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Universities and Development of Regional Innovation Ecosystems: Case of Kenya

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Abstract

Universities are considered important actors and drivers of socio-economic development in the regional innovation eco-system. This article investigates the role Kenyan universities and research institutes play in the development of regional innovation eco-system in the context of triple and Quadruple helices. A model involving Government, Industry, Universities and Society (Public) linkages in the regional innovation eco-system and with Information and Communication Technology as an enabler is used as a framework for analysing the nature of linkages in Kenya. The article uses literature review and case study methods to examine how universities and research institutes can spur the development of the innovation eco-systems. The research question is: what is the role of Kenyan universities and research institutes in spurring innovation ecosystems? Six cases of Kenyan universities and research institutes are considered in the light of Government Policy on Science, Technology and Innovation (STI) which is underpinned in Kenyan constitution 2010. The study contributes to the understanding of how deep collaboration among universities, government, research institutes, Science Cities, local, regional, national and international players spurs the creation of world-class innovation ecosystems which can contribute to regional development in developing countries like Kenya.

Keywords

Innovation hubs; Regional innovation systems; Innovation eco-system; Science parks; Triple helix; Quadruple helix

I. INTRODUCTION

It is recognized that companies serving global markets cannot survive on their own in today's extremely competitive business environment, and therefore need to engage in relationships with other companies for faster access to new markets, asset flexibility, complementary and new competencies, economies of scale, expanded product offerings, improved resource utilization, new technology and products, and risk reduction. Development of successful relationships involves commitment, compatible goals, complementary skills, co-operative cultures, trust, and commensurate risk among the parties. Parties will need to surmount challenges related to the management of contracting, information, collaboration, resources, New Product Development (NPD), technologies, and globalization (Brouthers et al., 1995; Chesbrough, 2003; Cooper, 2011; Distanont et al., 2011; Distanont et al., 2013; Meade et al., 1997; Melohn, 1994; Shamdasani and Sheth, 1995).

There are many ways companies can cooperate and the simplest form of business to business collaboration is buying products or services from other businesses. On the other hand, industry collaboration involves business networks, clus-

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ters, ecosystems, innovation hubs, triple and quadruple helices. The typical stakeholders that a company collaborates with in innovation and NPD contexts include customers, suppliers and other partners, competitors, and different institutions, research institutes and universities (Belderbos et al., 2004; Dermol and Breznik, 2012; Un et al., 2010).

It would be expected that advances in information and communication technology in Kenya would enable Kenyan firms to tap into the global network of knowledge, systems, and processes to make Kenya a regional innovation hub. However, it is observed that global processes are still concentrated in certain regions of the world that are able to access the global knowledge flows in a better way. These regions have continued to be powerhouses or knowledge hubs in global innovation networks. It is argued that the difference between sub-national regions around the world can be attributed to the different configurations of their regional innovation systems (Amin and Thrift, 1994; Chaminade and Vang, 2008; Chaminade and Plechero, 2015).

Chaminade and Plechero (2015) argue that the intensity of access to global Innovation Networks (GINs) is dependent on: availability and quality of specialized universities, research centres and ICT specific intermediate organizations in the region; the degree of ICT specialization in the regions, also in comparison with the country average; and other related elements used to assess the institutional thickness (levels of interaction, culture of collective representation and shared norms and values).

There is a need for interactions between universities, industries, and government (a triple helix model) to enhance innovation and also involving civil society in quadruple helix model. The city of Amsterdam adopts a regional triple helix model for economic development (Etkowitz and Leydesdorff, 2000; Leydesdorff, 2012; Mok, 2012).

A robust innovation environment system that fosters global competitiveness for firms and nations include university spin-offs, initiatives for knowledge-based economic development, formation of strategic alliances between companies, government laboratories, and academic research groups. It also includes government facilitation through setting of new rules, direct or indirect financial support or the creation of new foundations (Cavallini et al., 2016).

In the subsequent sections we set light on the research question on the role of Kenyan universities and research institutes in spurring innovation ecosystem in the context of context of Triple Helix and Quadruple Helix models using case studies. It can be argued that case studies and descriptive analysis constitute an adequate methodological approach to explore the type of relationships among firms within particular industrial contexts or to understand open innovation practices (Lechner and Dowling 2003; Yin 1994; Huizingh, 2011) as it is the case in this paper.

1.1 Innovation Hub

Prahalad and Krishnan (2008) refer to an innovation hub, or innovation center, as a region or a place with an extraordinary amount of accumulated knowledge and innovativeness. This is where the utilization of local knowledge and competences is intensified. Its distinguishing criterion is its connection to global value networks and its ability to create value in the global economy. Further an innovation hub is considered to be a centralized location or region where innovations occur, such as Zhangjiang Hi-Tech Park Pudong in China, Sophia Antipolis in France, and Silicon Valley in the US (Launonen and Viitanen, 2011).

An innovation hub framework consists of three, partly overlapping, elements which include: public policy activities, encompassing innovation policy, hub infrastructure and service structures, and education and training; public-private partnerships (PPP)-driven activities consisting of comprehensive R&D systems, cluster policies and programs, test-beds and living labs, and incubation environments; and company-driven activities, such as the creation of successful start-ups and small and medium-sized enterprises (SME) growth, and dynamic anchor companies that enable access and growth (Launonen and Viitanen, 2011). In addition, innovation hubs require a strong educational infrastructure with world-class universities providing new ideas via basic research and technology innovation. It also requires government policy that enables supporting activities, including, for instance, incentives for basic research and venture capital. Finally, the flow of ideas and people from other regions is needed, and the infrastructure and environment must offer a quality of life that is conducive to encourage innovators to stay in the region. Kenyan universities and research institutes are collaborating with world class universities such as MIT and KAIST to facilitate technology transfer (Majava et al., 2013; Suh, 2010).

Technology innovation is increasingly considered by governments across the world as a driver for national economic growth, and universities as the incubators of this national capacity. It has been observed that universities operating within established technology-driven innovation hubs, such as Sili-

con Valley and Kendall Square in the US, offer robust models for success within these environments. It is further noted that an increasing number of universities located within more challenging environments are also establishing strong entrepreneurship and innovation (E&I) profiles and reputations with great potential of some of them becoming future national and international leaders. Three universities have been identified as the world leaders – MIT and Stanford University, in US and the University of Cambridge in UK; and Technion (Israel), Aalto University (Finland), University of Michigan (US), KAIST (South Korea) and the University of Auckland (New Zealand) as the most highly-regarded universities operating in more challenging conditions (Graham, 2014).

