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Research Application Summary

**University research in development space in the wake of the Sustainable Development Goals: Perspectives for research development in Africa**

Adipala, E. & Egeru, A.

Regional Universities Forum for Capacity Building in Agriculture (RUFORUM), P.O. Box 16811  
Wandegeya, Kampala, Uganda

**Corresponding author:** [e.adipala@ruforum.org](mailto:e.adipala@ruforum.org)

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**Abstract**

Research and innovation is a critical and definitive determinant of national and regional economic transformation. Major global economies have developed due to their dominance of the global research and innovation systems. Africa's match to the competitive global knowledge economy is gradual yet rising. This article provides perspectives into research development in Africa at the backdrop of the Sustainable Development Goals (SDGs). It argues that the SDGs have provided a level platform for Africa and African researchers in universities, public research organisations and industry as well as African governments to strengthen research partnerships and collaboration and increase investments so as to build resilient research and innovation systems. Africa's share of global research output is still limited despite the observed increase to 2.3% in the last decade and so is Africa's patent fillings and trademark applications at 0.5% of the global consideration. Research impact measured through citations, patent fillings and trademark applications are critical indicators of research quality; Africa must address these shortcomings. Whilst Africa's global research output is rising, this is principally driven by collaborations and partnerships with United States and Western Europe and less with other African countries, researchers and industries. Further, Africa's doctoral graduate output is still low compared to that from the OECD countries that in the last decade witnessed a 40% increase. The low output of doctoral graduates in the continent could be attributed to static models of doctoral training, massification of higher education at undergraduate and masters level that do not translate to doctoral enrollment and limited doctoral programmes across disciplinary spectrum in African universities. However, innovations around doctoral training such as the Regional Doctoral Training Programmes in RUFORUM member universities provide evidence of possibility of increase doctoral production in disciplinary and multi-disciplinary spectrum with research quality.

Key words: Africa, Doctoral graduate, innovation system, patents, RUFORUM, SDGs

**Résumé**

La recherche et l'innovation constituent des déterminants essentiels and définitifs pour une transformation économique nationale et régionale. Les économies globales majeures sont développées grâce à leur domination dans la sphère de la recherche globale et des systèmes d'innovation. Le partenariat de l'Afrique avec l'économie mondiale de la connaissance est

en hausse progressive. Cet article présente des perspectives sur l'évolution de la recherche en Afrique dans un contexte des Objectifs pour le Développement Durable (ODD). Il a été argumenté que les ODD ont fourni une plateforme pour l'Afrique et les chercheurs africains des universités, les organisations publiques de recherche et industries, de même qu'aux gouvernements africains afin de renforcer les partenariats de recherche et la collaboration, et accroître les investissements de façon à développer des systèmes résilients de recherche et d'innovation. La contribution de l'Afrique à la production de la recherche sur le plan global demeure encore limitée, malgré l'augmentation jusqu'à 2,3% observée au cours de la dernière décennie, de même que les demandes de brevets et de marques de commerce de l'Afrique à 0,5% de la considération globale. L'impact de la recherche est mesuré à travers les citations, les compléments de brevets et les demandes de marques qui sont des indicateurs essentiels d'une recherche de qualité; l'Afrique doit donc répondre à ces lacunes. Alors qu'on note une augmentation de la production de la recherche en Afrique, cela s'explique principalement par les collaborations et des partenariats avec les États-Unis et l'Europe de l'Ouest et moins avec d'autres pays, chercheurs et industries en Afrique. De plus, la production des docteurs en Afrique est toujours faible, comparée à celle des pays de l'OCDE qui pendant la dernière décennie, ont enregistré une augmentation de 40%. La faible production des docteurs sur le continent pourrait être attribuée aux modèles statiques de formation doctorale, à une propagation de l'enseignement supérieur au niveau du premier et du second cycle qui ne se reflète pas au niveau doctoral, et des programmes de doctorat limités à travers un spectre disciplinaire dans les universités en Afrique. Toutefois, les innovations concernant la formation doctorale telles que les programmes régionaux de formation doctorale dans les universités membres de RUFORUM, témoignent de la possibilité d'augmenter la formation des docteurs dans un spectre disciplinaire avec une recherche de qualité.

