ABOUT THE JOURNAL

More than ever before there is a great challenge for developing countries in sub-Saharan Africa to improve the quality of life. The large proportion of this population consists of smallholder farmers whose livelihood is hinged on agriculture. As such, scientists are faced with the task of improving agricultural productivity, farmer incomes and the overall livelihoods of smallholder farmers. To respond to this challenge, universities and other institutions are intensifying efforts of working with rural communities to improve agricultural productivity and livelihoods.

Universities are increasingly institutionalizing outreach programmes to strengthen entrepreneurship along value chains; and to infuse experiential learning for graduate students, academic staff and other actors they interact with including communities. Other agencies notably NGOs and National Agricultural Research Institutes (NARIs) have well-established programmes for reaching not only to farmers but also to emerging agribusinesses along the entire agri-food systems and value chains. As part of its mandate to share lessons, the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) has launched the African Journal of Rural Development (AFJRD) in 2014.

The AFJRD is an on-line open-access journal published quarterly with an Editorial office at the RUFORUM Secretariat, Kampala, Uganda. The AFJRD publishes original research papers comprising emerging issues in rural development; authoritative reviews; synthesis articles and editorials; chapters and book reviews as well as short communications that may not warrant publication as full papers. All submissions must have a focus on sustainable development of rural communities and improving livelihoods generally and as such, authors and contributors will be required to contextualize their work to fit this focus and scope. The primary purpose of the AFJRD is to share knowledge, on all aspects that contribute to sustainable rural development and improving livelihoods and development broadly as widely as possible. All articles and opinions therein published in the AFJRD reflect views of the authors and not necessarily those of the African Journal of Rural Development.

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Editorial

Higher Education in Africa: Current status and perspectives for inclusive transformation

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ABSTRACT
African universities are expected to help tackle challenges facing the African society and realise the aspirations of the Africa Agenda 2063 and the UN Agenda for Sustainable Development Goals 2030 in the current context of globalization of higher education. Unfortunately, there have been substantial challenges affecting Higher Education in Africa, notably the disparities in gender inclusion, limiting the potential of women, and the decline in average public expenditure per tertiary education student, making Sub Sahara Africa tertiary education enrollment ratio the lowest in the world. This editorial introduces the third issue of the fifth volume of the African Journal of Rural Development. In this edition, we have published nine papers addressing issues related to higher education in Kenya, Uganda, Democratic Republic of Congo, Cameroon, Zambia, Mozambique, Ethiopia and Sudan. In particular, the issue brings insights into the future of the African University, the importance of regional academic training programs, the gender disparities in participation in Science, Technology and Innovation, and the mechanisms for financing and strengthening higher education in Africa. It is our hope that the readers will find this information useful to guide further decision in the efforts towards transforming the higher education sector in Africa.

Keywords: Academic programmes, gender equality, public investment, Science, Technology and Innovation; RUFORUM

RÉSUMÉ

Mots clés: Égalité-genre, investissement public, programmes académiques, Science, Technologie et Innovation, RUFORUM

1. On the future of the African University and needed interventions
In this issue, Akec (2020) reviewed the opportunities for better future of the African higher Education through university lens based on global and regional trends influencing reforms in higher education sector, and proposed necessary policy interventions in order to realise that future. In reviewing the functions of higher education in major western economies (Asby, 1958; Kerr 2001), Akec (2020) explained how education evolved from Greek academies to modern multiversity. The massification and spread of higher education throughout the world was the outcome of the need for a wider sharing of knowledge, and the evolution from one-to-one learning to one-to-many mode of instruction (Ernst and Young, 2017). The initial functions of higher education changed quickly from the ivory towers principle which underpinned the idea of university as institution devoted purely to research and pursuit of knowledge for its own sake to the idea of university being an instrument of service to society. Akec (2020) provided a substantial background on the reforms that affected the functions of universities globally, basing on the Humboldtian and the Napoleonic Models as well as the French, the Italian and the Japanese Models. The author further emphasized on the third mission apart from teaching and research, as the main pathway for transformation as well as the need for integration of technology in learning in African education. On reflecting on the state of African higher education Akec (2020) explained the factors and trends driving change in higher education systems in Africa, and proposed areas of focus for change. The focus on financing, massification, innovation and better leadership is central for African universities to continue to respond effectively to national and regional agenda and remain relevant to African communities and societies.

In response to the need to develop high-level skills, institutional capacities and critical technical skills, RUFORUM, a network of 129 universities in 38 African countries launched in 2008 doctoral regional training programmes in selected African
universities. Mweetwa et al. (2020) revisited RUFORUM’s contribution to rebuilding Africa’s research capacity through graduate training, and in particular, the then established programs, and how far they have gone in training Master and Doctorate holder professionals in the continent. The establishment of these training programs followed the implementation of RUFORUM strategic vision, which was informed by the needs assessment among the then 10-member universities in Kenya, Malawi, Mozambique, Uganda and Zimbabwe. Based on a demand-led curriculum, seven PhD programmes in rural innovations, food science, soil and water Management, fisheries science, agricultural economics, plant breeding and dryland resource were developed. Further five Master programmes in Agrometeorology and Natural Risk Management, Monitoring and Evaluation, Agricultural Information and Communication Management Plant Breeding and Seed Systems, and Research Methods, were also developed. These programmes have contributed to training over 420 doctorates in Africa, thereby contributing to the development of the continent (Mweetwa et al., 2020). Further, the attractiveness of these RUFORUM regional programmes has resulted into their introduction and adoption by other universities on the continent. To increase African universities competitiveness, appropriate continental initiatives are needed to strengthen university’s science, technology and innovation.

2. On the gender participation in Science, Technology and Innovation

The low access of women to education (less than 20% of African women have access to education) is a major constraint hindering inclusive education and continental growth for the benefit of present and future generations. STEM (Science, Technology, Engineering and Mathematics) sector has been recognized as one of the evolving and expanding fields in the current job potential and opportunity context. Whereas projections suggest that employment in wind and solar energy for example will rise to 8.4 million jobs by 2030, Africa’s current stock of skilled graduates is still highly skewed towards the humanities and social sciences, and the proportion of students in STEM averages less than 25 percent (http://africapolicyreview.com/stem-education-and-african-development/).

In this issue, four papers addressed gender inclusive participation in Science, Technology and Innovation. Nakayiwa et al. (2020) presented a gender focused baseline study on the ST&I ecosystem from four African countries, namely Uganda, Sudan, Mozambique and Ethiopia. The authors observed that female participation in ST&I education is still low and declines sharply at the graduate and academic leadership levels. For instance, in Uganda, despite the affirmative action to increase female enrolment in higher education, participation in STEM programs is still limited (NCHE, 2019), and only 28% of academic and research positions are occupied by women (Nakayiwa et al., 2020). Similar observation was made in other baseline study countries such as Mozambique where numbers of female students at higher education level have remained low compared to the male counterparts. To resolve the situation, the authors recommend policy frameworks at national and institutional level that target the overall education pipeline and provide a facilitating environment that supports
students in STEM and females in the R&D employment sector.

The three other papers also addressed gender aspects in ST&I in Zambia (Phiria and Mwaanga, 2020), Ethiopia (Moges, 2020) and Cameroon (Kinge et al., 2020). A striking common pattern from these studies was the extremely low participation of women in ST&I. For instance, Phiria and Mwaanga (2020) presented a ST&I analysis using a gender-based assessment of ST&I ecosystem in Zambia through a desktop review and key stakeholder discussions approach. The authors found that, although the Government of Zambia has developed policies and strategies to encourage female participation in science, technology and innovation, the latter is still low as in other SADC countries and Africa in general. They recommended a number of critical actions for promotion of women leadership in science and technology and innovation oriented careers. Similar to the observation in Zambia, Kinge et al. (2020) reported that the enrolment in ST&I fields is skewed toward males, and more students and lecturers are encountered in the natural sciences, while health sciences, agriculture and engineering record significantly low participation of females. They also reported a more pronounced disparity in the field of engineering where female students are near absent. In Ethiopia, Moges (2020) used both primary and secondary sources of information including journal articles to provide insights into the gender dimension of science, technology and innovation eco-system. The author also found out that the participation of women in the ST&I ecosystem was low in Ethiopia. In particular, undergraduate female enrollment in science and technology ranged from 31% in 2014 to 34% in 2018, while that of postgraduate female was lower, declining from 31% to 16% (Moges, 2020). For the academic staff, 19.3%, 11.2% and 6.9% of the women were holders of first degree, masters and PhD degrees in science and technology fields of study, respectively. Similar low participation was observed in the research and industry sector. The author attributed such a low participation to the lack of academic preparation for STEM fields, attitude toward science fields, lack of women’s self-confidence, lack of women role model scientists, lack of adequate support from higher education institutions and gender disparity in employment. The author suggested that collaborative effort from ST&I stakeholders is critical to implement gender equality-related policies and strategies of the country.

3. On financing and strengthening higher education in Africa

In this issue, three papers addressed financial investments in higher education in the Democratic Republic of Congo (Majaliwa, 2020), in Uganda (Owuor et al., 2020) and Kenya (Mukhwana et al., 2020). Majaliwa (2020) provided an overall overview of the current statistics (including investment) on Higher and Technical Education in DRC, with a focus on ST&I. In essence, it was noted that majority of the HEIs offer technical training followed by university training and pedagogical training (Majaliwa, 2020). The majority of HEIs, particularly the private HEIs are largely dependent on family funding. The author further explained the challenges for Higher Education, including, limited academic
autonomy in selecting leaders and designing programme curricula, proliferation of HEIs, and a plethora of administrative staff both in the ministry and in the HEIs. Finally, the author made substantial recommendations for strengthening the sector, particularly the need to ensure adequate funding of the education system and its future expansion, and to build capacity of HEIs academic and administrative staff, through south-south and north–south partnerships (See Majaliwa, 2020).

Owuor et al. (2020) provided a theoretical analysis of public expenditure on education in Uganda. The current increase in resource allocation to tertiary education universities seems to be mainly due to an increase in the number of public tertiary institutions. The authors pointed out that the level of funding at tertiary education level (0.3%) does not reflect the aspirations of the second National Development Plan (1% of GDP). The authors suggested that the current public finance model should take into account the returns to the investment approach and not merely look at provision of social services. For a country like Uganda that has 63% of the total population below the age of 24 years and 50% below the age of 15 years, human capital development though purposive skilling and knowledge formation is critical to achieve the aspirations its vision 2040.

In a discussion paper, Mukhwana et al. (2020) presented the status of financing higher education in Kenya, and the development achieved amid the challenges of insufficient funding. The author noted that that has been an increase in tertiary education funding in the recent years, however, unfortunately, this increase has not kept pace with the increasing student enrollment and numbers. As such, for the country to achieve its expansionary goals for the higher education sector in a financially sustainable manner, it is imperative that the Government increases development funding to the institutions considering the vast growth of the subsector and rapid changes in technology (Mukhwana et al., 2020). Similarly, more investment funding needs to be made in research and outreach for the higher education sector to leverage their impact in society.

CONCLUSION
In this issue, we showcase the recent development of the higher education sector and the gender disparities in access to ST&I education in selected African countries. A striking common pattern across these countries was the extremely low participation of women in ST&I. Although several governments have developed policies and strategies to encourage female participation in science, technology and innovation, the latter is still low in Africa in general. A number of critical interventions were recommended, among which is the need to promote women leadership in science and technology oriented careers, and for more investments in ST&I in Higher Education but with special attention to addressing the gender disparity.

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STATEMENT OF NO-CONFLICT OF INTEREST
The authors declare that there have no conflict of interest.
REFERENCES
Ernst and Young, LLP. 2017. Leapfrogging to Education 4.0: The Student at the Core. Ernst and Young LLP, Kolkata.
Envisioning the future of the African University: Needed reform, and adjustments to respond to the emerging challenges

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ABSTRACT
The paper shares the author’s perspective on the future of African higher education through a university lens. It identifies global trends and regional agenda that will influence change within the African university systems in the next decade. The paper is divided into eight (8) sections as follows: Section 1 introduces the background and purpose of the paper and its organization. Section 2 reviews the historical developments that influenced the emergence of the Multiversity in the nineteenth and twentieth centuries in the western world, especially the United States and Europe; and the implications for the reforms of university systems in the twenty first century. Section 3 reflects on the current global trends affecting the university governance, and driving change by reviewing a plethora of models of governance, especially the Anglo-Saxon, Homboldtian, Napoleonic, and Japanese models. Section 4 describes the role of university innovation and entrepreneurship in the fulfillment of the ‘third mission’ besides university core business of teaching and research. Section 5 covers the integration of technology in learning and transitioning of universities to Education 4.0 in order to serve the unfolding Fourth Industrial Revolution. Section 6 highlights the role of academic rankings in measuring success and fueling reputational competition; thus, leading to improvement in research output and impact, and influencing strategic choices in higher education globally. Section 7 reflects on the causes of stagnation of African higher education in comparison to BRICs’ explosive expansion in the last two decades, and proposes strategies for closing the gap in terms of graduate enrollment ratios and differentiation. Conclusions and key recommendations for reforms in African university are made in Section 8 and include massification of African higher education sector through cost-sharing, differentiation and vocationalization; less government regulation and more autonomy to universities; corporatization of management to improve academic leadership; cultivation of innovation and entrepreneurialism; integration of technology, and transitioning to Education 4.0 in order to serve African Agenda 2063 and Fourth Industrial Revolution.

Key words: Africa, Higher Education, transformative change

RÉSUMÉ
L’article partage le point de vue de l’auteur sur l’avenir de l’enseignement supérieur africain à travers une optique universitaire. Il identifie les tendances mondiales et l’agenda régional qui influenceront le changement au sein des systèmes universitaires africains au cours de la prochaine décennie. Le document est divisé en huit (8) sections comme suit: La première section présente le contexte et le but du document et son organisation. La seconde section passe en revue les développements historiques qui ont influencé l’émergence de la Multiversité aux XIXe et XXe siècles dans le monde occidental, en particulier aux États-Unis et en Europe; et les implications pour les réformes des systèmes universitaires au XXIe siècle.

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Envisioning the future of the African University: Needed reforms, and adjustments to respond to the emerging challenges

1. INTRODUCTION AND BACKGROUND
Higher education reform is mostly driven by what happens in universities (Keeling 2006). Hence, the goal of this paper is to share the author’s perspective on the future of African higher education through university lens based on global and regional trends influencing reforms in higher education sector, and to propose necessary policy interventions in order to realise that future or vision. It also aims to catalyze the debate and provide insights to others to emulate. To do this, the paper will strive to imagine how the African university systems can adjust in order to tackle the challenges facing the African society today and in the next decade or so; against the backdrop of African Agenda 2063, UN Agenda for Sustainable Development Goals 2030, globalization of higher education market, corporatization of universities, the impact of technology and the advent of Fourth Industrial Revolution, in addition to many other important mega trends. These regional, and global agendas and mega trends, will have impacts on how African universities teach, produce knowledge, and serve the African and global communities.

At the outset, it is worth pointing out that African universities, like their counterparts in the developing countries, were latecomers to the global higher education scene compared to European and American universities whose histories date back to medieval era and seventeenth century respectively. Michael Shattock opined that longevity of a university, improves its success opportunities (Shattock, 2009). And although African universities were initially conceived as extensions of the British and French university systems, in practice, they fell short of Oxbridge’s and grande école’s models that they were purported to replicate. Instead, initial goal of the early universities in Africa was to focus on training of colonial administrators and political elites of African post-colonial era (Cloete and Maasen, 2015).
What is more, the expansion and development of African higher education sector, especially in the sub Saharan region in the three decades that followed independence, was slowed down by the publication in 1986 of a hugely influential World Bank’s higher education policy report (Psacharopoulous et al., 1986). The report claimed that the returns to a dollar spent on primary education were twice the returns to a dollar spent on higher education (ibid:8). Following this 1986 publication, the World Bank and other international agencies active in field of education began to promote educational and funding policies that prioritized primary education and treated higher education as a luxury (Cloete Maassen, 2015). The result was a decline in average public expenditure per tertiary education student from a high USD 6,800 in 1980 to a very low average of USD 981 per student in some 33 sub Saharan African countries by 2009 (World Bank, 2009), or an astonishing reduction of 82% (Cloete Maassen, 2015). To this date, Sub Sahara Africa tertiary education enrollment ratio also remains the lowest globally.

Moreover, although African higher education has started to expand relatively in the late 1990 and early 2000, there has been hardly any differentiation. Rather, what we have at the moment are mostly over crowded elite higher education institutions (ibid.)

In contrast, starting in mid 1990s and for the next two decades that followed, the governments in Asia, Eastern Europe, and Latin America, especially the BRIC countries— Brazil, Russia, India, and China—succeeded in expanding their higher education systems considerably by making more resources available to tertiary education through a mix of subsidies and charging of tuition fees and expansion of private higher education (Carnoy et al., 2013). The reasons and causes of this divergence, and the lessons to be learned from BRICs’ experience, will be discussed in Section 7 of this paper.

While acknowledging the unique challenges that are still impacting the performance of the African university as a latecomer to higher education sector, the African university system is not an island unto itself, but forms part of dynamic global higher education systems that must continuously adapt their traditional roles, their internal organisations, their leadership modes, their governance structures, their intellectual cultures and values, their funding models, and their mode of operation and service delivery in response to new trends and demands placed on them by society (Bok, 1982; Kerr, 2001; Castells, 2009). Hence, Section 2 explores the global scene of higher education—including review of how university systems developed in the Western world from medieval era to present day, in order to identify and discuss the critical success factors and frameworks that must be met or followed in order to launch “the next generation” African university that is able to serve the unfolding Fourth Industrial Revolution, while able to tackle the pressing national, regional, and global agendas.

The paper is organised as follows: Section 1 presents a background introduction and sets the purpose of the paper; as well as describing how the paper is structured. Section 2 reviews the historical development that culminated in the emergence of multiversity in the nineteenth and twentieth centuries in the United States; and its implications for the development of university systems in the twenty first century. Section 3 reflects on the global trends affecting the university governance, and the factors driving change in university management and leadership by examining different university governance models, especially the Anglo-Saxon, Homboldtian, Napoleonic, and Japanese models. Section 4 examines the role of innovation and entrepreneurship in universities in fulfillment of ‘third mission’ that complements teaching and research as core businesses of the university in the 21st century. Section 5 covers integration of technology in learning and transitioning...
to Education 4.0. Section 6 describes the role of academic league tables in measuring university success and fueling reputational competition amongst universities, and leading to improvements in the quality of research and driving change in higher education. Section 7 reflects on the state of African higher education and proposes areas of focus and change as it responds to global challenges that are impacting global university systems; as well as how it may respond to challenges facing the African region socially, and economically. Conclusions and key recommendations for reforms in African university are made in Section 8.

2. The origin of modern university and birth of multiversity
A quick overview of the literature of historical and contemporary development in higher education in major western economies will help us identify the trends that had shaped in the past or continue to shape higher education globally in the present time. This in turn will help African university leaders as well as policy makers see what lessons to learn in order to transform higher education sector on the continent in the next few decades, as well as highlighting the policy interventions that will be needed in order to bring about the desired outcomes. Therefore, this section reviews the literature on the functions of university in the United States and Europe (Asby, 1958; Kerr 2001), and summarizes how the higher education sector has changed over decades in response to societal challenges after the World War II in the major developed and developing economies (Bok, 1982; Bowen, 1982; Clark, 1998; Kerr, 2001; Shatock, 2009; Shatock, 2010; Frenkel, 2012; Carnoy et al., 2013; Graf, 2013; Shatock, 2014).

From Greek academies to modern multiversity
The idea of university, as a central institution of higher education, has origin traceable to the Greek academies that were established by Plato, Sophists, and Pythagoreans in the sixth century. Plato academies were devoted to discovery of truth for its own sake and teaching philosophy to future kings; the Sophists gave instructions in rhetoric needed by their students to succeed in life; while the Pythagoreans taught mathematics and astronomy to natural philosophers (Kerr, 2007).

Henceforth, higher education began to evolve gradually from an informal education system and a low-base involving person-to-person interaction between teacher and student (ibid.). This early education system (also referred to as education 1.0) was focused on teaching religion and philosophy with the primary goal of preparing good citizens (Ernst and Young LLP, 2017). Education in the ancient and medieval times was championed by religious institutions-- mainly Christian monasteries and Islamic madrasas-- with the support of the kings. It targeted elites, mostly boys (ibid.:11).

However, according to Clark Kerr, the ‘modern university’ which began to emerge in the medieval period, comprised a “community of masters and students” with a unique personality and soul in form of “a central animating principle” (Kerr, 2001). This unique personality was identified by “a name and a central location, masters with a degree of autonomy, students, a system of lectures, and a procedure for examinations and degrees” in addition to “an administrative structure with its faculties”.

The impact of Printing Press on the spread of University Education
The advent of printing press in the seventeenth century allowed publication of books on a large scale not witnessed before. It permitted a wider sharing of knowledge, and resulted in moving education system from one-to-one learning, to one-to-many mode of instruction. That in turn allowed the massification and spread of higher education throughout the world (Ernst
The number of universities began to multiply, rising from 10 universities between 1800 and 1809, to 131 universities between 1850 and 1859 (Ernst and Young, 2017). By 1990s, the number of university degrees awarded in the United States rose to 1.05 million compared to 28,600 in early 1900s. Moreover, government influence began to increase from seventeenth century onwards, while the religious influence began to wane (Ernst and Young, 2017). And by 2003, United States had some 4000 institutions of higher education, of which 500 awarded doctoral degrees, 125 were classed as research intensive with 50 institutions receiving the highest concentration of research funds (Shattock, 2014). The trends that influenced the development of higher education and universities and their impacts between the sixteenth and eighteenth centuries are summarized in Table 1.

Meanwhile, the ‘animating principle’ that defined a university has been dynamic and changing from one era to the next, despite the views to the contrary. For example, the views about university such as once held and articulated by Cardinal Newman are being challenged. Newman argued that the binding principle of a university was cast as residing in the university’s responsibility to act as “high protecting power of all knowledge and science, of fact and principle, of inquiry and discovery, of experiment and speculation,” as well as curving out of “the territory of the intellect” by ensuring that “there is neither encroachment nor surrender on any side” (Newman, 1930).

### Table 1. Impact of printing press on development of Higher Education in Europe

<table>
<thead>
<tr>
<th>Period</th>
<th>Trends</th>
<th>Features</th>
</tr>
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| Before 17th century | • Scientism and rationalism  
• Schools conceived as scientific workplaces  
• Use of inductive and empirical methods                                                                 | • Renaissance increased government influence on education while it diminished the religious influence  
• Establishment of universities such as Harvard, Yale, Columbia, and Princeton in the US  
• Introduction of new teaching methods                                                                 |
| 18th century    | • Emergence of philosophical trends  
• Introduction of mother language in teaching  
• Inclusion of science curriculum  
• Improvement in teaching pedagogies                                                                 | • European universities emphasis on STEM and development of cognitive skills  
• Numbers of universities rose from 10 between 1800-1809 to 131 between 1850 and 1859  
• Higher education spread rapidly across the world                                                                 |
| 19th century    | • Emphasis on citizen’s welfare with the development of industrial revolution and increasing urbanization  
• State taking increasing responsibility of education                                                                 | • Public educational systems established in France and Germany  
• Participation of women given importance in US and UK  
• Germany established universities that carried out research  
• Number of bachelor degrees awarded by the US universities rose from 28,681 in early 1900s to 1.05 million by 1990s. |

Source: Ernst and Young LLP (2017)
Broader understood, universities in Newman’s view, were ivory towers that stood aloof outside the society, and were entirely absorbed in their core business, while resisting any temptation of being compromised by the society they were embedded in. And as echoed by Eric Ashby, similar ideals about the idea underpinning the function of the university were apparent in German’s seventeenth century tradition of Wissenschaft. Namely, the academic vocation was seen as “a single-minded, almost fanatical, devotion to advancement of knowledge” while excluding the application of science and concept of education-for-life (Ashby, 1958). This also rhymes very well with Welhem Holmholtz’s idea of the German university’s quest for scientific knowledge at that time (Helmholtz, 1873):

*Whoever, in pursuit of science, seeks after immediate practical utility, may generally rest assured that he will seek in vain. All that science can achieve is perfect knowledge and a perfect understanding of the action of natural and moral forces. Each individual student must be content to find his reward in rejoicing over new discoveries, as over new victories of mind over reluctant matter.*

And by the mid-twentieth century, Newman’s and Helmholtz’ ideals of what university and knowledge generation meant, had come to be at odd with a more utilitarian function of the university that is now taken as given. For example, Abraham Flexner in the United States context noted that “university is not outside, but inside the general social fabric of a given era;” and that it represents “an expression of the age, as well as influence operating upon both present and future” (Flexner, 1930).

Moreover, the Newman’s model of university in the molds of Oxford and Cambridge of that era, gave preference to “liberal knowledge” over “useful knowledge” which he saw as nothing but a “deal of trash” (Kerr, 2001). And reading Newman correctly, one can infer that the “animating principle” for him, and which underpinned the idea of university, is that of an institution devoted purely to research and pursuit of knowledge for its own sake, as opposed to being an instrument of service to society as understood by Francis Bacon (Bacon, 1937), or ‘the arm of the government’ that it later became as expounded by Kerr (2001). This extended function of the university fits with the view long espoused by Alfred North Whitehead and others (Whitehead, 1929):

*The universities are schools of education and schools of research. But the primary reason for their existence is not to be found either in mere knowledge conveyed to the student or in mere opportunity for research afforded to the members of the faculty...The justification for a university is that it preserves connection between knowledge and the zest of life, by uniting the young and the old in an imaginative consideration of learning...The Universities have trained the pioneers of our civilization – the priests, the lawyers, the statesmen, the doctors, the men of science, and the men of letters. They have been home of those ideals which lead men to confront the confusion of the present times.*

And to substantiate the above view, Whitehead points out that as early as in 1316, the University of Cambridge in England had established a college with the sole purpose of “providing clerks for the King’s service” (ibid:92).

Furthermore, Germany was the first to establish universities devoted exclusively to conducting scientific research (Ashby, 1958). The German model spread to British universities in mid nineteenth century, while the American universities borrowed from both the German and British models (Kerr, 2001) as recorded by Derek Bok (Bok, 1982):

*From Germany came the idea of a university dedicated to research conducted by the*
specialized professor with the help of student apprentices. From England came a strong emphasis on the teaching of undergraduates and a broad conception of education that embraced the moral and emotional as well as the intellectual development of the student.

The result was a unique mix and match for the American university model as Clark Kerr had observed (Kerr, 2001): Out of all these fragments, experiments, and conflicts a kind of unlikely consensus has been reached. Undergraduate life seeks to follow the British, who have done the best with it, and an historical line that goes back to Plato; the humanists often find their sympathies here. Graduate life and research follow the German, who once did best with them, an historical line that goes back to Pythagoras; the scientists lend their support to all this.

What’s more, Clark Kerr contents that the ‘central animating principle’ that binds “community of masters and students” -- teaching and discovery of new knowledge- has been changing shape and content over the centuries, leading to emergence of what he described as “the multiversity” with the implications that the modern university has come to serve many purposes in the society beyond teaching and research (Kerr, 2001).

Most prominent development in the American university function was the signing of Morill Act in 1862 by President Abraham Lincoln that led to the birth of land-grant universities in all States with the mandate of teaching “such branches as of learning as are related to the agriculture and the mechanical arts, in such manner as the legislature of the States may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in several pursuits of professional life.” (Bok, 1982).

Furthermore, as a consequence of the Morill Act, Charles Van Hise at Wisconsin University in Madison, declared that the borders of his university’s campus was going to be the boundaries of the state. That ‘Wisconsin’s idea’ was emulated by other land-grant universities, and the service-orientation, beside teaching and research, became the distinguishing mark of the American university model, as noted by Kerr (2001): The land-grant university brought schools of agriculture and engineering, of home economics and business administration; opened the doors of universities to the children of farmers and workers, as well as middle and upper classes; introduced agriculture experiment station and service bureau.

And as demonstrated during the World War II, American universities came out to assist in war effort, especially when the academic scientists played an important role in the development of weapons for the military and splitting of the atom for war and peaceful applications. The result was that the American Government recognized the university-based talent, and provided generous funding of research at university campuses (see Bok, 1982; Bowen, 1982).

Tensions in multiversity
The emergence of multiversity as espoused by Clark Kerr (2001) in the United States was not without controversy. It generated contradictions and tensions within the academic fraternity—mainly between the liberal activists on the one hand, and traditionalist conservatives on the other. The activists thought that the American multiversity has become a ‘hired-gun’ of the vested interests which exercised political power over the American society by offering support ranging from developing weapons for use by the military in war in distance lands, to consultancy services for industrial corporations and agricultural extension for wealthy farmer groups. In so doing, the academe was seen to have compromised the neutrality of university on issues dividing the society (Bok, 1982).

On the other hand, the conservative academics saw too much involvement of professors in societal affairs such as setting up specialized
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urban observatories, or establishing criminology research centres that solved social problems; as risking professors’ commitment to research and scholarship, and hence leading to the lost of traditional detachment from societal concerns that may compromise their academic objectivity.

Notwithstanding the tensions generated by public service-orientation of American university, Howard Bowen has articulated that universities have continued to carry out their traditional function of teaching and knowledge generation through scientific and applied research, beside preservation and interpretation of culture, carrying out policy analysis, acting as sources of national scientific expertise when needed, hosting centres for philosophical and religious inquiry, engaging in diverse forms of public service through training and research, and contributing to national economic prosperity (Bowen, 1982).

Moreover, Bowen has highlighted further key areas in which the university can contribute to the betterment of society. These are: creating society of educated people by continuing to increase access to higher education for wider sectors of population, inculcating good values in the student as well as imparting specialist knowledge, tackling special problems facing youth in the modern society, and contributing to global understanding.

3. Trends affecting the functions of universities globally

This section reviews the trends that are affecting university systems globally, with a specific focus on the Anglo-Saxon (US, UK, and Australia), Humboldtian (Germany, Norway, and Finland), Napoleonic (France and Italy), and Japanese universities. In particular, the analysis will focus on trends in governance of university systems in these countries, diversification of funding through innovation and entrepreneurship, and integration of digital technologies to respond to changing student needs and globalization of higher education market.

International reforms in university governance

International trends driving the modernisation of higher education include changing role of the State in university governance, its ramifications on university’s internal governance structure, and distribution of authority in the collegiate (Shattock, 2014). This modernisation push is driven by the recognition by governments and regional blocks such as EU of the important role universities play in knowledge economy, implications for funding, on how authority is shared within the university, and between university and external actors, including the State. Reforms in European and Japanese universities are driven by State legislation, but much less so in UK and Australia; while the state plays no role in regulating universities in United States.

The US and Anglo-Saxon reforms have tilted towards ‘enterprise university’ and marketisation of higher education system in line with new funding arrangements that give universities more autonomy. However, the US higher education system provides “the most diversified, individualized, and autonomous range of universities in any system”, according to Michael Shattock. Although received with some resentment within the European university system, giving universities more autonomy and borrowing business practices was aimed at improving decision-making processes in universities, as summarized in Lisbon declaration that embodied the need to reform governance at EU Member States universities:

*Universities must be autonomous and responsible in order to encourage innovation and assist change. This calls for a division of tasks between the Member States and the universities. The Member States should*
establish frameworks (rules, policy, funding, and incentives). The universities should establish new governance systems based on strategic priorities and on the professional management of human resources and administrative procedures. They should also reduce the fragmentation of their services and entities and assume responsibility for their results.

In other words, more autonomy to universities is the answer to more entrepreneurial and innovative universities.

Reforms at Humboldtian Model Universities
University governance systems in Germany, Norway, Finland, and a great number of Northern European universities share much in common. They were founded on German Humboldtian model that made emphasis on research-based teaching and significant freedom to the professor (Kehm, 2014; Salmela-Mattila, 2014; Stensaker, 2014).

Germany
Germany operates a binary higher education system comprising universities providing academic education, and universities of applied sciences that provides professional education, in addition to differentiated non-university or vocational education sector (Kehm, 2014). As characterised and argued by Kehlm (ibid.:8), higher education governance regime in Germany “consisted of detailed State regulation, weak presidents and rectors, a strong professoriate, no external guidance and no competition.”. German States regulate the universities within their borders, while the Federal Government provides a Framework Law that constraints the State laws governing universities to be compatible. The regulations governing universities cover recruitment of academic staff, funding, ownership and maintenance of buildings, approval of new study programmes, curricula, and degrees. All the authority relating to academic matters rests with the professoriate. The rector or president is regarded as “the first among equals.”

However, in the face of dwindling public funding, German universities are under pressure to “do more and better with with less” (ibid.:19). Efforts started in 1990 to make German universities more competitive and included performance based funding, more autonomy to universities in academic and financial matters, introduction of boards that have external members in order to strengthen institutional leadership; and Excellence Initiative in 2005 whose aim was to increase the number of German universities in the 100 top ranked World Class universities through competitive institutional development funding, and experimenting with foundation status at selected universities (Kehm, 2014).

Norway
Before 2013, Norway had a binary higher education system similar to German’s higher education setup in which some institutions were designated as universities and others as colleges; with a very strong regulatory influence by the Ministry of Education; weak institutional leadership, and huge departmental powers; and no tuition fees (Stensaker, 2014). As described by Stensaker (2014), several attempts were made to encourage universities to reform but this resulted in modest impact on the old system. The reforms included introduction of new quality assurance agency to accredit and approve programmes, experimenting with new governance measures; rolling out output and performance-linked funding; and appointing rectors by a board as opposed to rectors elected by academics. The effects of the changes were described as “modest” as far as the traditional Norwegian higher education system was concerned (ibid.:38).

Finland
Finland, typical of Humboldtian higher education systems, has binary higher education system comprising universities and universities of applied sciences. According to Samela-Mattila (2014), reforms at Finish universities
were initiated by the Ministry of Education in 2010. Universities were requested to profile in order to highlight their areas of excellence that are practice-oriented, attain excellence in teaching and research, build university-society relationships, and provide service to society. As a result, universities were transformed into autonomous self-governing entities under public law; while others became private foundations governed by private law. What is more, universities were obliged to be accountable like businesses corporations that are able to allocate financial resources more efficiently based on areas of their strengths and strategic growth; and were to be assessed on their societal impacts as opposed to the traditional old performance indicators and evaluation.