In this regard, the challenging environments in which the universities operated were typically characterised as cultures that did not support E&I, geographic isolation and/or a lack of venture capital. It is from the category of universities characterized by these challenging environments that we draw insights on what universities Kenya could do to drive and manage a process of institutional transformation towards a more entrepreneurial model, and how university-based ecosystems can be nurtured in cultural, economic and socio-political environments that may not be naturally conducive to Entrepreneurship and Innovation (E&I).

Building favorable conditions for innovation is a challenge for leaders at national, regional, and organizational level and is often a process that involves long-term, widespread structural changes (Geels and Schot, 2007). It is argued that systemic innovations require management of societal, cultural and technological changes. This necessitates the development of national innovation strategies with practical measures and guidelines. In this regard, Kenya has established a Policy on Science, Technology and Innovation (STI) which is underpinned in Kenyan constitution 2010 (Government of Kenya, 2008; Government of Kenya, 2010; Hautamäki, 2010).

1.2 Triple and Quadruple Helices

Both the Triple Helix (TH) concept and the Quadruple Helix (QH) approaches are based on the premise that innovation emanates from an interactive process which involves different spheres of players who contribute according to the function they play in society. The Triple Helix involves three spheres namely; University, Industry and Government and Civil Society is added as an additional player to form Quadruple Helix. It is contended that contribution to innovation can be viewed in terms of the sharing of knowledge and transfer of know-

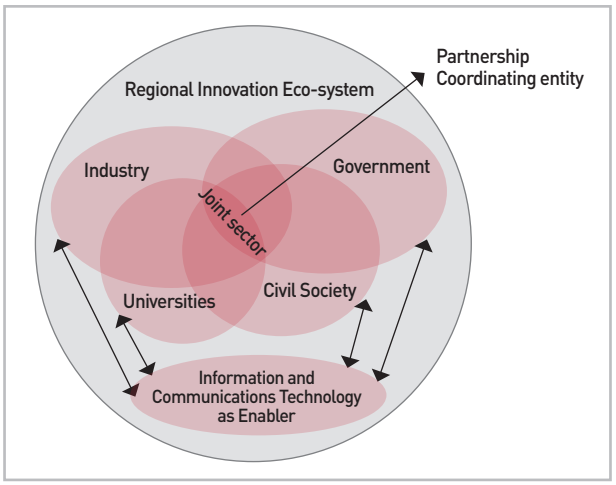

Fig. 1. Regional innovation eco-systems: Quadruple Helix

Source: author

how, with helices models showing the precise role to each dimension that supports economic growth that results from innovation (Cavallini et al., 2016).

Academia and Industry provide the necessary conditions for an integrated innovation ecosystem while governments provide the regulatory framework and the financial support for the definition and implementation of innovation strategies and policies. On the other hand, civil society not only uses and applies knowledge, and demands for innovation in the form of goods and services, but also forms an active part of the innovation system.

Further, information and communication technologies (ICT) are the enablers of bottom-up participation of civil society and among the rest of the players (Cavallini et al., 2016). It is also crucial to have a financial sector that can provide funds for operations, development and mass production by starts-ups until they are successful. This can be, like in the case Republic of Korea, in form of the central government's Technology Guarantee Fund and the Credit Guarantee to fund start-ups, thereby guaranteeing bank loans (Cho et al., 2017). The partnership relationships between the players should be managed by partnership coordinating entity. These relationships are depicted in Figure 1.

The Quadruple model as shown in Figure 1, introduced in this paper, should be seen as an analytical framework which might prove useful in understanding the role of universities in development of the regional innovation eco-system. The players in the regional innovation eco-system that form Quadruple

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Helix are the Government, Industry, University and Civil Society (Public) with the joint sector, that is, the partnership coordinating entity.

The model shows that ICT is an enabler. In the case of Kenya, the installation of fiber-optic linking Kenya to the world and also the major towns of the country has facilitated the development of IT infra-structure that is among the best in Africa which has enhanced interaction among the players in the innovation eco-system. In addition, the development of Mobile technology in Kenya has been a main spur to ICT and mobile industry base and innovation culture. One of the key innovations that has gained world acclaim is MPESA money transfer system and ICT firms such Ushahidi, a technology leader in Africa that provides software and services to numerous sectors and civil society to help improve the bottom up flow of information. The development in Mobile and ICT infrastructure has facilitated linkages between Industry, Government, Universities and Civil Society. The linkages between Government and Society in Kenya have resulted in e-Government platforms and the establishment of HUDUMA centres that has brought services closer to the citizens.

Other studies have widened the TH/QH by including new helices to better explain and analyse innovation paths and related growth effects at the local and regional level by moving beyond the concept of knowledge economy of the TH and the concept of knowledge society of the QH, to consider the Quintuple Helix (QuiH) innovation approach as proposed by Carayannis et al. (2012). Thus, besides UNI, IND, GOV, and Civil Society (CIV), they include the natural environment as "decisive for a sustainable development" and providing "people with a 'natural capital' (for example: resources, plants, variety of animals, etc.)". Carayannis and Campbell (2009) argue that [T]the Quintuple Helix has particular relevance to the current UN Sustainable Development Goals (SDs) emphasis on sustainable development and the implication for 'eco-innovation' and 'eco-entrepreneurship' in its application to the current situation and for our future.

It is important that collaboration between the Quadruple Helix (QH) players in the innovation eco-system is well nurtured. Pertuze et al. (2010) argue that often industry-university collaboration is viewed from the perspective of research outcomes emanating from such collaborations. But, from the industry standpoint, companies are concerned about how the new knowledge derived from the collaborative research can contribute to a company's performance in terms of new products, new and effective manufacturing processes, novel kinds of computer hardware or software that facilitate greater logistical efficiencies, patentable materials, designs and processes that enhances competitive advantage. This differences in expectations between the industry-university particularly in developing countries and Kenya in particular poses challenges in ensuring fruitful collaboration and hence the relevance of universities as seen by industry.

In the Kenyan context, it is important to enhance industry-university collaboration by ensuring: that the collaboration is aligned with the company's research and development strategy; ensuring that there are certain individuals who naturally engage in networking activities intended to maintain cross-organizational relationships; for academic research to have more impact on the company, it is necessary that university researchers have a strong knowledge of the business setting, company practices and how the research fits the company strategy; embrace multi-year collaboration programs to nurture long-term relationships and thus improve the success of the research outcome; establish strong communication linkage with the university team by ensuring that researchers visit the company and interact with the company personnel on regular basis; there is awareness of such collaborations with other company staff in order to increase of impact for the company; and aim to develop long-term relationships that go beyond the project deliverables of such collaborations (Pertuze et al., 2010).