Mots clés: Afrique, docteur, système d'innovation, brevets, RUFORUM, ODD

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## Introduction

Global discourse on the race to the top economically has placed emphasis on knowledge as a key driver (Michalski *et al.*, 2001; Boretos, 2009; Dutta, 2016). This has given resounding assurance to knowledge production and as such, the knowledge economy has become a treasured attribute in the economic growth and development. Accordingly, the place of universities and research institutions has once again become very critical in the development arena in both developed and developing nation states. King (2004) demonstrated that there is a direct relationship between research output and the wealth intensity of a country (Figure 1), providing a basis for advancement of knowledge as a key driver in the economies of the 21st century. Further, there is a direct relationship between an economy's performance and its pool of PhDs. For example, all developed nation states have at least above 170 PhDs per a million people. Meanwhile the emerging economies especially the BRICs have been able to move to the top of economic performance by escalating the ratio of researchers to the population. For example, China has been able to reach a ratio of 1200 PhDs per a million and this has provided a rapid transition in the

economy through production and innovation (Maguire, 2010; University of Pretoria, 2012; Lemarchand and Schneegans, 2014). Universities are knowledge production centres and staff and students at PhD level are a symbol of knowledge generation and innovations relevant to socio-economic development of a country and/or region. This cadre is also critical in making tacit knowledge locally available and can thus be volarized for national, regional and global development purposes (Hill, 2006). Further, universities are critical in providing differentiated and effective systems as well as making it possible for developing countries in which they operate to join the global knowledge society and compete with sophisticated knowledge economies (WUN, 2013).

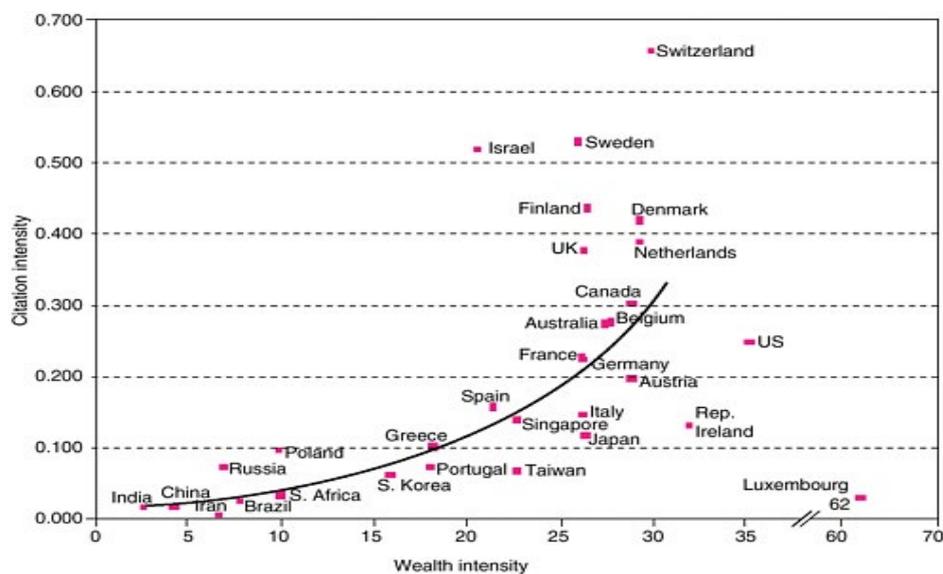


Figure 1. Comparing economic and scientific wealth. National science citation intensity, measured as the ratio of the citations to all papers to the national GDP.

The global development agenda and processes have an impact on the extent to which higher education and universities in particular influence development outcomes for example through the research and engagement with the communities and industry. In this regard, a missed opportunity was realised during the implementation of the Millennium Development Goals (MDGs) because universities followed the MDGs rather than being integral in their design, implementation and assessment (Warden, 2015). This is because the MDGs focused centrally on primary education and with a specific attention to access rather than educational outcomes. As such, the MDGs and international development linked to them became a study discipline by interested students and professors, producing volumes of research, data and analysis around MDGs. However, the Sustainable Development Goals (SDGs; Figure 2) places universities at the core of 2030 Agenda with Target 4.3 focused on the universities by petitioning for equal access for all women and men to affordable and quality technical, vocational and tertiary education including university.

Importantly, the SDGs have a strong commitment to research, technology development and innovation in the developing countries. For example, Targets 2a; 3b; 7a; 9.5; 9b; and 14a are all focused on strengthening research in the developing countries. Target 9.5 is particularly explicit with regards to investment in research and innovation. It is focused at enhancing scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending (UN, 2017).