For example, in Finish flagship universities such as University of Helsinki, a collegium composed of professors, research and teaching staff, and students’ representatives decides the composition of university board, reviews university financial annual reports, and discusses matters of importance to the university. A board consisting of internal and external members is the highest decision-making body for the university. The board has power to decide on the strategy as well as on operational and financial matters of the university. University Chancellor has a public role of promoting and managing University’s external relationships, including the promotion of sciences, arts, and humanities; while the rector, supported by a number of vice rectors, is in charge of financial and administrative affairs of the university. Central administration consisting of rector’s office and university services is run by a director. Faculties are headed by deans while independent institutes are managed by directors.

In other universities such as University of Tampere, rector serves as rapporteur to the board, while academic units comprise the schools managed by directors, and a board of directors selected by the university board. Directors are responsible for developing the schools based on university’s overall strategy.

The impact of reforms at Finish universities are beginning to work as summarized by Salmela-Mattila’s paper (ibid.:61):

*The reform was pushed through with a tight time... especially on the governance and administrative level... the new organisational arrangements are in place. In practice, management chains have become more straightforward, increasingly simple and possibly even more transparent. The administration whole seems to have evolved from a matrix structure, with sometimes very unevenly balanced actors, towards a line organisation with clearly defined responsibilities.*

**Governance reforms at the Napoleonic Model University Systems**

The Napoleonic system of higher education that exists in France, Italy, Spain, Portugal, and many countries in Southern Europe, is characterised by “a central State control and a general agreement between the State administration (the Ministry of Education) and the academic estate (or ‘the academic oligarchy’)” (Moscati, 2014). Chatelain-Ponroy et al. (2014), and Moscati (2014) have respectively reviewed the recent attempts to reform French and Italian university systems from 1990 onwards. These reforms were inspired in part by the advent of the new public management (NPM), and by the need to harmonize the European higher education systems with Bologna process. Below is a summary of the governance reforms at French and Italian universities.

**Reforms at French Universities**

The development and governance of the French higher education system has been shaped by historical events that included suppression of
universities by the French Revolution in 1793, and their resurrection in a modified form in 1806 by Napoleon as discipline-based faculties. Furthermore, an Imperial University for the whole France that is composed of lycees and faculties and led from Paris was established (Chatelain-Ponroy et al., 2014).

As part of adopting New Public Management in French public administration (LOLF), higher education institutions were also requested to present a budget linking a set of objectives to indicators that measure achievements in the following year (ibid.:67). Universities are led by presidents who are elected amongst academics by the staff. Policy making bodies comprised of elected members representing academics and administrative staff, students, and outside stakeholders. Universities also enjoy academic freedom and autonomy. The president’s term of office comprises four-year tenure, and renewable only once.

Overall, according to Chatelain-Ponroy (2014), the governance of French universities takes place through three channels: Administrative channel headed by registrars, political channel led by presidents, and deliberative channels led by university councils. Elected heads such as presidents, deans, and departmental heads are not regarded as part of the administration, but only exercise political power as ‘firsts among equals.’ It is also noted that for historical reasons, French grandes ecoles that are involved in specialist and professional type education are more prestigious than universities in French higher education system. Moreover, as departure from Humboldtian model, the Napoleonic system did not consider research to be one of the missions of universities but that of national research organisations (or Centres National de la Recherche Scientifique, CNRS), although the collaboration between universities and national research centres (CNRS) is gaining currency as part of university mission in French universities (ibid.:71).

To date, three models of power-relations operate in French universities. These are: the technocratic models in which central administration has more power over academic leadership, and is characterised by weak presidents and vice presidents who tow the lines recommended by registrars; functional politicization model in which presidential team exercise political power to overrule and bypass registrars to exercise direct control over specific administrative units; and most prevalent of all, is the so-called ‘dual-hierarchy’ in which the president manages vice presidents, while the registrar exercises administrative authority (ibid.:74).

Reforms in Italian University System
Following a Napoleonic system of higher education, the State exercises central control through the Ministry of Education that has agreed some ground rules to be observe by both sides with the ‘academic oligarchy’ (Moscati, 2014). And according to Moscati (ibid.), the balance of power that has been in operation for long between the Ministry of Education and universities has protected the later from outside interference, while providing no incentive for change. The motivation for reform that began in 1980s was meant to align Italian higher education system with EU models, and implement the Bologna process, has, according to Moscati (2014), followed a ‘stop-go’ path in line with Margaret Archer’s rule:

…the governing elite monitors educational development in relation to its own goals and to changing circumstances. It hesitates to introduce major changes until there is evidence that current polices are not working or not appropriate… (in general) the elites will hold back as long as possible because what is involved is a jump in the dark…thus leaps in the dark are resisted, until pushed by political supporters, or force of circumstances, and when they are taken they will be unadventurous, unless produced by a new group assuming power.
As described by Roberto Moscati:

“...reforms are introduced by Italian governments without any sort of involvement of academic world, which is always taken by surprise. After the shock a long period of implementation follows featuring more individual disagreement with collective opposition. As a result, norms are introduced in a series of compromises in a ritualistic and cosmetic way and the changes are formally visible but substantively have little effect.”

Oddly enough, attempts to grant Italian universities autonomy over academic matters, led to uncontrolled, and somewhat less responsible expansion of higher education sector in 1990s. It did not take long before the central authority began to regain control over all academic matters in Italian universities. In other words, marketization of the Italian higher education sector through granting more autonomy to universities did not produce desirable results as it it did in other Western systems such as the US and UK, or Australia (Moscati, 2014).

**Governance reforms at Japanese Universities**

The founding of Japanese universities in the latter half of nineteen century followed Humboldttian model that links research and teaching closely, while adopting Napoleonic system of central control through a strong Ministry of Education (Shattock, 2014. Hence, the Japanese universities until 2004, operated as integral part of national government under the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) (Oba, 2014). As noted by Jun Oba (ibid.:108), problems associated with the close integration of Japanese universities with government organisations included: internal conflict between state control and academic autonomy, widespread disaffection with disparities between national and private universities, and inefficiency in the management of public universities. Reforms were initiated to tackle the inefficiency and facilitate effectiveness of the Japanese university systems, and was driven by New Public Management thinking and implementation of neoliberal reforms in public service.

A National University Corporation Law was passed in 2003 that granted universities status of national university corporations (NUCs) with legal personality and autonomy, and gave strong powers to university presidents, in line with global trends (Christensen, 2010). Government supports NUCs with operational grant in addition to special grant allocated on competitive basis, while tuition fees form over 50% of revenues for universities. MEXT determines the level of tuition fees and allow universities to vary their fees at a rate that does not exceed 20% of MEXT determined fees. Operation grant is based on NUC’s mid-term goals that extends over six-year period. A National University Evaluation Committee assesses the achievement of mid-term goals based on self-assessment reports submitted by the NUCs.

Furthermore, the highest authority is exercised by NUC’s president and the board of directors. The president is the final decision maker of NUCs. He or she is selected by a special presidential committee and appointed by the Minister of Education. The terms of office are determined by the selection committee and legal provisions have been put in place to dismiss president if circumstances necessitate it. The Board of Directors supports the president. Its members are appointed by the president. The governing structure is composed of Administrative Council, Board of Directors, Education and Research Council, and President Selection Committee (with equal representation of members of Education and Research Council, and Administrative Council), and Auditors. At least one member
of the Board of Directors is external and mostly from business community, while at least 50% of Administrative Council are external members. The Administrative Council discusses matters of administrative nature, while the Education and Research Council is composed mainly of internal members and deliberates on academic and research matters. Under new law, NUCs have the discretion to decide over human resource management matters, including giving the president the appointing right. The new reform is not without its contradictions such as the difficulty of dismissing a president by the Minister of Education on the recommendation of a board of directors appointed by the President.

4. Innovation and Entrepreneurialism at University: The Third Mission

Increasingly, universities in advanced economies are viewed as key contributors to enhancing national economic competitiveness, especially the knowledge intensive sectors of the economy (Shattock, 2009). According to the European Commission, universities are strategically positioned at the crossroads of research, and education; and that ‘innovation universities’ hold the key to unlocking of knowledge economy. For example, in 2001, universities employed 34% of active researchers in the EU, while 80% of fundamental research in the EU Member States was carried out in universities. Moreover, the knowledge intensive sector of EU economy which employed mainly university graduates, was responsible for half of the new jobs created between 1997 and 2000.

In order to fulfil this ‘third mission’ (Williams, 2009) besides teaching and research, universities are under pressure to change the way they are organised and led; with a need for them to be more autonomous in their decision-making processes and capable of acting entrepreneurial in order to exploit opportunities in their economic environments in timely fashion (Shattock, 2009a).

Pathways of Transformation

To be entrepreneurial or innovative, Burton Clark (1998) argued that a university must be willing to put in place institutional structures capable of expending energy and taking risk on activities in anticipation of positive outcomes which cannot be guaranteed at the outset. Clark (1988) also identified five cardinal characteristics or pathways of transformation that are common amongst entrepreneurial or innovative universities. These are: strengthened steering core composed of central management group and academic departments that are committed to change and can respond quickly to opportunities arising in their operating environments; expanded development periphery in form of new organisational units (outreach offices for knowledge transfer, intellectual property development, and industrial training, for example) within the university that are capable of reaching out across old university boundaries and connect with the outside organisations in order to establish collaborations that tackle real-world industrial problems; diversified funding bases in form of additional financing portfolios for bringing in a third streams income for discretionary purposes (beside traditional government support and mainstream research grants); stimulated academic heartland in form of active commitment by the academic
departments and research centres to modify their belief systems in line with entrepreneurial values; and integrated entrepreneurial culture in form of set of beliefs embedded in university wide structures, symbols, and organisational practices.

And while entrepreneurialism does not always take financial nature, finance is a key driver and indicator of entrepreneurial activity; and that a university which has enough resources to fund all its activities will see no incentive in being more innovative (Williams, 2009). Depending on how financing of higher education is structured (the incentive arrangements), it may stimulate entrepreneurialism or impedes it.

The role of financial incentive and characters of institutional leaders
Williams (2009) observed several types of entrepreneurial behaviours in the case studies carried out on 28 universities in Russia and six European countries (Finland, Moldova, Poland, Spain, Sweden, and UK). These were: establishment of new private higher education institutions, government action stimulates new developments at public universities; public universities initiating institution-wide transformation, small ventures at departmental, faculty, or at centre levels; and mushrooming of freelance activities in teaching, and research. Moreover, the entrepreneurial character of the institutional leaders and managers is found to contribute to great extent to institutional entrepreneurialism (ibid:29).

Other driving factors of entrepreneurialism at universities
Shattock (2009b) notes that for technology transfer to take place from university to industry, there must be a ‘pull factor’ from society, and a ‘push factor’ from the government. That different kinds of innovation and entrepreneurial activity take place at different kinds of universities, ranging from comprehensive and research intensive universities, to regional universities, to specialist and research intensive universities, to private universities. Moreover, entrepreneurialism in teaching may be driven by one or more of the following factors: making regional impact, widening access function, commitment to professional domain, and linking teaching to research (Temple, 2009). And that change in curricula may be driven by one or a combination of knowing, acting, and being (ibid.:51).

Furthermore, Shattock (2009c) highlights the importance of aligning human resource management practices such as level of pay, academic promotion procedures, and system for motivation and recognition of staff performance, and so forth, with the institution’s strategic mission in order to stimulate entrepreneurial behaviour among staff. What is more, flexibility in the face of changing environments and contexts, as opposed to following rigid traditions and organisational cultures, is seen as more conducive to creating more entrepreneurial behaviours.

Moreover, Mora and Viera (2009) highlight the role of governance in enhancing or inhibiting entrepreneurial behaviour in the university. They argue that the following components of governance influence entrepreneurship to varying degrees. State regulation, stakeholder guidance, academic self-governance, managerial self-governance, and competition for resources. Areas of contentions include: relationship with the State (over regulation or micromanagement by the State), university internal governance (traditional collegial governance that may delay decision making), and management tools (identifying the right tools for ensuring effective consultation). And in this respect, European Commission university modernisation program identifies the following areas of change: less regulation, more autonomy to universities, increased funding for innovation, and better university leadership. It also recommended that
universities (ibid.80):
• Take more responsibility for their financial sustainability in the long term by diversifying their funding sources
• Establish stronger, sustainable, and collaborative linkages with the business community, and society in general on commercialisation of research output
• Share knowledge with business community for the purpose of exploiting intellectual property generated by research.

Finally, Martinez and Kitaev (2009) have described how internationalization of higher education is driving university entrepreneurialism. Internationalization has been defined as “the process of integrating international, intercultural and/or global dimension into the goals, functions, (teaching, learning, and research) and delivery of higher education.” Martinez and Kitave (ibid.:122), argue that “activities described under the headings like the impact of globalization on higher education, cross-border higher education and the global higher education market may lead to more entrepreneurialism through related international openness, exposure, visibility, competition, partnerships, ventures, and risk-taking.” And that entrepreneurial universities can explore and exploit opportunities through international cooperation.

5. The Impact of Technological Advancement (Especially electronic/digital communication technologies)

At the turn of the last century, Clark Kerr (2001) opined:

Perhaps above all, higher education is going through its first great technological change in five centuries – the electronic revolution. Late confrontation with fundamental technological change is the main reason why universities are the major institutions in the western world that has changed so little over the past five centuries. Agriculture, transportation, industry, and the military have all been impelled forward by new technology. Now it is higher education’s turn. It is too early to tell in detail how the electronic revolution will affect higher education, but it is likely to be dramatic.

Peter Drucker predicted the possibility of rise of distance learning as a substitute of campus learning (Drucker, 1998): “Long distance learning …may well make obsolete in 25 years [or by 2024] that unique American institution, the free American college.” This was further amplified by Arthur Levine when he argued that higher education administration will be dominated not by management of campuses, but will be preoccupied with “management of the distribution of knowledge to individual destinations, however remote.” Levine further likened the future organisation of the American higher education as a setup that will drive the prospective student into the “wilderness” (Levine, 2000).

The evolution of educational system came to be categorized into Education 1.0, Education 2.0, Education 3.0, and Education 4.0 (Ernst and Young LLP 2017) The historical periods and features are shown in Table 2.

Education 4.0 (Ernst and Young LLP 2017) will accompany Fourth Industrial Revolution (Kaku, 2011; Brynjolfsson and McAfee, 2016; Schwab, 2016) and will be characterised by:
• New disruptive technologies such as mobile internet, social media, cloud technology and big data, massive online open courses (MOOCs), the Internet of Things (IoT), 3D printing, robotics and artificial intelligence and machine learning, advanced materials, biotechnology and genomics
• Social and economic phenomena that include flexible work arrangements, rising geopolitical volatility, emerging young demographics and middle classes, rapid urbanization, climate change and transition to low-carbon economy, women rising aspiration and economic power, the demand
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- Student centric and competency based learning
- Flexible curricula and flexible completion time frame
- Globalization of higher education market
- Life long learning
- Skills for jobs yet unknown (Kaku, 2011).
- Increased student mobility

All this will put immense pressure on universities globally to get ready, or suffer immense consequences of increasingly competitive globalized high education market.

Table 2. Features of educational systems from ancient and middle ages to present day

<table>
<thead>
<tr>
<th>Education System</th>
<th>Period</th>
<th>Main Features</th>
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| Education 1.0    | Ancient time to Middle Ages (14th Century) | • Personalized  
• Very close contacts between teacher and students  
• Informal with no standardized curricula  
• Limited scaled (confined to few students)  
• Teachers were mostly philosophers or religious leaders  
• Started in Greece, India, China, Israel, Rome  
• Private with aim of producing good citizens  
• Dominance of religious and philosophy education in Western Europe and focus on scientific thought in Rome  
• Imparting of basic skills in reading, writing, and mathematics  
• Focus on upper class males  
• Later more formal education system began to appear and university system began including in Italy, China, Japan, Korea, UK, and France  
• No assessment or credentials  
• No diversification  
• Focus on learning of Greek and Latin classics |
| Education 2.0    | Mid-15th Century coinciding with the invention of printing press technology | • Printing press technology impacted literacy levels in France, England, and Germany  
• Emergence of one-to-many education  
• Number of books published increased between 16th and 18th century  
• Books provided the means of knowledge dissemination  
• Renaissance and Reformation, development of society |
• Inquiry and innovation encouraged
• Proliferation of educational institutes and centres for discussion, scientific inquiry and experimentation
• Growth of vocational education in India, Japan, South Korea, and Europe

<table>
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<tr>
<th>Education 3.0</th>
<th>20th Century to present day</th>
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<tbody>
<tr>
<td>▪ Exponential increase in demand for higher education globally</td>
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<tr>
<td>▪ Technology allowed the use of smart board to replace the chalkboard in higher education</td>
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<tr>
<td>▪ Increase use of personal computer, laptops, smart phone by students</td>
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<tr>
<td>▪ Use of learning management systems (LMS) and enterprise resource planning (ERP) and to improve the administrative functions</td>
<td></td>
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<td>▪ Use of electronic communication for improved interactions and collaboration between members of academic community</td>
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<tr>
<th>Education 4.0</th>
<th>The evolving/unfolding next generation of education for the 21st century</th>
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</thead>
<tbody>
<tr>
<td>▪ Driven mainly by the rapid advancement in information and communication technologies</td>
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<tr>
<td>▪ Technology disrupters include mobile internet, social media, cloud technology and big data, MOOCs, the Internet of Things (IoT), 3D printing, robotics and artificial intelligence and machine learning, advanced materials, biotechnology and genomics</td>
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<tr>
<td>▪ Social and economic disrupters include flexible work arrangements, rising geopolitical volatility, emerging young demographics and middle classes, rapid urbanization, climate change and transition to low-carbon economy, women rising aspiration and economic power, the demand for personalized learning</td>
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<tr>
<td>▪ Student centric and competency based learning</td>
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<td>▪ Flexible curricula and flexible completion time frame</td>
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<td>▪ Globalization of higher education market</td>
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<td>▪ Life long learning</td>
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<td>▪ Skills for jobs yet unknown</td>
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<tr>
<td>▪ Increased student mobility</td>
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</tbody>
</table>

Source: Ernst and Young LLP (2017)
6. The Push for World Class Status

A world-class university is described as aniversity with “highly ranked research output, a culture of excellence, great facilities, and a brand name which transcends national boarders” (Coete et al., 2015). It must also be ranked among top global universities in league tables that are published annually by non-profit academic ranking organisations. These ranking organisations include Times Higher Education World University Ranking (The WUR), Shanghai Jiao Tong Academic Ranking of World Universities (ARWU), QS World University Ranking, and US News and World Report global ranking (Shattock, 2010; Gadd, 2020). While 40 percent of Times Higher Education (THE) ranking is based on institutional reputation, Shanghai Jiao Tong league tables use statistical data to rank universities (Shattock, 2010).

International league tables fuel ‘reputational competition’ amongst universities globally based on their research performance (Shattock, 2010). However, the league tables are not necessarily without limitations and shortcomings as benchmarks for measuring institutional success. The ranking organisations have been criticised for some of indicators they use such as counting the number of Nobel prize-winning alumni as proxy of research excellence, favouring publications in English; that older and wealthier Northern American and European universities almost always top the list of the World rankings, while contributions to society and teaching are either ignored or undervalued (Gadd, 2020). Furthermore, some statistical analyses reveal that 71% of 100 top-ranked world universities come from English-speaking countries (Carnoy et al., 2013).

Nevertheless, the rankings have been influential in deciding who is eligible to receive scholarship grants based on the institution where they are based. They also influence the choice by scholars of where to work or study; therefore putting less reputable universities at disadvantage (Gadd, 2020).

Moreover, there are some expressed controversies seen as associated with when all universities aim to attain world class status. Most prominently, it is thought that such competition will eventually eliminate institutional diversity as everyone strives to look like Harvard or Oxford, a phenomenon described as institutional isomerism (Shattock, 2014). This was described as follows by Di Magio and Powel (1983):

*Once disparate organisations in the same line of business are structured into an actual field (...by competition, the state, or the profession), powerful forces emerge that lead them to become more similar to one another… Organisations may try to change constantly; but after a certain point in the structuration of an organisational field, the aggregate effect of individual change is to lessen the extent of diversity within the field.*

(Di Magio and Powel, 1983).

Nevertheless, league tables are influential in formation of institutional strategies (Shattock, 2020). Education Minister in Germany, for example, had suffered from the so-called ‘Harvard here syndrome’ when only very few German universities could participate in the annual top lists of academic ranking by Shanghai Jiao Tong Academic Ranking of World Universities (Kehm, 2014). This led to the birth of Excellence Initiative and change in funding structure of research in Germany with the aim of concentrating resources in fewer but competitive German universities. And in order to make universities more autonomous and more responsive to changing operating environment, Germany has been experimenting with giving selected universities foundation status.

Similarly, in Finland, University of Aalto
was formed as a merger of Helsinki School of Economics, the Helsinki University of Technology, and University of Arts and Design in order to pool resources and strive for world-class excellence (Salmela-Mattila, 2014).

An OECD report notes that global ranking tables are dominated by top research universities in industrialised countries, also known as Super RUs (Olsson and Cooke, 2013). This is a small percentage of all post-secondary institution and ranges from 3% in China, to 5% in US, to 25% in United Kingdom (Cloete et al., 2015). Table 3 shows the percentage of research intensive universities in three industrialised countries (US, UK, and China).

For research universities to flourish, national higher education systems are required to differentiate in their missions at post-secondary levels; and organize sensibly to align their programmes and priorities with appropriate missions. As outlined by Olsson and Cooke (2013):

*Certain higher education institutions address the growing demand for access, both from national populations as well as from international students. Others, notably research universities, align academic research to national economic growth and social development, thereby linking up to the national and global knowledge economy.*

In society where uniformity is preferred, in order to create equal society, vertical, as opposed to horizontal differentiation can be a challenge (Kehm, 2014). Finally, in order to attain world-class status, a research intensive university must be well led and governed, possesses a critical mass of talented staff and students, and have access to sufficient resources (Olsson and Cooke, 2013).

The mass higher education has been accompanied by a differentiation. According to Burton Clark (1983), a good example of differentiated higher education system is offered by the State of California comprising a number of private universities, and public universities with three tier system of 10 campuses of University of California with 220,000 students; State universities on 23 campuses with student population of 430,000; and an undefined number of open 2-year community colleges that enrolled 1.5 million students by 2009.

**The Future of African University**

Latecomer Status: The benefits and drawbacks. As explained in the introduction, African universities, like their counterparts in the developing countries, were latecomers to the global higher education scene compared to European or American universities whose histories date back to medieval era and seventeenth century, respectively (for the implications of longevity of university on its success chances, see Shattock, 2009). Although first African universities initially were conceived as extensions of the British and French university systems, Cloete and Maasen (2015) argues that African universities, in practice, fell short of Oxbridge’s and grande école’s models.

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of Post Secondary Institutions</th>
<th>Number of Research Universities</th>
<th>Percentage of Research Universities</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>4000+</td>
<td>220</td>
<td>5%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>100</td>
<td>25</td>
<td>25%</td>
</tr>
<tr>
<td>China</td>
<td>3000+</td>
<td>100</td>
<td>3%</td>
</tr>
</tbody>
</table>

Source: Extracted from Cloete et al. (2015)
that they were meant to imitate; and instead focused on training of administrators for colonial governments, and political elites of post-colonial era (Cloete and Maasen, 2015).

What is more, the expansion and development of African higher education sector, especially in the sub Saharan Africa region in the three decades that followed independence, was slowed down by the publication in 1986 of a hugely influential World Bank’s report (Psacharopoulous et al., 1986). The report claimed that the returns to a dollar spent on primary education were twice the returns to a dollar spent on higher education. Furthermore, Cloete and Maassen (2015) noted that the World Bank went as far as asserting its position at a meeting of African vice chancellors in Harare in 1986 that higher education was a ‘luxury’ (Cloete and Maassen, 2015). Moving forward, the Bank pushed for educational policies in the sub Saharan Africa region that shifted public funding from what was a highly subsidized tertiary education sector to general education sector. As a result, public expenditure per tertiary student began to decline from a high USD 6,800 in 1980 to a very low average of USD 981 in some 33 low-income sub Saharan African countries (World Bank, 2009). That policy still receives the lion share of the criticism directed at the World Bank for playing such a ‘damaging role’ in the underdevelopment of higher sector in Sub Sahara Africa (Monbiot, 2003; Cloete and Maasen, 2015).

**The Path Taken by BRICs**

Looking back, it is possible to think that the post-independence governments of Sub Sahara African region may have missed the opportunity to give World Bank’s higher educational financing policy recommendations due consideration and find sustainable financing solutions that could have allowed them to expand their countries’ higher education systems. The World Bank’s alternative financing policy options included considering families and students’ contribution to the cost of higher education through tuition fees payment, student loan schemes, and award of selective scholarships to poorer students who may not afford to pay for university education (Psacharopoulous et al., 1986). Evidently, the partial implementation of the report without mitigation measures (reducing expenditure on higher education), has resulted in the expansion of primary school enrolment, underinvestment in African higher education sector, and the lagging behind of higher education sector in terms of student enrollment ratios, declining public expenditure per tertiary student, and fall in African universities share of global research publication output (Cloete et al., 2015; Cloete and Maasen, 2015). It leaves so many unanswered questions as to why higher education was allowed to stagnate for too long.

However, some efforts were exerted at Makerere University in Uganda to apply market-based solutions to finance the expansion of university education (Mamdani, 2007). These included creation of part-time and temporary staff, development of competitive and income-generating vocational courses by various schools, and admission of private self-paying students at Makerere, and other public universities. This, according to Mamdani, amounted to nothing more than “commercialisation of the university at the expense of quality and research” (Cloete and Maasen, 2015).

In contrast, starting in the early 1990s and for the next two decades that followed, the Governments in Asia, Eastern Europe, and Latin America, especially the BRIC countries—Brazil, Russia, India, and China—succeeded in expanding their higher education systems considerably by making more resources available to tertiary education through a mix of subsidies and charging of tuition fees (see Carnoy et al., 2013).

As noted in Carnoy et al. (2013), the
Governments of BRIC countries recognized higher education as a source of economic competitiveness that, in addition, yields higher private returns to individuals. Based on that clear understanding and correct reading of the challenges of expanding higher education systems, BRICs responded robustly to the increased demand for tertiary education in their societies by soliciting contributions from the families towards the cost of higher education of their children, while encouraging the expansion of private higher education for those who could not get into public universities but can afford it.

And in a way, one many argue that BRICs succeeded through adapting some of the strategies and approaches proposed by the World Bank’s report -- implementing cost sharing policies, while finding ways to support the under privileged sectors of the society. The result was the massive expansion and growth of the sector over the same period in which African higher education systems had stagnated (Carnoy et al., 2013). In Brazil, for example, enrollment per 100,000 of population rose from 1,074 students in 1990 to 3,421 students by 2010; in Russia enrollment increased from 1,900 students to 6,599 students; in India from 585 students to 1,173 students per 100,000 of population over the same period. The expansion of higher education in three BRIC countries: China, Brazil, and India is shown in Figure 1 in terms of enrollment per 100,000 of population from 1920 to 2010.

The graduate enrollment rates for three BRICS countries (Brazil, India, and China), and that of Sub Sahara Africa between 1970 and 2009 are shown in Figure 2. It is noted that while graduate enrollment for Brazil, India, China, rose from 10, 5, and 1 percent, respectively, in 1975 to 36, 14, and 24 per cent in 2009; the gross enrollment ratio in higher education rose for Sub Sahara Africa average from 1.6 in 1975 to 7.4 by 2009.

Figure 1. Enrolment in higher education per 100,000 of population (Source: Extracted from Carnoy et al., 2013)
Figure 2. Gross Enrollment rates in higher education in three BRICs countries and Africa between 1970 and 2009 (Source: Carnoy et al., 2013 for BRICs, and World Bank data for Sub Saharan Africa)

Another feature of expansion of higher education in BRICs countries is differentiation, vocationalization, and inclusion/rationalization (Carnoy et al., 2013).

**Differentiation**

Differentiation allowed more high school graduates to enter universities by expanding second and third tier institutions to absorb en masse the new entrants. This allowed the quality of former elitist institutions to be preserved by continuing to educate fewer and most talented student.

In India, for example, institutions of tertiary education are grouped into three tiers (Ernst and Young LLP, 2017):

**Tier 1 Institutions**– Research focused, providing high quality research and innovation with critical national role in addressing intellectual imperative and educate fewer number of students

**Tier 2 Institutions** – Offering professional courses with prime aim of producing industry-ready graduates, with an important responsibility of addressing economic concerns. It is of lower cost and absorbs mass of new entrants.

**Tier 3 Institutions** – Foundation institutions offering diverse courses with purpose of producing well rounded graduates with skills needed by local industries, with responsibility of addressing social imperatives. It is open, wide spread, and non-selective non-university tertiary education.

**Vocationalisation**

Involves teaching of professional technical education in engineering and computer sciences (Carnoy et al., 2013). The returns to technical professional education have been increasing with globalization and demand for manufacture of high-value added goods.

**Inclusion/Rationalization**

Many countries including India, Brazil, and China strives to address inequality and bring on board socially and economically excluded groups through affirmative actions and tests,
quotas, and other schemes.

**The divergence between sub Sahara Africa higher education and the rest of the World**

Part of the reasons behind underdevelopment of African tertiary education is that while ‘engine of development’ role or ‘the arm of the State and industry’ function of the university has been recognized and put to good use in the US, Europe, and BRICS countries (Kerr, 2001; Carnoy, 2013), that function has not caught as much on the African Governments most of which were preoccupied with internal political power struggle, in addition to distortion caused by the policies promoted by the funding agencies such as the World Bank (Cloete and Maasen, 2015). Untangling itself from the distorting web of influence by the multilateral international agencies is one of the challenges Africa higher education policy must resolve if the sector can have any chance to expand.

In brief, the African university system is now faced with the twin challenge of expanding as well as catching up with the rest of the world. It is a situation that involves chasing ‘a moving target’ – it wants to be where ‘the rest’ are, whereas ‘the rest’ are already advancing ahead in order to remain relevant (Weigratz, 2009), and consequently suffer from Matthew Effect: ‘those who have will have more, and those who have not, will lose even the little they have’ (see Shattock, 2009).

In order to overcome this dual challenge, the African university system might decide to adopt the latest technologies and leapfrog into twenty-first century education 4.0 that will serve the Fourth Industrial Revolution (Abramovitz, 1986; Ohno, 2006; Akec, 2018b).

**7. African University in the context of a changing global higher education systems**

While acknowledging the challenges facing the African university as a latecomer to higher education sector, the African university system is not an island unto itself, but forms part of the global higher education system that must adapt its traditional roles, its internal organisation, its leadership, its governance structures, its intellectual cultures and values, its funding sources, and its operation and mode of service delivery in order to respond positively to new trends and demands put by the society on its intellectual services (Bok, 1982; Kerr, 2001; Castells, 2009).

As noted by Raina (Raina, 2015):

> We seem to have taken the university as the primary site for the production of knowledge for the last two centuries without in any way appreciating that the habitus of science within the university is as different from anywhere else. The future of the university of teaching is uncertain today, not because it is threatened by extinction, but because the university itself is likely to undergo downsizing or process of major reform. These transformations are affected by a wide variety of factors that include the changing constellations of knowledge and the context of its production.

The factors and trends driving change in higher education systems in Africa, include the ever increasing call on the universities to enhance national economic competitiveness through training and capability improvement in a globalized knowledge economy (Weigratz, 2009; Cloete et al., 2015; Akec, 2018a); to act as engines of national economic development, cultural renewal, military power, and social progress (Bowen, 1982; Castells, 2009; Akec, 2016); to catalyze innovation for national industrial development and value addition (Clark, 1998; Weigratz, 2009; Akec, 2018b); to respond to internationalization and globalization of higher education market (Martinez and Kitaev, 2009; Carnoy et al., 2013; Raina, 2015); to adapt to corporatization of university governance (Mamdani, 2007; Fazackerley and Chant, 2009; Shattock, 2014; Cloete et al., 2015).
2015; Raina, 2015); to diversify their resource bases in the face of falling public financing of higher education operation (Clark, 1998; Mamdani, 2007; Shattock, 2009; Williams, 2009; Carnoy et al., 2013); to provide educational opportunities to broader sectors of population, including the low-income groups in the society through massification (Bowen, 1982; Carnoy et al., 2013); and to weather the impact of health pandemics by use of communication technologies (The Economist, 2020, 15th August). Last, but not least, to differentiate academically by supporting its flagship universities (such as universities of Botswana, Cape Town, Dar es Salaam, Eduardo Mondlane, Ghana, Makerere, Mauritius, Nairobi, and others) to become first-tier research-intensive universities in order to join the ranks of the world-class universities, able to attract significant research funding, while serving a limited number of students; or otherwise choose to position themselves as second-tier ‘mass teaching universities’ and colleges that absorb the vast proportion of the students enrolling in higher education in many countries (Shattock, 2009; Carnoy et al., 2013; Cloete et al., 2015); and still others remain as third tier institutions in order to provide hands on and vocational training that impart practical skills needed by the industry.

But most importantly, university systems globally and also in Africa, must respond to the unfolding Fourth Industrial Revolution that is being set in motion by the advances in digital technologies. According to one of its ardent advocates, Klaus Schwab, the Fourth Industrial Revolution is a technological revolution that will fundamentally change the way we live, how we work, and how we relate to one another. It will be characterised by ‘fusing of different technologies and blurring of the lines between the physical, digital, and biological spheres’ (Schwab, 2016). And that an effective response will call for a concerted action by all the stakeholders in the global community, including the public and private sectors, academia, and civil society. The technologies underpinning the Fourth Industrial Revolution include mobile devices with large data storage and processing capacity, big data for decision support, robotics and autonomous vehicles, artificial intelligence, the Internet of Things, nanotechnology, 3D printing, biotechnology, and quantum computing, among others.

Furthermore, the digital technologies that are responsible for unleashing the Fourth Industrial Revolution will also usher in Education 4.0 that is going to force universities to review their enrollment policies, their educational delivery mechanisms, and their assessment and credentialing methods in order to enable personalized and life-long learning for their clients (Drucker, 1998; Kerr, 2001; Carnoy et al., 2013; Ernest Young LLP, 2017).

And while the African university system shares similar challenges as those facing university systems globally, it faces some very specific bread-and-butter pressures. These include mobilizing sustainable funding for expanding operational and research capacity, reducing gender disparities in science-related fields, building staff capacities for teaching and research, increasing access to higher education, gaining recognition as ‘the arms of the State’ – namely, an indispensable partner in economic development, industrialisation, and social progress, serving its communities better, decolonizing its curricula, and effecting improvement in STEM education (Kerr, 2001; Mamdani, 2007; Cloete et al., 2015; Juma, 2016; Akec, 2018b; Tikly 2020).