1.3 Public sector innovation initiatives of eGovernment

Innovation in the public sector is defined as the generation and implementation of new ideas which create value for society (EC, 2013). eGovernment seen as one of those Public sector's innovation, has been adopted as policy, strategy and initiative that its expected result is in improved access to information by users, more targeted and efficient services to citizens and businesses and increased participation of citizens in the decision making process (through public participation and consultations). The government of Kenya through Vision 2030 has one of its key pillars to be open, efficient and inclusive, provide seamless, personalised, user-friendly, end-to-end digital public services to all citizens and businesses. Therefore, the government of Kenya has embraced eGovernment and has established HUDUMA Centres to facilitate efficient and effective service delivery to all citizens and businesses and other stakeholders. Indeed the Kenyan Constitution 2010 underscores the importance of public and citizen participation in all the major decisions that the government undertakes (Gov-

ernment of Kenya, 2007; Government of Kenya, 2010; EC, 2016).

If ICT, overall, is at the basis of this transformation, acceleration towards modernisation requires the presence of at least three elements: interoperability, broadband access, and open governance. Interoperable applications are essential for eGovernment from the legal, organisational, semantic and technical points of view. Broadband access, reflects the existence of appropriate ICT infrastructure and is positively correlated to the level of regional innovation. Digitalisation drives innovation as it allows the opening of assets, services, and engagement. In the context of a helix approach, it creates knowledge and empowerment of the other elements of the ecosystem; enables co-creation of goods and services; and develops demand and tools for participation. Finally, open governance "reaches across many parts and levels of the public sector as well to other appropriate actors outside government" (Millard, 2013) and by implying change of roles, relationships, methodologies and forms of co operation, is wholly congruent with the helix concepts (Boelman et al., 2014).

While great strides have been made in the introduction of Huduma Centres, a eGovernment initiative, many government institutions and ministries are yet to fully automate their services, and especially at regional and local level or county levels. In addition, they are still struggling to come to terms with the meaning and value of opening their data, let alone how best to do so. It is argued that open data is a key element of an open government, and open government as one of the pillars of ICT-enabled public sector innovation (Cavallini et al., 2016). One of the challenges government face is how to stimulate digital innovation in all industrial sectors. This can be facilitated by the development of Digital Innovation Hubs (DIH) aimed at "spurring a wave of bottom-up innovations across sectors" (EC, 2016a).

II. THE CHANGING ROLE OF UNIVERSITIES

Universities have recently embraced contribution to innovation as one their main missions moving the position where they considered themselves producers of knowledge and thus earning the title of staying on 'ivory towers'. Hence there has been a clarion call to universities to climb down from the 'ivory tower', that is, "an atmosphere where intellectuals engage in teaching and research activities that are disconnected from the practical concerns of everyday life and society". They are increasingly becoming "key actors of economic and cultural growth, transforming themselves into engaged institutions with industry and society at large" (E3M project, 2011).

Various terminologies are used to describe the universities emerging missions and relationships including 'third mission' (TM) or 'stream' are which refer to relationships (intended as knowledge exchanges and productive interactions) of the university with non-academic stakeholders and, in particular, with those stakeholders belonging to industry, public authority and society (Schoen et al. 2007). Molas-Gallart et al. (2002) posit that "teaching, research and the communication of research results" should be considered "core" university activities. In this respect when the universities engage with non-academic actors and/or pursue mainly non-academic goals, the performance of such activities constitutes in itself an instance of Third Stream activity." Thus going beyond the simple Triple Helix relationships and adopting a more pragmatic concept of Entrepreneurial University based on the need for functional substitution, especially with the Industry sphere (Cavallini et al., 2016; Ranga and Etzkowitz 2013; Etzkowitz et al., 2008).

Notwithstanding often spoken commitment to the E&I agenda by university leadership and a flurry of high-profile and engaging entrepreneurship activities offered by various support functions, entrepreneurship activities are often not visible in university departments. This is partly due to the fact that universities do not build incentives for undertaking of entrepreneurship activities to facilitate transitioning to an entrepreneurial institution and goals relating to the entrepreneurial agenda hardly feature. Some of entrepreneurial measures (metrics) which would be incorporated may include E&I research-related invention disclosures, patents, number of spin-offs, licensing revenue, which are relatively easy to capture.

2.1 Case Study: Kenyan universities and research institutes in innovation ecosystems

While all the actors cooperate in the innovation process, universities and public research institutes should take the lead in making technologies and innovations for eventual uptake and commercialization by the private sector (Bolo et al., 2015; Bozeman, 2000; Crow and Bozeman, 1998). In the case of Kenya, the Science, Technology and Innovation (STI) policy framework as spelt out in the STI policy and strategy 2008 (Government of Kenya, 2008), the STI Act 2013 (Government of Kenya, 2013) and the Vision 2030 (Government of Kenya,

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2007) emphasize the need for a functional innovation system in which universities and public research institutes play a leading role in knowledge and technology generation through research and development.

It is expected in this policy framework that universities and public research institutes are equipped, and well prepared and committed to undertake this responsibility. However, the evidence based on patents, utility models and industrial designs applications and patents granted by the Kenya Industrial Property Institute (KIPI) over a period of twenty-three years (1990–2013) does not demonstrate that universities are making the technologies and disseminating them to industry. Instead, it is shown that companies and individuals (private sector actors) are outperforming the universities and public research institutes both in numbers of patents, utility models and industrial designs filed and granted over this period. In this period companies were granted 87 patents representing 54.7 per cent of the total national patents granted and individuals were granted 43 patents representing 27.0 per cent of total national patents, Public Research Institutes were granted 6 patents representing 3.8 per cent and universities and other learning institutions were granted 3 patents, which is 1.9 per cent of the total national patents granted. (Bolo et al., 2015)

It was further found that partnerships patent applications between universities/other learning institutions (OLIs) and individuals accounted for 12% and none was granted while university/university partnerships applications accounted for 1.5% (and none was granted). Industrial design applications show that partnerships between individuals were 75% (and 69.2% of these were granted), followed by partnerships between companies which accounted for 16.7% (15.4% of which granted). It is argued that applications filed by partnerships are an indication of the extent to which actors collaborate within the innovation system and with whom. It is contended that the pattern of patent applications submitted in partnerships depicts a very weak linkage between the universities and public research institutes with the private companies. It was also found that only 1 application was recorded between a university and a company representing 0.5% of all the applications in partnerships and similarly, only 1 joint application is recorded between University/PRI/Company partnerships over the 23 year period. (Bolo et al., 2015)

2.2 Kenyan universities and public research institutes responses to the third mission

The universities and Research institutes' ability to achieve the third mission is dependent on: Infrastructure to support innovation and entrepreneurship such as science parks, incubation centres, technology transfer offices; intellectual property rights regimes including the policy, legal and funding support towards IP protection; the institutional support for innovation and entrepreneurship, for instance, incentives, strategies, rewards, awards; and the linkages with the private sector and other actors. Further, universities and public research institutes should go beyond the simple Triple Helix relationships and adopt a more pragmatic concept of Entrepreneurial University based on the need for functional substitution, especially with the Industry sphere (Bolo et al., 2015; Cavallini et al., 2016; Ranga and Etzkowitz, 2013; Etzkowitz et al., 2008). The main universities and research institutes are considered.