Figure 2. Sustainable Development Goals (SDGs; 2030 Agenda)

This calls for increased research investment to drive quality and productive research well voiced in the SDGs framework. Target 2a also highlights the need to increase research investment, including through enhanced international cooperation in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries especially the least developed countries. The SDGs have thus not only provided a platform for negotiating for investment in research but have also set out the dimension of research as well as the requisite development outcome. By prioritizing the least developed countries, the SDGs are providing opportunity to redefine the place for research investment in the global south thereby altering the historical concentration of research in the developed countries as has been over the last century. It also provides opportunity for universities and research centers in the developing countries especially those in Africa to re-engineer their research priorities, re-align them to match the development needs and technologies appropriate to the local development priorities. Universities will therefore remain critical players in fulfilling the 2030 Agenda aspirations through three critical actions: expanding human capital, strengthening research and increasing action-oriented research outputs,

and implementing the agenda through multi-stakeholder partnerships (UNDP, 2017). This article provides insights into the role of university research in development from perspectives for research development in Africa.

### Global and Regional Research output

The global knowledge economy is at disproportionate odds; the Higher Education Institutions are in self-competition within and amongst themselves and across countries and continents. The competition surge is further accelerated by the developments in the global knowledge and research ranking systems. The Shanghai Jiao Tong University Institute of Higher Education and World University Rankings have become global change agents in how universities and researchers engage in the research, partnerships and collaborations (Marginson and Van der Wende, 2007). While these may not reflect the true quality of teaching and research process, they have become influential in guiding public opinion, resource allocation as well as public trust in universities that feature as either progressing towards closing the gap and/or maintain presence in the top tier of the rankings. According to King (2004) nearly 84.5% of the global publications cited between 1993-2001 was published by eight countries (United States, United Kingdom, Japan, Germany, France, Canada, Italy, Switzerland) and only 31 (in Western Europe, North America, Asia) of the 193 countries in the world produced 97.5% of the world's cited research (Figure 3). Africa as a continent, despite improving its share of the global research output is comparatively way below a competitive knowledge production levels. Even with the 2.3% level increase, the bulk (Figure 4) of this research output comes from South Africa, North Africa and a few premier universities in Uganda, Kenya and Nigeria in east and west Africa (Gondwe, 2010; Schemm, 2014).

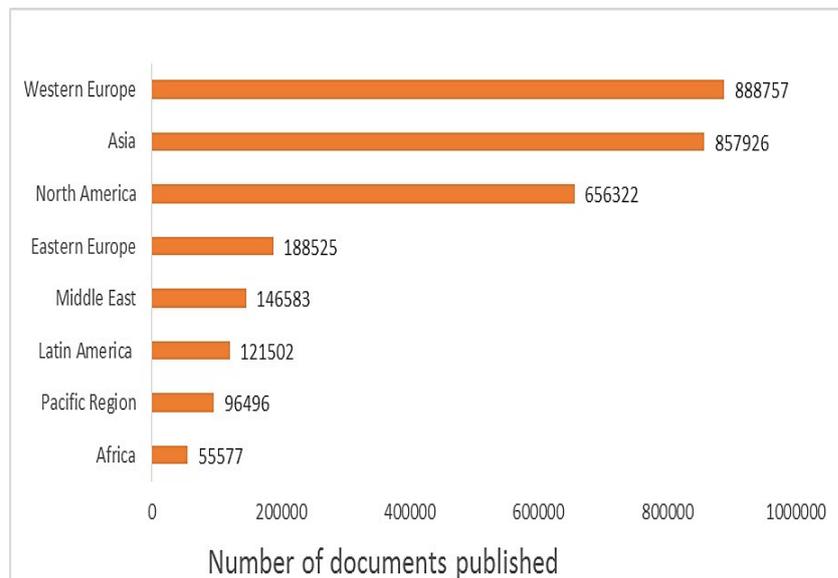


Figure 3. Global Scientific Output, 2015 (Tabaro, 2016)