One may also note that the challenges facing the African university as enumerated above are the same pressures that are facing universities globally—no university has enough of financial resources or enough of research funding to meet all its needs (Clark, 1998; Shattock, 2009). Hence, universities world over are
constantly striving for continuous improvement as they respond to declining public support, and changing global educational environments. That calls on African universities to be innovative and entrepreneurial in order to create third revenue streams besides government support and research grants (Clark, 1998)

Specific challenges that will drive change in African university

At the core of the challenges facing African universities in particular, and the higher education sector in general, is the need to establish credibility by demonstrating their real potential as development partners to national governments and communities they serve as the experience has shown elsewhere (see Shattock, 2010:7).

African universities can establish this credibility by responding in timely manner to regional agendas such as: African Union Agenda 2063, and Comprehensive African Agricultural Development Programme (CAADP) (Akec, 2018b). It can also respond to global agenda such as: UN Agenda for Sustainable Development Goals 2030, adapting to digital technologies revolution, responding to Fourth Industrial Revolution (Schwab, 2016), and transitioning to Education 4.0 (Bunting et al., 2015; Cloete and Maasen, 2015; Juma, 2016; Akec, 2018b; Tikly, 2020).

The regional forces that will also shape the African university in the next two decades are the expectations by governments (research and policy advice, and human resources development), providing relevant education to the rising student population (youth bulge will demand universal access to quality higher education and needs for decent jobs in post-university);

Furthermore, African universities are under pressures to respond to the competitive global knowledge-based economy and its implications for the national industries (the need to innovate and vocationalize). The advances in communication technologies (with implication of integration of ICT and digital technologies as enablers of Education 4.0) has changed the nature and needs of today’s student (lifelong learning calls for flexible learning curricula and academic programmes).

The increasing threats of the pandemics (the new normal, wild-cards, or black swan events that impact methods of education delivery such the need of social distancing that followed Covid-19 pandemic) needs to be accommodated (Kerr, 2001). All these factors will combine to differentiate the winners from the losers in the race towards realisation of the ‘next generation African university’. The pressure to respond and adapt to these multiple overlapping, and sometime conflicting challenge on African university is like nothing we have seen before. The role of governments in the transition will also be critical.

The role of leadership in managing change

Like their global counterparts, African universities need to be well-led and better managed, beside excelling in their core functions of teaching and research in order to succeed (Shattock, 2010). A successful institution, as expressed by Shattock, is one that can ‘punch above its weight.’ Namely, an institution managed and led in such a way as to perform ‘better than its circumstances might suggest it could.’ According to Shattock (2010): 

> Success does not occur as a result of a single critical decision but because the institution finds ways of getting a lot of relatively small decisions right over a long period, and these decisions reinforce one another, and because its machinery and its organisational culture encourages consistency of purpose, and imposes an unspoken coordination on decision making so as to concentrate rather than dissipate institutional energies.

Moreover, the goal to succeed must be inspired
Envisioning the future of the African University: Needed reforms, and adjustments to respond to the emerging challenges

by, for example, the ambition to attain a world-class status, or move to higher relative positions nationally. New kinds of leadership will be needed for African universities aspiring to join the ranks of the world-class universities. As noted by Olsson and Cooke (2013):

This role requires persons of exceptional talent whose responsibilities are multi-faceted, inter alia: defining a mission for the institution and its creative strategy for change in an evolving social context, responding to policy opportunities, protecting scholarship for quality research, encouraging bold experimentation in teaching and learning, forging alliances with stakeholders, spearheading fund-raising efforts and communicating the institution’s activities to concerned partners. This leadership agenda is realised through efficient and effective management strategies which clearly demonstrate the institution’s contribution to local and international development.

Furthermore, African universities will need to be autonomous and accountable like businesses, able to manage their resources efficiently and respond quickly to changing environment. This will have implication on how it is governed in term of distribution or concentration of authority. It should take note of the move in European countries to align with New Public Management that give more power and authority to university presidents.

Finally, it is worth adding that the development of new African university will be best led by foxes as opposed to hedgehogs in order to succeed (“hedgehog knows one big thing, and fox knows many small things” (Berlin, 1953)). According to Clark Kerr (2001):

Academic leaders of this new century, or at least of its early decades, may be able to identify no great single vision to guide them or great and compatible forces to dominate them; they may need to look in more directions, to be sensitive to many diverse opportunities and to many threats. They may be best be foxes or “entrepreneurs” ... looking around every bush, avoiding every trap, eating everything that happens to come along that can’t eat them. No great visions to lure them on, only the needs of survival for themselves and their institutions. They may have no clear picture of the world they are destined to inhabit; no total assurance about the future. This is not a fault. The situation is not suited to concentration on one or a very few great visions.

8. CONCLUSIONS AND RECOMMENDATIONS

African university is not an island unto itself, but situated in the global higher education environment. It is impacting the sector and is being impacted by it. Most of the factors that will drive African higher education are global. Others are regional and unique to the African continent. The paper has reviewed at depth the factors driving reforms in higher education in several developed countries, and outcomes of such reforms. And it is observed that these factors are changing and as a result universities have been changing in the way they are managed, teach, conduct research, and serve society.

Moreover, it could be seen that over the centuries, universities in the developed and in developing world have moved from being institutions serving the privileged in the society, to institutions providing mass higher education to wide sectors of society following the invention of printing press in the sixteenth century. The development of internet at the end of twentieth century opened up new opportunities for distance and life-long learning. Further development in communication technologies, increasing computing power, cloud computing, and large data, as well as the availability of Massive Online Open Courses (MOOCs), will further impact universities in ways not yet known or seen. The advent of machine learning and artificial intelligence will cause some jobs to disappear and create jobs whose qualifications are yet unknown.

African universities must learn from how universities in the advanced economies have evolved and continue to change in response to changing economic, cultural, social, and technological conditions. Equally important,
African universities must continue to respond effectively to national and regional agenda in order to stay relevant to African communities and societies they serve. An African university must generate technologies necessary for the improvement of agricultural productivity, value-addition, food and nutritional security, and industrialisation of African natural resource-rich economies. Cultivating entrepreneurship and innovation must be part of an African university mission and culture.

To succeed, African higher education institutions must massify and differentiate into three or more tiers in order to cater for different needs of the communities they serve, including meeting intellectual, economic, and social imperatives of the African society. Massification will only serve its purpose if Africa has fewer research intensive world-class universities, as well as second and third lower tier universities that can provide professional, technical, and vocational education that is capable of producing large number of industry-ready graduates in such areas, but not limited to, finance, management, economics, agriculture, engineering, and computer science.

Massification will not be possible without sustainable financing. Experience of BRICs has shown that returns to university education are highest for individuals. Hence, individuals are obliged to contribute to cost of higher education in their countries. Governments must design sustainable loan schemes in addition to scholarships for the underprivileged and marginalised members of the society, including increasing the number of women in engineering and sciences.

African universities must be innovative and entrepreneurial in order to bring in third streams income that can support research, academic, and extension programs. Innovations should include support of local and regional industries. Incentive systems and administrative structures must be designed in such a way as to promote and reward entrepreneurial culture throughout the organisations.

African universities must be well managed and well led in order to thrive. The university governance structures need to be reformed in line with New Public Management (NPM) in order to create more dynamic organisations that are agile and responsive to their environments. African universities should be managed as accountable and responsible businesses that are able to allocate their scarce resources efficiently. This will call for less government regulation, more university autonomy, as well as giving more executive powers to university presidents, vice chancellors, and rectors, with due consideration to how information is shared with the stakeholders (professoriate, administrative staff, students, government, and business community). Deans of schools must become manager-deans responsible for implementing the strategies designed by the university central administration. Academic leadership as a career must be made attractive, and rewarding in order to inspire the most talented African academics to consider university leadership as a worthwhile vacation, even as a life’s calling.

The possibilities for a thriving future African university are limitless as far as they are led by entrepreneurial presidents, vice chancellors, and rectors. In other words, Academic leaders, as argued by Clark Kerr, must be entrepreneurs or ‘foxes.’

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REFERENCES


Clark, B.R. 1983. The Higher Education


Ernst and Young, LLP. 2017. Leapfrogging to Education 4.0: The Student at the Core. Ernst and Young LLP, Kolkata.


Envisioning the future of the African University: Needed reforms, and adjustments to respond to the emerging challenges


Building higher level skills to drive development in Africa: The case of the RUFORUM Doctoral Regional Training Programmes

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ABSTRACT
Africa still lacks the required human capacity to respond to critical development challenges. Skills are inadequate in many areas from primary to tertiary level, and vocational training. There is need to develop high-level skills, institutional capacities, critical technical skills, and resources in key investment areas. The current situation is a major constraint to the implementation of development programmes and continental frameworks hence the foreseen delayed emergence of African counties as knowledge economies. Progress has so far been made by several regional stakeholders to identify the key critical soft and hard skills that are necessary to drive the Africa Agenda 2063. With this, educational institutions being the main actors in the skills, competencies and technological development value chains, are expected to transform and realign their interventions to develop the high-level skills needed to deliver Africa Agenda 2063. The Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) responded by commissioning an institutional and competence analysis of its then 10 member universities to document strengths and weaknesses, status of facilities, human resources/expertise and experiences to map out the niche areas as well as institutional comparative strengths and weaknesses. Other studies also identified skills and competence gaps in students graduating from African universities. A key outcome of this process was the adoption of strong course-based doctoral training that involved engagement with other leading experts in and outside Africa in the training. In 2008, RUFORUM launched the coursework-based doctoral regional training programmes, and has since supported the establishment of seven such programmes, namely Agricultural Rural Innovations, Food Science and Nutrition, Soil and Water Management, Aquaculture and Fisheries, Agricultural Resource Economics, Plant Breeding and Biotechnology, and Dryland Resource Management. As part of building institutional capacity and recognizing excellence, some of programmes have become part of the African Higher Education Centres of Excellence. These include: African Centre of Excellence in Agro-ecology and Livelihood Systems (ACALISE) at Uganda Martyrs University in Uganda; Africa Center of Excellence for Climate Smart Agriculture and Biodiversity Conservation at Haramaya University in Ethiopia; African Centre of Excellence in Sustainable Agriculture and Agribusiness Management at Egerton University in Kenya; Africa Centre of Excellence in Aquaculture and Fisheries Science at Lilongwe University of Agriculture and Natural Resources (LUANAR) in Malawi; and Makerere Regional Center for Crop Improvement at Makerere University in Uganda. These programmes have supported training of over 420 doctoral students in Africa who are now contributing to the development of the African continent in different capacities in the agricultural sector and leadership positions. These programmes remain relevant today and are inspiring the development of other regional training programmes to fill the required skills and knowledge gaps in the continent.
Building Higher Level Skills to Drive Development in Africa: The Case of the RUFORUM Doctoral Regional Training Programmes

Key words: Africa, Doctoral training, Higher Education, RUFORUM

RÉSUMÉ
L’Afrique manque toujours des capacités humaines nécessaires pour relever les défis du développement. Les compétences actuelles restent insuffisantes dans beaucoup de domaines, du primaire au tertiaire et dans la formation professionnelle. Il est donc indispensable de développer des compétences de haut niveau, des capacités institutionnelles, des compétences techniques essentielles et des ressources dans les domaines d'investissement clés. La situation actuelle entrave la mise en œuvre des programmes de développement et des cadres de travail continen	aux, d'où une émergence retardée des pays africains pour devenir des économies du savoir. Des progrès ont été accomplis par plusieurs parties prenantes régionales pour identifier les compétences essentielles nécessaires pour conduire l'Agenda 2063 de l'Afrique. Ainsi, les établissements d’enseignement étant les principaux acteurs des chaînes de valeur d’éducation, de compétences et du développement technologique, devraient se transformer et réaligner leurs interventions pour développer ces compétences. Le Forum régional des universités pour le renforcement des capacités en agriculture (RUFORUM) a commissionné une analyse institutionnelle des compétences dans 10 universités membres pour documenter l'état des infrastructures, les ressources humaines/expertises et les expériences afin de mettre en évidence les forces et faiblesses comparatives institutionnelles. D'autres études ont également identifié des lacunes de compétences chez les étudiants diplômés des universités africaines. Un résultat clé de ce processus a été l'adoption d'une formation doctorale qui impliquait l'engagement des experts d’Afrique et d’ailleurs. En 2008, RUFORUM a lancé des programmes régionaux de formation doctorale et a soutenu la création et la mise en exécution de sept programmes de ce type dans les domaines des innovations agricoles rurales, des sciences alimentaires et de nutrition, de la gestion des sols et de l'eau, de l'aquaculture et la pêche, de l'économie des ressources agricoles, de la sélection végétale et de la biotechnologie et de la gestion des ressources des terres arides. Dans le cadre du renforcement des capacités institutionnelles et de la reconnaissance de l'excellence, certains de ces programmes font partie intégrée des centres d'excellence africains de l'enseignement supérieur. Il s'agit notamment: du Centre africain d'excellence en agro-écologie et systèmes de moyens d'existence (ACALISE) à l'Université Des Martyrs de l'Ouganda; du Centre africain d'excellence pour l'agriculture climato-intelligente et la conservation de la biodiversité à l'Université Haramaya en Éthiopie; le Centre africain d'excellence en agriculture durable et gestion de l'agro-industrie à l'Université d'Égerton au Kenya; le Centre d'excellence africain en aquaculture et sciences halieutiques à l'Université de Lilongwe (LUANAR) au Malawi; et le Centre régional pour l'amélioration génétique à l'Université de Makerere en Ouganda. Ces programmes ont soutenu la formation de plus de 420 docteurs en Afrique, qui depuis, contribuent au développement du continent africain à différents niveaux dans le secteur agricole et à des postes de direction. Ces programmes restent pertinents aujourd'hui et inspirent le développement d'autres programmes régionaux de formation pour combler les lacunes en matière de compétences et de connaissances requises sur le continent.

Mots clés: Afrique, Formation doctorale, Enseignement supérieur, RUFORUM
BACKGROUND

The decade of the 1990’s saw the implementation of various economic recovery programmes in Africa to catalyze and underpin economic growth. The period into the 2000s saw the fastest and steady economic growth in the continent. During this period of fast economic growth, the proportion of people living in poverty fell to less than 45% and 41% in 2012 and 2015, respectively, from over 50% in 1981. Overall, while Africa has slowly regained its economic growth, albeit below 3% annually, after the global economic crises of 2008 (AUC/OECD, 2018), growth in recent years has not translated into rapid structural transformation and job creation. Most African economies largely rely on agriculture to underpin Africa’s development as espoused in Agenda 2063 and other medium-term development frameworks, including the Comprehensive Africa Agriculture Development Programme (CAADP) (Okori, 2014; AUC/OECD, 2018; UDNP, 2020).

While indications are that Sub-Saharan Africa (SSA) has steadily increased its trained human capital, it still lags far behind other continents (UNDP, 2020). Training of right-skilled youth is critical to enable the continent sustain a common vision of unlocking prosperity and opportunity for its burgeoning young population for formal and informal work life settings (Motlanthe, 2010). A robust higher education system is critical for the development of any nations’ capability to harness its resources for advancement. Indeed, higher education is critical for developing requisite knowledge and skills for agriculture, science, technology and innovation generation in Africa (Boni et al., 2016; Nyerere et al., 2016; Anonymous, 2018). Higher education is widely recognized as being central to development, contributing not only to enhancing individual opportunities in life, but also in creating a vibrant democracy, innovative economy and a range of other societal benefits in areas such as health, nutrition, governance and environmental protection (Nyerere et al., 2016). While Science, Technology and Innovation (ST&I) education are critical for skilling today’s and tomorrow’s workforce, and are the key drivers for development, the quality of training in many African countries is weak. Governments in Africa are cognizant of this and are implementing various agenda, mostly focusing on strengthening the Technical Vocational Education and Training (TVET), as well as higher level degrees (Nega and Kassaye, 2018). Development of higher education systems is particularly critical in a region like Africa, given the significant youth population, the need for innovation to create new forms of employment, and the potential of research to address the significant social and environmental challenges (Anonymous, 2018). These steps are critical for Africa to step up the pace of its demographic transition needed to underpin any demographic dividend for its young population (Choi, 2016). Specifically, education must unlock opportunity for women delaying early child birth and consequently reducing the fertility rate by getting more women into employment after completing their education.

Like many sectors in African economies, the ST&I and Agricultural Higher Education sectors continue to face challenges characterized by low gross enrolments, limited infrastructure for research and training, mismatch in the skills of the graduates produced to meet industry requirements, as well as low staff capacity to train, especially at doctoral level (Nakayiwa, 2016). The low number of staff with high degree (doctoral) training especially in institutions of higher learning, has reduced capacity to generate required knowledge and appropriate technologies, and to train and produce post-graduates (Okalany et al., 2016; Anonymous, 2018). Overall, competitiveness of SSA economies could be improved by strengthening higher-degree education and innovation, that are key pillars of economic competitiveness (Olssen and Peters, 2005; Okori, 2014; Kruss et al., 2015).
After several decades of economic and agricultural stagnation, and even decline, in Africa especially in the period 1960’s to 1990’s, agricultural growth and productivity steadily improved, especially over the past two decades (Fuflie and Rada, 2013; Block, 2016). Growth however, was mostly due to expansion of hectarage, rather than improvement in total factor productivity (Liu and Benin, 2013). Furthermore, in order to improve land and labor productivity, there is need to enhance production and adoption of new agri-innovation (Liu and Benin, 2013; Kufuor, 2014). For an agriculture underpinned economies, like for most of African countries, a 1% increase in staple crop yield could lift 2 million people out of poverty in Africa (Thirtle et al., 2003). However, while Africa agriculture sector related total factor productivity (TFP) has risen in past decades, it has not recovered to the levels recorded in the early 1960’s (Badiane and Collins, 2016). This calls for strong integration of science capacity rebuilding efforts in the continent, that are strategically linked to education and ST&I sectors. That way, Africa will be able to harness science, technology and innovation especially for agricultural growth, as the African countries become competitive in the knowledge economy (Asongu and Odhiambo, 2019). Moreover, a stronger education sector will increase the science footprint from its current levels of just 1% of global knowledge (Nakayiwa et al., 2016).

At the start of the current millennium, African Universities through their umbrella organization, the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM), begun to re-engineer their programmes in research and outreach to intensify contributions and impact on development needs and trajectory of the continent. In this paper, RUFORUM’s contribution to rebuilding Africa’s research capacity through graduate training is shared and discussed.

**RUFORUM’s Contribution to human capital development for Africa**

RUFORUM was formed in 2004 by 10 universities in five countries in East and Southern Africa to primarily strengthen and promote the role of universities in agricultural and national development. The new member-based organization was guided by a strategic framework that had seven objectives, three focusing on: (i) Human resource development as a core function of universities; (ii) Production of high quality post-graduates and innovations by African University against a backdrop of limited resources; and, (iii) Effective and efficient contribution to national development through relevant and responsive research and training programmes. Implementation of this strategic vision required ground-truthed facts to guide investments and construction of a shared vision. A needs assessment was conducted among the then 10-member universities in Kenya, Malawi, Mozambique, Uganda and Zimbabwe to establish member universities’ capacities, which could be harnessed for training and research for the greater good of the Network and region (Blackie and Woomer, 2005). The needs assessment identified critical operational strategic challenges that African Universities needed to address in order to proactively engage in development processes and practices of their countries (Table 1).

From the needs assessment, RUFORUM was able to anchor its strategic investment planning to national development agenda including the Millennium Development Goals (UNDP, 2003), and the CAADP, key development areas of countries at that time. This process anchored universities within the broader national agricultural innovation systems and development agenda, unlocking opportunity for African universities to engage and contribute to the continent’s development agenda and process.

The multi-partners’ participatory nature of
Table 1. Strategic challenges to increased operational and strategic engagement and delivery by Africa Universities in national human capital development, research, policy and innovation

<table>
<thead>
<tr>
<th>Challenge/gap</th>
<th>Characteristics</th>
</tr>
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<tbody>
<tr>
<td>Limited capacity for graduate training and alignment to Africa’s development priorities</td>
<td>In 2004, among member Universities¹, there was no coursework based doctoral programme.</td>
</tr>
<tr>
<td>Limited number of staff with PhD</td>
<td>There was insufficient number of doctoral level trained faculty to fully supervise the incoming graduate students</td>
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<tr>
<td>Gender and diversity inequality</td>
<td>In several universities staffing reflected a shortage of females. This shortage presented a challenge for the development of gender-sensitive and appropriate on-farm technologies for improving food security and household income by smallholder farmers, and the general lack of female voices in agricultural education and training. In addition, this shortage spoke directly to the need for ‘Increased participation and voices of women in training, research, and production and marketing of knowledge’ as outlined in RUFORUM’s Strategic Objective 5</td>
</tr>
<tr>
<td>Overseas staff training</td>
<td>Members of staff on study leave to pursue doctoral training create staff shortages for research and student training in their home institutions</td>
</tr>
<tr>
<td>Limited dissemination of research findings</td>
<td>Research outputs were seldom translated into simple extension messages intended for grassroots efforts. This gap was worsened by the lack of consistent faculty policy concerning collaboration with the Agricultural Research and Extension Service in most universities</td>
</tr>
<tr>
<td>Rampant ‘Brain Drain’</td>
<td>In pursuit of better conditions of service and opportunities, some of the best lecturers were leaving for universities in South Africa or outside Africa were being recruited by international organisations</td>
</tr>
<tr>
<td>High cost of tuition and few scholarship opportunities</td>
<td>There was limited numbers of graduate students in existing graduate programmes due to limited funding opportunities and high costs of training</td>
</tr>
<tr>
<td>Inadequate and poor research and training facilities</td>
<td>In some universities, library and laboratory facilities were old, not updated and unmaintained</td>
</tr>
<tr>
<td>Limited collaboration amongst Africa’s universities</td>
<td>Other gaps were commonplace in the higher education sector which hindered universities from executing their roles in the development process. These included, limited participation of universities in National Agricultural Innovation Systems, limited voice from universities in policy agenda, limited capacity by individual universities for graduate training; limited networking and partnership among African universities leading to poor use of resources (human and infrastructure)</td>
</tr>
</tbody>
</table>

Source: Blackie and Woomer, 2005

¹RUFORUM Founder member universities- Uganda-Makerere University, Kenya - Egerton University, University of Nairobi, Kenyatta University-, Jomo Kenyatta University of Agriculture and Technology, Moi University, Malawi- University of Malawi- Bunda College of Agricultural Sciences- now LUANAR, Zimbabwe-University of Zimbabwe, Africa University, Mozambique- Eduardo Mondlane University-Mozambique
Building Higher Level Skills to Drive Development in Africa: The Case of the RUFORUM Doctoral Regional Training Programmes

RUFORUM’s strategic planning process in Kenya, Malawi, Mozambique, Uganda and Zimbabwe (Figure 1), along with needs assessment recommended establishment of a shared and common future, where existing capacities are exploited for national and regional solidarity engagements. Accordingly, joint regional higher education programmes were designed following the Centre of leadership model (Figure 2), in which one lead university provided training for others in the region (Okori, 2014). This design allowed for scaling out of jointly developed curricula and for building physical capacity, and renovation of infrastructure at participating institutions.

RUFORUM’s Regional training programmes. A guiding principle for the development of RUFORUM’s regional training programmes was the need to train Africa’s next generation of agricultural scientists needed to undertake and lead agricultural development. Indeed, the continent already had a low scientist-to-development population target ratio, with 91 Full Time Equivalent (FTE) available per million, well below a desirable target of 1 083, the gap being less in northern Africa at 495 FTE, and favourable for the Republic of South Africa (Soete et al., 2015). Indeed, in 2011, SSA employed an estimated 14,300 agricultural researchers with most countries having less than 15 FTEs per 100,000 farming population (Beintema and Elliott, 2016). Accordingly, RUFORUM efforts, amongst other initiatives in the continent are working to address this issue by strengthening postgraduate training to increase staff recruitment at its research and training institutions in the continent.

Africa’s low scientist-to-development target population, clearly required strategic investments, first to stop and or reduce the severe human resource attrition at that time due to socio-economic reasons and diseases such as HIV/AIDS and; secondly, initiate sustainable programming to rebuild capacity for training in the region for the region. Indeed, rebuilding the Africa’s human resources may require investment levels similar to what China, South-East Asia and the emerging economies of Brazil and Argentina undertook to strengthen innovations systems for agricultural sector expansion and science-led growth of their economies. RUFORUM responded by developing training programmes among its member universities to: (i) Build teaching and research capacity of member universities and the national agricultural research and extension systems; (ii) Enhance development relevance of training and research programmes to deliver science solution for their respective countries and; (iii) Build capacity in strategic science and development “challenges” especially of SSA’s Agri-food systems in line with the continental
and country aspirations as guided especially by the CAADP.

The design process of the new regional graduate programmes considered experiences from countries in and outside of Africa especially, Brazil, where significant science and technological innovation progress has been achieved through tri-partite linkage between universities, research institutions and the private sector. It also considered some of the key challenges faced by Higher Education Institutions (Table 1). Through a consultative process, seven doctorate and five master’s programmes, that address challenges of agricultural tertiary education in Eastern and southern Africa, were developed (Njeru, 2014b) (Table 2).

Each programme was designed contextually to respond to demand in the country and region of operation. However, in general, programme designs considered the large science human resource gap in the region, and the fact that isolated cases of expertise existed across the region that could be harnessed to implement quality graduate programmes. Scoping visits and consultations were made with European, South African and USA universities and allied academic and research associations to learn about their institutional arrangements for delivery of quality PhD programmes. A key outcome of this process was the adoption of strong course-based PhD training that involved engagement with leading experts in the training from within and outside of the continent. Since PhD training programmes in African universities were mostly research based (Blackie and Woomer, 2005; Nega and Kassaye, 2018), course-based training in targeted courses were integrated in the PhD training to complement knowledge and skills from research. Further, as learnt from benchmark studies in Europe and South Africa, each regional programme adopted benchmarks for research and quality training. For example in the Regional PhD for Plant Breeding and Biotechnology hosted by Makerere University, the Swedish University Agricultural Sciences and Stellenbosch University and the African Centre for Crop Improvement at University of KwaZulu at Natal in South Africa, were the benchmarks. A regional academic advisory board was established for each programme comprising of lead scientists in and outside of the continent. Additionally, partnerships were established with national, regional and or international research agencies such as the CGIAR centers for student attachment and co-supervision. Initial intakes focused on rebuilding training capacity at member Universities and as such, faculty staff were prioritized for training at partner universities. To take advantage of the experience and expertise at leading member and non-member universities, national and international faculty from different universities were engaged in teaching delivery (Figure 3). The programmes covered several areas of specialization distributed among the 10 member universities and were introduced starting from 2008 (Table 2). The thematic areas for PhD Regional Programmes included Dryland Resource Management; Soil and Water Resource Management; Food Science and Nutrition; Plant Breeding and Biotechnology; Agricultural and Rural Innovation; Agricultural and Resource Economics; and Aquaculture and Fisheries (Njeru, 2014b). Additionally, regional masters programmes were developed and covered the areas of Research Methods; Plant Breeding and Seed Systems; Agrometeorology and Natural Risk Management; and Agricultural Information Communication and Management (Njeru, 2014a). The Masters programmes were developed as a rapid response strategy in areas that were deemed critical for supporting the PhD Programmes or required immediate human resource capital particularly to service the national agricultural research systems. Subsequent reviews led to development of a Masters programme in Monitoring and Evaluation and two PhD programmes, namely, PhD in Agroecology and Food Systems, and PhD in Food Systems and Agribusiness.
<table>
<thead>
<tr>
<th>Programme</th>
<th>Programme Goal</th>
<th>Year</th>
<th>Host University, Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD Agricultural Rural Innovations</td>
<td>To produce top-level skilled professionals with interdisciplinary orientation to facilitate the development of institutions and structures for sustainable utilization of knowledge and technologies in agricultural and rural development in an integrated way</td>
<td>2012</td>
<td>Makerere University, Uganda</td>
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<td></td>
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<td>2013</td>
<td>Sokoine University of Agriculture, Tanzania</td>
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<td></td>
<td></td>
<td>2012</td>
<td>Egerton University, Kenya</td>
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<tr>
<td>PhD Food Science and Nutrition</td>
<td>To build, sustain and strengthen human resources capacity for teaching, learning and practice of food and nutritional sciences for development and scientific progress</td>
<td>2009</td>
<td>Jomo Kenyatta University of Agriculture and Technology, Kenya</td>
</tr>
<tr>
<td>PhD Soil and Water Management</td>
<td>To develop and strengthen regional human resources and build institutional capacity in impact-oriented research in soil and water management issues primarily to enhance natural resources use and sustainability</td>
<td>2010</td>
<td>Sokoine University of Agriculture, Tanzania</td>
</tr>
<tr>
<td>PhD Aquaculture and Fisheries Science</td>
<td>To develop and build capacity for aquaculture and fisheries sector; equipping students with a deeper understanding of the theoretical framework underlying aquaculture and fisheries sciences and practices, and skills for articulating aquaculture and fisheries issues for public and private sectors as well as strengthening regional collaboration while rationalizing the use of existing resources (human and infrastructure) in the region</td>
<td>2009</td>
<td>Lilongwe University of Agriculture and Natural Resources, Malawi</td>
</tr>
<tr>
<td>PhD Agricultural Resource Economics</td>
<td>To meet regional as well as international demand for highly qualified and relevant professionals for planning and policy formulation in Africa</td>
<td>2009</td>
<td>Lilongwe University of Agriculture and Natural Resources, Malawi</td>
</tr>
<tr>
<td>PhD Plant Breeding and Biotechnology Programmes</td>
<td>To develop and strengthening the human resource and research capacity for Crop improvement and related development areas in Sub-Saharan Africa</td>
<td>2008</td>
<td>Makerere University, Uganda</td>
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<tr>
<td>Programme</td>
<td>Objective</td>
<td>Year</td>
<td>Institution</td>
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<tr>
<td>PhD Dryland Resource Management Programme</td>
<td>To train a critical mass of doctoral cadre of experts in dryland resource management for the region, which will subsequently be utilized to address land degradation and climate change challenges</td>
<td>2008</td>
<td>University of Nairobi, Kenya</td>
</tr>
<tr>
<td>MSc Agrometeorology and Natural Risk Management</td>
<td>To produce a new cohort of professionals able to support agrometeorology services including early-warning systems and responsive capacity for disaster management</td>
<td>2010</td>
<td>Haramaya University, Ethiopia</td>
</tr>
<tr>
<td>MSc Monitoring and Evaluation</td>
<td>To strengthen the relevance, efficiency, effectiveness, impact and sustainability of interventions by governments, civil society and non-government organizations as well as development partners through the development and enhancement of capacity for monitoring and evaluation</td>
<td>2012</td>
<td>Uganda Martyrs University, Uganda</td>
</tr>
<tr>
<td>MSc Agricultural Information and Communication Management</td>
<td>To train professionals that would support dissemination of research information and knowledge and support agricultural institutions and processes for better communication of the sector’s needs, opportunities and challenges</td>
<td>2009</td>
<td>Egerton University, Kenya</td>
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<tr>
<td></td>
<td></td>
<td>2010</td>
<td>Haramaya University, Ethiopia</td>
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<tr>
<td></td>
<td></td>
<td>2008</td>
<td>University of Nairobi, Kenya</td>
</tr>
<tr>
<td>MSc Plant Breeding and Seed Systems</td>
<td>To train a pool of middle career professionals (MSc graduates) able to initiate and manage plant breeding programmes and with a business orientation to ensure that their products (improved seed) reach the market</td>
<td>2009</td>
<td>Makerere University, Uganda</td>
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<td></td>
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<td></td>
<td>University of Zambia, Zambia</td>
</tr>
<tr>
<td>MSc Research Methods</td>
<td>To develop a new cadre of professionals who are able to: i) Support scientists in the planning, implementation and reporting of effective research for development; ii) Train scientists in the research methods needed to work in emerging areas</td>
<td>2009</td>
<td>Jomo Kenyatta University of Agriculture and Technology, Kenya</td>
</tr>
</tbody>
</table>
Figure 3. Curriculum development and implementation of RUFORUM regional graduate training programmes

Achievements, impacts and Lessons
The implementation of RUFORUM Regional Training Programmes since their introduction starting from 2008, has benefited the Network and the host universities as highlighted below.

Co-developed and implemented for common development goals. Most of the development challenges faced by the region are common. Thus development of the next generation of leaders trained using a shared curriculum such as implemented by RUFORUM are advantageous in that: (1) Joint curricula development ensures relevance to the broader development challenges of the region, in line with the current wave of economic integration; (2) Student and staff exchange creates regional professional teams, which start to work together, leveraging each other’s strengths; (3) Completed and uncompleted research results especially for the PhD thesis, can be ultimately developed into technologies that are relevant to local needs; (4) Once capacity is built, participating universities may initiate similar or other academic programs; (5) Hosting universities have an opportunity to strengthen their own curricula (Tizikara, 2020). By virtue of hosting the programs, universities have benefited from enhanced infrastructure, networks, income accrued from tuition and enhanced profiles by enrolling students from throughout the continent. Running the programs has resulted into beneficial changes in the host universities such as: the adoption of the wide use of modern and multiple learning approaches and tools; emphasis on practical components in training and attaching students in relevant institutions where mentoring and practical skills are enhanced; integration of cross-cutting skills make the graduates more marketable; and, the consultative approach to curricula development and review promotes collaboration and partnerships (Njeru, 2014a). Over the years, RUFORUM has awarded Institutional Strengthening Grants to develop new graduate programmes and university
Table 3. Transformation of RUFORUM Regional Training Programmes into African Higher Education Centres of Excellence

<table>
<thead>
<tr>
<th>Name of ACE, Host</th>
<th>ACE Objective</th>
<th>Postgraduate Programmes under the ACE</th>
</tr>
</thead>
</table>
| Makerere Regional Center for Crop Improvement (MaRCCI), Makerere University, Uganda | To provide educationally innovative PhD and MSc programs that produce “fit-for-purpose” graduates with “market-relevant” skills that will drive economic transformation on the African Continent | MSc: Plant Breeding and Seed Systems  
PhD: Plant Breeding and Biotechnology |
| Africa Centre of Excellence in Aquaculture and Fisheries Science (AquaFish), LUANAR, Malawi | To foster innovation and entrepreneurship in the production of high skilled fit-for-purpose critical mass of agricultural scientists for improved aquaculture and fisheries management in order to enhance food, nutrition and economic security in Eastern and Southern Africa | MSc: Aquaculture; Agricultural Economics;  
Food Science and Technology;  
Agribusiness Management; Rural Development and Extension  
PhD: Aquaculture and Fisheries Science;  
Agricultural and Resource Economics |
| African Centre of Excellence in Sustainable Agriculture and Agribusiness Management, Egerton University, Kenya | To contribute to sustainable agriculture and agribusiness management through capacity development, research, innovation and technology transfer for enhanced food security | MSc: Livestock Production Systems;  
Animal Nutrition; Soil Science;  
Dry Land Farming; Horticulture;  
Agribusiness Management; Agri-Enterprise Development; Food Science; Agricultural Engineering;  
Agricultural Extension  
PhD: Soil Science; Agronomy; Animal Science; Plant Biotechnology;  
Agribusiness Management; Food Science |
| Africa Center of Excellence for Climate Smart Agriculture and Biodiversity Conservation (ACE Climate SABC), Haramaya University, Ethiopia | To improve the quality of postgraduate education and research in eastern and southern Africa to foster enhanced capacity to adapt and mitigate effects of climate change and weather variability, and ensure biodiversity conservation more effectively in the region | MSc: Climate Smart Agriculture;  
Biodiversity and Ecosystem Management  
PhD: Smart Agriculture and Biodiversity Management |
| African Centre of Excellence in Agro-ecology and Livelihood Systems (ACALISE), Uganda Martyrs University, Uganda | To streamline the production of high level, well-motivated and ethically conscious critical mass of Agro-ecology and Livelihood systems experts | MSc: MSc in Development Economics;  
Monitoring and Evaluation Agro-ecology; Bio Ethics; Livelihood Systems; Micro-Finance  
PhD: Management and Entrepreneurship; Agro-ecology and Food Systems |
outreach to communities to strengthen universities (Tzikara, 2020).