2.2.1 Moi University

Moi University endeavours to achieve the third mission in their strategic plan by emphasizing two key objectives states which as to: achieve excellence in academic, research and extension programmes; and be an innovative and entrepreneurial modern university that engages in value addition and product development. In furtherance of these objectives the university has strategies which include establishing of a science and technology park and institutionalization of research and extension policies within all the schools and department.[1]

The university has taken a number of initiatives which include acquiring and reviving RIVATEX EAST AFRICA LTD, through which the University engages in manufacturing and commercialization of innovations in textiles and provision of expert support training, consultancy, research, product development and extension[2].

In addition, the University has established a farmers' soil testing centre, which will serve farmers in the Western, Rift Valley and Nyanza provinces, eliminating the need for costly travel more than 300 kilometres to have their soils tested (Verchot et al., 2007). It has also established Moi University Holdings Ltd., (a fully owned subsidiary) with a technology transfer office (TTO) to manage the university's intellectual property (Zuniga, 2011).

[1] https://www.mu.ac.ke/index.php/university-news/390-commercialisation-of-ip-intellectual-property-by-dr-derekpalmer

[2] http://www.rivatex.co.ke/overview.html

The university has developed IP policies with intension of creating incentives for their scientific researchers, to facilitate technology transfer and ensure equitable distribution of revenues and commercialization of research results. It has further developed Moi University Research Policy and Moi University Extension and Outreach Policy. In addition the university has set up a research fund that provides small grants of up to Kshs. 500,000 (US$5,000) to its researchers to undertake research of relevance to the community which is awarded annually and compliments large research grants as well as encourages junior faculty to engage in research. One of the research output is the introduction into the market of a locally manufactured industrial dye derived from Tagetes Minuta (Bolo et al., 2015).

2.2.2 Jomo Kenyatta University of Agriculture and Technology (JKUAT)

The University has the application of Science, Technology and Innovation as key elements in its Strategic Plan and their goal is to enhance strategic and value-added research and innovation through the development of Centers of Excellence in key strategic thematic areas. JKUAT has also established an internal research fund for research projects and innovation projects. The internal research and innovation funds have supported about 52 on-going research and 23 innovation projects. The university plans to increase their research and innovation funds from Kshs 52 million (US$ 520,000) to Kshs. 100 million by 2017.

The university has also established a Research, Production and Extension Division (RPE) which houses a Research Management Office that coordinates all research activities within the University. The RPE has the objectives of: enhancement of strategic and value-added research and innovation; Increasing production and income generation activities within the University; Dissemination of research results and innovations to target users for application; Facilitating transfer of appropriate technologies; Dissemination and diffusion of new knowledge and information across the various sectors of the Kenyan economy; Provision of community need-based extension services; improving university linkages and partnerships with industry, off-shore, research and development institutions among others for joint projects and programmes; and increasing the use by industry and other external organizations of the university's technology, research outputs and innovations to create socio-economic benefits, while generating income to support research and education (Bolo et al., 2015).

In addition, JKUAT has put in place some infrastructure to support innovation and entrepreneurship including the Nairobi Industrial and Technology Park, which helps the University to incubate a number of student innovations into commercially viable business ventures[3]. A Science and Technology (S&T) Park is under construction (started in 2012) on a land of 32 acres which is a collaborative endeavour with ministry of industrialization and other partners was signed in 2008[4]. The university has also taken various initiatives to establish Partnerships/collaborations with other institutions. One of this partnership/collaboration is the Pan African University Institute of Basic Sciences Technology and Innovation that is a graduate school aimed at promoting Africa's integration and Business mentoring and incubation Centre, which is being put up in partnership with Kuza Biashara Limited[5]. An agreement for the construction of the Incubation Centre, with capacity of 500 incubatees, was signed in February 2014[6].

2.2.3 The University of Nairobi

The University of Nairobi considers its role as the transformation of Kenya's economy through high quality, cutting-edge research, development and commercialization of market demanded products, and large-scale dissemination of new technologies to various stakeholders. In this furtherance of this role the University has created a new division for research, production and extension led by Deputy Vice Chancellor[7]. The University has also a fabrication laboratory (Fablab) hosted at the department of Mechanical Engineering Building. The FabLab serves both as a fabrication lab and as well as an incubation center for SME's[8]. Apart from contributing to high quality human resources, the Fablab has spun out technologies like seed development for Kenyan climatic conditions and other agricultural and food processing technologies.

[3] http://www.jkuat.ac.ke/nairobi-industrial-park/
[4] http://www.jkuat.ac.ke/2012/02/industrial-park-to-foster-industrialization/
[5] http://www.jkuat.ac.ke/2014/02/varsity-set-business-incubation-centre/
[6] http://www.jkuat.ac.ke/2014/02/varsity-set-business-incubation-centre/
[7] http://dvcrpe.uonbi.ac.ke/sites/default/fi les/centraladmin/dvcrpe/RPE%20Annual%20report%20-February%202013_0.pdf
[8] http://dvcrpe.uonbi.ac.ke/node/2423

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The University also established the Technology and Innovation Support Centre (TISC) in 2013 enabling researchers and innovators to gain access to online patent and non-patent databases, international journals, get assistance in searching and retrieving technology information, monitoring technology trends and competitors and basic information on industrial property laws, management and strategy and technology commercialization and marketing[9]. The UoN has Intellectual Property Management Office (IPMO) which was established in 2008 with three main segments: commercialization, outreach and IP and contract research[10].

The university also provides research funding/grants through the Deans Committee Research Development Fund with an annual budget of Ksh. 250,000 (US$2500) per year, per project, for a maximum period of 3 years. The funds provided are mainly on food science, nutrition and technology, chemistry, metrology, plant science and crop protection research[11]. The research amount set aside may not adequate other sources for research funds need to be explored to complement this.