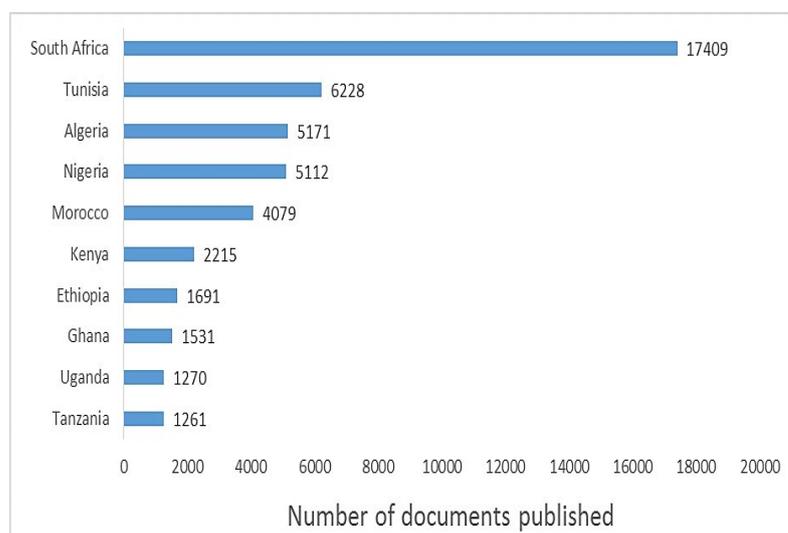


Figure 4. Africa Scientific Output, 2015 (Tabaro, 2016)

Recent improvements in Africa's contribution to the global knowledge system through published works from 1.2% to 2.3% during the 1996 to 2012 period and is projected to rise (unfortunately no definite level determined). This growth can potential be doubled if strategic interventions are taken to enhance skills development and awareness of free and low cost access to peer reviewed research in African universities (Schemm, 2014). Already, it appears that universities and research institutions in the continent that have strengthened access to quality peer reviewed and open access research have a doubling of research output. This is particularly so because open access increases research dissemination, especially to researchers and institutions that cannot afford subscriptions and thus spur research and improving productivity at universities and research institutions (Tempest, 2013). However, improving access alone does not guarantee returns on investments; the International Network for the Availability of Scientific Publications (INASP) has demonstrated in 22 countries that providing a full cycle of research capacity building including developing discounted consortia arrangements, training librarians in managing digital resources, mentoring researchers in academic literacy and authorship skills and supporting the process of local online journal development and hosting dramatically increases researchers-universities productivity (Schemm, 2014).

It is also important to recognise that publishing in top notch international peer reviewed journals is cost limited; the cost of open access is too high for many African researchers (Tempest, 2014). Innovative alternatives that provide opportunity for African researchers to publish ought to be explored. In championing the development of the African Journal of Rural Development (AFJRD; <http://www.afjrd.org/jos/index.php/afjrd>), RUFORUM was seeking to provide African researchers opportunity to communicate Africa's relevant research to the global community through a no-cost open access publishing. No-cost because researchers are not required to pay for article processing fees. This however does

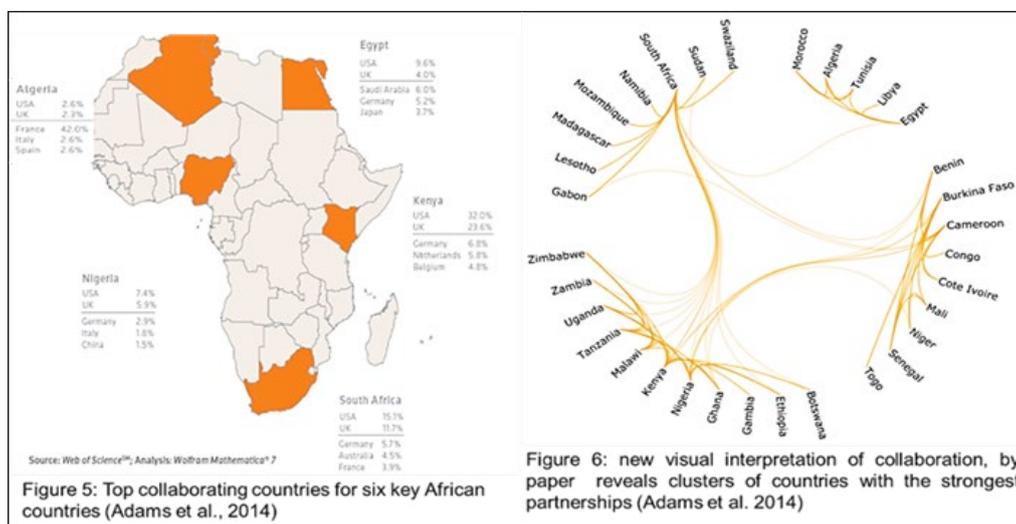
not mean that RUFORUM does not incur costs in the production process. Such costs are absorbed by development partners such as Bill and Melinda Gates Foundation, Mastercard Foundation and Carnegie Foundation that believe in increasing scientific and research output from Africa (Nampala *et al.*, 2017). Other players such as Elsevier have certainly contributed to the increased availability of open access publications through collaborations and partnerships such as Research4Life (Gedye, 2013).