Further, training has been done by teams of professionals drawn from multiple institutions and the knowledge pool has contributed to the high quality of training. Such networks of specialisation are recommended as a strategy for RUFORUM members to promote complementarity and synergy. The Programmes have facilitated the successful implementation of other Network initiatives such as the Intra ACP and Intra Africa Mobility projects, and the Graduate Teaching Assistantship Programme (Adidja et al., 2019).

The attractiveness of RUFORUM regional programmes has resulted into their introduction and adoption by other universities. For example, the University of Nairobi started a PhD in Agricultural Information and Communication Management (AICM) and Masinde Muliro University in Kenya launched a programme on Research Methods. This is an indication of the potential for further scaling out of the programmes for greater impact. Some of the Regional Training Programmes transformed into African Centres of Excellence with the support of the World Bank under ACE II as shown in Table 3. The transformation of the Regional Training Programmes into ACEs has enhanced regional specialization among participating universities in areas that address specific common regional development challenges (ACE, 2020). The transformation has also expanded the admission base and the training coverage. It has also strengthened capacities of these universities to deliver high quality training and applied research as well as meet the demand for skills required for Africa’s development. RUFORUM has remained supportive towards the development of new masters and doctoral programmes, and regional centres, such as African Centre of Excellence in Agro-ecology and Livelihood Systems (ACALISE) hosted at Uganda Martyrs University, Uganda.

Training the next generation of African scientists. The Programmes have remained popular for on-time completion and regional scope that has promoted networking. Figure 2 a and b show the contribution of the Regional Training Programmes to building continental higher-level skills. The programmes have had a wide admission base and have added value to a range of academic backgrounds. Academic staff and students have also realized enhanced networks. The programs have remained relevant and still meet the needs of professionals for discipline depth and fundamental skills needed for upward career mobility, and for expanding career opportunities and enhance performance in current positions.

Because of their regionality, the Programmes have allowed students to be trained in Africa for a fifth of the cost of training one student abroad, while offering opportunities for international exposure. The Programmes have also provided opportunities for mature students to upgrade their qualifications while in-service. One of the strongest pillars of regionally hosted PhD training or their variants, where students conduct thesis research in their home countries is that the research can be carried out in ways that directly benefit surrounding communities and the African agenda. The applied and high quality research conducted by the Programmes has contributed significantly to the body of knowledge and remains relevant to the development of the continent. So far, it has contributed to the generation of over 300 technologies, innovations and management practices across the continent.

Science leaders for African research and training Institutions: Higher education is a vital aspect for building of State infrastructures through the teaching, research and outreach mandates. RUFORUM, through the Strengthening Capacity for Agricultural Research and Development in Africa (SCARDA) project supported strengthening capacity for the then fragile States of Rwanda,
Burundi and Sudan. This was undertaken by enabling research organizations to adopt and engage several tools and methodologies in capacity strengthening including, institutional analysis to identify capacity and resource gaps; gender analysis to identify opportunities for targeted gender support; change management for embedding new approaches and addressing systemic capacity issues; and, introducing additional skills such as proposal writing to help win new proposals. Through the project, 78 students from 15 countries in Eastern, Central, Southern and West Africa were trained in plant breeding, rangeland management and agricultural information and communication management. Several graduates developed and submitted publications in peer reviewed journals and were further provided opportunity to present some of their research findings in international conferences. Other graduates received support for doctoral studies, and this further increased their career opportunities as some of them received promotions to lead agricultural development programmes in the respective institutions. Thus, young graduates trained in the region are retained and deployed to serve their countries, with about 98% retention in the continent (Tizikara, 2020). Graduates of the Regional Training Programmes are also serving their countries in different capacities, i.e., extension service, international organizations, in universities, private sector, NGOs, CGIAR and NARS, to mention a few. Generally, the programmes are perceived as positively impacting rural livelihoods and the continent’s economy. The RUFORUM supported regional MSc and PhD programmes have responded and continue to respond to specific capacity gaps within the realm of agriculture in Africa (see Table 4) and especially in support of the Comprehensive Africa Agricultural Development Programme (CAADP). Of recent, students and staff exchanges have involved North Africa, turning the regional programmes into continental training centres.

Relevance to mitigating emerging global challenges. The ongoing COVID-19 Pandemic and climate change and variability have underscored the importance of multi-lateral approaches to combat such global challenges.

<table>
<thead>
<tr>
<th>Programmes</th>
<th>2008-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSc. Plant Breeding and Seed Systems</td>
<td></td>
</tr>
<tr>
<td>MSc. Agricultural Information and Communication</td>
<td></td>
</tr>
<tr>
<td>PhD. Agricultural and Rural Innovations</td>
<td></td>
</tr>
<tr>
<td>MSc. Research Methods</td>
<td></td>
</tr>
<tr>
<td>PhD. Plant Breeding and Biotechnology</td>
<td></td>
</tr>
<tr>
<td>PhD. Dryland Resource Management</td>
<td></td>
</tr>
<tr>
<td>PhD. Agricultural and Resource Economics</td>
<td></td>
</tr>
<tr>
<td>PhD. Soil and Water Management</td>
<td></td>
</tr>
<tr>
<td>PhD. Aquaculture and Fisheries Science</td>
<td></td>
</tr>
<tr>
<td>PhD. Food Science and Nutrition</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2a. Number of Masters and Doctoral Graduates from RUFORUM Regional Training Programmes: 2008-2020
Some are fast spreading giving very limited room to wiggle. The COVID-19 first reported in Wuhan, Hubei Province, China in the last quarter of 2019 and declared a pandemic by WHO in March 2020, spread rapidly globally and the World reacted by shutting down economies with disastrous effects. According to the International Monetary Fund (IMF), the global economy is projected to shrink by 3.2% mostly due to COVID 19 lockdown effects. In the case of Africa, the region is expected to experience its first recession in 25 years (IMF, 2020). This will affect various sectors of the economy thus slowing down progress made especially over the last decade. Equally important is the threat posed by climate change and variability, especially the combined effects of drought and excess water. According to the Intergovernmental Panel on Climate Change (IPCC) Working Group, III temperature increase in the region is projected to be higher than the global mean temperature increase; regions in Africa within 15 degrees of the equator are projected to experience an increase in hot nights as well as longer and more frequent heat waves (Shepard, 2019). Climate change will also amplify existing stress to water, negatively affect both terrestrial and ocean ecosystems which will impact agriculture especially in semi-arid ecologies and fisheries (inland and ocean) and ecotourism, an important emerging sector (Niang et al., 2014). African Universities must invariably be part of the solution to these major threats including other potential ones. In fact, Africa is the source of three major zoonotic diseases with Ebola hemorrhagic fever (Pourrut et al., 2005) being the most recent. Others include Zika virus disease (Anonymous, 2014), and West Nile virus disease (Mackenzie et al., 2004). Additionally, the increasing outbreaks of army works in the Horn of Africa and North Africa, crop diseases outbreaks, and very frequent pandemics of Transboundary animal diseases call for new initiatives to develop response capacities in the continent. Part of this will require rebuilding capacities in foundation or frontline sciences such as Epidemiology, Plant Pathology, Entomology, Virology, Genomics, etc and emerging needs such as molecular diagnostics, among others. A key strategy will be to take advantage of institutions with comparative advantages, and promoting joint regional initiatives as done under the RUFORUM Regional Training programmes.

The African University is pivotal to generating...
Table 4. Contribution of RUFORUM’s Regional Training Programmes to Africa’s science leadership for research and human capacity development

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Type</th>
<th>MSc</th>
<th>PhD</th>
<th>Staff</th>
<th>Total Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharing Capacity to Build Capacity for Quality Graduate Training in Agriculture in African Universities (SHARE)</td>
<td>Intra-ACP</td>
<td>52</td>
<td>17</td>
<td>8</td>
<td>77</td>
</tr>
<tr>
<td>Inter-University Cooperation to Train Crop Scientists for Enhancing Agriculture in Africa (CSAA)</td>
<td>Intra-ACP</td>
<td>43</td>
<td>20</td>
<td>10</td>
<td>73</td>
</tr>
<tr>
<td>Mobility to Enhance Training of Engineering Graduates in Africa (METEGA)</td>
<td>Intra-ACP</td>
<td>44</td>
<td>20</td>
<td>8</td>
<td>72</td>
</tr>
<tr>
<td>Partnering for Health Professional Training in African Universities (P4PHT)</td>
<td>Intra-ACP</td>
<td>43</td>
<td>18</td>
<td>8</td>
<td>69</td>
</tr>
<tr>
<td>Collaborative Training in Fisheries and Aquaculture in East, Central and Southern Africa (COTRA)</td>
<td>Intra-ACP</td>
<td>24</td>
<td>12</td>
<td>10</td>
<td>46</td>
</tr>
<tr>
<td>Regional Academic Exchange for Enhanced Skills in Fragile Ecosystems Management in Africa (REFORM)</td>
<td>Intra-Africa Mobility</td>
<td>23</td>
<td>11</td>
<td>6</td>
<td>40</td>
</tr>
<tr>
<td>Partnership to Train Scientists in Crop Improvement for Food Security in Africa (SCIFSA)</td>
<td>Intra-Africa Mobility</td>
<td>24</td>
<td>12</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>Mobility of African Scholars for Transformative Engineering Training (MASTET)</td>
<td>Intra-Africa Mobility</td>
<td>22</td>
<td>12</td>
<td>6</td>
<td>40</td>
</tr>
<tr>
<td>Mobility for Innovative Renewable Energy Technologies (MIRET)</td>
<td>Intra-Africa Mobility</td>
<td>33</td>
<td>12</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>RUFORUM Graduate Teaching Assistantship programme</td>
<td>RUFORUM</td>
<td>21</td>
<td>119</td>
<td>-</td>
<td>140</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>329</td>
<td>253</td>
<td>65</td>
<td>647</td>
</tr>
</tbody>
</table>

science solutions to mitigate existing and emergent threats. The Universities must also develop contemporary systems of operation including new-normal operations such as ICT underpinned training. The RUFORUM model builds on a proven approach of collective engagement through multilateralism to address cross-national challenges. This approach still remains relevant and in fact is more than ever before necessary given the multi-country and multi-sectoral nature of today’s development threats.
Looking Ahead

While the Regional Training Programmes have trained students from across the continent, they have been hosted mainly in the Southern and Eastern Africa regions of the continent. With RUFORUM’s expansion into other regions of the continent, an opportunity exists to sprawl and scale out into West, Central and Northern parts of the Continent while in the process address the needs of universities at different levels of development. This scaling out could now take into consideration Africa’s very poor performance in science, technology and innovation (ST&I). This is especially so in terms of ICT readiness, Science, Technology, Engineering and Mathematics (STEM), staff capacity to deploy ST & I to support agriculture, science education, emerging fields, such as data science and genomics, and the need to increase technical skills for the attainment of the aspirations of Agenda 2063. Efforts in these direction must give emphasis on training female scholars and building capacities for fragile States.

Accordingly, RUFORUM’s new initiatives: Strengthening Africa’s Innovation and Entrepreneurship Capacity (SASTIE); Building Africa’s Science, Technology and Innovation Capacity For Economic Growth (BASTIC); Africa Digital Agricultural Programme: Digital Technologies for Agricultural Transformation (AfriDAP); and, the Regional Initiative to Strengthen Staff Capacity and Increase the Pool of Women Scientists in African Universities (RISSCAW) and their various components should inform the next needs assessment and gap identification for developing Regional Training Programmes. The proposed Regional Training Centres embedded in the new initiatives aim to support development of relevant human resources across continent, and foster learning and collaboration within the continent. In addition, using the RUFORUM’s fifth initiative - Strengthening Higher Agricultural Education in Africa (SHAEA), the approach could be used to strengthen linkages between selected African universities and regional agricultural sector/ actors including policy to develop required human and research capacities to spur agricultural transformative in the continent. All these initiatives recognize the need for private sector and other stakeholder involvement in curriculum development, strengthening university-industry linkages especially to turn university research into business opportunities, and subsequent ‘fit for purpose’ human capital development in a feedback mechanism.

In order for these and other initiatives to take full effect and support the development of the required capacity for Africa’s advancement, there is a need to address challenges that still hamper delivery of high quality education and learning experiences in African universities, such as limited funding and human and infrastructural capacity. There is therefore urgent need for increased short and long term funding towards higher education on the continent. At their Conference on Higher Education in Agriculture in Africa (CHEA) held in Kampala, Uganda, 15th – 19th November 2010, the Ministers committed to increased investment in higher education in agriculture in Africa and for higher agricultural education to be included as an integral part of agricultural development investment in the CAADP Country Compacts (investment plans) and Medium Term Agricultural Productivity Programmes. Further Ministries responsible for higher education, education institutions and other relevant actors committed to creating conducive and friendly environments for women and girls education and career advancement at all levels (CHEA, 2010). More recently, during the Ministerial meeting held on 5th December 2019 at RUFORUM Annual General Meeting in Ghana, the Ministers endorsed RUFORUM’s five (5) continental initiatives for strengthening Africa’s innovation capacity, increasing its competiveness, enhancing youth employability and entrepreneurship. These, and
other commitments need to be fully actualized by Member States to support higher agriculture education, science, technology and innovation in order to achieve the continental goals and aspirations for Africa’s own development as enshrined in Africa Agenda 2063.

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STATEMENT OF NO CONFLICT OF INTEREST
The authors declare that there is no conflict of interest in this publication

REFERENCES
Boni, A., Lopez-Fogues, A. and Walker, M.


CHEA. 2010. Ministerial Communiqué: Issued at the Ministerial Conference on Higher Education in Agriculture in Africa (CHEA), Kampala 15th – 19th November 2010


Liu, Y. and Benin, S. 2013. Options and priorities for raising and maintaining high agricultural productivity in Africa. Regional Strategic Analysis and Knowledge Support System (ReSAKSS) Facilitated by IFPRI, A Programme of CAAPD implementation. Issue Note 20


Njeru, R. 2014a. Case studies on RUFORUM Regional Master’s degree programs. RUFORUM, Kampala, Uganda

Njeru, R. 2014b. Case studies on RUFORUM Regional PhD Dryland Resource
A. M. MWEETWA et al.

Management, Soil and Water Management, Food Science and Nutrition, Plant Breeding and Biotechnology and Agricultural and Rural Innovation training programs.
RUFORUM Secretariat, Kampala. 134 pp.

Nkurayija, J. C. 2011. The impact of globalization on Africa’s development: Rwandan tourism as key to mobilize revenue and investment. National University of Rwanda (NUR), Kigali.


Niang, I., Ruppel, O.C., Abdurabo, M.A.,
Building Higher Level Skills to Drive Development in Africa: The Case of the RUFORUM Doctoral Regional Training Programmes


ABSTRACT
Demand for tertiary education in Kenya has significantly increased and continues to swell against the backdrop of insufficient funding thus affecting the quality of teaching and learning. The population of the tertiary education age group in the country (between 18 and 25 years) was 6.9 million in 2019 representing 3 per cent share of the total population. This calls for a review of the higher education spending in order to prioritise providing equitable opportunities for training this critical category that is expected to contribute towards national growth and competitiveness. This paper discusses the status of financing higher education in Kenya and points to developments that have been achieved by the subsector amid the challenges of insufficient funding.

Key words: Funding, Higher Education, Kenya

INTRODUCTION
In Kenya, demand for higher education has significantly increased over the years. The government’s blue print - Vision 2030, at its core articulates the need to emphasize science and technology courses to help the country transform into “a newly industrializing, middleincome country providing a high-quality life to all its citizens by the year 2030” (GoK, 2007). Kenya’s Vision 2030 has placed special
demands on the tertiary sector as the leading engine that the economy must essentially rely upon to produce adequate numbers of middle level professionals needed to drive the economy towards the attainment of the Vision. The Government continues to reform the education and training sector to respond to the emerging issues aimed at ensuring that the country’s goals and aspirations are realized (MOE, 2019).

Tertiary Education and Training in Kenya has experienced modest growth over the last 50 years. However, the country is yet to produce adequate and skilled middle level human resource required to meet the demands for national development. (MOE, Sessional Paper, 2019). To compete internationally, countries need mass high-quality higher education that immediately raises the question of how to pay for it. Kenya Government’s effort to support the education sector is evidenced by among other factors the significance increases in the number of higher education institutions across the country as well as growth in enrolment rates.

**Growth of Higher Education Institutions, 2015 - 2019.** The number of higher education institutions in the country has grown remarkably over the years. As shown in Table 1, the number of Technical Vocational Education and Training institutions in the country rose from 874 to 2,191 between the years 2015 and 2019, a growth of 87%. The significant growth of TVET institutions was occasioned by the deliberate move by the Government to reinvigorate the sector in recognition of the pivotal role that the sector is envisaged to play in the social, economic and technological development of the country; laying a foundation for the vocational skills required for socio-economic development, equipping students with entrepreneurial skills and positive attitudes for self or formal employment, and providing practical training that is responsive and relevant to the country’s sustainable economic and industrial development (Akala and Changilwa, 2018). The rejuvenated interest in TVET has exploded into a national debate resulting in the restructuring of the entire arm of education.

The TVET sub-sector has embarked on reforms geared, inter alia, towards enhancing access, retention rate and quality. Unfortunately, inadequate funding has over the years curtailed the anticipated growth, forcing institutions to operate with insufficient resources, thus failing to perform at optimal levels. Other factors aggravating sub-optimal performance include low level of involvement of enterprises in TVET training, out-dated equipment and infrastructure at training institutions, and lack of well-trained teachers (German Development Cooperation in Kenya, 2017; Akala and Changilwa, 2018).

The university subsector has similarly experienced tremendous expansion in the last couple of years (Table 1). Key developments in university education were the establishment of the Commission for University Education (CUE) under the Universities Act, No. 42 of 2012, as the successor to the Commission for Higher Education. The CUE is a Government agency mandated to regulate university education in Kenya. The second development was the initiation of parallel track (of private, non-subsidized) admissions to public universities. Beginning in 1998, courtesy of the pioneering work of Makerere University in Uganda followed closely by the University of Nairobi (UoN), a number of public universities started dual track admission programmes. All public universities now have these programs in place. These initiatives have greatly expanded university education opportunities, leading to a significant increase in university enrolments over the last decade (Mukhwana *et al.*, 2017).
Table 1. Number of Higher Education Institutions in Kenya

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>TVET</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Vocational Training Centers</td>
<td>816</td>
<td>816</td>
<td>1186</td>
<td>1200</td>
<td>1200</td>
</tr>
<tr>
<td>Private Vocational Training Centers</td>
<td>0</td>
<td>29</td>
<td>47</td>
<td>47</td>
<td>47</td>
</tr>
<tr>
<td>Public Technical and Vocational Colleges</td>
<td>55</td>
<td>62</td>
<td>91</td>
<td>101</td>
<td>191</td>
</tr>
<tr>
<td>Private Tech and Vocational Colleges</td>
<td>0</td>
<td>382</td>
<td>627</td>
<td>628</td>
<td>742</td>
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<tr>
<td>National Polytechnics</td>
<td>3</td>
<td>11</td>
<td>11</td>
<td>11</td>
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</tr>
<tr>
<td>Total</td>
<td>874</td>
<td>1300</td>
<td>1962</td>
<td>1987</td>
<td>2191</td>
</tr>
<tr>
<td>Universities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Chartered Universities</td>
<td>23</td>
<td>30</td>
<td>31</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>Public Constituent Colleges</td>
<td>8</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Private Chartered Universities</td>
<td>17</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>Private Constituent Colleges</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Private Universities with LIA</td>
<td>12</td>
<td>12</td>
<td>14</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>Registered Private University</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>66</td>
<td>69</td>
<td>74</td>
<td>74</td>
<td>74</td>
</tr>
</tbody>
</table>

The number of universities increased by 12.12% from 66 to 74 universities within the five-year period. Despite its rapid expansion, Kenya’s university sector is fraught with a number of serious challenges which, among others, include insufficient/declining public funding, declining quality and inadequate and outdated infrastructure (Gudo, 2016). The case of TVET Education in Kenya.

In Kenya TVET remains fragmented and delivered by different providers at various qualification levels. The fragmentation has arisen from the un-coordinated actions of multiple government and non-government actors. Governmental TVET institutions under the education ministry have been concentrating on producing middle level technical workers. Meanwhile, in non-formal TVET programs, NGOs, and private institutions offer employment-oriented TVET programs to various target groups, including school leavers, people in employment, school drop outs and marginalized groups in the labour market. But unlike formal TVET, these programs are not yet systematically delivered (Mukhwana et al., 2017). Informal on-the-job training is widespread, but due to the absence of a systematic assessment and certification system there are currently no mechanisms to recognize informal occupational learning. Traditional apprenticeships in the small and micro enterprise sector constitute another presumably important, yet entirely un-researched, training environment. As a result of these challenges, the Kenya government embarked on TVET reforms a decade ago.

TVET reforms in Kenya reflects an important paradigm shift of recent years and place quality and relevance as its priority. The reforms focus on integrating global best practices to link to the TVET system outputs with labour sector requirements. TVET must respond to the competence, motivated and adaptable workforce capable of driving economic growth and
Development. The reforms have been majorly focusing on institutions, Human Resource Development (HRD), and improvement of the quality of teaching and training through infrastructural development and provision of equipment. Kenya hopes to achieve a TVET system which is relevant and flexible, effective, efficient, accessible, sustainable, and which fulfills its general obligations in an integrated training and working environment. TVET reforms aim to provide the Kenyan labour force with market-oriented training, a structural ability to adapt quickly to changing circumstances and market needs, and high quality in teaching through comprehensive and continuous teacher training and system. The Constitution of Kenya 2010 and Vision 2030 acknowledges the need to reform education and training through sessional paper no. 14 of 2012. There is need for better integration between the basic, TVET and University sectors in training. The TVET subsector focuses on providing skills that meet the workplace as well as self-employment guaranteeing human and economic development and therefore its outcomes must be human resources fit for the job market.

TVET funding and reforms in Kenya. Over the last 10 years, the government has enacted the TVET act of 2013 through which it created several institutions. These include the TVET Authority which accredits and carries out quality assurance for TVET training and educational institutions, the TVET CDACC which develops curricular and carries out assessment and examinations for the sector; and the TVET funding to support resource mobilization and management for the sector. In 2014, the Government enacted the Kenya National Qualifications framework act, which established the Kenya National Qualifications Authority (KNQA). The work of the KNQA cuts across the basic, TVET and university to bring better coordination and harmony between the various levels of the education system. In recognition of the important role that the sector is playing in supplying manpower to the nation, the Government is now building and equipping at least one TVET institution in each of the 290 constituencies in the country. Public TVET colleges students are also now funded by the Government according to the number of students that they have enrolled (Ksh 30,000 or US$300 per student per year) and students also have access to higher education loans (upto Ksh 40,000 or US $400 per student per year). Fees for all TVET students has also be standardized at Ksh 56,000 or US$ 520 per year. The Government has also started implementing Competence-based Education and Training (CBET) for the sector; and rebranding is on-going.

Sector Skills Councils and Occupational Standards. Quality and relevant skills development all over the world has been achieved through the involvement of the industry and in most cases coordinated by chambers of commerce and industry. Most of the chambers in many countries draw membership from the corporate sector, both private and public, including SMEs (Mukhwana, 2020). Chambers in many ways have supported skills development through engaging different players which include academia and industrialists as seen in many countries like Germany, Singapore, India, South Korea among other countries. Industry supports skills development through the development of occupational standards (OS) which inform training standards to guide curriculum development, delivery, assessment and certification. Kenya does not have a structured industry that supports skills development. A few attempts that have been made on an adhoc basis but whose success is yet to be felt and these include efforts by organizations like LIWA, KAM, HFCK, among others. A more comprehensive attempt
is currently being considered through PWG Permanent working groups, however, this is yet to yield satisfactory results. For the country to develop and implement a comprehensive and sustainable skills development system, the KNQA is now in the process of developing the national skills development council and also formalizing formation of 9 sector skills councils (Mukhwana, 2020). This change of strategy is working to ensure that industry plays a more prominent role in the development of occupational standards through their respective Sector Skills Advisory Committees (SSAC). This system seeks to bring on all the players, with the KNQA developing a national policy on development of a sustainable skills development system; development of occupational standards with various sectors; while TVETA is developing training standards to ensure that training matches expectations of industry. Actual training takes place in technical and vocational training institutions with TVETA providing quality assurance. National Industrial Training Authority (NITA), Federation of Kenya Employers (FKE), Kenya National Chamber of Commerce and Industry (KNCCI), Micro and Small Enterprise Authority (MSEA), and Association of Professional Societies in East Africa (APSEA) are part of the core team that is involved in coordination of this vital sector and ensuring that training is both sustainable and meets industry needs.

**Enrolment in Higher Education Institutions, 2015 – 2019.** Expansion of the higher education sector has resulted in significant increase in enrolment in TVET institutions and Universities. Between the years 2015 and 2019, TVET subsector recorded a substantial increase in enrolment of approximately 70% from a total of 142,410 in 2015 to 430,598 in 2019. Enrolment in the university sector recorded a minimal decrease from 539,739 in 2015 to 509,473 in 2019 (KNBS, 2020).


The sharp upsurge in TVET enrolment over the years is occasioned by the Government’s deliberate effort to sensitize students on relevance of TVET courses and dispelling the long-standing notion that TVET courses are inferior and unmarketable and instead instilling a positive perception of TVET among the general public. Table 3 shows growth in enrolment over the years in both TVET and University subsectors.

<table>
<thead>
<tr>
<th>Category of University</th>
<th>2016/17</th>
<th>2017/18</th>
<th>2018/19</th>
<th>2019/2020</th>
</tr>
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<tbody>
<tr>
<td>Private Universities</td>
<td>85,195</td>
<td>80,928</td>
<td>86,217</td>
<td>96,628</td>
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<tr>
<td>Public Universities</td>
<td>452,494</td>
<td>441,131</td>
<td>433,245</td>
<td>412,845</td>
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<tr>
<td>Total</td>
<td>539,739</td>
<td>522,059</td>
<td>519,462</td>
<td>509,473</td>
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Source: Economic Survey, 2020
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<tbody>
<tr>
<td><strong>TVET</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Polytechnics</td>
<td>5,717</td>
<td>3,920</td>
<td>18,540</td>
<td>11,676</td>
<td>24,205</td>
<td>16,513</td>
<td>14,508</td>
<td>30,838</td>
<td>60,234</td>
<td>41,844</td>
</tr>
<tr>
<td>Vocational Training Colleges</td>
<td>47,625</td>
<td>29,840</td>
<td>46,340</td>
<td>34,565</td>
<td>59,756</td>
<td>44,685</td>
<td>66,894</td>
<td>47,590</td>
<td>81,421</td>
<td>54,129</td>
</tr>
<tr>
<td>Public Technical and Vocational Colleges</td>
<td>32,221</td>
<td>23,087</td>
<td>17,589</td>
<td>9,569</td>
<td>29,584</td>
<td>17,982</td>
<td>49,454</td>
<td>34,948</td>
<td>65,347</td>
<td>46,763</td>
</tr>
<tr>
<td>Private Tech and Vocational Colleges</td>
<td>27,280</td>
<td>30,298</td>
<td>35,951</td>
<td>38,689</td>
<td>41,623</td>
<td>43,997</td>
<td>39,484</td>
<td>41,376</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sub Total</strong></td>
<td>85,563</td>
<td>56,847</td>
<td>109,749</td>
<td>86,108</td>
<td>149,496</td>
<td>117,869</td>
<td>172,479</td>
<td>157,373</td>
<td>246,486</td>
<td>184,112</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>142,410</td>
<td></td>
<td>195,857</td>
<td></td>
<td>267,365</td>
<td></td>
<td>329,852</td>
<td></td>
<td>430,598</td>
<td></td>
</tr>
<tr>
<td><strong>Universities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Universities</td>
<td>278,155</td>
<td>183,655</td>
<td>267,774</td>
<td>191,182</td>
<td>257,252</td>
<td>180,332</td>
<td>241,178</td>
<td>163,936</td>
<td>251,540</td>
<td>161,305</td>
</tr>
<tr>
<td>Private Universities</td>
<td>39,125</td>
<td>38,804</td>
<td>45,833</td>
<td>42,527</td>
<td>53,115</td>
<td>47,024</td>
<td>52,154</td>
<td>45,279</td>
<td>51,494</td>
<td>45,134</td>
</tr>
<tr>
<td><strong>Sub Total</strong></td>
<td>317,280</td>
<td>222,459</td>
<td>313,607</td>
<td>233,709</td>
<td>310,367</td>
<td>227,356</td>
<td>293,332</td>
<td>209,215</td>
<td>303,034</td>
<td>206,439</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>539,739</td>
<td>547,316</td>
<td>537,723</td>
<td>502,547</td>
<td>509,473</td>
<td></td>
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</tbody>
</table>

Higher Education financing

Higher education is expensive and expansion of the sector as well as improving quality comes at a price. Typically, countries pursue three goals in higher education namely, larger quantity with good access, higher quality, and constant or falling public spending (Barr, 2011). One of the key challenges to access, equity and relevance in Kenya’s higher education has been the issue of funding. Demand for higher education in the country has continued to swell against a backdrop of decreasing ratio of financial allocation to universities from the Government, which has had a significant impact on access, equity, relevance and quality of education (Nyangau, 2014; Gudo, 2016). Many universities lack adequate physical and academic facilities to cater for the numbers of students that they have, such as lecture rooms, internet connectivity, libraries, books, laboratories, hostels, among others. As such the quality of the learning environment has been deteriorating over time and dropout rates are on the increase (Mukhwana et al., 2017). This has in turn affected the employability of the graduates with employers contending that many students are deficient in technical skills in the areas they have been trained.

Funding not only affects what is offered in the curriculum but also how it is offered, who teaches and the resources they utilise for teaching, as well as the teaching related support activities that they engage in. Tasked with teaching and research, the university, for example, requires academic staff to engage in both activities, so that newly generated information can impact on teaching and the assimilation of that information (Akuna et al., 2017).

Challenges in Kenya’s education sector financing began way back in 1970s when the International Monetary Fund (IMF) pushed for implementation of Structural Adjustment Programmes when Kenya sought financial assistance to implement some of its development policies. The recommendation by IMF was informed by among other factors, corruption and ethnically inspired inefficiencies and inequity (MOE, 2008). Reduction of government spending in social sectors led to the introduction of user fees also referred to as cost sharing.

The Kamunge Report of 1988 recommended the adoption of a cost-sharing policy for financing education in Kenya. It recommended that the Government was to meet salaries of teachers and education administration as well as fund some limited school facilities while parents were to provide for tuition, textbooks, activity and examination fees. The communities on the other hand were to be responsible for putting up physical structure and ensuring their maintenance (MoE, 2008). Consequently, in 1994 the Government of Kenya decreased the education budget from 37% of its total annual recurrent budget to about 30%. Further, in 2006/07 public expenditure on higher education decreased by 9.4% (Sihanya, 2008). The effect of this included but not limited to a significant drop in enrolment rates, increased dropout rates, rationalized expenditure on education by spending less on teachers’ salaries resulting in poor pay for teachers and ultimately a perceived poor quality education (AAIK, 2009). This low budgetary allocation has continued to be a major constraint in the higher education sector and yet the sector is the key vehicle for rapid industrialization as outlined in Vision 2030.

Over the years and in the endeavour to ensure that the tertiary sector is able to contribute to the country’s development goals, the Government has been trying to prioritise spending in Higher education; gradually increasing capitation towards the sector, but the capitation has not been adequate to ensure that the institutions have the right infrastructure in place (MoE, 2016; German Development Cooperation in Kenya, 2017). A glance at the expenditure by the Ministry of Education for the period 2015 to 2019 shows that capitation towards recurrent expenses has been increasing at a much higher rate than the development expenses indicating that institutions have not been receiving enough monies for infrastructure and other development
projects. Table 4 shows the amount of recurrent and development monies spent in TVET and Universities during the period 2015 to 2019.

An increase in Government spending on higher education was recorded, with funding on TVET institutions remarkably rising by 310% within the 5-year period, while university funding increased with 87%. The education budget in 2019/2020 almost exclusively supported recurrent spending (87%). Despite the notable increase, capitation to higher education institutions has not been commensurate to the expansive growth of the subsector. To ensure that more students are able to access higher education, funding through the Higher Education Loans Board (HELB) has been increasing despite the cuts especially to universities.

State Department for Vocational and Technical Training budget was expected to grow by 5.9 per cent to KSh 9.8 billion in 2019/20. The expected rise in development expenditure for the two State departments is mainly due to increases in funding to support infrastructure development in secondary schools and TVET institutions. The development expenditure for the State Department for University Education was expected to decline by 9.1 per cent to KSh 9.2 billion in 2019/20, on account of the reforms undertaken by the Government on the reduction of the number of public university campuses established (KNBS, 2020).