2.2.4 International Centre for Insect Physiology and Ecology (ICIPE)

The mission of ICIPE is to conduct fundamental scientific research while providing practical solutions that make a real change in the lives of people in Africa, primarily the rural and urban poor[12]. In furtherance of its mission ICIPE created the Technology Transfer Unit (TTU) in 2002 to serve as a link between ICIPE research scientists and end users with emphasis on small-scale farming communities. This Unit's responsibilities include implementation of research information dissemination through advisory and training in integrated crop management with emphasis on knowledge management and packaging for improved agricultural productivity and market access[13].

ICIPE launched in November 2011 of the Martin Lüscher Emerging Infectious Disease (EID) Laboratory, which provides a specialized platform to undertake studies that will improve risk detection, early warning and response capabilities, to outbreaks of vectorborne infectious diseases of national programmes in Kenya, and Africa in general[14]. In addition, ICIPE in collaboration with Bridgeworks launched the Incubation Centre dedicated to the Research and Commercialization (Spielman et al., 2010). Further, ICIPE, with the support of an IFAD grant, has been developing and promoting off-the-shelf technologies for East African beekeepers and testing market access for their products (Carr and Hart, 2008).

The centre has strong collaborative and partnership arrangements with a number of institutions which include[15]: Kenya wildlife Services, Bridgeworks Africa, ICRISAT, CIAT, World Agro forestry Centre; On-Farm Innovative Enterprises in Watershed Programme at ICRISAT; Allanblackia Development for Smallholder Cultivation at the World Agroforestry Centre; the Latin American Fund for Irrigated Rice at CIAT; and various commercialization activities conducted by the Centre (Napasintuwong, 2010). In addition, ICIPE has linkages with biotechnology companies like Novozymes and Diversa for the collection and study of microorganisms (Laird and Wynberg, 2008).

2.2.5 Kenya Medical Research Institute (KEMRI)

KEMRI has created offices to give emphasis to commercialization, application and linkages such as the KEMRI Production Department (KPD) facility; Production department which has Procurement Officer and Marketing Officer[16]. KEMRI established a 5 million dollar production facility to facilitate commercialization of its innovation (Simiyu, 2011). It has established strong linkages with industry and other private sectors to provide institutional support to the innovators including institutions of higher learning such as University of Nairobi, Egerton University, JKUAT, Maseno University, Kenyatta University, Makerere University; collaborating with Kagoshima University, Center for chronic viral Diseases, Japan; Institute for Primate Research and Bill and Melinda Gates Foundation. It also hosts the Nairobi Centre for the Nagasaki University Institute of Tropical Medicine (NUITM) and has de-

[9] http://www.uonbi.ac.ke/sites/default/fi les/main_uon/Intellectual

[10] http://www.uonbi.ac.ke/node/5323

[11] http://icipe.org/index.php/news/740-farewell-interview-with-icipe-outgoing-director-general-prof-christian-borgemeister.html

[12] http://icipe.org/index.php/research/research-support-units/technology-transfer.html

[13] http://icipe.org/index.php/news/740-farewell-interview-with-icipe-outgoing-director-general-prof-christian-borgemeister.html

[14] http://icipe.org/index.php/about-us/staff/senior-management/director-of-research.html

[15] http://www.kemri.org/index.php/key-personnel;

[16] http://www.kemri.org/index.php/centres-a-departments/production

veloped collaboration between the Center for Microbiology Research (KEMRI), the University of California San Francisco (UCSF), the University of Nairobi (UON) and University of Washington (UW)[17].

Other collaborations and relationships include Japan International Cooperation Agency (JICA) and KEMRI on parasitic and infectious disease research; establishment of relationships that have resulted in training programs at international organizations on innovations management with the Swedish government innovation agency (VINNOVA) and the Office of Technology Transfer of the NIH in the US; Collaborations with pharmaceutical companies based in Kenya for product distribution; Collaboration between KEMRI scientists and traditional healers to develop antimalarials isolated from plants at KEMRI's Centre for Traditional Medicine and Drug Research . KEMRI has adopted an 'open innovation business model' commercialization strategy which deals with investors, research partnerships, licensing opportunities, and revenue from contract manufacturing. In addition, KEMRI provides internal research funding/grants for Clinical work, diagnostic and academic services with annual budget for grants of $1.875 million (Simiyu et al., 2010).

2.2.6 Kenya Industrial Research and Development Institute (KIRDI)

The vision of KIRDI is to become a centre of excellence in industrial research, technology and innovation while its mission is, "to undertake industrial research, technology and innovation and disseminate findings that will have positive impact on national development[18]." To fulfil its mission, KIRDI has established a number of departments and programmes including the Corporate Services Department that deals with intellectual property related issues such as IP registration[19]. There are also various guidelines supporting engagement with stakeholders, in particular, Micro, Small and Medium Industries (MSMIs), the development, implementation and commercialization of research findings and innovations[20].

KIRDI has developed an infrastructure that supports innovation and entrepreneurship by establishing Technology and Business Incubator that provides the incubatees with the requisite technical support to help them absorb and assimilate the technology as well as with the business development services (BDS) and business growth skills to ensure successful uptake of the technologies[21]. KIRDI's Incubation program addresses areas such as entrepreneurial culture in the region, facilitating the creation of enterprise start-ups; micro, small and medium-sized enterprise (MSME), provision of handholding support till the enterprise matures before moving out of the Incubation[22].

KIRDI has also provided other infrastructural facilities which include the Engineering Development and Service Centre (EDSC) which provides technical services in engineering design and prototype development and training to the manufacturing industry; the Leather Development Centre (LDC) comprising a pilot tannery with an effluent treatment plant and a leather goods design unit providing training, contract work in leather processing and product development to both local and regional leather industries; and the Laboratory Services Centre (LSC), which provides analytical and quality control services to industry in Kenya and in the East African sub-region. The LSC in particular supports R&D activities by providing analytical, testing services and quality control services to private and public sectors and provides training for laboratory staff from industry, universities and colleges[23] (Ziyane, 2012).

In addition, through the collaboration between Nairobi Industrial and Technology Park (NITP), Jomo Kenyatta University of Agriculture (JKUAT), Kenya Industrial Estates (KIE) and Kenya Industrial Research and Development Institute (KIRDI) steps have been taken to incubate to commercial level, a wide range of industrial and end user products. In particular, KIRDI's role in this partnership will be to support enterprise development for value addition and technology transfer[24].