Africa is certainly not at slumber; several initiatives at continental level are in offing and/or have been promulgated to increase research output as well as strengthen investment in research, science, technology and innovation including engineering and mathematics. The Lagos Plan of Action and the African Union 2007 initiative calling on African countries to allocate 1% of their GDP to science are some of the efforts and commitment from African Governments if fulfilled could increase Africa's competitiveness in research (Gurib-Fakim, 2015). Further, taking forward the aegis of the Partnership for Applied Science, Engineering and Technology (PASET) that was overwhelmingly endorsed by African ministers in 2014 in Kigali forward will significantly increase investment in research and improve relevance, quality and excellence in learning in higher education in Africa (World Bank and Elsevier, 2014). Fundamental to all these initiatives is to keep them on a long term basis projected to require about 15-20 years investment time span as opposed to piecemeal investments with a short duration cycle of 1-5 years as research excellence attainment is a gradual process often requiring transformation of processes as well as mindsets.

### **Research collaboration in Africa**

In a globalized world as today, research is defined by ubiquitous character explaining why despite diplomatic disagreements the United States of America and the Russian Federation still cooperate on major space research undertakings. For example, US-Russia signed a bilateral agreement to further research development collaboration in nuclear energy and security in 2013 (US Department of Energy, 2013); they also have a collaborative research partnership agreement on the prevention and treatment of HIV/AIDS and HIV-associated comorbidities (Department of Health and Human Services, 2016). What is clear in all these is that governments are making use of research collaboration in one way or another as a policy instrument for technology transfer; this be it from universities and research councils to industry, for knowledge transfer from abroad, as a means to improve diplomatic relations as in this case between US-Russia relations by creating goodwill, and to gain political mileage (Wagner *et al.*, 2002; Pouris, and Ho, 2014).

In the African context, in a study conducted by the World Bank and Elsevier analyzing the decade long development in sub-Saharan African Science, Technology, Engineering and Mathematics Research, collaboration within and among African countries was found to be between 0.9%-2.9% with inter-Africa collaboration without any South African or international collaborator comprising 2% of all East African research, 0.9% of West and Central Africa, and 2.9% of Southern Africa. Further, extra-regional collaboration provided the largest share of sub-Saharan Africa's research with 42%, 68% and 79% of total research output in West and Central, East and Southern Africa, respectively, being



generated through collaboration. It is however, important to note that within East Africa, intra-regional collaboration has increased from 9.8% to 13.6% of the total research output (World Bank and Elsevier, 2014). A clustering of collaborating countries in Africa (Figure 5 and Figure 6) has been observed to include Kenya, South Africa, Nigeria, Algeria, Tunisia and Egypt (Adams *et al.*, 2010). Emergent in this clustering is the underlying fact that Africa's research collaboration is largely driven by geography, shared culture and language; an inheritance of the colonial past. How Africa begins to unravel these closely niched and nested networks will define the next stage that will increase Africa's research output. One way to break these barriers is increased intra-Africa mobility of staff and students which open-up barriers and doors to learning new cultures, language and practices. RUFORUM has in the recent past emphasised intra-Africa mobility with support from the European Union leading to the training of 291 African students from across Africa. Further, academic staff from Benin, Sudan, Nigeria, Malawi, Uganda and Cameroon have had opportunity to visit and teach at Makerere University and Lilongwe University of Agriculture and Natural Resources (Tanyi, 2017; RUFORUM, 2017a). This effort is further being intensified with 48 research teams from North, East, South, Central and West Africa being mobilised in 2017 to competitively raise resources for Intra-Africa mobility. Over the next five years, 106 African students, 20 academic and 17 support staff will have the opportunity to be part of the Intra-Africa mobility programme (RUFORUM, 2017b). This intra-Africa mobility has enhanced partnerships and initiated wide ranging research collaborations whose track can be traceable in the coming one to two decades as the current crop of the next generation researchers rise through their careers.