Table 5 shows Government capitation to HELB, loan repayments, and loans and bursaries awarded from 2014/15 to 2018/19. Government capitation was reduced by 7.9 per cent to KSh 7.0 billion in 2018/19, while loan repayments declined by 12.0 per cent to KSh 4.4 billion in 2018/19. The amount of loans awarded increased by 5.7 per cent to KSh 11.7 billion in 2018/19 from KSh 11.1 billion in 2017/18. The total amount of loans and bursaries awarded stood at KSh 11.9 billion in 2018/19 (KNBS, 2020).

Table 6 shows the number of loan applicants, beneficiaries and amount of loans awarded to students in public and private universities and TVET institutions by Higher Education Loans Board (HELB) from 2014/15 to 2018/19 academic years. The total number of loan applicants increased by 6.0 per cent from 281,044 in 2017/18 to 297,989 in 2018/19, with 171,851 and 126,138 total males and females loan applicants respectively in 2018/19. The total number of loan beneficiaries rose from 275,823 in 2017/18 to 293,249 in 2018/19, representing an increase of 6.3 per cent. The amount of loan awarded increased from Kshs. 11.1 billion in 2017/18 to Kshs.11.7 billion in 2018/19.


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</thead>
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<tr>
<td>Recurrent Expenditure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Department for</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>University Education</td>
<td>57,971.43</td>
<td>54,025.03</td>
<td>87,311.67</td>
<td>91,661.06</td>
<td>108,723.07</td>
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<td>State Department for</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocational and Tech Training</td>
<td>2,308.13</td>
<td>2,479.53</td>
<td>2,511.6</td>
<td>7,777.79</td>
<td>17,100.86</td>
</tr>
<tr>
<td>Subtotal</td>
<td>60,279.56</td>
<td>56,504.56</td>
<td>89,823.27</td>
<td>99,438.85</td>
<td>125,823.93</td>
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<tr>
<td>Development Expenditure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Department for</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University Education</td>
<td>5,002.01</td>
<td>9,106.74</td>
<td>3,569.62</td>
<td>10,155.01</td>
<td>9,253.23</td>
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<tr>
<td>State Department for</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocational and Tech Training</td>
<td>4,248.17</td>
<td>5,746.18</td>
<td>8,454.88</td>
<td>9,245.2</td>
<td>9,787.14</td>
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<tr>
<td>Subtotal</td>
<td>9,250.18</td>
<td>14,852.92</td>
<td>12,024.5</td>
<td>19,400.21</td>
<td>19,040.37</td>
</tr>
<tr>
<td>Total Expenditure</td>
<td>69,529.74</td>
<td>71,357.48</td>
<td>101,847.77</td>
<td>118,839.06</td>
<td>144,864.30</td>
</tr>
</tbody>
</table>

Source: KNBS Economic Survey Report, 2020
Table 6. Loan applicants, beneficiaries and amount of loan awarded by sex

<table>
<thead>
<tr>
<th>Academic year</th>
<th>No. of Loan Applicants</th>
<th>No. of Loan Beneficiaries</th>
<th>Amount of Loan Awarded (Kshs. Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Total</td>
</tr>
<tr>
<td><strong>Public Universities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014/15</td>
<td>112495</td>
<td>59931</td>
<td>172426</td>
</tr>
<tr>
<td>2015/16</td>
<td>119,225</td>
<td>64662</td>
<td>183887</td>
</tr>
<tr>
<td>2016/17</td>
<td>137476</td>
<td>74026</td>
<td>211501</td>
</tr>
<tr>
<td>2017/18</td>
<td>130285</td>
<td>91531</td>
<td>221816</td>
</tr>
<tr>
<td>2018/19*</td>
<td>122,522</td>
<td>84777</td>
<td>207299</td>
</tr>
<tr>
<td><strong>Private Universities</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014/15</td>
<td>3335</td>
<td>2390</td>
<td>5725</td>
</tr>
<tr>
<td>2015/16</td>
<td>3198</td>
<td>2344</td>
<td>5542</td>
</tr>
<tr>
<td>2016/17</td>
<td>4086</td>
<td>2958</td>
<td>7044</td>
</tr>
<tr>
<td>2017/18</td>
<td>7384</td>
<td>5844</td>
<td>13228</td>
</tr>
<tr>
<td>2018/19*</td>
<td>14402</td>
<td>10968</td>
<td>25370</td>
</tr>
<tr>
<td><strong>TVET</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014/15</td>
<td>5051</td>
<td>2551</td>
<td>7602</td>
</tr>
<tr>
<td>2015/16</td>
<td>9823</td>
<td>5507</td>
<td>15330</td>
</tr>
<tr>
<td>2016/17</td>
<td>22326</td>
<td>12058</td>
<td>34384</td>
</tr>
<tr>
<td>2017/18</td>
<td>24425</td>
<td>21575</td>
<td>46000</td>
</tr>
<tr>
<td>2018/19*</td>
<td>34927</td>
<td>30393</td>
<td>65320</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014/15</td>
<td>120881</td>
<td>64872</td>
<td>185753</td>
</tr>
<tr>
<td>2015/16</td>
<td>132,246</td>
<td>72,513</td>
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</tr>
<tr>
<td>2016/17</td>
<td>163887</td>
<td>89042</td>
<td>252929</td>
</tr>
<tr>
<td>2017/18</td>
<td>162,094</td>
<td>118950</td>
<td>281044</td>
</tr>
<tr>
<td>2018/19*</td>
<td>171851</td>
<td>126138</td>
<td>298989</td>
</tr>
</tbody>
</table>

Source: KNBS Economic Survey Report, 2020
The amount of loan awarded to male applicants increased by 6.5 per cent to Kshs. 6.8 billion in 2018/19 while that of female applicants increased by 4.6 per cent to Kshs. 4.9 billion in the same period. During the period under review, almost all loan applicants from public and private universities, and TVET institutions were awarded loans, based on the needs assessment.

CONCLUSION AND RECOMMENDATIONS

The financial allocation made to higher education institutions is essential to ensure adequate human and physical resources. Considerations of resources include the total amount available nationally for higher education, as well as effective allocation and equitable distribution between and within institutions. Perception of lack of resources is common to all universities and TVET institutions across the world, and desire for additional resources may indeed be limitless. As the Government continues to support growth of the tertiary education subsector, it is worthwhile to note that an efficient sufficiently scaled, well-functioning and efficiently endowed system to support students at tertiary level is critical if Kenya is to achieve its expansionary goals for the higher education sector in a financially sustainable manner, while concurrently ensuring promotion of equity and quality (Blom et al., 2017). While an increase in tertiary education funding has been observed in recent years, this has not kept pace with student numbers; and it is important for the Government to increase development funding to the institutions considering the vast growth of the subsector and rapid changes in technology. It is also important that increasingly Kenya Government increases funding for research and outreach to institutions of higher learning in order to leverage their impact in society.

The role of Higher Education, especially, universities has often been stated as teaching/training, conducting research to get solutions to diverse challenges confronting communities and disseminating their findings. While universities have done satisfactorily well in training and graduating students, the same cannot be said about their research activities and providing solutions to emerging issues in industry or society. It is understandable that universities have experienced huge cuts from the exchequer, but they also stand indicted for not aggressively generating fundable projects, which would interest partners to pump in their resources. As is the practice in the West or developed world, corporate entities, government agencies and NGOs work closely with universities – thus providing the much-needed funds to support research initiatives. This is the direction which universities need to give more attention to in order to remain relevant and sustainable. It is imperative that our higher education institutions involve industry and NGOs in their teaching, research and outreach to achieve this objective. This paper makes the following specific recommendations:

1. The Kenya Government and indeed other African Governments should make deliberate effort to increase funds towards development activities in both TVET institutions and Universities;
2. TVET institutions and universities should adopt financial leakage-proof systems to ensure that internal systems are not susceptible to weak financial management, thus undermining transparency and accountability;
3. There is need for prudent accounting (and auditing) of all resources raised under parallel programs at public universities in Kenya and in other countries implementing such a system;
4. There is need for a comprehensive study and report on sustainable mechanisms for funding tertiary education in Kenya; similar studies should also be conducted in other African Countries;
5. There is need to adopt the Differentiated Unit Cost (DUC) method of sharing funds for public universities as this provides more effective and efficient approach to financing Higher Education; and encouraging universities
to offer programs that are in demand though expensive to run; and
6. Higher Education sector should engender strong partnerships with the private sector that could motivate them to support some programmes or research agenda.

ACKNOWLEDGEMENT
This paper is a result of many years of work by the authors within the higher education sector of Kenya. Our work and research have been inspired by the many universities, TVET institutions, NGOs, development partners and students that we have worked with in ensuring quality education in Kenya. It has been informed by the rich and fruitiful interactions that we have had with many people. We believe that the paper will go a long way, not only in creating better understanding of the funding situation for higher education in Kenya, but also help shape its future. We thank RUFORUM for convening some of the meetings and conferences at which we have had opportunity to share and sharpen our ideas.

STATEMENT OF NO CONFLICT OF INTEREST
The authors declare that there is no conflict of interest in this paper.

REFERENCES
Mukhwana, E. 2020. Reforming the TVET Sector for Improved Productivity in Africa. Thought piece presented during the 15th RUFORUM Annual General Meeting, 2-6 December 2019, University of Cape Coast, Ghana.

Strengthening higher education capacity to promote gender inclusive participation in Science, Technology and Innovation

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ABSTRACT
Despite global Science, Technology and Innovation (ST&I) initiatives to ensure achievement of Sustainable Development Goal (SDG) number 5 on gender equality, and those geared towards supporting greater engagement of women especially in research for development, fewer women are still employed in the Science, Technology and Innovations (ST&I) sector. The Forum for African Women Vice Chancellors (FAWoVC) is exploring interventions to promote women in higher education, and ST&I. A baseline study of the ST&I ecosystem from four African countries, reveals that higher education is still skewed against ST&I. Female participation is still low and steeply declines at the graduate and academic leadership levels. In promoting female engagement, the policy framework at national and institutional level needs to target the overall education pipeline and create an environment that supports students in Science, Technology, Engineering and Maths (STEM) and females in the R&D employment sector.

Key words: Africa, gender, higher education, Science, Technology and Innovation

RéSUMÉ
Malgré les initiatives mondiales de ST&I visant à assurer la réalisation de l'objectif de développement durable (ODD) numéro 5 sur l'égalité des sexes, et celles visant à soutenir un plus grand engagement des femmes, en particulier dans la recherche pour le développement, moins de femmes sont encore employées dans le secteur de la science, la technologie et les innovations (ST&I). Le Forum des femmes africaines rectrices (FAWoVC) explore des interventions pour promouvoir les femmes dans l'enseignement supérieur et en ST&I. Une étude de base de l'écosystème ST&I de quatre pays africains révèle que l'enseignement supérieur est toujours biaisé par rapport aux ST&I. La participation des femmes est encore faible et diminue fortement aux niveaux de gradués et la direction universitaire. En promouvant l'engagement des femmes, le cadre politique aux niveaux national et institutionnel doit cibler le pipeline global de l'éducation et créer un environnement qui soutient les étudiants en sciences, technologie, ingénierie et mathématiques (STEM) et les femmes dans le secteur de l'emploi en R&D.

Mots clés: Afrique, genre, enseignement supérieur, science, technologie et innovation

INTRODUCTION
Promoting gender equality, Science, Technology and Innovation (ST&I) policies to benefit both men and women are acknowledged as fundamental to reducing poverty and ensuring equitable development (United Nations, 2019). Indeed a UN Women discussion paper contends that gender equality and poverty are intrinsically linked (Nieuwenhuis et al., 2018). The World Economic Forum Gender Report (WEF, 2018) further contends that female participation does not only provide talent to tackle the challenges facing humanity, but has other equity and social security benefits such as well-paid careers that boost the economic security of women, and provides the foundation for greater social and political influence. Despite the several global ST&I initiatives to ensure achievement of Sustainable Development Goal (SDG) number 5 on gender equality, and those geared towards supporting greater engagement of women especially in research for development, fewer women are still employed in the ST&I sector. Participation and employment of women in higher education, and ST&I remained low (UN, 2019).

Sub-Saharan Africa (SSA) at approximately 31% female in the key ST&I areas is no exception to under representation against the world average of 29.3% (UNESCO, 2019). In many African countries, university departments and research institutes are often led by men who also occupy key leadership positions of responsibility. Within the R&D sector, women scientists experience challenging work environments, which are compounded by persistent gender biases, and stereotypes entrenched within the research and academic institutions. In addition, several institutions are yet to adopt programmes that provide professional support to attract, recruit and retain women scientists. This coupled with the absence of mentoring programmes and undefined career path, inhibit female participation in ST&I (Muthumbi, 2015).

The majority of African countries recognize the need to increase female participation in higher education and ST&I. However, the actions taken at national, sub regional and continental levels to promote women in higher education, science and technology are yet to deliver on this promise. The East African Community (EAC), the Southern Africa Development Community (SADC) and the Economic Community for West African States (ECOWAS) for example have all come up with initiatives to promote women in ST&I. In most cases, they have adopted Gender and ST&I frameworks to promote gender mainstreaming and equity, entrepreneurship training, and education. Innovative solutions and initiatives such as the continental African Union Kwame Nkrumah Regional Award for Women Scientists geared towards creating awareness and improving women participation in ST&I with a view to promoting equitable development and livelihoods have been developed.

Through the Forum for African Women Vice Chancellors (FAWoVC) support from the Islamic Development Bank to develop initiatives to increase participation of women in ST&I in Africa, country focused Gender ST&I studies were commissioned in Ethiopia, Mozambique, Sudan and Uganda. The FAWoVC is an umbrella group of female university leaders in Africa that was created in 2016 to spearhead gender responsive training in higher education institutions and to increase the enrolment of female students in Science, Technology Engineering and Mathematics (STEM), as well as galvanize women to take up leadership positions in the academe. The FAWoVC establishment recognized that mainstreaming gender within higher education is of paramount importance for enhancing the performance of higher education institutions and enabling them to fulfil their mandates to train the next generation of talent that will drive the African continent forward. Women, STEM and education are key tenets of the global development agenda as espoused in the SDGs, and the African Union Agenda 2063.
The overall objective of the commissioned studies was to gain a scientifically based understanding of the status of ST&I in the four countries to guide future capacity development. The studies premised to establish the gaps that have been created because of inadequate focus on gender and ST&I and to identify the gender-based capacity gaps, challenges, opportunities and future prospects. The studies outlined the key actors at country level, the link between higher education to the national ST&I ecosystem and explored strategies to increase participation of women in ST&I.

Through literature review, compilation of secondary data, documents analysis and semi-structured interview, a team of country-based experts undertook gender focused assessment of higher education systems, with specific emphasis on current gaps to support ST&I in national agricultural innovation systems. Data on female enrolments, graduation and academic staff in the higher education institutions were analysed, providing an overview of female participation in ST&I. Specific attention was paid to case studies of universities in the countries of focus.

All countries in this study have complex ST&I ecosystems that would make it difficult to operationalize the ST&I agenda at national level. A multiplicity of players ranging from research institutes, universities, technology transfer agencies, chambers of commerce and industry, to financing institutions, investors, government departments, regulatory agencies as well as Ministries of Agriculture, Finance and ST&I where applications have a role (see Table 1). Apart from Mozambique and Ethiopia, these ecosystems do not have special focus on gender as a key attribute and driver for ST&I.

The ST&I Ecosystem Actors in Ethiopia, Mozambique, Sudan and Uganda

Although most African countries have ST&I policies and strategies, their capacity to implement them remains low. Indeed ST&I institutions remains underdeveloped and have not effectively deployed knowledge and technological innovations for socioeconomic growth (ACBF, 2017). The status largely reflects the inadequate staffing, skills, expertise, financial resources, infrastructural capabilities, and equipment in the ST&I institutions. Inadequate capacity and utilization of advances in ST&I prevents African countries from capturing the benefits of S&T, leading to missed opportunities, that are common place in other parts of the world (Watkins and Ebst, 2008).

Sound innovation ecosystems must balance start-ups, scale-ups, and mature firms’ (Cornell University, INSEAD et al., 2020). The ST&I ecosystems of the countries in the study do not clearly articulate this trajectory, which is an indication of the policy direction and status of innovation at national level. For Ethiopia, Mozambique and Uganda that are ranked by the global innovation index, their score is beyond 100 out of the 129 ranked countries in 2019 (Cornell University, INSEAD et al., 2019) with a decline registered in 2020 out of the 131 countries ranked (Cornell University, INSEAD et al., 2020).

Uganda and Ethiopia have independent Ministries of Technology and Innovation, to drive the ST&I agenda in their respective countries, while the Ministries responsible for higher education have the mandate in Sudan and Mozambique. Ministry of Science and Higher Education in Ethiopia is mandated to manage higher education and Technical and Vocational Education and Training (TVET) institutions. In addition, largely due to R&D funding process, the ST&I agenda and indeed the ecosystem is driven by the international development agencies. In all four FAWoVC study countries, the General Expenditure on Research and Development (GERD) at less than 0.6% of GDP is below the recommended average of 1%, a role taken on by external resources and the private sector. The sections below provide an overview of the ST&I ecosystem by country.
Table 1. Key actors in the ST&I ecosystem in study countries

<table>
<thead>
<tr>
<th>Key Actors</th>
<th>Sudan</th>
<th>Uganda</th>
<th>Mozambique</th>
<th>Ethiopia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinating Entity</td>
<td>Ministry of Higher Education</td>
<td>Ministry of Science, Technology and Innovation</td>
<td>Ministry of Science, Technology, Higher and Technical-Professional Education</td>
<td>Ministry of Science and Higher Education</td>
</tr>
<tr>
<td>Inclusion/Gender Focus</td>
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<td>×</td>
<td>√</td>
<td>√</td>
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<td>√</td>
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<td>√</td>
<td>√</td>
</tr>
<tr>
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<tr>
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<tr>
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<td>×</td>
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<tr>
<td>Quality Infrastructure</td>
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<td>Ministry of Science, Technology and Innovation</td>
<td>Science and Higher Education</td>
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<td>×</td>
<td>×</td>
<td>Technology, Higher and Vocational Education</td>
<td>Education</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Industry</td>
<td>Education and Human Development</td>
<td>Innovation and Technology</td>
</tr>
</tbody>
</table>
Sudan

The ST&I ecosystem in Sudan has evolved over the years from 1902 when the first R&D laboratory (The Welcome laboratory) and the Agricultural Research Station were established in 1904. The National Council for Research (NCR) was established in the 1970 as a governmental body responsible for formulating policies and plans for coordinating national science and technology efforts. The NCR ceded responsibility to the Council of Higher Education and Scientific Research in 1991-1992 and later to the Ministry of Science and Technology (MOST) that was abolished in 2015.

The current ST&I configuration is distributed across four key players namely, i) The Agricultural Research Corporation and Livestock Research Corporation at the Ministry of Agriculture and Livestock, ii) The National Information Centre at the Ministry of Information and Communication Technology, iii) The National Research Centre and Universities at the Ministry of Higher Education (MOHE), and iv) The Industrial Research and Consultation Centre at the Ministry of Industry. This in addition to private sector and other players (see Figure 1). The complexity of the science ecosystem notwithstanding, the number of players is an indication of fragmentation that affects the central coordination and harmonisation of ST&I initiatives in the country. Sudan is not ranked by the Global Innovation Index that provides a detailed metrics about the innovation performance of countries and economies around the world.

Figure 1. Sudan Science, Technology and Innovation ecosystem
Uganda

In Uganda, similar to Sudan, the complexity and harmonization of the ST&I ecosystem has evolved over time, from the National Research Council (NRC) in established in 1970 to the Uganda National Council for Science and Technology (UNCST) established by Act of Parliament in 1990. A Ministry of Education, Sports, Science and Technology to oversee ST&I was created operating in parallel with the UNCST which was superintended by the Ministry of Finance, Planning and Economic Development. In 2016 an independent Ministry of Science, Technology and Innovation (MoSTI) was created with the UNCST as an agency under the new Ministry. The MoSTI has developed the ST&I policy that guides the ecosystem and incorporates other ministries, higher education institutions and the private sector while recognizing the role of foreign direct investment (Figure 2). In terms of innovation, Uganda ranked 102 in the Global Innovation Index of 2019 sliding to 114 in 2020 (Cornell University, INSEAD et al., 2019; Cornell University, INSEAD et al., 2020).

![Figure 2. ST&I ecosystem in Uganda](image-url)
Mozambique

The Mozambique ST&I ecosystem is equally complex and has evolved from 2000, when the first Ministry of Higher Education, Science and Technology was established with the aim of development of a skilled workforce, expansion and equity of access to quality higher education, development of technologies and identification of Mozambican resources and products that could serve as development factors. In the last 20 years, this Ministry has experienced different formats. From 2005 to 2015, the Ministry changed its focus to only Science and Technology and was renamed Ministry of Science and Technology (MCT) to coordinate the implementation of the S&T strategy with a separate Ministry responsible for Education. Since 2015, MCT has been reconfigured by re-integrating higher education as well as technical and vocational education, and renamed Ministry of Science, Technology, Higher and Technical-Professional Education (MCTESTP). These iterations similar to Uganda and Sudan signify fragmentation and a multiplicity of ST&I actors in the country that require clear thought processes for harmonization. A schematic representation of the Mozambique ST&I ecosystem is given in Figure 3. Mozambique was ranked 119 in 2019 and 124 in 2020 by the Global Innovation Index, (Cornell University, INSEAD et al., 2019; Cornell University, INSEAD et al., 2020)

![Figure 3. Mozambique Science Ecosystem](image-url)
Ethiopia

Science, Technology and Innovations gained prominence in Ethiopia from 1975 with the establishment of the Ministry of Science and Technology. The primary aim at the time was to provide evidence-based recommendations for adopting and revising polices, strategies, laws and directives for the development of ST&I that support the realization of the country’s development objectives, (Tesfa, 2015). Currently it is designated as the Ministry of Innovation and Technology (MoIT). The country applies ST&I as an instrument to achieve the long-term vision of the country to reach middle-income status (Ministry of Education, 2015). Ethiopia developed its ST&I policy in 2012 with a vision of establishing the capabilities, which enable rapid learning, adaptation and utilization of effective foreign technologies by the year 2022/23 (Federal Democratic Republic of Ethiopia, 2012). Similar to other countries in the study, Ethiopia has a complex ST&I ecosystem (Figure 4). Ethiopia was ranked 119 in the Global Innovation Index of 2019 sliding to 127 in 2020 (Cornell University, INSEAD et al., 2019; Cornell University, INSEAD et al. 2020).

All countries acknowledge that academic institutions are key actors in the ST&I space as generators of knowledge. For Ethiopia, quality Infrastructure and inclusive innovation for sustainable development stand out. As such, one can deduce that gender and youth issues have been placed at the centre of the ST&I for sustainable development trajectory.

Figure 4. Key actors and policy issues in STI Ecosystem in Ethiopia (adopted from World Bank, 2016)
Participation and Access to Higher Education Science and Technology

Science, technology and innovation is critical for responding to the challenges of African agriculture and to elevate its performance and contribution towards economic development and poverty alleviation (Watkins and Ehs, 2008; ACBF, 2017). Universities have a key role to play in producing the next generation of the African workforce, including researchers/scientists, extension and advisory service practitioners, input dealers and other development practitioners that are expected to generate, translate, extend and share knowledge with rural farmers to increase agricultural productivity, agribusiness and incomes (ACBF, 2017). Trained human resources in a wide range of topics, aligned to the Science Agenda for African Agriculture, are central to stimulating science-based technology innovation. Research has shown that returns to investment in higher education are around 20%, and in Africa closer to 30%, and are higher than returns in both secondary and primary education (Montenegro and Patrinos, 2013; Borland et al., 2000).

Despite a higher proportion of women in sub-Saharan Africa (SSA), women are under-represented in key areas of ST&I and higher education. The UNESCO (2015) Science Report indicates very low representation of females in all science fields with 17.1% (natural sciences), 23.3% (engineering and technology), 30.6% (medical), 19.7% (agricultural sciences) and 27% (social sciences). The gender gap in ST&I is apparent in academic and research institutions at student, staff and leadership position level.

In Uganda, while affirmative action has increased female enrolment in higher education, participation is STEM programs at 37% is still limited (NCHE 2019). At Makerere University, the country’s largest and premier university in Uganda, only 28% of academic and research positions are occupied by women, with similar situations exhibited in all 46 universities (NCHE, 2013). With only four female Vice Chancellors, the gender equity status in Uganda can benefit from mentorship and grooming of female academic leaders. Overall, ST&I remains below 30% of total enrolment over the years (NCHE, 2019), Figure 5.
For Busitema University as a case in the current study, despite a strong commitment to gender parity in the administration, female staffing and student enrolment, is still elusive. There are only five (25%) female members of the University Council and 23.8% of the academic staff with no females at professor or associate professor levels and only one (1) female Senior Lecturer (representing 6.7%). Only one (14.3%) of the Heads of the seven academic units is female. However, the university had the opportunity of having the first female Vice Chancellor of the nine public universities in Uganda.

With respect to enrolment, female participation in 2018/2019 stood at (27.1%) for courses in engineering and science and education (27.8%), compared to health sciences (38.9%), agriculture (31.4%), natural resources management (31.8%) and business (37.1%). The proportion of females enrolling for postgraduate study is equally low at (25.2%) with noticeable differences for medicine (33.3%) and business administration (40.7%) compared to irrigation and drainage engineering (7.1%), industrial mathematics (11.1%) and computer forensics (7.7%)\(^1\).

In Mozambique, apart from medical sciences where women make up 53% of scientists, women lag behind in the rest of the fields. For both Uganda and Mozambique (focus countries for the FAWoVC proposed intervention), the numbers of female students at higher education level have remained low compared to the male counterparts (Figure 6).

Across the education levels, the percentage of female PhD researchers in Mozambique is lower than the ones with MSc and with BSc, confirming the ‘leaky pipe’ of lost talent for females and suggesting that males are more likely to advance their academic qualifications than females. The Ministry of Science data indicate that by 2016, out of the 7,030 researchers in the country only 28.9% were female. Researchers with PhDs accounted for 14.8% out of which 11.3% were male and 3.5% female, respectively. The number of male researchers at all levels is more than two times greater than female researchers. Similarly, women in Mozambique are under represented in the academic staff of higher education institutions (António and Hunguana, 2013).

\(^1\)Computed from university records

![Figure 6. Students enrolment trend in Mozambique](image)

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In Ethiopia, similar to other countries in sub-Saharan Africa, higher education enrolment has improved over the past three decades and the proportion of undergraduate female students increased from 29% in 2008/09 to 36.9% in 2017/18 academic year. The percentage of postgraduate students increased from 11.3% in 2008/09 to 18% in 2017/18 academic year (Figure 7).

The Government 70:30 policy in favour of STEM outlined in six discipline specific bands for participation in higher education in public universities has increased participation in ST&I. Unlike other countries in the study, Band 1, Engineering and Technology has the highest number of undergraduate students enrolled in Ethiopia. Band 6, Social Science and Humanities and Band 5, Business and Economics followed this. Band 2 Natural and Computational Sciences, Band 3 Medicine and Health Sciences and Band 4 Agricultural and Life Sciences took the 4th , 5th and 6th rank, respectively.

Combined, while the ST&I bands (1-4) have more students than the humanities at 63% for males and 57% for females, they were yet to reach the target ratio of 70% across the years 2014/15 – 2018/19 (Figure 8). Analysed further, the female percentage in the humanities is higher than in the sciences compared to the male counterparts. The composition was 148,966 (74%) male and 53,656 (26%) female in Band 1, Engineering and Technology for academic year 2018/19, Band 6, Humanities and Social Sciences at 100,701 (61%) male and 65,664 (39%) female. Band 3, Agricultural and Life Sciences had parity at 50% for both male and female in the same academic year. The adopted 70:30 policy for increasing participation in ST&I while good may have disadvantaged females from participation in higher education in Ethiopia (Ministry of Education, 2016; Ministry of Education, 2018; Ministry of Science and Higher Education, 2020).
For Haramaya University as a case study, the gender disaggregated academic staff position in the ST&I bands is disturbing, both in terms of adequacy and number of females. Out of the 712 staff with the rank of lecturer and above reported in 2019/20 academic year only 65 (9%) were female, with no females at the higher ranks of Professor and Associate Professor level and only 7 at the Assistant Professor level found in 2 out of the seven Colleges at the University (see Table 2). In addition to the gender disproportion, apart from the College of Agriculture and Environmental Sciences all the other six colleges do not have staff at the Professorial level. The College of Health and Medical Sciences with the highest number of females 32 (12.5%) has no professor and only 8 (3%) Associate professors. The College of Veterinary Medicine has no female staff with the rank of lecturer and above at all. This does not only represent low capacity and role modelling for female staff and student but a need to review staffing structure and capacity for ST&I research and development at the university in general.

The trend is different in Sudan, the third focus country of the FAWoVC initiative. Female students form the majority (55%) of enrolment at undergraduate level in higher education institutions and in some cases even reaching 70-80%. However, the majority of these female graduates are unemployed, and representation in research and development is low. Overall, even with Sudan, universities produced more graduates in social sciences and humanities than graduates from engineering and science between 1990 and 2019. In the year 2016/2017 for example, about 67,357 students graduated in social sciences compared to 15,958 from science and 13,434 from engineering field at the undergraduate level. Figure 9 gives a snapshot of gender-based enrolment by discipline in Sudan in 2017/18. Females had more participation in health studies and Educational Studies at 69% compared to Engineering studies at 27%.
Table 2. Gender disaggregated academic staff ranks at Haramaya University, 2019/20

<table>
<thead>
<tr>
<th>Band</th>
<th>College/Institute</th>
<th>Lecturer</th>
<th>Assistant Professor</th>
<th>Associate Professor</th>
<th>Professor</th>
<th>Total</th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td>M  F</td>
<td>M  F</td>
<td>M  F</td>
<td>M  F</td>
<td>No</td>
</tr>
<tr>
<td>1</td>
<td>Haramaya Institute of Technology</td>
<td>93 7</td>
<td>8 0</td>
<td>3 0</td>
<td>0 0</td>
<td>111</td>
</tr>
<tr>
<td></td>
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<td>47 7</td>
<td>4 0</td>
<td>1 0</td>
<td>0 0</td>
<td>59</td>
</tr>
<tr>
<td>2</td>
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<td>49 1</td>
<td>16 0</td>
<td>7 0</td>
<td>0 0</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>Sciences</td>
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<tr>
<td></td>
<td>Sport Science Academy</td>
<td>9 1</td>
<td>3 0</td>
<td>0 0</td>
<td>0 0</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>College of Health and Medical Sciences</td>
<td>144 27</td>
<td>71 5</td>
<td>8 0</td>
<td>0 0</td>
<td>255</td>
</tr>
<tr>
<td>4</td>
<td>College of Agriculture and Environmental Sciences</td>
<td>61 15</td>
<td>40 2</td>
<td>13 0</td>
<td>9 0</td>
<td>140</td>
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<tr>
<td></td>
<td>College of Veterinary Medicine</td>
<td>8 0</td>
<td>41 0</td>
<td>7 0</td>
<td>0 0</td>
<td>56</td>
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<tr>
<td>Total</td>
<td></td>
<td>411 58</td>
<td>183 7</td>
<td>44 0</td>
<td>9 0</td>
<td>712</td>
</tr>
</tbody>
</table>

Source: Haramaya University, 3rd Quarter (2019/20) Performance Report (2020); HRMDD (2020)

Figure 9. Summary of students enrolled in Higher Education Institutions by fields in academic year 2017-2018- Source: MOHE (2020)
Strengthening Higher Education capacity to promote gender inclusive participation in ST&I

The scenario in Sudan although unique, still has parallels with other countries on the continent. In Kordofan University as a case study, males out number female enrolment at graduate MSc and PhD level. This disparity also applies at the academic staff level where females represented only 39% of the staff in the Sudan university and only 12% at professorial level. A further review of female professors reveals that there was only one professor in engineering, compared to 32 (16%) in agriculture and 28 (12%) in medicine (see Figure 10). Kordofan University with a total number of 740 staff 320 (43%) female has no female professor and only one female associate professor at Faculty of Agriculture.

The under-representation of women in ST&I and participation in higher education could be attributed to, among other reasons, policy, institutional and individual factors. These range from options for access through financial and other resource provisions, to career guidance and the time at which the choices to pursue the Arts & Humanities or ST&I is made. In all the four countries, the subject path/career choice is made at an early stage before students can adequately appreciate the desired professional orientation. This becomes a major hindrance for increasing the number of students pursuing STEM at the university level. For female students, it is compounded with peer pressure, stereotype types and cultural inhibitions.

In the Mozambique education system, students have to choose between STEM and Social related subjects when they finish 10th grade (INDE, 2007). In Uganda students chose discipline orientation when they finish the lower secondary education before they are admitted for the higher school certificate. For Sudan, which currently does not have the intermediate secondary section, students from primary school move to higher school certificate and make the choices in the third and final year before they go to University. This could be the reason why there are more STEM students in university in Sudan than in the other two countries.

However, while the numbers are more favourable in Sudan, female students, are more inclined to care giving professions such as health and teaching while male students prefer to choose mathematics and engineering subjects because they have better job prospects after graduation and there is chance for self-employment. Sudan is not different from other African countries where female graduation in the sciences is inclined towards health and welfare as opposed to engineering or mathematics (Figure 11). Globally, only a fraction of female students select STEM-related fields in higher education at 3% for information and communication technology, 5% join mathematics and statistics courses, and 8% of students joining engineering, manufacturing and construction courses are female (United Nations, 2019).

Figure 10. Gender disaggregation of Staff in Universities in Sudan
Although gender participation in ST&I may be similar across the continent, there are variations. Disparities also exists across the education pipeline and by level. In all countries, the gender participation gap increases with progression across the education value chain. In Sudan, for example, cases of gender discrimination in academic programs at university level still exists. Some public universities limit engineering fields such as survey, petroleum and excavation engineering to boys only. In addition, several private institutions in Sudan similar to in Uganda do not offer science based academic programmes such as engineering. This is an indicator of capacity challenges to offer ST&I in African countries largely caused by under investment in R&D and or higher education. Poorly equipped laboratories and research fields do not have the capacity to attract applicants not to mention females in the ST&I programmes. This coupled with few role models, ST&I male dominated academic staff and inadequate mentorship limit female participation (ACBF, 2017).