KIRDI has also established collaborations and partnerships in various areas which include joint research, training, exchange of information, sharing of research facilities and shar-

[17] http://www.kemri.org/index.php/ctmdr;http://www.kemri.org/index.php/cmr-centre-programmes/rctp
[18] http://www.kirdi.go.ke/about-us-kirdi/service-charter
[19] http://www.kirdi.go.ke/kirdi-departments/corporate-services
[20] http://www.kirdi.go.ke/downloads/category/11-2010-2015-strategic-plan
[21] http://www.kirdi.go.ke/centers/business-incubation
[22] http://www.kirdi.go.ke/centers/ict-software-incubation
[23] http://www.kirdi.go.ke/centers/commercial-and-service-centers
[24] http://www.kirdi.go.ke/partnerships/124-fostering-kenya%E2%80%99s-manufacturing-sector

WTR 2017;6:113-129 https://doi.org/10.7165/wtr17a1115.17

ing of professional expertise. KIRDI has established linkages and works in collaboration with several national, regional and international organizations and agencies. At the international level, linkages have been set up with UNIDO, UNDP, and World Association of Industrial and Technological Research Organizations (WAITRO). Regionally, the Institute works with African Regional Centre for Technology (ARCT), African Regional Centre for Engineering Design and Manufacturing (ARCEDEM), Tanzania Industrial Development and Research Organization (TIRDO), and Council for Scientific and Industrial Research (CSIR). Within Kenya it has signed Memoranda of Understanding (MOU) with two universities, namely: Kenyatta University and Jomo Kenyatta University of Agriculture & Technology[25]. In collaboration with Kamtech Associates Pvt. Ltd., an Indian IT and software development company, KIRDI launched and established ICT incubation program in November 2008 and set up ICT Incubation center. The 2008 ICT Incubation program was run in collaboration with the Kenya ICT board, Ministry of Industrialization, UNIDO and Kamtech Associates Pvt. Ltd[26].

III. THE INNOVATION ECO-SYSTEM IN KENYA

Innovation is a key driver for economic growth both in developed and developing countries. Developing nations are introducing policies that will increase their innovation capacity and embracing of innovation to boost their industrial and economic growth. Kenya launched its first innovation policy in 2006 with its Vision 2030 strategy. The policy declared that Kenya would break from the past and start doing things differently. Kenya's Vision 2030 underscores the importance of institutional reforms, human resource development, and enhanced R&D as well as improved science and technology infrastructure. It emphasizes the need for pursuing more and better collaborations and partnerships (Government of Kenya, 2007).

In 2008, the Government of Kenya formulated the National Science, Technology and Innovation (ST&I) Policy and Strategy (PS) {STIPS} to guide and promote focused integration of ST&I in all sectors of the economy in order to achieve objectives of Vision 2030. Priorities under STIPS include agriculture and rural development; health and life sciences; trade and industry; human resource development; physical infrastructure; energy, environment, and natural resource management; and ICTs (Government of Kenya, 2008). In addition, the STI policy and strategy (2008) emphasizes the need to encourage and support collaborative, multi disciplinary scientific research in universities and other academic, scientific and engineering institutions. Further, it is advocated that there is an increase in public investment for universities, government laboratories and research institutes in facilities, and equipment to enable them to conduct research for that is critical in the identified national strategic priority areas (Government of Kenya, 2008).

The Ministry of Education, Science and Technology was created to spearhead capacity building and innovation. The ministry has created a number of institutions that support capacity building and innovation which include the National Commission for Science, Technology and Innovation; the Kenya National Innovation Agency; and the National Research Fund. In addition, within the innovation eco-system, there is Kenya Education Network, which facilitates the sharing of educational and research resources through a government-subsidized national broadband network and also serves as the National Research and Education Network (Dutta et al., 2015: 131-137).

The 2010 Constitution of Kenya recognizes the role of science and that indigenous technologies should play in the development of the nation and underscore the promotion of intellectual property rights of the people of Kenya (Government of Kenya, 2010). The constitutional mandate was operationalised by the enactment of the Science, Technology and Innovation Act 2013 (Government of Kenya, 2013a).

Sessional Paper No. 10 of Vision 2030 recognizes the role of science, technology and innovation (STI) plays in boosting wealth creation, social welfare and international competitiveness. The Sessional paper highlights four elements that allow effective exploitation as: an economic and institutional regime that provides incentives for the efficient use of the existing knowledge, the creation of new knowledge, and the flourishing of entrepreneurship; an educated and skilled population that can create, share and use knowledge well; a dynamic information and communication infrastructure that can facilitate

[25] http://www.kirdi.go.ke/about-us-kirdi/collaboration

[26] http://www.kirdi.go.ke/centers/ict-software-incubation

processing, communication, dissemination; and finally, an effective innovation system (that is, a network of research centres, universities, think tanks, private enterprises and community groups) that can tap into the growing stock of global knowledge, assimilate and adapt it to local needs, while creating new knowledge and technologies as appropriate (Government of Kenya, 2012).

The Sessional paper No. 10 further underscores the intention of Kenya becoming a knowledge-led economy wherein, the creation, adaptation and use of knowledge will be among the most critical factors for rapid economic growth. Kenya plans to harnesses science, technology and innovation in all aspect of its social and economic development in order to foster national prosperity and global competitiveness. In addition, there are plans to mainstream science, technology and innovation in all sectors of the economy through carefully-targeted investments. This is expected to create a strong base for enhanced efficiency, sustained growth and promotion of value addition in goods and services.

Apart from the policy statements, it is observed that universities and public research institutes include in their vision and mission statements aspects of their third mission. As part of the vision and mission statements and motto, many universities and public research institutes now have the words innovation, entrepreneurship, community outreach, extension, enterprise. In addition they have created offices with their top management ranks in charge of the third mission such as deputy vice chancellors and directorates, with many public universities also having some form of technology transfer office. However, it is argued that universities need to rally the staff, students and the entire university fraternity to embrace the need to demonstrate societal relevance of their activities because while this is desirable, the fact that the incorporation of innovation and entrepreneurship in university's vision, mission does not automatically translate to real support to innovation and entrepreneurship agenda. It is important for universities that wish to establish entrepreneurial partnerships with local actors that such partnerships and the innovation strategies that underpin them are locally relevant and responsive to the needs and aspirations of the local stakeholders. In the case of Kenya, all the 47 counties have their relative strengths and have developed their own county integrated development plans and frameworks and those unique situations must be taken into consideration. (Bolo et al., 2015; Graham 2014)

Agricultural and health sectors in Kenya have a long history of R&D as well as of creating new products. In particular, institutions such as the Kenya Agricultural Research Institute, the Kenya Industrial Research and Development Institute, and the Kenya Medical Research Institute, as well as research into tea and coffee development, all have great traditions of research and innovation. However, the ICT sector came late to innovation, but it has had a greater impact than other sectors. It is argued that innovation in Kenya is driven by pockets of institutions that either have a history of R&D or are led by individual risk takers. This is particularly the case with the emerging ICT innovation hubs which are driven by a few individual risk takers, both in government and industry. It is contended that the success of the crisis-mapping software Ushahidi and the mobile money platform M-PESA, has been a catalyst to a rising trend of innovators especially young group of developers going by the name 'skunkworks' who have begun to organize BarCamps around Nairobi to share their innovations, thus leading to the development of software development hubs. Following on these initiatives, corporations have joined in by financing the development of some applications for the mobile platform. While Aid agencies have also begun to fund Hackathons, thus attracting large numbers of youth keen on showcasing their innovations (Dutta et al., 2015: 131-137).