The intensity of intra-Africa research collaboration and partnership is a growing pattern with South Africa (Figure 7) being a greater player in the collaboration ring in the continent. North Africa is also having an active collaboration and partnerships with the rest of Africa but this is principally dominated by Egypt (Adams *et al.*, 2014). Whilst South

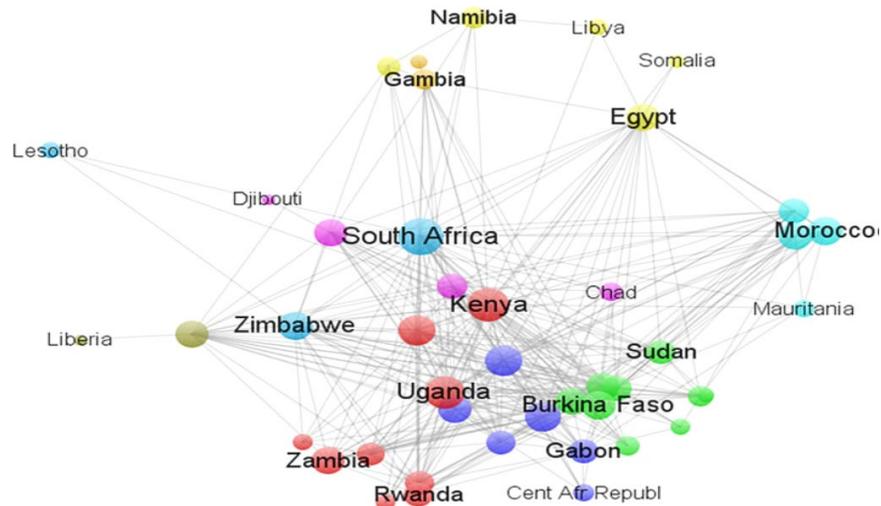


Figure 7. Co-authorship relations between 46 countries within Africa in 2011

Africa has demonstrated continental leadership in research collaboration and partnerships, it has not fared well at country level in terms of inter-disciplinary, inter-institutional and inter-sectoral collaboration. Collaboration in South Africa is highest within academic institutions and related disciplines (Mouton, 2000). It is important to note that critics and skeptics of research collaboration under the north-south partnerships opine that it is a neo-colonial approach to ensure continued subjugation of Africa (Boshoff, 2009). These counter arguments notwithstanding, research collaboration remains one of the key steps to narrowing the gap between Europe, Americas and Asia and Africa and facilitate rapid acceleration and advancement in Africa based on technology development as well as technology transfer. This is also particularly important in building and integrating the Africa's innovation system (Toivanen and Ponomariov, 2011).

### **Does Africa's research lead to patents**

Patents are a difficult and delicate balance in research particularly in university based research from three counts (Pouris and Pouris, 2011). Firstly, most of the university research is funded by public resources and/or philanthropists whose finances have a social-good course whose funding conditionality often provide for non-exclusivity of generated knowledge and technologies (Verspagen, 2006). The exception to this is with the Republic of South Africa that has allowed researchers to obtain intellectual property rights from publicly financed research and development under the Act 51 of 2008 (IP Act) (Bansi and Reddy, 2015). Secondly, patenting research leads to exclusivity and profiteering yet most academics and universities in Africa especially in sub-Saharan hardly have technical knowledge and expertise in filing for patents. Thirdly, patenting is a tedious and a costly affair whose expertise and resources are hardly available from within the university budgets. However, the interest on patenting university based research is on the

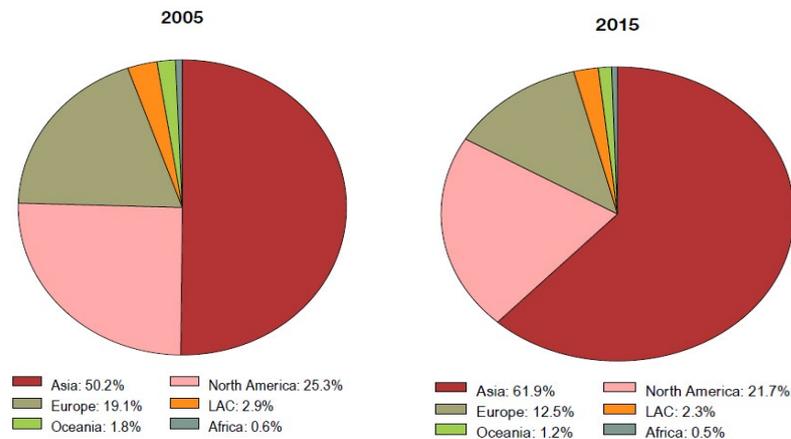


Figure 8. Patent applications by region (WIPO, 2016)