Other reasons for limited participation in ST&I for both male and female students include the industrialisation level of the focus countries and the capacity to absorb graduates in gainful employment. Few countries have been able to build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation as articulated by SDG 9. In Ethiopia for example, despite the affirmative action to increase Engineering and Technology graduates (Band 1), the Draft Education Development Road Map stated that under the current pace of the manufacturing sector development, it was less likely to employ all the graduates of engineering fields (Ministry of Education,
Strengthening Higher Education capacity to promote gender inclusive participation in ST&I

2018). Political leadership and affirmative action have also been instrumental in increasing female participation in Sudan and Uganda. For example, Sudan adopted the 40% government policy for female representation after the 2018 revolution. Consequently, the number of female Vice Chancellors increased to five, while the number of Deans increased to nine in AlNeelain University and 11 in Sudan University of Science and technology.

The challenges of female participation in higher education, ST&I notwithstanding, once admitted the percentage of female graduating is higher than for males. This positive graduation performance was also observed by Zavale et al. (2017) in Mozambique and evident from the graduation booklets at Makerere University in Uganda. It is however, different in Haramaya University where attrition rate for female undergraduate students although decreasing from 3.09 in 2015/16 to 1.85 in 2017/18 is still higher than for the males at 0.77%.

Gender –ST&I Strategy

Many countries in Africa have gender sensitive ST&I policies that aim at promoting the participation of women in science at all levels, but these are rarely implemented (ACBF, 2017). All countries considered by this study except Mozambique have gender strategies independent from the ST&I strategy. Countries recognize the importance of gender equity on livelihoods and poverty, but the linkage between gender and ST&I has not been explicitly articulated. On the other hand, where gender policies exists it has been noted that several focus on women as people and not the structural conditions that produce their disadvantage and by implication their limited participation in higher education or ST&I (Ssali, 2019). This comes out in Mozambique where the gender criteria is yet to prioritise women for research fund allocation but rather focuses on the gender dimension of team composition, the project beneficiaries and the project outcomes.

Further for Mozambique, the draft gender equity in higher education strategy [2018-2023] recognizes the need for greater interface between the two ministries (MCT and MINEDH) noting that the challenges of gender equity and women participation in STEM, start during primary and secondary education. Mozambique has ongoing work to constitute a women’s forum for STEM to support dissemination and appreciation of STEM by women for women. The country is however, yet to formulate country specific policy instruments that promote female participation in ST&I.

In Sudan, the Ministry of Higher Education ST&I framework “Policies and Strategies of Science, Technology and Innovation” has no mention of gender or gender equity. Gender equity is mentioned in the framework of Ministry of Security and Social Development : National Policy of Women Empowerment 2007 (updated 2018) but there is no clear focus on ST&I issues.

In Uganda, gender and development is championed by three key government agencies instituted at intervals to drive the equity issues for practice and at policy level. The Ministry of Gender, Labour and Social Development was established in 1987, the National Women's Council in 1993, and the Equal Opportunities Commission was instituted in 2007. These are more inclined towards gender acculturation and independent of the ST&I development processes highlighted in section two of this paper. The National Gender Policy 2007 promotes gender mainstreaming in all government Ministry of Departments and Agencies (MDAs) and local governments, mandating women inclusion in leadership positions.

A significant number of laws targeting gender issues have been enacted in Uganda. Policies and programs that sought directly or indirectly to improve women's (social, educational, and health) conditions; economic autonomy, civic participation, and empowerment have been implemented. Gender equality is upheld in
local frameworks such as the 1995 Constitution, Vision 2040, National Development Plans (NDPs) and National Women’s Council Act 1993. These do not pay specific attention to how gender influences ST&I or higher education. It is acknowledged that most of these policies are issue-specific, often deploying gender equality as a means to an end as opposed to mainstreaming it in implementation and without paying due attention to the drivers of gender inequality (Ssali, 2019). Yet Uganda is ranked favourably according to the different gender parity indices (WEF 2018).

Policy examples in Mozambique, Sudan and Uganda demonstrate that gender issues have gained recognition on the African continent. There is however, a need for a deliberate effort to ensure implementation that will promote not only female participation in higher education, ST&I but ensure active involvement in research and the 4th Industrial revolution skills (WEF, 2018). In Uganda, Ssali (2019) in her analysis and documentation of gender equality laws and policies in Uganda concludes that while strong gender-sensitive policies and legislative measures exist, implementation of these laws and policies remains a challenge.

Fitting within the Global Agenda for Gender and ST&I

International conventions provide frameworks, standards and guidelines of operations at national and local levels. Countries signing and assenting would imply that the frameworks would guide practice at the local level. The Sustainable Development Goals and Africa’s Agenda 2063 for example, are clear about inclusivity and participation in ST&I and articulate the 1% of GDP target for R&D investment. Countries considered in this study subscribe to international protocols that would influence, gender, higher education, R&D as well as ST&I.

Mozambique

The Mozambican State is a signatory to various international and regional conventions that promote the principles and practices of gender equity and equality. Noteworthy is the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW); the Beijing Declaration and Platform of Action; the Sustainable Development Goals; and the SADC Protocol on Gender and Development. The importance of the Science and Technology sector was distinguished and highlighted within the Government development program in the year 2000, when first Ministry of Higher Education, Science and Technology was established.

Sudan

Sudan as one of the countries participating in the Global SAGA project funded by Swedish International Development Agency, aimed at development and deployment of a set of indicators concerning women’s involvement in STEM in different countries has adopted initiatives such as the UNESCO Chair in Women, Science and Technology established in 2003 at the University of Sciences and Technology. The purpose of the Chair is to promote an integrated system of research, training, information and documentation activities in the field of Women, Science and technology. The Chair serves as a means of facilitating collaboration between high-level, internationally recognized researchers and teaching staff of the University and other institutions in the Arab States and Europe.

Sudan has advanced in moving towards public support to R&D in line with the SDGs and the African Union and UNESCO target of 1% of GDP. Through the Sudan Presidential Initiative for ST&I, the amount released from MOHE to universities increased from 2.3 million SDG in 2009 (920 thousand US$) to 250 million SDG (six millions US$) in 2019. Through this Fund, university staff members have been able to develop useful technological packages.

Uganda

Uganda subscribes to the Science, Technology
and Innovation Strategy for Africa (STISA), which the African Heads of State adopted in 2014 to accelerate Africa’s transition to an innovation-led, knowledge-based economy by improving ST&I readiness in terms of infrastructure, professional and technical competence, and entrepreneurial capacity. Uganda similar to other countries in this study subscribes to Agenda 2063, which recognizes ST&I as the driver for global competitiveness as much as it underscores the need for gender equality and empowerment of women. At the East African Community (EAC) level, Uganda is a constituent member of the East African Science and Technology Commission (EASTECO) that champions The East African Regional Science, Technology and Innovation Policy that will ensure that universities are enhanced to be centres for excellence for investments in education.

On the gender front, Uganda in addition to national laws and policies is signatory to several convention that promote gender equality. These, among others, include The African Union Gender Policy, The Beijing Declaration and Platform for Action [1995] as well as the UN Security Council resolutions and the Commonwealth Secretariat’s Gender Equality Policy [2012]. This subscription has neither translated into a full gender integration nor does it address issues of female participation in ST&I.

Ethiopia
Ethiopia has been among the countries striving to achieve the objectives of Agenda 2063 including ensuring gender equality in all spheres of life. The country has policies that are in line with sustainable development goal 5 (achieve gender equality and empower all women and girls). The second growth and transformation plan (GTP II) is considered as the development strategy to implement the SDGs (National Plan Commission of Ethiopia, 2017). Ethiopia has been among the African countries which incorporate ST&I in its long-term development plans and visions (African Academy of Sciences, 2018). Ethiopia is also a signatory of various global agreements such as the Convention on Elimination of all forms of Discrimination against Women (CEDAW), Convention of Civil and Political Rights, and Convention on Economic and Social and Cultural Rights. The Beijing Declaration and Platform for Action (BDPFA) and the Protocol to the African Charter on the Rights of Women in Africa (Maputo Protocol) were also conventions that Ethiopia ratified.

Initiatives to Promote Gender ST&I
All the four countries in the study have adopted legislation, policies and initiatives in one form or another to promote ST&I as well as gender equality at national level. Attempts have also been made at the higher education institution level to mainstream gender into university activities, promote female access to university education and most especially increase the number of female students admitted to ST&I academic programmes. Specific initiatives adopted at country level include establishing bodies to oversee the ST&I portfolio. This in some cases such as in Mozambique doubles as the Ministry in charge of Higher, Technical and Vocational Education.

Mozambique
In Mozambique, the Action Plan for Poverty Reduction (PARPA), Agenda 2025, and the five-year Government plan [2015-2019] that emphasizes the need to develop human and social capital through promotion of an inclusive education system with actions and polices that promote gender equity. In addition, the National Strategy for Science, Technology and Innovation [2010-2016], a Higher Education Strategic Plan [2012-2020] and a Gender Strategy for Education and Human Development [2016-2020] were developed to promote the Gender and the ST&I tracts.
The Gender Strategy [2012-2016] includes initiatives to encourage participation of females’ students in S&T related subjects in order to influence an increase of university females’ students in S&T programs. The strategy also includes initiatives to attract and retain women in key areas of science and technology. However, there are not yet any specific policy instruments that promotes female participation in ST&I areas. This gap is acknowledged in the Science and Technology Policy and Strategy and has been addressed in the new Gender Strategy for Higher Education [2018-2023]. At the SADC level, there is a move to constitute a Women’s Forum for STEM. The Forum will promote and support dissemination of research and other works by women in STEM and is expected to increase promotion and appreciation of STEM by women for women, and build the role model culture (Zavale et al., 2017).

Uganda
In Uganda, several universities have instituted gender mainstreaming policies, and affirmative action for female to access university education commonly referred to as the ‘1.5 point scheme’ which has been adopted by all public universities in the country. The policy provides an additional 1.5 points to female students to enable them access academic programmes and gives them an edge over their male counterparts. However, while this is the general policy direction, there have been cases where the cut off points for admission to the government scholarship favours male students. This is largely because admission is demand driven and the entry points are determined by the number of applicants for a specific programme, irrespective of their gender. It is also an indicator of the challenges that exist in ST&I participation and access to university education.

Beyond admission, Busitema University has been conducting gender sensitive tailor-made career guidance sessions in secondary schools in Eastern Uganda. This offers both sensitization about the potential and opportunities to pursue STEM academic programmes and provides role models for the lower secondary level.

Sudan
In Sudan, the Sudanese Researchers Initiative (SRI), established in 2009 has created a hub to promote idea generation, R&D and sharing among Sudanese researchers in a web-based platform. The mentorship platform further facilitates young and junior researchers to discuss their ideas openly. Other initiatives to support ST&I in Sudan, include:

a) The creation of Incubators to support technology-based and innovation-oriented entrepreneurs, provide a flexible environment and offer open workspace shared facilities, and management training to ensure the business will survive;

b) The UNESCO Chair for Woman in Science and Technology, under Sudan University for Science and Technology was launched in 2003. The Chair aims at promoting an integrated system of research, training, information and documentation activities in the field of Women, Science and Technology. The Chair serves as a means of facilitating collaboration between high-level, internationally recognized researchers and teaching staff of the University and other institutions in the Arab States and Europe. The UNSECO Chair launched the STEM Girls Club targeting gender participation in ST&I and is championing Global SAGA project funded by Swedish International Development Agency, aimed at development and deployment of a set of indicators concerning women’s involvement in STEM in different countries in Sudan.

c) Sudanese Women in Science Organization (SWSO) started in 2013 as an arm of Organization for Women in Science for Developing World (OWSD), with the objectives to strengthen capacity building programs, community development.
programs, awareness campaigns, and establish central laboratories; and,
d) Innovation and Entrepreneurship Community (IEC), which started as an arm of Institute of Electrical and Electronic Engineers (IEEE) Sudan subsection, which was known as IEEE Sudan entrepreneurship Centre (ISEC). The IEC was launched in April 2013, with the objective to support the entrepreneurial activity in Sudan.

Ethiopia
Beyond the 70:30 policy to promote ST&I, Ethiopia has come up with initiatives to promote female participation. The Growth and Transformation Plan II (GTP II) [2015/16-2019/20] gives emphasis to gender equality at all educational levels and women’s participation in the overall development of the country. In addition, the Higher Education Proclamation (Proclamation No. 650/2009) also strives to increase the proportion of women in senior positions, and as an affirmative action for students’ enrolment into higher education institutions that gives special consideration to female students (Federal Negarit Gazeta, 2009). At the institutional level, policies to support women in leadership positions, excel in their performances and eliminate all forms of abuse have been developed.

The Ministry of Education Action Plan of the Education Sector Development Program (ESDP IV) incorporates females’ equitable access to education at all levels as one of its objectives (MoE, 2015). The higher education road map drafted in 2018 proposes to further strengthen the affirmative action and to narrow the gender gap in higher education institutions.

The duration of all programs offered in higher education institutions has been changed to include an extra year to enable females have enough time to be familiar with the environment including the nature of the programs before choosing academic programmes. The initial year is dedicated to general courses with sufficient guidance and mentorship that will promote female participation in ST&I. In addition, female students receive tutorials to support their academic progress. Universities such as Haramaya and Hawasa have established STEM Centres to support high school students to excel in science education.

CONCLUSION AND RECOMMENDATIONS
The study gives the status of higher education, ST&I with a gender lens in Ethiopia, Mozambique, Sudan and Uganda. It provides a snapshot of the baseline of these attributes that can inform further interventions by the Forum for Women Vice Chancellors and the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) efforts to increase the pool of women scientists in Africa. All countries in this study are aware of the challenges that exist in the ST&I gender terrain. Strategies have been developed and the regulatory and policy frameworks put in place to promote female participation in higher education and ST&I.

The Mozambique gender strategy for example, acknowledges the need to enhance articulation and collaboration between the various ministries to handle secondary schools’ students and the challenges associated with the early selection of academic areas of focus. For all countries in the study, it emerges that keen attention has to be paid to the overall education ecosystem. Students and especially female students at the secondary school level need to be incentivized through role modelling and sensitization to offer STEM subjects. It is these students from the lower level that will translate into higher ST&I participation at the university level and beyond.

In Uganda, the adoption of the affirmative action has increased access and participation for females in higher education. However, because it is at the point of entry into the university it has not effectively increased the percentage share of girls taking ST&I programmes. Similarly, in
Ethiopia the 70:30 ST&I higher education policy is yet to reach the target and or translate into parity for males and females. The outcomes of these policies at national and institutional levels bring out the need to review and strengthen the criteria for ST&I scholarship and attribution at the lower levels of education.

A gender lens should be applied to research infrastructure, enhanced technical competencies of human resources through capacity building, training and curriculum reforms, in addition to offering incentives and motivation for females and their communities to join the STEM program. R&D financing should be broadly considered to include infrastructure, environment and incentives for effective female representation and participation within research and academic institutions.

In all countries and institutions alike, it is important to continually review policies and strategies, taking into consideration the changing gender terrain. This calls for constant research, dissemination and engagement of all actors on the gender attributes in higher education, research, ST&I. Policies dismantling the perceptions and stereo types about the performance and participation of females in the ST&I realm and workplace are urgent. Policy engagement and advocacy should target the socio-cultural, technological and financial aspects that will narrow the gender in education, ST&I as well as technical and leadership positions.

ACKNOWLEDGEMENT
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REFERENCES
Ministry of Education, M. 2015. Education Sector Development Program V (ESDP
Federal Democratic Republic of Ethiopia.
Montenegro, C. E. and Patrinos, H.A.  
WHO-TDR.
Nieuwenhuis, R., Munzi, T., MunziJorg, N., Omar, H. and Palmisano, F. 2018. Gender equality and poverty are intrinsically linked: A contribution to the continued monitoring of selected Sustainable Development Goals Project: In it together? Supporting women's employment to reduce economic inequality among all households UN Women.
Ssali, S. N. 2019. A matrix and analysis of Gender Equality laws and policies in Uganda. School of Women and Gender Studies, Makerere University, in partnership with University Forum on Governance under the Gender Equality Project.
ABSTRACT
The development of a country is primarily based on the progress made in science, technology and innovation (STI), and the equitable contribution of both men and women in the STI ecosystem. However, there is a big gender gap in the ecosystem as the participation of women is very low in science, technology, engineering and mathematics fields. This study assessed the gender dimension of science, technology and innovation eco-system in Ethiopia. Both primary and secondary sources of data were used. The primary data were collected from key informants, and reports of various UN agencies, Ministry of Education (Ethiopia), Ministry of Science and Higher education (Ethiopia) and journal articles were among the major secondary sources reviewed. The study found out that the participation of women in the STI ecosystem was low in Ethiopia. Undergraduate female students who were studying science and technology (Engineering and technology; natural and computational sciences; medicine and health science; and agricultural and life sciences) comprised 31%, 29.4%, 30.7%, 31.4% and 34.4% of the student population in 2014/15, 2015/16, 2016/17, 2017/18 and 2018/19, respectively. In 2014/15, 2015/16, 2016/17, 2017/18 and 2018/19, the percentage of postgraduate female students in science and technology were 30.8%, 19%, 14.7%, 15% and 15.6%, respectively. Among the academic staff of higher education institutions on duty in 2017/18 academic year 19.3%, 11.2% and 6.9% of the women were holders of first, masters/speciality and PhD/ sub-speciality degrees in science and technology fields of study, respectively. The participation of women in research and industry that requires higher skills were also very low. The low level of women’s participation in STI ecosystem was attributed to various challenges such as lack of academic preparation for science, technology, engineering and mathematics (STEM) fields, attitude toward science fields (stereotype that science is for men), lack of women’s self-confidence, lack of women role model scientists, lack of adequate support from higher education institutions and gender disparity in employment. Therefore the collaborative effort of the STI stakeholders especially ministries of education, science and higher education, technology and innovation, schools and higher education institutions is essential to implement policies and strategies of the country related to gender equality. Moreover, the international and regional cooperation has to be strengthened in order to secure funding for women’s education and research in science and technology.

Key words: Gender; Ethiopia Higher Education; Science, Technology, Engineering, Mathematics

RÉSUMÉ
Le développement d’un pays repose principalement sur les progrès réalisés dans le domaine de la science, de la technologie et de l’innovation (STI), et sur la contribution...
équitable des hommes et des femmes dans l’écosystème des STI. Cependant, il existe un écart important entre les sexes dans l’écosystème, car la participation des femmes est très faible dans les domaines des sciences, de la technologie, de l’ingénierie et des mathématiques. Cette étude a évalué la dimension de genre de l’écosystème scientifique, technologique et d’innovation en Éthiopie. Des sources de données primaires et secondaires ont été utilisées. Les données primaires ont été recueillies auprès d’informateurs clés, et les rapports de diverses agences des Nations Unies, du ministère de l’Éducation (Éthiopie), du ministère de la Science et de l’Enseignement supérieur (Éthiopie) et des articles de revues ont été parmi les principales sources secondaires examinées. L’étude a révélé que la participation des femmes à l’écosystème STI était faible en Éthiopie. Les étudiantes de premier cycle qui étudiaient les sciences et la technologie (génie et technologie; sciences naturelles et informatiques; médecine et sciences de la santé; et sciences agricoles et sciences de la vie) représentaient 31%, 29,4%, 30,7%, 31,4% et 34,4% en 2014/15, 2015/16, 2016/17, 2017/18 et 2018/19, respectivement. En 2014/15, 2015/16, 2016/17, 2017/18 et 2018/19, le pourcentage d’étudiantes de troisième cycle en sciences et technologie était de 30,8%, 19%, 14,7%, 15% et 15,6%, respectivement. Parmi le personnel académique des établissements d’enseignement supérieur en service au cours de l’année académique 2017/18, 19,3%, 11,2% et 6,9% des femmes étaient titulaires de diplômes de premier, de maîtrise / spécialité et de doctorat / sous-spécialité dans les domaines d’études scientifiques et technologiques, respectivement. La participation des femmes à la recherche et à l’industrie qui nécessitent des compétences plus élevées était également très faible. Le faible niveau de participation des femmes à l’écosystème des STI a été attribué à divers défis tels que le manque de préparation académique pour les domaines des sciences, de la technologie, de l’ingénierie et des mathématiques (STEM), l’attitude envers les domaines scientifiques (stéréotype selon lequel la science est pour les hommes), le manque de confiance, manque de femmes scientifiques modèles, manque de soutien adéquat des établissements d’enseignement supérieur et disparité entre les sexes dans l’emploi. Par conséquent, l’effort de collaboration des acteurs de la STI, en particulier les ministères de l’éducation, des sciences et de l’enseignement supérieur, de la technologie et de l’innovation, des écoles et des établissements d’enseignement supérieur, est essentiel pour mettre en œuvre les politiques et stratégies du pays liées à l’égalité des sexes. En outre, la coopération internationale et régionale doit être renforcée afin d’assurer le financement de l’éducation des femmes et de la recherche scientifique et technologique.

Mots clés: sexe; Enseignement supérieur éthiopien; Science, technologie, ingénierie, mathématiques

INTRODUCTION
Science, technology and innovations (STI) are important contributors to sustainable development. UN Secretary Report (2013) indicated that ‘STI has been proved to be an important prerequisite for the social and economic transformations that enable sustainable economic growth, human development and poverty eradication’. The successful implementation of Sustainable Development Goals (SDG) will also be realized with the support of STI. Studies that have documented the contribution of STI-based strategies to economic and social development (Giovannini et al., 2015; UN, 2019), indicated that countries that employed and promoted STI have exhibited more economic development (Bokova, 2012; Ihueze et al, 2015). Hence, because of the crucial role of STI, the African Union has taken it as part of its development strategy Agenda 2063 (Bobadoye, 2015).

In sub-Saharan African countries like Ethiopia, technology and innovation has played a significant role in improving the livelihood of their citizens. Science, technology and
innovation has improved the health and the working and living condition of people, and it also contributes to increase their income and amount of leisure time (Amha and Mekuriaw, 2008). Above all, in a country where food insecurity prevails and is impacted by climate change, the need for science, technology and innovation is enormous.

The first half of the 20th century is considered as the beginning of application of modern science and technology in Ethiopia, along with the establishment of higher education institutions (Amha and Mekuriaw, 2008). Ethiopia established the Ministry of Science and Technology for the first time in 1975 as a commission and currently it has been renamed as Ministry of Innovation and Technology (MoIT). The Ministry was established with the aim of providing study-based recommendations to the Government of Ethiopia for adopting and revising polices, strategies, laws and directives for the development of STI that support the realization of the country’s development objectives (Tesfa, 2015). The country applies STI as an instrument to achieve the long-term vision of the country to be among the middle-income counties (MoE, 2015).

**One of the cross cutting issues in STI ecosystem is gender.** In a country where gender inequality prevails, ensuring gender equality in all spheres of life is the cornerstone for sustainable development. More importantly, ensuring gender equality in STI plays a crucial role in meeting the needs of the country through the contribution made by women. Despite this fact, gender imbalance exists in many fields particularly in higher education institutions in Ethiopia. Though various measures have been taken to redress the gender inequality by enhancing the participation of female students and instructors in higher education institutions in science, technology, engineering and mathematics (STEM), the result obtained has not been satisfactory as only few women are involved in such fields of study. Thus, this study assessed the status of women in STI ecosystem and explored the gender-based capacity gaps, challenges and opportunities to participate in STI in Ethiopia.

**METHODOLOGY**

Both qualitative and quantitative data were used for the assessment. It was done with the data obtained from literature and primary data collected from key informants. The literature essential for this paper were accessed from different sources. Reports from Ministry of Science and Higher education (MoSHE) and Ministry of Education (MoE) were among the sources consulted. Policy documents and statistical data of student enrolment and academic faculty were also reviewed. In order to see the changes in students’ enrolment of undergraduate and postgraduate programs in higher education institutions and Technical and Vocational Education and Training (TVET) colleges in the country, trend analysis was done. Comparisons between male and female students and academic staff in STEM fields in higher education institutions were made. The primary data were collected through phone calls and email correspondences. The data collection and analysis process is summarized in Table 1.

**Findings**

**Higher education and STI in Ethiopia**

Academic institutions are the prime source of knowledge and innovation at national, regional and international levels (Kearney, 2009) and key actors in STI eco-system. Higher education provides a conducive environment for the development of STI and a suitable exploitation of the full potential of STI to support sustainable development (African Union, n.d). Higher education in Ethiopia includes education programs offered as undergraduate degree for three, four or more years, second degree (Master’s and speciality programs) and third degree (PhDs and subspeciality programs). The focus areas of higher education institutions of the country are teaching, research and community services (MoE, 2018a).

Due to the demand for skilled manpower in the country, the number of higher education
institutions has increased since 1992. Until 1992, there were only two Universities in the country, namely, Addis Ababa University established in 1950 and Haramaya University established in 1954. Between 1992 and 2009, 21 more universities were established and by the year 2013, the country had 33 universities (Gizaw, 2019). Currently there are 49 government and 128 accredited non-government higher education institutions in the country (MoE, 2018b).

The fields of studies given in higher education institutions in Ethiopia are divided into six bands. Table 2 shows the classification.

The overall enrolment of students in Ethiopian higher education institutions are increasing. The number of undergraduate students in both Government (public) and non-government (private) institutions increased from 309,092 in 2008/09 academic year to 825,003 in 2017/18 (Figure 1). The proportions of female students increased throughout these years. The percentage of female students was 29% and 36.9% in 2008/09 and 2017/18 academic years, respectively.

### Table 1. Process of data collection and analysis

<table>
<thead>
<tr>
<th>Data collected</th>
<th>Method used to collect the data</th>
<th>Source of the data</th>
<th>Methods of data analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>STI policy and strategies of Ethiopia</td>
<td>Document review</td>
<td>National Science, Technology and Innovation Policy of Ethiopia</td>
<td>Content analysis</td>
</tr>
<tr>
<td>STI actors in Ethiopia</td>
<td>Literature review</td>
<td>Report of UN agencies (UNICEF, UNDP) World Bank, AU</td>
<td></td>
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<tr>
<td>Sex disaggregated data of enrolment of students at undergraduate and postgraduate level</td>
<td>Document review</td>
<td>Reports of Ministry of Education (MoE) of Ethiopia</td>
<td>Descriptive statistics (frequency and percentage)</td>
</tr>
<tr>
<td>Sex disaggregated data of academic staff by field of study</td>
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<td>Reports Ministry of Science and Higher education (MoSHE) of Ethiopia</td>
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<tr>
<td>Sex disaggregated data of enrolment of TVET students and trainers</td>
<td></td>
<td>Quarterly reports of higher education institutions</td>
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<tr>
<td>Sex disaggregated data of researchers</td>
<td>Literature review</td>
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<tr>
<td>Participation of women in STI</td>
<td>Semi-structured interview checklist</td>
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<td>Gender-based capacity gaps, opportunities and challenges</td>
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<td>Study participants</td>
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### Table 2. Programs of the Ethiopian Higher Education System

<table>
<thead>
<tr>
<th>Band</th>
<th>Fields of Study</th>
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<tbody>
<tr>
<td>Band 1</td>
<td>Engineering and Technology</td>
</tr>
<tr>
<td>Band 2</td>
<td>Natural and Computational Sciences</td>
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<tr>
<td>Band 3</td>
<td>Medicine and Health Sciences</td>
</tr>
<tr>
<td>Band 4</td>
<td>Agricultural and Life Sciences</td>
</tr>
<tr>
<td>Band 5</td>
<td>Business and Economics</td>
</tr>
<tr>
<td>Band 6</td>
<td>Social Science and Humanities</td>
</tr>
</tbody>
</table>
The number of postgraduate (Masters and PhD) students also increased from 10,125 in 2008/09 to 76,795 in 2017/18 (Figure 2). In terms of female enrolment, only 11.3% of the students were female in 2008/09 whereas it increased to 18% in 2017/18 academic year.

In addition to producing qualified graduates, higher education institutions contribute to the STI eco-system by conducting research and publishing articles in reputable journals. According to Salmi et al. (2017), Ethiopian higher education institutions produce around 1,500 publications each year. There have also been improvements in the capacity of conducting research in Ethiopia. For example, the citable research documents, which were mainly conducted by faculties of higher education institutions in Ethiopia, increased from 774 in 2010 to 1552 in 2015 (SCImago Journal and Country Rank as cited in Salmi et al., 2017). However, the contribution of the research in terms of knowledge generation for national development has been generally low and they lack responsiveness in addressing societal challenges (Nega and Kassaye, 2018).

Technical and Vocational Education and Training (TVET) in Ethiopia

Technical and Vocational Education and Trainings (TVET) has been taken as a means of supporting youth develop skills essential for engagement in various professions as well as promote entrepreneurship (AU, 2018). TVET are ‘those aspects of the educational process involving, in addition to general education, use of technologies and related sciences, and the acquisition of practical skills, attitudes, understanding and knowledge related to occupations in various sectors of economic and social life’ (UNESCO and ILO, 2002).

Figure 1. Trends in enrolment of undergraduate students
The emergence of Technical and Vocational Education and Training (TVET) in Ethiopia dates back to 1942 (Teklay, 2012). The first TVET institute was Addis Ababa Technical School which was named as Ecole National des Artes Technique during its establishment (Likisa, 2018). Since then different policies were enacted to promote TVET in Ethiopia, and in 1970s selected high schools were converted to comprehensive high schools where students could have both academic and vocational education (MoE, 2018a). In 2004, competency-based training was introduced to the TVET system in Ethiopia to respond to the skill needs of the labor market (Likisa, 2018). In 2008, the country developed national TVET strategy revising the older version which was prepared in 2002. The revised strategy was envisioned ‘to create competent and self-reliant citizens to contribute to the economic and social development of the country, thus improving the livelihoods of all Ethiopians and sustainably reducing poverty’ (MoE, 2008).

The importance of expanding and strengthening TVET has been justified because of the need to enhance the manufacturing sector and improve the employability of Ethiopian youth (Trines, 2018). Moreover, TVET in Ethiopia was designed to redress the challenges of poverty, unemployment, low technological development, and low productivity of the economy (MoE, 2008). It is categorized into five levels (level 1 to level 5) to provide relevant and demand-driven education and training (MoE, 2018b). An informant from Federal TVET Agency indicated that currently the fields of study in TVET are classified into eight major sectors: agriculture; industrial development; trade; health; culture, tourism and sport; mining; economic infrastructure; and community service. TVET is led by Ministry of Science and Higher Education. The overall implementation of the TVET strategy has been overseen by the Federal TVET Agency and a Federal TVET Institute has been working to produce competent TVET trainers.

Figure 2. Trends in enrolment of postgraduate students
Regional States of the country have their own TVET offices/agencies that are in charge of the TVET institutions in their respective regions. According to MoE (2017b) the country has 582 public and private TVET institutions.

Since the launch of the TVET program, it has expanded in terms of enrolment in which the number of students increased from 106,336 in 2004/05 to 352,144 in 2014/15 (MOE, 2018b). However, since 2014/15 academic year, the number of TVET students has declined. For example, the total enrolment decreased from a total of 352,144 in 2014/15 to 292,378 in 2017/18. The decline could be because of the fact that some regions did not report the number of students in the TVET institutions of their regional States on time (MOE, 2018b).

**Women’s participation in science, technology and innovation ecosystem**

People all over the world have benefited from STI. The value of STI significantly increases when it supports women who have been disadvantaged throughout their life time. Giving the opportunity to women in the fields of studies such as science, technology, engineering and mathematics (STEM) contributes to have healthier families as well as they become more successful at their homes and in their career (Egne, 2014). Polcuch et al. (2018) justifies the need for gender equality in STI from the point of view that gender equality and access to science are recognized as human rights; the need for participating women in the scientific workforce to have sustainable development; and the contribution of women to come up with varied and society relevant research results. Moreover, STI policies and programs could not be effective unless they consider the concerns and abilities of both men and women (United Nations, 2011). Giving equal opportunity to women in STI is also justified as it assures better scientific and technological results and the best use of them (Lane, 1999), and the more inclusive the STI ecosystem, the more it becomes innovative and productive (National Academy of Sciences, 2006).

The Government of Ethiopia, with the aim of producing more graduates in the fields of STEM, developed a policy that 70% of students who join higher education should study natural sciences whereas the remaining 30% to enrol in social science fields. This policy has increased the number of science, technology and engineering students since its development in 2008. However, it has not been successful in terms of bringing gender equality in STEM fields of study. The new enrolment policy (70:30) excludes female students from science and engineering in higher education (Tsegai, 2010).

Figure 3 shows gender disaggregated enrolment of undergraduate program students in government (public) universities in Ethiopia in various fields of study from 2014/15 to 2018/19 academic years. The percentage of female students in the science and technology fields increased to some extent since 2016/17. In spite of this fact, there was big gender disparity among undergraduate students in such fields of study of the higher education institutions of the country. Female students comprised 31%, 29.4%, 30.7%, 31.4% and 34.4% in 2014/15, 2015/16, 2016/17, 2017/18 and 2018/19, respectively.

The participation of females at postgraduate level, like in the undergraduate programs, was also lower than male students as shown in Figure 4. The proportion of female postgraduate students was lower than for male students since 2014/15 academic year. In 2014/15, 2015/16, 2016/17, 2017/18 and 2018/19, the percentage of female students in science and technology were 30.8%, 19%, 14.7%, 15% and 15.6%, respectively (Figure 4).

The gender disparity in science and technology fields of study was also observed in the academic staff of higher education institutions. The proportion of women, like the students, was by far less than that of the men. Figure 5 shows the number of women academic staff at public universities by field of study.
Gender-based assessments of Science, Technology and Innovation (STI) ecosystem in Ethiopia

Figure 3. Enrolment in undergraduate programs in Government/public universities, by field of study and gender
Source: MoE, 2016; MoE, 2017a; MoE, 2017b; MoE, 2018b; MoSHE, 2020

Figure 4. Enrolment in postgraduate programs in public universities, by field of study and gender
Source: MoE, 2016; MoE, 2017a; MoE, 2017b; MoE, 2018b; MoSHE, 2020

* Engineering and technology; natural and computational sciences; medicine and health science; and agricultural and life sciences
Figure 5. Number of academic staff at public universities, by gender and field of study (2017/18)

As Figure 5 shows the percentage of women academic staff decreased as the level of education increased. In science and technology fields of study, 19.3%, 11.2% and 6.9% of the women earned first, Masters/speciality and PhD/sub-speciality degrees, respectively.