It is commendable that following the success of Ushahidi[27], an open source software developed in Kenya for information collection, visualization, and interactive mapping, that the premier innovation hub I-Hub has now progressed from branched software to hardware by coming up with their first product connectivity device called 'BRCK'. BRCK was designed and prototyped in Nairobi. This is a device that is meant to solve local problems of erratic electricity and Internet in both rural and urban areas. It is notable that the success of BRCK has led to the establishment of a prototyping technology shop in Nairobi, the first of its kind in Kenya which is intended to help small and medium - sized enterprises (SMEs) create new products and introduce them to the market. There are innovative products, which seek to improve productivity, in different sectors including agriculture, manufacturing, health, and financial services being facilitated by Information Communications Technology (ICT). An example of these innovative products is

[27] http://www.ushahidi.com/product/ushahidi/

WTR 2017;6:113-129 https://doi.org/10.7165/wtr17a1115.17

iCow[28] service, which provides livestock farmers with information, and which is aimed at improving dairy production in Kenya.

There are important initiatives in development of the innovation ecosystems which is being facilitated by the fact that all universities now have a senior staff member, at the level of deputy vice-chancellor, who is in charge of research which has resulted in the development of supporting infrastructure. Such developments by universities in the development of innovation ecosystem include Jomo Kenyatta University of Agriculture and Technology who have put up an Industrial Technology Park for research output; Manu Chandaria Incubation Centre of Kenyatta University[29]; the University of Nairobi C4DLab Incubation centre[30] and also intends soon to establish its own science park, which will focus more on its fab-lab[31], in conjunction with the Massachusetts Institute of Technology (MIT). On a larger scale is the Konza City Technology Park[32] which is expected to harmonize university research activity with industry and government. It is noted that most universities are collaborating with international partners to enhance knowledge transfer while, at the same time, providing new solutions.

Konza Techno City or what is being called 'Silicon Savanna' is hoped to be Kenya's answer to U.S. tech hub Silicon Valley. Konza Techno City is 37 miles (60 kilometres) from the capital City Nairobi, will rise from 7.7 square miles (20 square kilometers) of African grasslands over the next 20 year and aims to attract about 200,000 IT jobs. This is US$14.5 billion project flagship initiative in Vision 2030, the government program to make Kenya a globally competitive country by 2030. The development authority has completed construction of the preliminary access roads and Kenya Power has laid power lines. The development authority intends attract IT related businesses and jobs by building 35,000 homes as well as schools, university, hotels and hospitals. The government- backed authority is overseeing the project infrastructure components which include power, water, waste, public transit while communications such as fiber-optic cable will be accomplished through public-private partnerships. To allow for time to address challenges like funding, timelines and coming on board of investors, the development of the city is being implemented in phases. There is a master plan for the entire city which helps to keep the project's goal clear and the development to progress in an orderly manner. The challenge is, as the city develops, there will be need to preserve its habitat and in particular to ensure no displacement and disturbance of wildlife. In this respect, to minimize the negative impact and to offset potential objections from public stakeholders the team will create a 2.4-square-mile (6.2-square-kilometer) wildlife corridor. In addition, an in-progress water and sanitation project had to be redesigned to accommodate Konza's estimated water needs of 100 million liters (26.4 million gallons) each day by digging boreholes to provide around 2 million liters (528,000 gallons) per day (Haak, 2015, March; KONZA Technopolis, June 2017)

Notable development in the innovation ecosystem is that multinational corporations are also setting up research labs in Kenya to expand their own research reach, while getting closer to the source of unique problems. For example, IBM has set up a research lab at the Catholic University of Eastern Africa and is collaborating with the Kenyan government to create innovations around big data and the next generation of government.

Kenya has continued to improve in its global innovation rankings, which is being attributed to innovative applications of ICTs in various sectors. In particular the financial sector is expected to experience tremendous transformation as a result of a partnership between Kenya Commercial Bank (KCB), the largest bank in the country, and Safaricom, the largest mobile network operator and the owner of M-PESA that enables mobile customers to access credit of up to 1,000,000 Kenyan shillings (US$11,000) without actually having to go to the bank or provide security. Equity Bank, another large bank, has also acquired a mobile virtual network operator license to compete with the Safaricom/KCB partnership. It is such initiatives that contribute to Kenya's excellent performance within its region in the Global Innovation Index (GII), especially in market and business sophistication, which is measured in credit availability, investments, trade, and competition (Dutta et al., 2015).

[28] http://icow.co.ke/

[29] http://www.ku.ac.ke/chandaria-biic/

[30] http://www.c4dlab.ac.ke/

[31] https://www.fablabs.io/universityofnairobi/

[32] http://www.konzacity.go.ke/

It is further noted that such rapid innovations, encouraged by greater capacity for technology diffusion, occurred before the country had a relevant policy framework in place, and in fact, the emerging innovation community did not pay attention to these developments when they did finally happen. It is argued that although it was a policy framework intended for all sectors, there was little awareness of this policy outside the Ministry of Science and Technology and a few research institutions. The launch by the government of the Kenya Open Data initiative has benefited the ICT sector and this has resulted in collaboration between the Ministry of Information and Communication (MOIC) and the developer community. The collaboration has resulted in establishment of various innovation hub including I-Hub, I-Lab, and A-Lab that has produced innovations, mentoring and incubation programmes that have been beneficial to a cross-section of economic sectors.

There are a number of challenges facing Kenya in achieving a robust innovation ecosystem which include lack of national commitment to leverage innovation for greater economic expansion. In particular, resource allocation to R&D is often not guaranteed, and the little that is allocated to research institutions is spent on recurrent expenditures. There are also serious coordination gaps arising from lack of both of central coordination of R&D and of advocacy for multidisciplinary research which continue to undermine innovation. It is noted that even within the government, research is undertaken largely in silos, leading to capacity underutilization. It is argued that lack of coordination means that SMEs do not have the R&D support necessary to bring new products to market. In addition this is further complicated by the fact that technical, industrial, and vocational education training institutions (TIVETs) are declining, as some have been converted into universities. However it is reassuring that the government is undertaking policy initiatives by creating a TIVET Authority and to build new institutions (Government of Kenya, 2013b).