rise particularly because the knowledge economy has taken a center stage and the amount of licensing contracts backed by patents on a global domain is higher than US\$100 million (Pouris and Pouris, 2011). Patents are an embodiment of intellectual property and the commercialisation of university innovation. This practice that has taken route in advanced economies is increasingly being adopted in Africa but still at low level even in South Africa where universities have had considerable appreciation (Bansi, 2016).

Patented research innovations are an excellent indicator for research quality and increased innovation processes as well as the need for high quality research output (Bansi, 201). It encourages greater research interaction and interaction is an important research artery facilitating greater technology transfer, innovation and learning processes (Verspagen, 2006). It is also generally acknowledged that granting universities and public research organisations rights to own intellectual property (e.g. patents, copyrights, trademarks, utility models, industrial designs) and allowing these institutions to commercial the results, accelerates the transformation of scientific discoveries into industrial applications and increases collaborative ties within and among universities and the private sector (Zuniga, 2011). This pattern seems to have driven the Chinese, Koreans, United States and Brazilian research and innovation system. For example in 2015 patent filings on a global average grew by 7.8% and trademarks by 15.3% with China being the largest source of this growth increasing by 18.7% (patents) and 27.4% trademark applications. This was generally far higher than the total patent filings for the entire Africa that stood at 0.5% (3.1% growth rate) of the global average and Africa, LAC and Oceania altogether at 4 percent (Figure 8; WIPO, 2016). The telling truth is that unfortunately, Africa is no near competitive bracket in the filling of patents and trademarks and reflects the level and quality of research and innovations coming out of the continent as well as the match of the researchers on the continent per capita level. This is because compared to Germany, whose research output

from universities has not exceptionally grown in the last 10 years to the trend observed in Africa, the number of patent filings over the last 10 years has been growing (Neuhausler *et al.*, 2017). This pattern could be explained by the focus of the research being undertaken as well as the awareness and technical expertise available to university researchers. Thus, systems and organizational structuring are critical in driving this process forward.

### **Doctoral Education in Africa: success and research implication**

Africa needs tens of thousands of doctorates; this demand is premised not on the traditional role of the PhD and the provision of a future supply of academics but rather on the increasingly important role of higher education particularly provision of high level skills in the knowledge economy (Cloete and Mouton, 2014). Unfortunately, Africa has had limited throughput of PhDs (McGregor, 2013; Bingley, 2014). For example, 1,240 PhDs, 56 PhDs and 2 PhDs were produced by South Africa, Makerere University and Gulu University in 2015, respectively. This is by far below the 2,400 PhDs produced by the University of Sao Paulo in Brazil (Cloete, 2015). South Africa has recognised that building a knowledge-based economy that is positioned between developed and developing countries requires that it increases its PhD production rate by a factor of five over the next 10-20 years bringing at least 6,000 PhDs into the fold by 2018 (DST, 2008). In that regard, the South Africa National Development Plan 2030 has made bold proposals to train 100 PhDs per a million people translating to 1,420 per annum in 2010 to 5,000 per annum by 2030. These bold proposals require an investment of US\$580 million per year for it to be realised (Cloete *et al.*, 2015). While South Africa knows its PhD gap, a number of countries in sub-Saharan Africa have no definite statistics on the number of PhDs required to close the PhD gap at country level.

