complement its cultural strengths. In Rwanda, the rate of adoption and integration of science and technology in socio-economic life is very low; and the shortage of technically qualified professionals is visible at all levels, as noted in the country's vision 2020 (Republic of Rwanda, 2000). Thus, until 2020, Rwanda can only hope to have adequate, highly skilled scientists and technicians to satisfy the needs of the national economy.

The Government recognises that there is a need to generate, disseminate and acquire scientific skills, as well as technological innovations, in addition to integrating them into the social and economic development drive of the country.

The country is committed to achieving this objective through the development of the teaching of science and technology at secondary and university levels. The Government also intends to facilitate the creation of high and intermediate technology enterprises, and to develop access to ICT down to the administrative

sector level, in accordance with the national ICT plan. Investing in higher education is not an option for Rwanda; it is essential. And the Government expresses the view that the future success of the country depends on using the imagination, creativity and talents of the Rwandan citizens, and on how the country uses knowledge and understanding to build economic strength and social harmony.

Since 1994, the country has invested in building the quantity of higher education. Much has been achieved; and the focus now is on establishing quality within the country's education system. The government stresses the need to produce graduates that are fit for all purposes, and internationally credible; to invest in research and knowledge transfer that would support Rwanda in achieving sustainable economic growth; and to encourage education institutions to meet these challenges, in order to realise Vision 2020.

Rwanda's Higher Education Policy guides the transformation of higher education. It points in the direction of establishing a stable, underlying structure that should enable institutions to develop their strategies for supporting the realisation of the ambitions for higher education. It sets out the Government's vision, mission and policy objectives for higher education, and provides the anchor and the route map for the strategic planning of the higher education sector as a whole, and for individual institutions. In developing the country's Higher Education policy, six key challenges were taken into account. These are: the shift to the "knowledge society"; globalisation; under-resourcing; increased competition amongst providers; the diverse needs of society and learners; and the need to serve as an engine for social and economic development.

The Policy, therefore, declares the Government's intention to make appropriate decisions that would enable the country to build on the institutional structure put in place, and to create a higher education system that would provide a foundation for the country's social and economic development. To do so, the government recognises the requirement for a stronger partnership between students and higher education institutions, government, the private sector, communities and international donors.

For instance, policy objective no. three is supporting research, innovation and knowledge transfer for sustainable development, and the strategies on which the government is working include:

- Regular audit of research and knowledge-transfer capacity. This is to enable the current quality and extent of research and knowledge-transfer activity to be properly assessed.
- Higher Education institutions are required to include a strategy for developing research and knowledge transfer activities across the range of academic provision to support teaching at Honours degree and postgraduate levels.
- Higher education institutions are encouraged to selectively provide postgraduate research and training programmes that would lead to economic development.

- The Government, in partnership with the higher education institutions, aims to reach an agreement on the priority areas in which each institution would be required to develop research, and to ensure that it develops its taught provision, investment in infrastructure and equipment and staff development in line with those areas in which institutions are expected to develop research expertise.
- The Government is committed to establishing the National Research Council, which would be responsible for funding research in line with national policy and priorities.
- Higher education institutions are required to demonstrate that they have established research and knowledge-transfer units, and that they are actively seeking research funding and knowledge-transfer contracts from international funders of research and consultancy, as well as the private, voluntary and State sectors in Rwanda.

Among the things that the Government advocates are strong collaboration between the higher education institutions in terms of sharing facilities, equipment and teaching staff, where appropriate. Regional links and networks that enhance teaching, learning and research are also very important for the development of the sector.

However, even with these developments, the sector still faces significant challenges. Within the wider context of the social, economic and political development of the African Sub-Saharan Region, and the specific development of Rwanda in particular, the Higher Education system is confronted with various challenges, which the government recognises, and which have been taken into consideration in the policy initiative: i) Science and Technology – with the Rwandan Government commitment to the building of a “knowledge-led” economy, coupled with the societal development needs to be at the heart of the curriculum; ii) Research – with the government admitting that historically, there has been little awareness of the importance of research as an essential process in social and economic development; and thus, emphasising the importance of well-coordinated research activities; iii) resources and equipment – with the government taking on the challenge to put a National Research Strategy in place that would require lecturers, as part of their contracts, to undertake research that leads to publication in relevant journals; and iv) knowledge-transfer – with the Government’s commitment to optimal utilisation of the role of higher education institutions as absorbers and transmitters of knowledge.

In this, the Government takes on the challenge to ensure that higher education institutions are encouraging and supporting their staff in undertaking consultancies and engaging in other knowledge-transfer activities.

Higher Education Research, Science and Technology-Policy Initiatives in Burundi

The crisis of 1993 and the long drawn-out conflict that followed in Burundi had a devastating effect on education; and these issues greatly exacerbated the underlying problems that had previously existed. However, a new momentum has been achieved; and Burundi is now fully in recovery. The Burundi education system comprises formal and informal teaching. The formal education is made up of four levels: pre-primary (kindergarten); primary; lower secondary; technical secondary; and upper secondary. Kindergarten schools enrol children aged three to six years. The schools providing this type of education in Burundi are mostly privately owned. Primary education lasts for six years – leading to the Certificate d'Etudes Primaires (elementary education).