It is argued that the establishment of Technopolis and the development of the innovation ecosystem have made an important contribution in South Korea's latest industrial and regional innovation system establishment. In particular, the regional innovation policy based on technopolis has been a critical instrument in achieving regional economic growth and sustainable development through networked collaboration between Higher Education Institutes (HEIs), research institutes, industries and government (Triple Helix). It is contended that Daedeok Innopolis has been responsible for the central role in the strategy of establishment of science-technology based innovation cluster in Korea. Daedeok Innopolis has played a pivotal role in the development of Korea's high-tech industry with over 1300 companies having started and grown in the area through the start-ups ecosystem (Lee and Oh, 2016).

It is encouraging that Kenya has tried to develop close technical collaboration with Republic of Korea enabling some Kenyans, for example, to go to the Korean Advanced Institute of Science and Technology (KAIST), which has played a key role in the development of the country. Following such collaboration, KAIST plans to establish a university at Konza Techno City.

In addition, borrowing from the Korean experience Kenya can forge closer collaboration between SMEs and research institutions by establishing a more business-friendly education system that addresses cultural and other barriers to start-ups. This kind of collaboration can be enhanced by embracing an education system that has structures that provide systematic support for public private innovation partnerships and that develops high highly trained students that join innovation-oriented companies, particularly SMEs, to support industrial innovation. Kenya can also encourage more start-up creation and SME growth through tax credits to enhance radical innovation.

An innovation ecosystem consists of a group of local actors and dynamic processes, which together produce solutions to different challenges. The main features of the ecosystem include top-level universities and research institutions, sufficient financing for new companies and research plans, a symbiotic combination of large established companies and new startups, specialization of and cooperation among companies, service companies specialized in the needs of local companies, a sufficient local market for new innovative products, and global networking (Munroe, 2009; Kenney, 2000). In addition, successful ecosystems have a "community of fate", meaning that the actors of the region see that their success is linked to the success of the whole region (Hautamäki, 2010).

Kenya can also learn from the USA through the establishment and strengthening of the partnerships between US universities and local universities such as MIT and University of Nairobi for developing new products using the fab-lab technologies. It can further learn from the USA's TechShop concept which is new approach for building a community of innovators that is increasingly becoming the playground for innovation in the USA. TechShop centres ('hackerspace' or 'learning centres') comprehensive tools, software and space

WTR 2017;6:113-129 https://doi.org/10.7165/wtr17a1115.17

for fabrication and prototyping, as well as classes. It is argued that University of Nairobi's collaboration with MIT and other similar arrangements can provide the best chance for successful transfer knowledge from the USA to Kenya (Dutta et al., 2015).

To make the ecosystem alive and renewable, a risk taking entrepreneurial culture is essential. Another special feature is re-cycling, the continuous movement of ideas and people. People move easily between companies and from research institutions to business and vice versa. Interactive, dynamic companies are at the core of the ecosystem. The most famous example of this characteristic is Silicon Valley, with its highly entrepreneurial, radical-thinking and risk-taking culture. It is one of the most important and best-known innovation ecosystems, and its experiences are emulated in other places all over the world, from Tel Aviv, Israel to Bangalore, India (Hautamäki, 2010; Kao, 2009; Kenney, 2000; Munroe, 2009; Saxenian, 2006). Supporting services are similarly important. These include intermediary organizations, which are often local organizations such as technology centers, enterprise incubators, and development companies whose primary tasks are to facilitate the transfer and commercialization of technology, and the development of innovation networks (Oksanen and Hautamäki, 2014).

IV. CONCLUSIONS

In this paper we have examined the research question: what is the role of Kenyan universities and research institutes in spurring an innovation ecosystem? There has been varied success that has been recorded by various Kenyan universities and research institutes. It is concluded most universities are collaborating with both local and international partners to enhance knowledge transfer while, at the same time, providing new solutions. Collaboration and innovation activities are critical in spurring an innovation eco-system. In furtherance of this, key stakeholders including industry, universities, research institutes, government and civil society should engage with one another to build a robust innovation eco-system. Universities and other knowledge intensive institutions create new know-how and build up the knowledge space. Industry and business utilize this new knowledge and develop the innovation space. The public sector acts as an enabler of the innovation environment. The process brings together different actors to brainstorm, discuss, and evaluate proposals. In addition, industry-university collaboration can be enhanced by ensuring that the collaboration is aligned with the company's research and development strategy.

The model presented in this article has implications for innovation processes, innovation management, and innovation studies. The development of innovation hubs and ecosystems is rationalized for two reasons. First, innovation hubs as specialized places of knowledge and business produce value for global networks. Second, building innovation hubs is presented as one possible response to regional structural changes and crises. The development methodology of such environments is crystallized into four concepts and development measures that need to be actualized systematically. Open dialogue is needed in order to form common views and goals. Deep and long-term collaboration between universities, industry, and government acts as a basic model for regional cooperation and agreements.

Kenya has developed a comprehensive innovation policy framework, played an important role in creating an effective triple helix that will eventually harmonize innovation programmes for greater economic growth, but the communication of policy to innovation actors must be enhanced.

Despite often spoken commitment to the Entrepreneurship and Innovation agenda by university leadership and a flurry of high-profile and engaging entrepreneurship activities offered by various support functions, entrepreneurship activities are often not visible in university departments in Kenya. This is partly attributed to the fact that universities do not build incentives for undertaking of entrepreneurship activities to facilitate transitioning to an entrepreneurial institution and goals relating to the entrepreneurial agenda hardly feature.

The examination of the cases above also indicate that there are a number of factors including the state of infrastructure, the institutional environment for research and innovation, the policies and reward systems, the institutional IP policies that have impacted the performance of the universities and public research institutes in achieving their third mission and the development of a robust innovation ecosystem.

Innovation in Kenya is driven by pockets of institutions that either have a history of R&D or are led by individual risk takers. This is particularly the case with the emerging ICT innovation hubs which are driven by a few individual risk takers, both in government and industry

Resource allocation to R&D is often not guaranteed, and the little that is allocated to research institutions is spent on recur-

rent expenditures. In addition, there is lack of central coordination of R&D and of advocacy for multidisciplinary research which continue to undermine innovation. To facilitate the building of innovative capabilities, consideration should be given to the extension of tax credits to the private sector for research activities.

There is also need to review the Kenyan education system through industry-academia cooperation to improve the capacity building in Science, Technology, Engineering Mathematics (STEM) subjects and anchor entrepreneurial education in all institutions.

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