Doctoral education is a critical factor in the university research capacity and serves the core function of research productivity and innovation in the global knowledge economy (Nerad *et al.*, 2008). Given the focus of doctoral training, it is by nature expected to produce new, cutting-edge and original ideas and knowledge, through research and exchange of ideas, knowledge and information between professors, researchers and students (Sehoole, 2011). Accordingly, there has been an increased focus to increase the number of doctoral graduates globally. As such, enrolment and production of doctoral graduates has seen a rise but this growth in doctoral enrolment and production is not uniform. In the past decade for example, the OECD countries experience a 40% growth in doctoral graduates (Cyranoski *et al.*, 2011). By contrast, the growth in Africa was dismal in spite of the fact growth was actually taking place. A plethora of issues foment this sort of limited throughput in the production of the doctoral graduates on the continent. Firstly, a general pipeline problem affecting the production of doctorates as well as associated research training and publications, the huge increase in the undergraduate and master's students and academic programmes which draw time away from the senior faculty and do not also translate into PhD enrolment. Secondly, doctoral programmes are limited in many African universities and across the disciplinary spectrum. This affects enrolment as well as the potential research and knowledge output emerging from the training process. Thirdly, the models adopted by many African universities for doctoral training mirrored those that were

used in European universities owing to the colonial legacy yet the European universities have since then transformed their training systems and greatly innovated doctoral training; Africa's largely remained static (Cross and Backhouse, 2014).

The realisation and appreciation of the full extent of the enormous challenge around doctoral production influenced the development of the RUFORUM Regional Doctoral Training Programmes based on the respective universities comparative advantage and areas of historical expertise. This led to several doctoral programmes including: PhD in Dryland Resources Management (University of Nairobi), PhD in Plant Breeding and Biotechnology and PhD in Agriculture and Rural Innovations (Makerere University), PhD in Soil Science (Sokoine University), PhD in Agricultural Economics and PhD in Fisheries and Aquaculture (Lilongwe University of Agriculture and Natural Resources). Besides the regionality and university comparative advantage, these doctoral programmes embody a great deal of intra-Africa mobility pulling doctoral talent from all regions of Africa both for students and staff with a clear doctoral training pipeline. The programmes are also designed with a unique attribute being taught PhD programmes providing for a closer interaction between the doctoral students and academics as well with a suit of facilitative programmes including skills enhancement, field attachment and placement, and interaction with wider national and regional research system (Figure 10). Since the inception of the Regional Doctoral Training Programmes in 2008, 417 doctoral graduates have been trained. Another innovation around facilitating increased enrolment and production of doctoral graduates through the RUFORUM network has been the introduction of the Graduate Teaching Assistantship (GTA) program. The GTA model functions by alleviating the constraints faced by African universities in meeting the costs of doctoral training of their academic staff. Under the GTA framework, the doctoral student is exempt from paying tuition fees in the university he/she is placed. The parent university where the academic staff is originating from provides stipend and research costs. The GTA initiative was initiated by the RUFORUM Vice Chancellors in 2015 with target of producing 325 doctoral graduates in five years. Since its inception, 75 doctoral students have been placed with 122 pending placement as of 2017. It is also important to note that by developing the regional doctoral programmes, an impetus for moving and solidifying the respective universities' excellence positions were sowed. Accordingly, these programmes provided a basis upon which some of these universities now host the World Bank Africa Higher Education Centres of Excellence such as the Makerere University Regional Centre for Crop Improvement (MaRCCI).

### **Concluding remarks**

This article has focused on providing perspectives for research development in Africa coming from the background of the Sustainable Development Goals (SDGs). The article has highlighted a number of fundamental issues that are worth consideration at this level. Firstly, universities will and are critical to the implementation and attainment of the SDGs and as such higher education institutions universities inclusive can no longer afford to take a back stage in the 2030 Agenda. They must come to the forefront and provide evidence and science relevant to SDGs success. Secondly, Africa strongly needs a catch-up in terms of closing the knowledge economy gap and there is no shortcut to this but African



Figure 9. RUFORUM Regional MSc. and PhD Programme model suite

Governments must invest in science, technology and innovation. This is particularly important as the innovation ecosystem in many African countries requires to be jam-started and strengthened to function to be able to compete on a regional and global level. Thirdly, Africa's knowledge and research output far lags behind that of the rest of the world despite observed increases in the last decade. At present, the continent's total research output to the global system is far less than that produced by China alone. Fourthly, owing to a low research output and perhaps quality, Africa's index on the global patent filling and trademarks applications is dismal; a push towards doubling this from within universities and public research organisations requires considerable efforts by all stakeholders. Fifth, inter-Africa research collaboration is still limited; it is therefore important to explore unique models that increase inter-Africa research collaboration as well as mobility of researchers on the continent. Finally, the models of doctoral training and other constraints curtail the throughput of doctoral graduates on the continent; continuous innovation around doctoral training is urgently required to increase completion as well as research quality.

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