Unlike in the higher education institutions, the participation of female students in the TVET institutions was better than that of men. Figure 6 shows the number of students from 2013/14 to 2017/18 academic year. As Figure 6 depicts the number of female students was higher than for male students between 2014/15 and 2017/18. Among all the students, females constituted 51.3%, 52.4%, 51.9%, 51.3% and 50.8% in 2013/14, 2014/15, 2015/16, 2016/17, and 2017/18, respectively. Regarding TVET trainers, the trend analysis shows an increase until 2016/17, but the number of the trainers declined in 2017/18 (Figure 7). Considering the gender dimension, the number of women was very much less than that of men trainers. The percentage of women were 22.5%, 22.2%, 21.9% and 19.9% in 2014/15, 2015/16, 2016/17 and 2017/18, respectively.

Women in higher education and TVET institutions are also contributing in the research enterprises, and the percentages of women researchers increased considerably. In spite of this fact, females are still not adequately represented in the research endeavor. Female researchers were 13.3% in Ethiopia in 2014 (UNESCO Institute for Statistics, 2019, which was more than that of 2005 (i.e., 6%) (UIS, Education Database and Science and Technology Database, 2007 as cited in UNICEF, 2007). In terms of fields of study, the lowest percentage of women researchers was found in technology and engineering. In 2013, female researchers in Ethiopia were 12.2%, 7.1%, 26.1%, 7.6% and 13.2% in natural sciences, engineering and technology, medical sciences, agricultural sciences, and social science and humanities, respectively (UNESCO, 2015).
Gender-based assessments of Science, Technology and Innovation (STI) ecosystem in Ethiopia

Figure 6. Trends in TVET enrolment by gender (2013/14-2017/18)
Source: MoE, 2018b

Figure 7. Trends in TVET trainers by gender (2014/15-2017/18)
Source: MoE, 2016; MoE, 2017a; MoE, 2017b; MoE, 2018
The participation of women in the industry sector, the other major actor in the STI ecosystem, has been also low in the country. Mostly women tend to participate in occupations that require less skills. Higher-skilled positions are occupied by men. For instance, it was reported that, in Ethiopia, the proportion of women that work as high-skilled production workers decreases as the tasks become more skill-intensive; 35% in textiles and garments and 15% in chemical and pharmaceutical industries (UNDP, 2018).

Gender-based capacity gaps and challenges of women to participate in STI in Ethiopia

Scientists have uncovered the absence of significant biological difference in men’s and women’s ability to perform in science and mathematics (Ceci and Williams, 2007 as cited in Castillo et al., 2014). Despite this fact, only few women participate in the STEM fields in Ethiopia. The low participation of women has been attributed to various gender-based capacity gaps and challenges. The major gaps and challenges are highlighted below.

Lack of academic preparation for science, technology, engineering and mathematics (STEM) fields. To be successful in science, technology, engineering and mathematics fields at higher education institution, it is essential to have preparation from the early stages of schooling. However, most females in Ethiopia do not get such opportunities since they are expected to engage in household activities. Due to this fact, they lack the preparation to join the fields of study that require strong background in science. A study conducted in Ethiopia among students of Addis Ababa University and Adama Science and Technology University confirms this notion. Among the students who were studying science, technology, engineering and mathematics, and social sciences, 75% and 85% of them respectively indicated that most Ethiopian female students show little interest towards hard sciences due to lack of academic preparation starting from the lower grades (Egne, 2014). In support of this Tamrat (2017) asserts that the poor academic background of female students is the major obstacle for their success. A university lecturer, in an interview conducted, commented that due to the poor science methods of teaching at elementary school, many students especially females are not equipped with the required science knowledge and skill for their grade level.

Attitude toward science. The attitude of female students to science, technology, engineering and mathematics subjects is among the factors that hinder females not to choose these fields of study. Traditionally, natural sciences have been perceived as fields of study for men whereas humanities have been given to women (Francis, 2000) and scientists as predominantly male (Makarova et al., 2019). Similarly, MoE (2014) and UNESCO (2018) also highlight the prevalence of stereotypes on girls and women to engage in natural science streams, technology and mathematics. An interviewee (statistics graduate) indicated that female students usually assume science field such as mathematics to be the most difficult subjects so they prefer to study social sciences. Based on the information obtained from women officials in MoIT of Ethiopia, Beyene (2015) also indicated that only few Ethiopia women participate in STI mainly because of the ‘prevailing belief that science is not a suitable field for women’. The students’ enrollment and the proportion of female academic staff in Ethiopian higher education prove point to this perception. For instance, among the public higher education students enrolled in 2018/19 academic year, 17.3% of female students were studying social science and humanity fields (band 6) whereas the percentage of female students in the same year who were studying Engineering and Technology (Band 1) and Natural and Computational Sciences (Band 2) were 16.2% and 12.4%, respectively. Regarding the academic faculty, among the staff members with postgraduate degree (Masters and PhD) the percentage of women in the fields of engineering and technology (Band 1) and Natural and Computational Sciences (Band
2) were 9.2% and 8.3%, respectively. On the other hand, about 11% of the female academic staff held postgraduate degree in social science and humanity fields (band 6) in the same year (2018/19).

**Lack of self confidence.** Due to various socio-cultural factors, women have not been considered as confident enough to perform challenging tasks. As science, technology, engineering and mathematics are taken as difficult subjects, women are not usually expected to study such fields. It is men who are assumed to have self-confidence and skills in fields like engineering (UNDP, 2018). Interviewed key informant mentioned that female students are not confident enough to study STEM fields at higher education institutions as they feel they are not good at it. A female faculty also indicated that females do not opt for STEM fields because they perceive that they may not be successful. Moreover, a woman respondent in a study conducted by Asmamaw (2017) commented that ‘women are not expected to excel in the sciences’. In support of this, MoE (2014) asserted that lack of self-confidence and existence of low expectations for girls to study sciences and mathematics make them avoid such fields. It has also been noted that the perception of faculty members of higher education institutions that women lack the ability to perform well in STEM fields has also made women not to be confident enough to study these subjects (Hafkin, 2016).

**Lack of female role model scientists.** Most often, in Ethiopia, men are those who are known for their expertise in the fields of science and technology. The low number of female professors in the country’s higher education institutions can be an indicator of such phenomenon. Due to this, female students do not usually have the opportunity to see successful women scientists who motivate females’ interest and self-confidence to join STEM at various levels. Women in academic institutions serve as a role model and their presence is crucial to recruit more women in science fields (Kvach et al., 2017) and they can help mitigate the negative stereotypes about women’s ability in STEM subjects (UNESCO, 2018). In spite of this fact, lack of women role model instructors and scientists who could inspire and inform female students has been a challenge (Samulewicz et al., 2012; Mamo et al., 2017). Hafkin (2016) also argues that scarcity of women instructors/role models has been a bottleneck for females not to opt for STEM in Ethiopia.

**Lack of adequate support from higher education institutions.** If students are to select STEM fields, there is a need for orientation and guidance during the admission choice process (Egne, 2014), including during their earlier career guidance during their studies. Universities are also expected to give sufficient support in all aspects in implementation of Government policies and strategies in relation to higher education. To this end, higher education institutions should increase the number of females students and reduce their attrition in STEM fields. However, some of the instructors at higher education are blamed for not implementing the policies and strategies that have been put in place. Wondimu (2004) argues that some of the measures such as affirmative action have not been supported by some officials and teachers of higher education institutions. It was also noted that low enrolment and high attrition rate of female students in STEM had also emanated from lack of support from instructors (Hafkin, 2016). Moreover, weak gender based guidance, counselling, information and lack of remedial learning programs have been the other challenges in efforts to bring gender equality in science and technology fields in Ethiopia (MoE, 2014). The tutorial sessions intended to support female students at higher education institutions, though it has benefits, has been given arbitrary without any guideline and needs assessment, as one informant explained.

**Gender disparity in employment.** Ethiopia is a country with a remarkable economic
growth. Despite this fact, the unemployment rate among female graduates attests to the prevalence of gender inequality in getting jobs in their fields of study. Considering the women unemployment during the period 2009 to 2013, Jote (2017) indicated that on average 26.6% of female electrical engineering graduates could not get jobs whereas the unemployment rate was only 15% among male graduates in the same field. Cognizant of this fact, MoE (2018a) in its education development road map stated that under the current pace of the manufacturing sector development, it was less likely to employ all current graduates of engineering fields. As a result, unemployment becomes higher among the engineering graduates than in other fields.

Opportunities and future prospects for women’s participation in STI in Ethiopia

Though women have been disadvantaged in participating in STI ecosystem of the country, a number of opportunities have been put in place which could be used to motivate them to participate more competetively in STI. Since Ethiopia is a country striving to bring gender equality in all endeavors of life, in the policies and strategies designed, gender parity is among the priority areas.

The Growth and Transformation Plan II (GTP II) (2015/16-2019/20) of the country is one of the major documents giving emphasis on women’s participation in the overall development of the country. One of the major targets of GTP II is ‘Ensuring gender equality at all educational levels, creating conducive environment for female students, increasing number of female teachers, increasing gender equality in employment….’(Federal Democratic Republic of Ethiopia, 2016). The Higher Education Proclamation (Proclamation No. 650/2009) also dictates to increase the proportion of women in senior positions, and under taken affirmative action for students’ enrolment into higher education institutions that gives special consideration for female students (Federal Negarit Gazeta, 2009). Furthermore, having considered gender issue among the problematic areas of the education system of the country, the Ministry of Education Action Plan of the Education Sector Development Program (ESDP IV), has incorporates females’ equitable access to education at all levels as one of its objectives (MoE, 2015). The higher education road map prepared in 2018 also proposes to further strengthen the affirmative action already in place to narrow the gender gap in higher education institutions. Moreover, one of the guiding principles of the national TVET strategy of the country is to let women have equal access to TVET, and the TVET institutions are expected to develop gender sensitive policies that women will not be discriminated against (MoE, 2008).

Since 2018/19 academic year, the Ethiopian Government in its higher education road map, changed the duration of all programs offered in higher education institutions. For example: programs that were taking three years to earn bachelor degree have been changed to four years. All the first year students take general courses so that females can have enough time to be familiar with the environment including the nature of the programs. If they are offered sufficient guidance and mentorship, they go for science and technology fields of study. The national STI ecosystem of the country also takes human resource development as one of the policy issues (Federal Democratic Republic of Ethiopia, 2012). Among the strategies to implement the human resource development is increasing the proportion of female students who enroll in science and engineering fields in higher education institutions. The increasing numbers of universities that give STEM in the country also offer opportunity for those who are interested to study in these fields.

CONCLUSION AND RECOMMENDATIONS

The STI ecosystem in Ethiopia has been given attention as it is considered key to achieve sustainable development in the country. The country has developed STI policy and the stakeholders of the eco-system are operating to realize the country’s aim to be among the
middle economy countries. Higher education, as a key actor of the STI ecosystem, is contributing by producing competent graduates and researchers. Moreover, an extensive effort has been made to make the ecosystem inclusive so that women can take part in it. This is because participation of women in STI ecosystem is not only to give equal opportunity to them to attend STI fields of study in higher education institutions but also to enable them contribute to the development of technology and innovation. However, the percentage of women is very much less than men in STI ecosystem in Ethiopia. The gender disparity in the enrolment of both undergraduate and postgraduate programs and the employment opportunities in high skilled positions testify to this. It is hardly possible to find women with PhD degrees in STEM fields in most of the higher education and TVET institutions in the country. The low participation of women is attributed to various constraints/challenges. Therefore, it is critically important to work towards redressing the challenges so as to bring more women in the STI ecosystem in Ethiopia.

Recommendations

Despite the fact that the Government of Ethiopia has policies in place to achieve gender equality in the education sector and tries to create conducive environment to redress the prevailed gender inequality in the STI ecosystem, the gender gap remains big. The situation calls for a continuous effort to achieve the objectives set so that the participation of women in STI is enhanced. To do so, the following are recommended:

- Awareness creation among female students at early stages: female students have to be given orientation about STEM at school so that they develop interest and self-confidence towards the fields.
- Elementary school teachers have to contextualize science education to the real life situation of the students so that females will develop interest and positive attitude towards it.
- Affirmative action has to be given more attention in relation to admission of female students to higher education and recruitment of female faculty in STEM fields of study. Higher education institutions need to aggressively work to implement the affirmative action in STEM fields and the outcome of the affirmative action has to be regularly monitored and impact evaluated.
- Arranging freshman/fresh woman advising and mentoring, and organizing training to develop research skills of female students should be periodically undertaken.
- Gender awareness training has to be given to school teachers as well as instructors at higher education institutions to enable them to motivate female students develop interest in the fields of STEM.
- The success stories of female scientists (role models) in STEM have to be told to female students and schools and higher education institutions should invite these figures to inspire female students and boost their confidence to take science fields.
- Make research fund available to female academic staff in higher education and research institutions with a particular emphasis on researchers in science and technology fields, and reward those who excel in their performances.
- Ensure women take advantage of travel to attend national and international conferences and workshops, and motivate and support them to present their research findings, and publish in reputable journals.
- Provide accommodation and other amenities to female students and academic staffs in higher education so that they have sufficient time to focus on their studies and research.
- Any academic support to female students (such as tutorial programs) have to be need-based (i.e., based on specific needs and gaps of female students) and has to be given in planned and organized ways.
- Strengthen international and regional cooperation to secure funding for scholarship and research grants for women.
- Strengthen academia-industry linkage: the
linkage will serve to support the industry labour needs. Moreover, through equitable participation of women in manufacturing, women unemployment will be reduced.

- Promote visibility of women in STEM careers, especially in leadership positions in public offices, industries, business enterprises, higher education, and research institutions.

STATEMENT OF NO-CONFLICT OF INTEREST
The author declares that there is no conflict of interest in this paper.

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REFERENCES


Gizaw, A.K. 2018. Ethiopia’s STI Policy,
Gender-based assessments of Science, Technology and Innovation (STI) ecosystem in Ethiopia


Current statistics in Science, Technology and Innovation in higher education in Cameroon and the establishment of gender participation

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ABSTRACT
Higher Education (HE) in Cameroon aims at promoting and strengthening Science, Technology and Innovation (STI). However, statistical evidence indicates that there is no clear policy that addresses STI educational concerns in Higher Education in Cameroon. This study was carried out to document current statistics in Science, Technology and Innovation in Higher Education and to establish gender participation. The findings indicate that enrolment in STI fields for students and lecturers is relatively high in the natural sciences, but diminishes significantly in health sciences, agriculture and engineering. Numerical evidence indicate that there are more males enlisted in STI fields than females. This disparity is more pronounced in the field of engineering where female students are near absent. There is a need for more investments in STI in Higher Education in Cameroon but with special attention to addressing the gender disparity.

Keywords: Cameroon, Gender, Innovation, Science, Technology

RESUME
Au Cameroun, l’enseignement supérieur a manifesté beaucoup d’intérêt pour la promotion de la science, la technologie et l’innovation. Cependant, les statistiques probantes indiquent qu’il n’y a pas une politique claire pour adresser les problèmes posés par le STI dans l’enseignement supérieur, et il existe des disparités du point de vue du genre. Cette étude a été menée pour documenter les données actuelles vis à vis les STI au niveau de l’enseignement supérieur au Cameroun, et établir la participation du genre féminin. Les résultats montrent que le taux d’inscription des étudiants et enseignants est assez élevé pour les sciences naturelles, et diminue progressivement pour les sciences de la santé, l’agriculture et l’ingénierie. Les statistiques attestent que beaucoup plus de genre masculin s’inscrivent dans les STI que les filles. Cette disparité s’aggrave encore dans le domaine de l’ingénierie où les filles sont quasi absentes. Il est nécessaire que le Cameroun fasse un peu plus d’investissement pour les STI dans l’enseignement supérieur.

Mots clés: Cameroun, Gender, Innovation, Science, Technologie

INTRODUCTION
Cameroon is a country in Central Africa situated below the Gulf of Guinea between the 2nd and the 13th degrees of the North latitude and 9th and 16th degrees of the East longitude. The surface area is estimated at 475,650 km². It has the form of a triangle that stretches from the south up to Lake Chad (close to 1,200 km), whereas the base spreads from West to East for about 800 km. It has at the South-West, a maritime border of 420 km along the Atlantic Ocean. Cameroon is bordered in the West by Nigeria, in the south by Congo, Gabon and Equatorial Guinea, in the east by Central African Republic, and in the north-east by Chad (National Institute of Statistics, 2013). It is a bilingual country with English and French as official languages, and operates with two subsystems of education inherited from its colonial masters.

The terms ‘science and technology’ can be understood in a broad sense, including fields as different as physics, political science and literature, or in a narrow sense that covers primarily academic and professional disciplines related to natural sciences, engineering, mathematics and computing. This report uses the latter definition. It is also important to recognize that the definition of science can include indigenous science and traditional knowledge systems. The concept of technology is, likewise, socially and culturally diverse, referring to hand-made tools as well as complex products and processes, for instance information technology (IT) systems. According to the Merriam Webster dictionary, Innovation can refer to something new or to a change made to an existing product, idea, or field.

Higher Education, also known as tertiary education in some countries, refers to all post-secondary education, including both public and private universities, colleges, technical training institutes, and vocational schools (World Bank, 2017). Higher education is instrumental in fostering growth, reducing poverty and boosting shared prosperity. A highly-skilled workforce, with a solid post-secondary education, is a prerequisite for innovation and growth: well-educated people are more employable, earn higher wages, and cope with economic shocks better. Higher education benefits not just the individual, but society as well (Jowi et al., 2016; Sam-Amoah et al., 2020). Graduates of higher education are more environmentally conscious, have healthier habits, and have a higher level of civic participation. Also, increased tax revenues from higher earnings, healthier children, and reduced family size all build stronger nations. Summarily, higher education institutions prepare individuals not only by providing them with adequate and relevant job skills, but also by preparing them to be active members of their communities and societies (World Bank, 2017).

Science and technology has gained increased prominence on the international political agenda due to its impact on sustainable development and democracy (UNESCO, 2015). Science, Technology and Innovation (STI) has been highlighted as an important driving force for countries’ socio-economic development (Osagie and Alutu, 2016; Zavale, 2017). The ability to generate scientific and technological knowledge and translate it into processes or new products is a key instrument of economic growth and development (Mormina, 2019). In Higher Education (HE), universities are generally expected to play a critical role in the development of national and regional STI capabilities. One of the key factors of promoting scientific mind sets among learners is developing positive attitudes towards the science related disciplines and meaningful related career overtures (George, 2006). Given its long-standing commitment to the improvement of the status of women, UNESCO pays special attention to equal access of girls and women to scientific, technical, vocational education and training. In its Agenda for Gender Equity, UNESCO commits itself to
encouraging the equal access to knowledge in all fields, notably within science and technology as well as aiming at substantially increasing the participation of women in science and technical education programmes in order to provide them access to scientific and decision-making bodies.

Rationale and objectives of the study

In Cameroon, Higher Education plays a critical role in promoting science, technology and innovation. Indeed STI in Higher Education are central to economic development, trade competitiveness, and social progress. Improvements of STI in Higher Education are likely to promote better healthcare for the people, more innovative and productive businesses, the modernization of farming and agribusiness, and an enhanced human capital to address the challenges of climate change. Although STI and Higher Education are universally recognized as critical drivers of economic development, a major challenge is how to identify the right matrix of factors and policy initiatives that positively impact socio-economic development.

In Cameroon, many of the building blocks required to support STI and Higher Education policy development are universities, research institutes, Ministry of Scientific Research and Innovation, Ministry of Mines, Industry and Technological Development, National Science Academies and a growing private sector such as NGOs. However, the STI and Higher Education systems do not seem to be effectively coordinated and adequately focused on Cameroon’s socio-economic needs. Furthermore, existing STI and Higher Education programmes intended to attract the private sector support do not appear to be motivating enough to drive investments and technological upgrading. Consequently, many of the country’s important STI institutions are unable to effectively carry out their mandates. Despite the importance placed by UNESCO on gender equality in all fields of education especially in Science, Technology, Engineering and Mathematics (STEM) many females especially in Higher Education in Cameroon are still absent from these fields. From the Population Reference Bureau (2016), women represent a greater percentage (51) of the Cameroon population but are underrepresented in the fields of STI. It is within the above context that the aim of this paper was to review the current statistics for science, technology and innovation including investments in higher education in Cameroon and establish gender participation.

RESEARCH METHODOLOGY

The study was carried out mainly as a desk study involving literature review and document analysis. The desk research helped in the retrieval of information on statistics on STI for Higher Education in Cameroon. Additional information was collected through face to face and phone call interviews with key informants from the Ministry of Higher Education, Ministry of Scientific Research and Innovation, National Academies involved in STI and National Institute of Statistics in Cameroon. Data obtained during the study was analyzed by descriptive statistics using Microsoft Excel 2010. The data collection process is shown in Table 1.

For the analysis, the current available statistics on Higher Education in Cameroon in science, technology and innovation from 2015 to 2018 were collected and the evolution of STI in different State Universities in Cameroon was characterized in terms of student enrolment, human, infrastructural and financial investments. From interviews with different actors, the paper captured their perception about the STI situation in Higher Education in Cameroon. A comprehensive review was done on gender participation in STI, and key underlying issues, gaps and challenges for Science, Technology and Innovations (STI) in Higher Education in Cameroon. Subsequently recommendations were derived to improve STI in Cameroon’s Higher Education at the national, regional and international levels.
Table 1. Summary of data collection process

<table>
<thead>
<tr>
<th>Data and information collected</th>
<th>Method</th>
<th>Sources</th>
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<tbody>
<tr>
<td>Gender gaps and challenges in STI</td>
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<tr>
<td>Recommendations</td>
<td>Document analysis and interviews</td>
<td>Annual Reports Key informants, Websites, Key informants from relevant ministries, national academies, HEIs, relevant stakeholders from government and private sector were interviewed.</td>
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<tr>
<td></td>
<td>Compilation of secondary data and interviews</td>
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**FINDINGS AND DISCUSSION**

**History of Higher Education in Cameroon**

The Cameroon higher education system presents a ‘unitary’ structure (Doh, 2007). Although each Higher Education Institution (HEI) has a considerable degree of autonomy, they are centrally administered by the Ministry of Higher Education to which they are accountable. Higher education is considered a national priority, organized and controlled by the State (ESSP, 2006). The Ministry of Higher Education (MINESUP) is the main governance body and defines policies for both the State and private higher education institutions. The Ministry is headed by a Minister who is assisted by a Secretary General, a General Inspectorate for academics and service control as well as various directors of departments (MINESUP, 2018). Universities are headed by Rectors or Vice-Chancellors in the French and Anglo-Saxon universities, respectively. They are assisted by Vice Rectors or Deputy Vice-Chancellors respectively. In addition to the Rectorates or Vice-Chancellery are the offices of the Secretaries General or Registrars for French and Anglo-Saxon Universities, respectively. They are in charge of routine administrative matters in the Central Administration of the universities. The Secretaries General or Registrars are statutory secretaries to the various decision-making organs of the Universities (e.g. the Committee of Deans and Directors, Senate and the University Councils). Directors head various services in the Central Administration of the Universities and Deans and Directors head faculties, schools and institutes. In the basic units of the universities there are heads of department and programme coordinators. Each University has a governing council.
presided over by the ‘President du Conseil de l’Administration’ (Chairman of the University Council). In this council, the presidency of the country, the ministries of higher education, finance, public service, planning and labour as well as external stakeholders are represented (MINESUP, 2020).

The languages of instruction in higher education in Cameroon are French and English. Both languages are used in the bilingual Universities for teaching and learning depending on the first language of the student or teacher. Only French or English is used in the monolingual Francophone or Anglo-Saxon Universities, respectively. Admission into the university is based on the two high school graduate qualifications, the General Certificate of Education (G.C.E) Advanced Level and Baccalaureat (BAC) for English and French speaking high school graduates, respectively. Other requirements include language proficiency and relevance of high school subjects to the intended field of study. Admission into professional and technical university centres, schools and institutes are based on highly competitive entrance examinations (Njeuma et al., 1999).

Before 1993, the structure of the Cameroon Higher Education system was dominantly French-patterned. The pre-1993 higher education system consisted of the main university (the then University of Yaoundé) with several university-level institutions, professional/technical schools, institutes and centres which were completely separated from or simply lodged in the university. Thirty (30) years after its creation, this university had 40,000 students in a campus meant for 5000 students (Njeuma et al., 1999). There were funding problems and quality decline in the University of Yaoundé between 1992 and 1993, and the Government initiated a vast reform of the Higher Education system. The reforms were contained in presidential decrees numbers: 92/074 of 13th April 1992, 93/026 of 19th January 1993, 93/034 of 19th January 1993 and 93/027 of 19th January 1993. The objectives addressed by these decrees included amongst others: a) to encourage the participation of the different partners in the management and financing of Higher Education Institutions, b) enhance autonomy in academic, administrative and management issues, c) professionalize the higher education system, d) deconcentration and decentralisation, and e) increase inter-university and international cooperation. A principal feature of the reforms was that it granted autonomy to universities to generate extra funds through projects.

Besides education and general government strategy papers, there have been revisions and additions to the 1993 reforms which relate to higher education. Some of these include:

1. Law No. 005 of 16th April 2001 (LOHE) on the orientation of higher education in Cameroon. It defines the orientation of higher education in terms of teaching, research, and contribution to development, bilingualism and cooperation.
2. Decree No. 2005/383 of 17th October 2005 on New University Governance laid down the financial regulations applicable to universities.
3. The 9th August 2008 decree creating the University of Maroua.
4. Decree No. 2010/372 of 14th December 2010, creating a second Anglo Saxon State university, the University of Bamenda.
5. The University-Industry Charter signed on 20th December 2010 expressing the values that should be upheld and the rules and regulations in university-industry relations.
6. The 2006-2009 Education Sector Strategic Plan (ESSP).

Before 2008, the higher education system in Cameroon comprised of two degree structures according to the French and Anglo-Saxon (or Anglo-American) systems. To ensure mobility
between the two subsystems and in response to the pressures of regional integration and globalisation, the degree structures were harmonised according to the Bachelor, Master and Doctoral structures. The Francophone structure today is called the LMD system (Licence, Master and Doctoral cycles of 3+2+3 years each) corresponding to BMD (Bachelor, Master and Doctoral cycles) which existed in the Anglophone system. This new and comparable degree structure went operational from 2008. As at 2017/2018 academic year, the student population in State universities was 269,509 with 2112 teachers (MINESUP, 2018). There are 08 publics and 245 private HEIs in Cameroon (MINESUP, 2018). Public and some private and denominational Higher Education institutions in Cameroon are shown in Table 2.

Higher Education Objectives
Higher education objectives result from overlapping national and international policies. Cameroon is a signatory to several international conventions related to education. As a developing and aid-dependent country, Cameroon’s higher education system is influenced by the UNESCO, World Bank, the African Development Bank and other sub regional organizations which shape what is deemed strategic for higher education (Doh, 2012). The history of Cameroon’s higher education explains why and how the higher education objectives are shaped. The priority was and still is to reform the higher education system and enhance its relevance to societal needs.

At independence, higher education was mainly for training of cadres to replace the departing colonialist in the State administrative machinery. The issue of relevance to the job market was not a problem until the early 1980s. In 1983-84 the population grew fast and the State was unable to absorb all Higher Education graduates. From 1984, there was an economic crisis: State companies were closed and recruitment into the public service was stalled. This is when the question of relevance to the labour market became increasingly crucial. In the 1990s when liberalism, multipartism and university crises kicked in, the 1993

<table>
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<tr>
<th>Types of University</th>
<th>Names of Universities/Institutes</th>
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<tbody>
<tr>
<td>Public</td>
<td>The University of Bamenda, University of Buea, University of Douala, University of Dschang, University of Maroua, University of Ngaoundere, Yaoundé I and Yaoundé II</td>
</tr>
<tr>
<td>Private Higher Education Institutions</td>
<td>Bamenda University of Science and Technology (BUST), International University, Bamenda and the Fots Victor University, Saint Monica University, Saint Louis University, American Institute of Cameroon, Université des Montagnes, Cameroon Petrochemical Engineering Academy, The ICT University, Institute Siantou Supérieur, Fomic Polytechnic Institute</td>
</tr>
<tr>
<td>Private University which are denominational</td>
<td>Université Adventiste Cosendai, Catholic University of Cameroon, the Catholic University Institute of Buea, Catholic University of Central Africa, Catholic University, Protestant Christian University, Bali</td>
</tr>
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</table>

Major training institutes: most are affiliated with State universities.
Annual Statistics for the Ministry of Higher Education, Cameroon for 2015, 2016, 2017 and 2018
university reforms were initiated. There was a need to partner with the socio-professional environment to have an exact idea of what they needed. This information had to be the basis of reforming study programmes. However, when it was noticed that the enrolment capacity of the university had been largely exceeded while the university centres had under enrolment, without thinking, university centres were turned into full-fledged universities. The idea was that some students will enroll in the university centre-turned university and the former lone University of Yaoundé would be decongested. In actual fact the reforms were more infrastructural while the study programmes remained the same.

Another objective of Higher Education was to enhance professionalism and employability. The idea was not just for the student to fit the needs of the job market but to be able to create jobs and be self-employed. This has been achieved to a great extent through the creation and opening of professional schools like Higher National Polytechnic Institute (ENSP) which was created specifically to train cadres for civil service and engineers for the development of Cameroon. Like its French counterparts, the focus on ENSP was rigorous science and competitive entrance examinations. While present-day ENSP has aligned its degree structure with the Bologna Process, ENSP has focused on structural changes by adopting the Anglo Saxon Bachelor-Master-Ph.D. (BMP) model from which the French License-Master-Doctorat (LMD) is derived, in a bid to align its systems with the global educational practices.

**Enrolment in STI in Higher Education in Cameroon**

University education in Cameroon takes three years for the liberal arts, science and business courses, four to five years for engineering courses, and six to seven years for medicine (EPDC 2014). Cameroon has recorded rapid progress, raising its enrolment rate from 5.8 percent in 2005 to 11.9 percent in 2011 (UNESCO, 2015). More high school graduates are enrolling into higher education after meeting all academic requirements, thanks to the creation of higher institutions of learning. Literacy among people aged 15-24 in Cameroon is 85% (EPDC, 2014). Cameroon’s education sector strategy paper observed that, for the 2010–2020 periods, the annual growth rate was predicted at 2.1% corresponding to a yearly increase of about 420,000 inhabitants.

From 2015 to 2018, private universities in Cameroon have been expanding rapidly, both in terms of number and size while the State universities have increased in size but not in numbers. Though enrolments in higher education have increased significantly, the proposed programmes might not meet the needs of the job market. Enrolments have increased since 2015 mainly in public tertiary education institutions. But the allocation of students by discipline still suggests that there is a gap with the needs of Cameroon’s economy. Enrolment in STI has increased from 2015 to 2018 in the classical scientific disciplines but much progress still needs to be made in Engineering and Agriculture; Engineering, for instance, accounted for fewer students in higher education enrolments between 2015 to 2018 (Table 3). This is contrary to the ratio of engineering to science students which is much higher in Ethiopia (59%) than in Cameroon (6%). The highest number of student enrolment in STI fields in Cameroon State universities is in the Faculty of Science followed by Faculty of Health Sciences, Agriculture and Engineering disciplines in seven out of the eight state universities which offer programmes in STI. The trend in evolution is shown in Figures, 1, 2 and 3.
Table 3. Evolution in Enrolment in STI fields in State Universities in Cameroon

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Cameroon’s Ministry of Higher Education Statistical Year book 2015, 2016, 2017, 2018

Figure 1. Evolution of Student enrolment in the Faculties of Science in seven State universities

Figure 2. Evolution of Student enrolment in the Faculties of Health Sciences in six State universities
It is evident that STI in higher education plays a pivotal role in the socio-economic transformation of the country. Rapid growth of enrolment in STI will lead to poverty reduction and economic growth. However, Higher education enrolment in Cameroon remains very low in comparison to countries like Ethiopia, Nigeria, and Ghana. The fast growth of countries such as the Republic of Korea was simultaneously accompanied by a rapid growth in university enrolment. The recent fast pace of poverty reduction and economic growth in China has also been accompanied by a significant growth in university enrolment.

**Human investment in STI in higher education in Cameroon**

The importance of high-quality higher education in developing human capacity for economic growth and competitiveness in a knowledge-driven economy has prompted many African countries including Cameroon to prioritize it. For several decades, Cameroon has neglected and underfunded higher education, believing that it yielded lower social returns than other investments in the field, particularly primary and secondary education. A theoretical underpinning was that investments in higher education were regressive, reproducing existing social and economic inequalities (APLU, 2014). Prior to 2018, one of the challenges faced by universities in Cameroon was the shortage of lecturers inspite of the recruitment of 1000 university lecturers in 2010 by the Ministry of Higher Education to solve the problem of shortages of lecturers. To bridge this gap, in 2018 the recruitment of 2000 university lecturers was authorized by the Ministry of Higher Education in all State universities for a period of three years from 2019 to 2021. The recruitment of 1000 university lecturers was implemented in 2019 and presently 500 university lecturers are in the process of recruitment for 2020 while 500 lecturers will be recruited in 2021. Other lecturers were also recruited in State universities in 2020 through numerical replacements of all those lecturers who had abandoned their duties, those who had died and those retired. In State universities in Cameroon, many lecturers within the STI fields are in the Sciences, followed by Agriculture and least in Engineering. This is shown in Table 4.
Table 4. Lecturers in STI fields in State Universities in Cameroon

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Source: Cameroon’s Ministry of Higher Education Statistical Year book 2015, 2016, 2017, 2018
Infrastructural investments in STI in higher education

Readiness to support innovation and facilitate competitive business activities requires infrastructure such as basic telecommunication services, broadband Internet access, good transportation networks, water, reliable electricity supply, laboratory facilities, and tax systems that support private sector innovation. However, in many HEIs in Cameroon there is lack of broadband internet, the electricity supply is not constant, there is poor road network and insufficient laboratory facilities. Among the public universities, the University of Yaounde 1 and the University of Dschang have the highest number of laboratories while the University of Bamenda has the least. This is shown in Figure 4.

In recent years, both the private sector and the Government of Cameroon have made huge investments in the overall infrastructural development of educational institutions in Cameroon. Such developments include the establishment of new faculties within universities, the creation of new universities and other institutions of higher learning. All these are in a bid to respond to the growing domestic and international demand for quality graduates within the country, in particular, and the Central African sub-region as a whole. Despite these investments, the number of State universities is still insufficient though there is a proliferation in private institutions of higher learning.

Investment in the generation of human capital in areas of importance to national development is seen as essential to meeting development challenges and realizing opportunities. For example, as Cameroon depends on mining operations, and as such, institutions dedicated to training of mine managers and professionals have been created in HEIs. Also Agricultural-based institutes and health based institutions have been created to meet the need of the society. Despite these different institutions involved in training specialists, skilled manpower is required in all sectors of society. This makes generic training particularly important. For instance, engineers may be employed in a variety of sectors such as communication, education, energy, health,
sanitation and transport, among others.