Higher education is mainly provided by the University of Burundi (Republic of Burundi, 2001). It is largely financed by the State; and it enjoys administrative and management autonomy. It is administered by a Rector appointed by the president of the Republic for four years. Policy-making is the responsibility of a governing board appointed by the president of the Republic, and representing the major spheres of activity in higher-education development. Higher education in Burundi is also provided by private institutions. At the higher education level, the focus has been on training teachers and developing retention strategies for teachers. The strategy also calls for a balance between training needs and market needs at the university and other colleges of higher learning.

The University of Burundi, in Bujumbura, has faculties of sciences, medicine, psychology and education, agriculture, and applied sciences. Besides higher-education institutions, there are other institutions in Burundi that are involved in science and technology activities. These include: The National Center of Hydrometeorology; the Ministry of Geology and Mines; the Institute of Agronomical Sciences of Burundi; and a medical laboratory devoted to nutritional studies. The country receives technical aid from donors, including the European Economic Community (EEC), the International Bank for Reconstruction and Development (IBRD), and various other countries, including Belgium, France, Germany, the United States of America, Switzerland, and China.

The Government of Burundi co-ordinates its research activities through the Ministry of Higher Education and Scientific Research. Science and technology activities are taken care of in the education development plan that spells out the government strategy for the education sector. The country has, in addition, a national ICT for development policy that focuses on the adoption and use of ICT by the country, in order to achieve its strategic objectives.

The use of ICT at the university level is increasing, although the facilities are still insufficient. The University of Burundi has a campus network for approximately 500 users, which was funded mainly by the United Nations Development Programme (UNDP). This network is connected to the Internet through

one of the local ISPs. Connectivity between its campuses in Bujumbura is achieved through an omni-directional wireless link. This is placed at the same campus that has the connection to the ISP.

Unlike the other four countries: Kenya, Tanzania, Uganda and Rwanda (forming the East African Community), Burundi is at its initial stages of developing Higher Education research and technological innovations. The country is, however, on the right track with the establishment of the Ministry of Higher Education and Scientific Research.

Conclusion

Science and Technology is, and has always been, important for development; but the unprecedented pace of advancement of scientific knowledge is rapidly creating new opportunities for – and threats – to development. Producing a high-level expertise to create, access, adapt, consume, and disseminate knowledge has become critical for national development. Hence, integrating science, technology and higher education as a national knowledge-development strategy for a sustained and meaningful social and economic transformation is gaining more ground. Most developing countries are largely unprepared to deal with the changes that science and technology advancement bring about, where advances in science and technology generate massive amounts of knowledge and information – with all the subsequent opportunities, potentials and challenges to nations.

Coupled with the need to apply science and technology for development, is the fact that Governments – and especially in the developing countries – can no longer cater for university education (Nyerere, 2011); and thus, there is the necessity to link the institutions with industry as one of the ways through which their funding can be diversified. These twin goals could be achieved through the participation of industry in enhancing science and technology in institutions of higher learning; and a smooth transfer of these technologies to the industry for development is becoming increasingly important in the modern world.

Although these objectives are yet to be fully achieved, all five of the East African Community countries have shown their commitment through the formulation of relevant policies and the establishment of bodies in charge of higher education science and technology. It is imperative that East African countries establish partnerships that could both harness the innovation potential of research and training institutions, and meet the needs of the market for industrial development. These needs could be realised if – and when – the Governments, through their respective agents, bring together the institutions of higher learning, research institutions and the industry, and spearhead meaningful collaborations.

This link, and the participation, of the East African governments is currently missing.

There are bodies dedicated to Higher Education research, Science and technology already in place in East Africa – the National Council for Science and Technology (NCST) in Kenya, the Commission for Science and Technology (COSTECH) in Tanzania, the National Council for Science and Technology (UNCST) in Uganda, the Ministry of Education in Rwanda, and the Ministry of Higher Education and Scientific Research in Burundi. These point to recognition of the role of higher education research, science and technology transfer in economic development in the East African countries. All of these five countries that currently form the East African Community are making an effort in the realisation of higher-education research, innovations and technology – through the formulation of enabling policies.

They have formulated policies to guide research and innovations and technology transfer, which, if fully implemented, would see great accomplishments in higher-education research, science and technology activities, as well as increased collaborations with industry that would lead to the economic development of these nations.

Despite the efforts already made, it is notable that there is still a general lack of recognition, and of the “clout” of ministries of science and technology, in their respective governments in Africa. Senior science and technology officials of African governments attending an International Network for Higher Education in Africa conference in August 2010 recounted their continued difficulties in raising support for their ministries – due to the lack of immediate and “tangible” deliverables. They admitted that, whereas the chronic challenges of funding higher education in Africa are well documented, it appears that the problem runs deeper for such ministries and bodies. The efforts made would bear more fruit if adequate funding were allocated to the ministries and bodies concerned with Higher education, Science and Technology – in order for their activities to succeed.

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