Financial Investment in research in STI in Higher Education in Cameroon

In Cameroon, most universities rely heavily on Government subsidies for their budget. Apart from reduced State budgets given to universities, the Government eliminated bursaries and student welfare support and introduced registration fees in 1993 for all the universities (Njeuma et al., 1999). For universities, reduced Government spending on education presented a huge financial challenge. The universities could raise money from the private sector and industries but this has been difficult (Njeuma et al., 1999).

The lack of funding has prevented the universities from expanding their infrastructure to meet soaring enrolment rates. In addition, inadequate funding has impacted on the universities’ ability to acquire good pedagogic equipment (Odiahmbo, 2011). According to Njeuma et al. (1999), in order to ensure quality education students must have access to good pedagogic equipment and classroom space. The State budgetary mechanism exacerbated the falling quality of higher education in Cameroon. UNESCO (2003) highlights the imbalance in the allocation of the university budget, which is tilted towards administrative expenses to the detriment of teaching and research. Inadequate research and teaching budgets deter research or impede the quality of research carried out by universities (UNESCO, 2003; Materu, 2007).

The cut in budgetary support to universities and the lack of safety net for the students was reported to have a huge impact on the quality of learning outcomes of the students (Njeuma et al., 1999; Konings, 2004). The elimination of student bursaries designed to attract students to universities increased the university dropout and failure rates (Njeuma et al., 1999; UNESCO, 2003). In Cameroon, the population living below the poverty line in 2000 was estimated at 48% (CIA, 2014) and 39.9% in 2007 (World Bank, 2014), and, therefore, the lack of some form of support to students from poor and marginalized backgrounds could put an end to their educational career or reduce the quality of their learning, especially if they are not able to meet the demands and cost associated with learning (UNESCO, 2003). In contrast to State funding of higher education, Psacharopoulos (1991) asserted that charging fees provides an ‘efficient selection mechanism’ and only those who are willing to be successful would pay the fees. Furthermore, charging fees would introduce accountability and transparency both at institutional and student levels. In Cameroon’s Higher Education, fees are charged for professional programmes in State universities whereas private universities do charge fees for all their programmes.

To increase schooling and offer alternate paths to general education and training, the Government of Cameroon is preparing new strategies for Technical and Vocational Education and Training (TVET) and higher education with the goal of increasing investments in both. Doing so would better align the education and training system to the labour market needs of a middle-income country. The Government’s ambitious targets require some key adjustments especially in rationalizing public spending on education to boost efficiency, and improving service delivery by ensuring, among other aspects, that a greater percentage of the education budget is decentralized to support school-based management.

Table 6 shows the investment budget in eight State universities in Cameroon from 2015 to 2018. From 2015 to 2016, the investment budget for many universities reduced or remained the same except for the youngest State university, the University of Bamenda. By 2018, most of the investment budgets of the universities were reduced except for the University of Bamenda and the University of Maroua where there was an increase in investment budget. It should
be noted that the University of Maroua and the University of Bamenda are the youngest State universities created in 2008 and 2010, respectively. Figure 5 shows the differences in investment budget in eight State universities. In 2015, the highest investment budget was allocated to the University of Yaoundé 1 while the least was to the University of Maroua. In 2018, the highest investment budget was in the University of Maroua while the least was in the University of Ngaoundere.

The priorities of the 2019 budget of Cameroon

Table 7 gives an economic look on the 2019 budget allocations of some Cameroon’s ministries which directly or indirectly relate with STI in Higher Education. It suggests that the national priorities of the Cameroonian government in 2019.

Table 6. Investment Budget in State Universities in Cameroon (In Millions CFA)

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Source: Cameroon’s Ministry of Higher Education Statistical Year book 2015, 2016, 2017, 2018

Figure 5. Differences in Investment Budget in eight State Universities in Cameroon
policy priority of the Government is not job creation. It includes expenditure lines related to human capital (primary education, secondary education and public health), debt service (domestic and external debt service), public works, government common expenses, grants and contributions to organizations and public institutions, defense spending and pensions. It is a rational choice to prioritize the investments in human capital and road construction and maintenance (public works) but not necessarily at the expense of the other expenditures. It is well known that human capital and public works have a significant positive effect on the GDP over a relatively long term. The investment in human capital in Cameroon is not targeted at both promoting entrepreneurial education (programs that teach people how to start businesses and thus creating jobs) as well as increasing significantly the number of STI graduates. Yet entrepreneurial education and STI skills are needed to catalyze Cameroon economic transformation through improved productivity (House of Commons Committee of Public Accounts, 2018).

Human capital which includes health and STI-education contributes to approximately two-thirds of the GDP of nations (Nkafu Policy Institute, 2018). Arguably, the budget allocation for health and education should be amongst the top five budget allocation of Cameroon. Currently it is ranked #10 for health and #3 for secondary education (it is #8 for primary education and #19 for higher education). As regards research and innovation which is another component of human capital, Cameroon’s 2019 budget allocation is about 12 billion FCFA (i.e., 1 billion/month), or 0.25% of the annual budget. This is less than 0.1% of Cameroon’s GDP (around $35 billion (CIA World Factbook, 2018) and is small when compared to the research budget (as a percentage of the GDP) of emerging economies like South Africa, i.e., 0.8% of the GDP (Government of South Africa, 2017).

**Investment in Research and Development in Cameroon’s STI**

In Cameroon, like in most African countries, research is relegated to the background with no substantial budget allocated to it. It is common place to find research and innovative results lingering in the drawers or at their prototype state because funding is not readily available. The country’s Ministry in charge of research for example, was allocated only a paltry of FCFA 10.3 billion in 2018 with little over FCFA 3 billion devoted to investment and research activities.

In 2015 for example, the Institute of Agricultural Research, IRAD was allocated FCFA 6.5 billion for research activities out of a total budget of FCFA 12.2 billion required during that year. As one researcher noted, good research results attract funding bodies on their own. Other researchers hold the view that it is better to fund their research at the initial stage for clarity purposes. Apart from the Government assistance to researchers through JERSIC, other funding bodies like the African Development Bank, World Bank and bilateral partners finance research initiatives in Cameroon. In 2015, the Ministry of Scientific Research and Innovation and Cameroon’s Employers Syndicate (GICAM) agreed to work hand-in-hand so that research and innovative projects could be financed but the impact of that accord is yet to be felt. However, higher education and GICAM organize yearly innovation competition during university games and select and award prizes to the top three innovators from schools and faculties in Higher Education Institutions. Also, a Cameroonian business magnet, P.K. Fokam launched an award for Science and Technology in 2016 to promote applied research in Africa. However, the impact of these funding initiatives which for now are still inadequate is difficult to evaluate in terms of the contribution of research and innovation to the economy. The domain of technological innovation is notwithstanding promising with many youths making strides in development of apps.
Table 7. Budget of Cameroon’s Ministries Concerned with STI in 2019 - Allocation (in million FCFA)

<table>
<thead>
<tr>
<th>Ministries</th>
<th>2018</th>
<th>2019</th>
<th>DF</th>
<th>Weight 2019</th>
<th>Rank 2019</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher Education</td>
<td>61401</td>
<td>55952</td>
<td>-5449</td>
<td>0.91</td>
<td>1.15</td>
<td>19</td>
</tr>
<tr>
<td>Scientific Research and Innovation</td>
<td>10300</td>
<td>11916</td>
<td>1616</td>
<td>1.16</td>
<td>0.25</td>
<td>38</td>
</tr>
<tr>
<td>Mines, Industry and Technological development</td>
<td>10409</td>
<td>11255</td>
<td>846</td>
<td>1.08</td>
<td>0.23</td>
<td>39</td>
</tr>
<tr>
<td>Public Health</td>
<td>175240</td>
<td>207943</td>
<td>32703</td>
<td>1.19</td>
<td>4.29</td>
<td>10</td>
</tr>
<tr>
<td>Agriculture and Rural Development</td>
<td>86613</td>
<td>84980</td>
<td>-1633</td>
<td>0.98</td>
<td>1.75</td>
<td>15</td>
</tr>
<tr>
<td>Livestock, Fisheries and Posts and Telecommunications</td>
<td>35100</td>
<td>32343</td>
<td>-2757</td>
<td>0.92</td>
<td>0.67</td>
<td>25</td>
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<tr>
<td>Employment and Vocational Training</td>
<td>46845</td>
<td>48351</td>
<td>1506</td>
<td>1.03</td>
<td>1.00</td>
<td>22</td>
</tr>
<tr>
<td>Forests and Wildlife</td>
<td>18591</td>
<td>19179</td>
<td>588</td>
<td>1.03</td>
<td>0.40</td>
<td>30</td>
</tr>
<tr>
<td>Environment, Nature Protection and Sustainable Development</td>
<td>8042</td>
<td>8009</td>
<td>-33</td>
<td>1.00</td>
<td>0.17</td>
<td>48</td>
</tr>
</tbody>
</table>


In Cameroon’s 2020 finance bill, the budget allocated to the Ministry of Higher Education is XAF65.2 billion. In this bill, the ministry’s operating budget has increased by XAF13.4 billion to XAF50.7 billion while its investment budget decreased by more than XAF10.2 billion. The reasons for this budgeting are still unknown but the presentation shows a real desire for change in higher education in the country. For university research, the budget is XAF11.6 billion and the stated objective is to increase the exploitation of research results on the priority development sectors of the Growth and Employment Strategy Paper within no more than two years. However, the budget does not indicate whether the university research budget will be allocated exclusively to public higher education or whether it will be extended to the private sector. Since 2009, the President of the Republic, through the Ministry of Higher Education gives research modernization allowances to lecturers in State universities in trimesters to carry out research.

The integration of graduates from traditional higher education faculties has also been taken into account in the budget. An allocation of XAF8.1 billion is earmarked for it. With scientific and technological fields poorly equipped and literary studies disconnected from reality, the achievement of this objective must be monitored. Finally, XAF7.4 billion will
be spent to increase the number of students in technological and vocational courses.

**Professionalism in Cameroon’s Higher Education**

The primary goals of the 1993 university reforms were to: “Make university programmes more varied, professional, adapted and responsive to the needs of the job market by providing more programmes that will enable graduates to find jobs in the private sector as well as create self-employment”. While some State universities have made strides in the provision of professional education (University of Douala with its Institut Universitaire De Technologie, University of Dschang with its School of Agronomy, University of Bamenda with the College of Technology, just to name a few), this form of education is mainly seen at private universities within the country. The success rate of professional programmes has been formidable; more than 85 percent of graduates getting work within the first year of graduation versus graduates of non-professional programmes who find it difficult securing paid jobs after completing their studies. The majority of the programmes of most State universities have few links to the needs of the labour market and, according to the World Bank Human Development Network report, the private sector is minimally involved in the design of university programs and the curriculum contents in Cameroon. The report states that the education system of the country is rooted in the traditional Francophone African model, tilting towards the production of civil servants. It is no longer in sync with the needs of the economy in this era of neither «shrinking public services nor international best practices». Hence, there is a call for a constructive reformation which involves all stakeholders.

Many State universities, compared to their private counterparts, are under-equipped in terms of classroom infrastructure and modern libraries. The student-lecturer ratio is highly skewed to the disadvantage of the students. Lecture halls are overcrowded with as many as 1000 students scrambling for as few as 700 seats. The implication is that the lack of one-to-one encounters result in unsolved study-related problems. Additionally, unlike their private counterparts, State universities have limited internet connectivity, making research and access to useful online material difficult. In an information age where decisions are made in real time and based on analysis of life streaming data, the one thing an institution of higher learning cannot afford to be lacking is uninterrupted internet connectivity.

Given all of these public university shortcomings, the less-than-perfect private sector has been able to fill the gap in the development of the relevant human capital with highly sought skills both within and out of Cameroon. This is a clarion call for action on the part of the State to make the necessary reforms. Improving the quality of education in Cameroon will go a long way to set not just the country’s standard but the standard for other nations of the region, and the needed response to the needs of both government and private enterprises. Actions such as, but not limited to the following, are necessary:

- Professionalize all State university programmes not only in name but course contents.
- Liaise with the private sector; formulate and shape course content for different programmes with consideration to areas of interest.
- Establish partnerships with reputable universities, both within Africa and out of Africa, and promote the development of exchange visits by lecturers. This will help improve teaching methods.
- Establish a Public-Private partnership whereby students will be required to undergo internships in private companies. Students will gain specific job skills that are directly transferable to paid employment upon
Current statistics in Science, Technology and Innovation in higher education in Cameroon

graduation.

- Promote the April 2001 National Assembly law which called on private enterprises and public organs to work together to provide coordinated training opportunities for students beyond the secondary school level of education.

- Finally, in the words of Professor Michel Tchotsoua during a symposium on industrialization in Cameroon organized by the Foretia foundation (held on April 21, 2016), the strategy of education has to be "Formation Opérationnelle", Stakeholders take into consideration current projects going on within the economy, as well as long term labour needs, before forming modules of university courses. By doing this, in the long term, there will not be any need to hire foreign experts to execute or maintain projects in Cameroon. These jobs will be done more cost effectively by Cameroonians. It is only when the Government considers and acts on these suggestions and those from studies of other international bodies that public sector education will begin to be representative of what it is intended to be the human capital needs of the job market within and beyond Cameroon.

Technology in Higher Education in Cameroon

Analysis of the technological structure of industrial production reveals that Cameroon's manufacturing industry is still heavily biased towards traditional low-value-added, low-wage activities, given its inability to adapt over time its production structure to higher-value-added activities involving more complex technologies (medium-and high-technology products). Devaluation of the CFA franc in 1994 did allow some gains in exports but this mainly benefited enterprises which were already exporting and sectors that were generally more prone to be involved in trade.

If the Cameroonian economy is to become an emerging economy by 2035, it must move from an economy of consumption to an economy that transforms raw material as well as ideas into refined products. This may only be possible if knowledge gained through research (either public or private) is shared with industry. For this to happen, enough sensitization must be done and sufficient information needs to be imparted on the issue. Stakeholders’ awareness must be raised to the fact that productivity may only be boosted through technology transfer. These stakeholders include researchers (students and lecturers) but also industry leaders, promoters of small and medium size enterprises, decision makers and the general public.

There are various formal and informal ways through which technology may be transferred and the process certainly results in significant benefits for any economy. Whether the technology has resulted from public research in universities and research centres or from private research in companies’ Research and Development departments, there are several ways in which it may be transferred to industry. These include both formal and informal ways. Formal technology transfer includes training and education by universities, the hiring of graduates and university researchers, collaborative research between universities and companies’ research and development departments, technology services and consultancy from academia for the benefit of industry, patenting, licensing and any other form of commercialization of universities’ protected intellectual property as well as spin-offs run by universities themselves. Informal technology transfer includes any informal exchange, that is, any exchange which is not subject to a contract but most often, researchers’ publications (in scientific journals and other reviews) and paper presentations in conferences, seminars and colloquia.

For technology transfer to take place and deliver the expected benefits there must be a clear policy. Designing and adopting policy is the role of Government through policy documents, laws, regulations and any other
instruments. Political will is an essential but not the unique requirement for technology transfer; universities must be willing to disseminate their knowledge and industry must be ready to absorb that knowledge in the many existing ways and put it into practice. Then, universities and industry must not be stopped by a lack of clear Government policy or appropriate instruments that promote technology transfer as they can yield huge benefits in the process whether or not a clear national legal framework exists as there is no law that prohibits it. Instead there are several pieces of legislation that provide for technology transfer. In fact, people and passion are taken to be the main ingredients for technology transfer success. Besides, knowledge may only be generated through sound and reliable research. This means that universities must put mechanisms in place that promote research best practices thereby creating a conducive environment for innovation. If universities fail to innovate, then, there will be no knowledge to share. Well skilled personnel in management, accountancy, economics, intellectual property and basic contract law must be hired to perform these duties. Universities must therefore adopt sound strategies to manage research and research results determining the best ways to protect and commercialize them.

Technology transfer offers many benefits to the various stakeholders. For industry, and mainly local small and medium size enterprises, knowledge from universities may help in reducing production costs and increase revenue with new and more efficient operating methods. Technology transfer helps companies increase their technical capabilities and access management and marketing expertise as well as new sources of capital. Use of transferred technology warrants access to larger markets whether local or international and, consequently, to new distribution channels. All of this helps companies acquire and retain competitive advantage for their growth and that of the country. For universities, technology transfer helps in strengthening and establishing research conventions with industry in order to fund research and harness revenue to finance other activities within the university. Patenting, licensing and other commercialization of generated intellectual property (knowledge) helps universities establish their leading role or signaling their expertise in any given field. Technology transfer in the form of graduates and research staff recruitment in companies benefits universities in their graduates’ employability skills as well as giving teaching staff more practical knowledge and experience that will result in better programme delivery and professionalization. Technology transfer allows universities to disseminate and impart knowledge generated more effectively which is their primary duty. The main benefit being diversification of sources of income and extra income funding. For Government, technology transfer helps in increasing productivity and competitiveness at both national and international levels and, hence, boosts economic growth. For technology transfer to occur in the Cameroonian context there must be a conducive environment. This is what is lacking in most developing countries. This notwithstanding, disparate and various policy and legal instruments, though not specifically devoted to technology transfer, exist that may help foster it. Besides, there are many other challenges that may hinder the process.

Cameroon lacks a clear policy on technology transfer or at least effective implementation mechanisms of some of the measures that may be used to carry it out. Some of these measures are contained in various laws including the 2002 Investment Charter, the 2013 Law on Incentives for Investment and Public Private Partnerships law and regulations. Specifically, there have been some attempts to make technology transfer formal and regular between universities and industries in Cameroon. One of such attempts is evidenced by a Charter that was signed in 2011 by the Ministry of Higher Education and Groupement Interpatronal du Cameroun (GICAM), one of the most influential
Cameroonian industry groupings. Its full implementation is still hindered by the fact that incentives that may promote technology transfer between university and industry have not been well developed. There, however, exist some conventions between public universities and private institutes of higher education and industry to foster technology transfer through collaborative curricula development to ensure degree holders’ employability as well as organising internships and field visits to companies. Moreover, specific policy and legal instruments on technology transfer need to be adopted in Cameroon’s Higher Education (Mekongo, 2017). Startups in Silicon Mountain face a lot of difficulties which they think can partly be solved by the Government. Approximately 90% of its startups cannot survive because of the taxation system and other laws in the country. If the laws recognized the startup status and its inability to raise funds during its early stage, things would have been lighter on startups. Also, internet connectivity has retarded startup growth. This is the most basic, necessary and primary tool techies use to build their products. There will be no tech product without the internet.

However, Cameroon has launched programmes and initiatives to promote science, technology and innovation which benefitted universities. Cameroon’s Vision 2035 embraces science and technology as ‘key to global competitiveness’ and turning the country into one of the top 20 economies in the world. In 2018, enrolment in agriculture, forestry, fisheries and veterinary programs increased in Cameroon while enrolment in health and welfare programs fell in Cameroon’s Higher Education. Despite the existence of engineering institutions in Cameroon and sub-Saharan Africa that have been graduating hundreds of engineers annually, there has been little progress in the acquisition and effective utilization of technology for industrial development. Most industries in the region still depend heavily on imported technology and equipment, and on imported technical expertise for maintenance. One of the main reasons for this problem may be the type of training given by local institutions, most of which are more or less carbon copies of foreign institutions.

Assessment of Cameroon’s Global Innovation Profile

According to the Competitive Industrial Performance (CIP) index established by UNIDO, Cameroon ranks at the bottom end of the scale, along with other low-income Sub-Saharan countries. This ranking indicates that CIP of low-income Sub-Saharan economies (Cameroon, Malawi, Uganda, Central African Republic, Madagascar, Zambia, Ghana, Tanzania, Zimbabwe and Senegal) declined between 1985 and 1998 as these economies failed to orient their production and export structures towards higher-value-added and more technology-intensive products (Schwab, 2013). The Global Innovation Index (GII) captures the multidimensional facets of innovation by measuring the innovation capacity of countries across the world and provides tools to tailor policies for promoting long-term output growth, improved productivity, and job growth (WIPO, 2015). The assessment of Cameroon’s STI capacity is summarized in Table 11. Overall, Cameroon’s STI-driven capacity development profile is poor. The WIPO (2018) report indicated that Cameroon was ranked 118 out of 138, and 111 out of 126 countries in the 2016 and 2018 global innovation index rankings, respectively.

Another useful index in assessing STI is the Networked Readiness Index (NRI), which measures countries’ capacity to leverage information and communications technology (ICT) for increased competitiveness and wellbeing. The NRI has been initiated for the Global Information Technology Report (Dutta et al., 2015) and is designed to assess the state of networked readiness of some selected economies. The NRI framework is based on six principles (Deloitte, 2012):
(i) a high-quality regulatory and business environment is critical in order to fully leverage ICTs and generate impact; (ii) ICT readiness is a pre-condition to generating impact; (iii) fully leveraging ICTs requires a society-wide effort: the government, the business sector, and the population at large each has a critical role to play; (iv) ICT use should not be an end in itself, the impact that ICTs actually have on the economy and society is what ultimately matters; (v) the set of drivers interacts, coevolves, and reinforces each other to form a virtuous cycle; and (vi) the networked readiness framework should provide clear policy guidance. The NRI framework defines a composite indicator made up of four main categories (Deloitte, 2012): environment, readiness, usage, and impact. The environment is related to political and regulatory environment, as well as the business and innovation environment. The readiness includes the infrastructure, the affordability, and the skills. As for the usage, there are indicators for individual usage, business usage and Government usage. Finally, the impact highlights the economic and social aspects. According to the 2015 Global Information Technology Report the rankings of the overall NRI 2015 showed that advanced economies are better than developing ones at leveraging ICTs. The NRI for Cameroon in 2015 was 126 out of 141 countries and in 2016 it was 124 out of 139 countries (Table 8).

Table 8. Cameroon’s Innovation Capacity Profile

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Year</th>
<th>Innovation Ranking</th>
<th>Source of Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ranking: Global Innovation Index (GII)</td>
<td>2018 ranking (out of 126)</td>
<td>111th</td>
<td>ACBF report, 2017, Annex 1</td>
</tr>
<tr>
<td></td>
<td>2017 ranking (out of 127)</td>
<td>117th</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2016 ranking (out of 138)</td>
<td>118th</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2015 ranking (out of 141)</td>
<td>110th</td>
<td>GII Rankings 2018</td>
</tr>
<tr>
<td>Network Readiness Index Ranking</td>
<td>2016 ranking (out of 139)</td>
<td>124th</td>
<td>ACBF report 2017, Annex 2</td>
</tr>
<tr>
<td></td>
<td>2015 ranking (out of 141)</td>
<td>126th</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2014 ranking (out of 141)</td>
<td>131th</td>
<td></td>
</tr>
<tr>
<td>Gross expenditure on research and development in Africa as a percentage of GDP and per capita</td>
<td>NE</td>
<td>NE</td>
<td>WIPO, 2018</td>
</tr>
<tr>
<td>GERD contribution</td>
<td>NE</td>
<td>NE</td>
<td>WIPO, 2018</td>
</tr>
<tr>
<td>Research and Development</td>
<td>2018</td>
<td>117th</td>
<td>WIPO, 2018</td>
</tr>
</tbody>
</table>

NE=

Innovation Spaces for Higher Education in Cameroon

There are a number of innovation spaces active around the country which higher education students and graduates utilize and these include: Centre for Entrepreneurship, Research and Innovation (CERI ) hosted by Catholic University Institute of Buea, ActivSpaces found in Buea and Douala, ZixtechHub found in Limbe, Agro-Hub found in Buea and Silicon Mountain found in Buea. The primary focus of these innovation spaces are on supporting pre- Incubation, Incubation and Acceleration.
The CUIB Centre for Entrepreneurship, Research and Innovation (CERI) was established in June 2011 as the business and research arm of the Catholic University Institute of Buea. The CERI focuses on Science, Technology, Engineering and Mathematics disciplines (STEM). The aim is that over time CERI will evolve into a Research Park, and supports training and development of entrepreneurs, leaders and innovators within the STEM disciplines. Further CERI is focused on fostering innovation and economic competitiveness through collaboration among national and international stakeholders from the education and research, public and private sectors.

ActivSpaces has established two co-working spaces in Douala and Buea in Cameroon, focused on supporting web and mobile developers, designers, researchers and entrepreneurs. There are a number of business models being applied, including a monthly fee for co-working space offered to freelancers and entrepreneurs, free co-working space for innovative tech start-ups, and revenue share for start-ups accepted in their six-month Activation Bootcamp (which started in January 2015). ActivSpaces is a member of the AfriLabs Network. MTN partnered with Microsoft and ActivSpaces to launch a competition from July - October 2015 to identify software developers who can support local content development. The winners received a six-month incubation period with ActivSpaces among other items. ActivSpaces has organised a number of events focused on Java and training for start-ups.

Agro-Hub was founded in 2009 based on a recognized gap of marketing and distribution infrastructure for agriculture. During 2015, it focused on inbound marketing for agriculture in Cameroon to provide content to persons wishing to buy agricultural products or invest in agriculture in Cameroon. It works with small scale farmers and buyers to support resilient and sustainable supply chains. ZIXTECH Hub was set up in 2018 as a division within Zixtech Organisation in Limbe. ZixtechHub provides co-working space and incubation services, business support as well as a 6-month incubation program. It became a member of AfriLabs in September 2018.

Another innovation space is the Silicon Mountain found in Buea. This is a privately-run center for high technology, innovation and social media that has produced groundbreaking innovations. The aim of Silicon Mountain is to assist students connect to the cyberspace to tap the latest knowledge and enhance their studies and assure success, as well as drive the country’s digital economy. The Silicon Mountain is serving as home for techies, designers, tech enthusiasts and techpreneurs from around Cameroon who are comfortable settling in Buea. Some interviewees suggest that the Silicon Mountain should be supported and sustained by the Government with the budget for “densification” of research and development and promotion of innovation.

Silicon River is another innovation space which the Government of Cameroon plans to open in Yaounde in 2030. This is in their effort in scaling up the digital economy and spurring innovations. “Every African country needs to have its own African Silicon Valley. Cameroon wants to build a silicon nation, that is to say put in together all the efforts to be number one in Africa in terms of technology and innovation,” said the Head of Department of Technological Innovations at the Ministry of Scientific Research and Innovation. The new tech hub will be modeled after the U.S. Silicon Valley and will take up a sizeable portion of the country’s budget, officials said. An inter-ministerial committee has been set up to spearhead the initiative. The Government says Cameroon Silicon River will be a platform for research and innovation that provides infrastructure and support for young, creative,
and entrepreneurial software developers and other technologists.

It should be noted that at individual university level there are ground breaking innovations taking place. A student in the National Higher Polytechnic Institute (NAHPI) in the University of Bamenda has constructed a functional ATM machine while another student in the Faculty of Engineering (FET) in the University of Buea has constructed a 3D printer from waste electronic components. The President of the Republic of Cameroon has been encouraging university students with ground breaking innovations. There is a yearly presidential prize for innovation through the Ministry of Higher Education and the Ministry of Mines, Industry and Technological Development. Also, the President of the Republic through the Ministry of Higher Education has provided 500,000 laptops to university students in both public and private Higher Education Institutions to boost innovation.

Supporting bodies for STI in Higher Education in Cameroon

Many Governmental and non-profit organizations have been established to enhance and promote the STI in Higher Education in Cameroon. Some of these are shown in Table 9.

<table>
<thead>
<tr>
<th>Name of Supporting bodies</th>
<th>Key STI Activities</th>
</tr>
</thead>
</table>
| Ministry of Mines, Industries and Technological Development | - Carry out technological development in conjunction with the Ministry of Scientific Research and Innovation.  
- Promote and defend a quality label for products meant for the local market and for export in conjunction with the administration concerned.  
- Facilitate liaison between government and the World Intellectual Property Organization (WIPO), the African Intellectual Property Organization (OAPI), as well as the United Nations Industrial Development Organization (UNIDO) in conjunction with the Ministry of External Relations. |
| Ministry of Scientific Research and Innovation | - Responsible for the development and implementation of scientific research and innovation policies.  
- Intensify the transfer function of research results to the economic sectors, promoting the culture of innovation and creating new mechanisms to finance the national research and innovation system.  
- Organize yearly editions of excellence days of Scientific Research and Innovation. |
| MIPROMALO (Local Materials Promotion Authority) | - It is a State research and innovation structure playing a leading role in the production of scientific knowledge and technological innovations on local materials to meet the demands of the Cameroonian people in search of a better life as well as our more efficient and competitive industry. |
| African Institutes for Mathematical Sciences (AIMS), Cameroon | - It is a pan-African network of centres of excellence for postgraduate education, research and outreach in mathematical sciences.  
- Its mission is to enable Africa’s brightest students to flourish as independent thinkers, problem solvers and innovators capable of propelling Africa’s future scientific, educational and economic self-sufficiency. |
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Denis and Lenora Foundation - Was established to catalyze Africa’s economic transformation by focusing on social entrepreneurship, science and technology, innovation, public health and progressive policies that create economic opportunities for all.
- The activities coalesce around the following core programs: The Health Initiative, the Small Business and Entrepreneurship, the Sustainable Development Program and the promotion of Sciences, Technology, Engineering and Mathematics (STEM).

Higher Institute for Growth in Health Research for Women (HIGHER Women) - Created to empower Cameroonian women scientists who have a motivation and inspiration for health research.
- They provide the country’s early-career women scientists with the mentoring, skills development and career planning they need to establish an enduring presence in the field of health research.

Organization of Women in Science for the Developing World, OWSD-Cameroon - Seeks to empower female scientists and promotes their access to science and technology and increase their participation in decision-making process for the development of their countries and the international scientific community.
- The activities include: setting up STEM clubs in secondary schools; collecting data on gender statistics and participation of women in STEM research; teaching and governance; advocating for policies for gender mainstreaming in science and women’s equal access to educational training and resources; and providing training and resources for women scientists, for career development and work-life balance.

Cameroon Academy of Sciences (CAS) - The main goal of the Academy is to promote the progress of science, technology, and innovation for the economic, social, and cultural development of Cameroon.

Cameroon Academy of Young Scientists (CAYS) - The main goal of the Academy is to promote the progress of science, technology, and innovation for the economic, social, and cultural development of Cameroon.

Gender Gaps in Science, Technology and Innovations in Higher Education
Despite the importance placed by UNESCO on gender equality in all fields of education especially in Science, Technology, Engineering and Mathematics (STEM) many females especially in Higher Education in Cameroon are still absent from these fields. From the Population Reference Bureau (2016), women represent a greater percentage (51) of the Cameroon population but are underrepresented in the fields of STIs. This is shown in Table 10.
The situation of under-representation of females is more profound in science and technological fields. The highest number of student enrolment by gender in the Faculties of Science, Agriculture and Engineering field in Cameroon state universities is dominated by males. The trend in evolution is shown in Figure 6 and 7. Even though in some regions of Cameroon females out number males in secondary schools, this numerical strength for females does not translate into their numerical strength at the tertiary level. Science subjects are not
considered to be among the favourite subjects of lower secondary school students. Francis et al. (2003), for example, reported that 14-year-old students had negative attitudes towards science subjects and positive attitudes to their native language. The situation is worse at the tertiary level, where most female students are found in fields of study traditionally perceived as “female territory”. These disciplines include among others, teaching, nursing and social work. In most trade training institutions, female students are found in secretarial, dress making, cookery, marketing and accounting programs; while the males dominate in mechanical and crafts areas. The gender gap is more in engineering and technology fields. At the Higher Education level, females appear to lose interest in science, technology and innovation, and continue to drop out of STI related disciplines. With Cameroon intending to have an emerging economy by 2035, which requires a scientific and technological foundation, this may not be feasible if half of the population (female) continue to pursue careers only in the social and service sectors. This has been a concern in Cameroon’s Public Policy Framing where some initiatives have been undertaken to encourage and motivate more girls to science related subjects. For example, the Ministry of Scientific Research and Innovations, initiated an innovation prize in 2018 during the 6th edition of the Excellence week for scientific research and innovations. This project “Youth’s Innovation and Research”, was aimed at motivating the youths especially the females into science oriented professions. Also, the Perl Foundation in August 2015 launched a one-month program to train women and girls on introduction into computer science using the python programming language. The course was massively attended by many women and girls in the city of Bamenda in the North West Region of Cameroon.

Figure 6. Statistics on gender gaps in student enrolment in the Faculties of Science in Cameroon State Universities
Globally, there is an indication that there is gender imbalance of STEM students in Higher Education. According to UNESCO’s report, female students represent 35% in STEM related specialisation in Higher Education. It goes further to state that the highest gap is seen in Information Management and Technology where only 3% of female students register in the field, 20% are software developers, 7.4% as construction managers and 24.8% are in technological agriculture. These statistics portray that these fields are male dominated because of one reason or the other. According to UNESCO Institute for Statistics (2015) only 10% of female students were enrolled in STI related fields in the tertiary level in Cameroon. The gender gap in Cameroon is felt more in engineering and technology fields, as shown in the case of University of Buea (Table 11).

### Table 11. Statistics showing gender gap on student enrolment in Technology related fields at the Faculty of Engineering and Technology in University of Buea

<table>
<thead>
<tr>
<th>Programmes</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Engineering</td>
<td>46</td>
<td>168</td>
<td>214</td>
</tr>
<tr>
<td>Power Systems</td>
<td>55</td>
<td>325</td>
<td>380</td>
</tr>
<tr>
<td>Software Engineering</td>
<td>04</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>Telecommunication and Network</td>
<td>10</td>
<td>26</td>
<td>36</td>
</tr>
<tr>
<td>Total</td>
<td>115</td>
<td>539</td>
<td>654</td>
</tr>
</tbody>
</table>

Ministry of Higher Education 2018 Annual statistics (July 2020)
Looking at technology in Higher Education especially with reference to Information Communication and Technology (ICT), Castaño et al. (2011) explained that the gender digital divide is a gap between men and women in the intensity of the use of computer and internet connection as well as in the participation in the basic uses of the internet. They indicate that this kind of segregation could be measured through equality and ICT indicators. In the Cameroon context very few female students are enrolled in Computer Sciences.

Sikora (2014) explored gender patterns in the participation in school science subjects and in adolescent career preferences. In secondary schools, of the students drawn to science careers, boys are four times more likely than girls to be attracted to occupations related to physical science subjects such as physics, mathematics, engineering and computing, while occupations related to life science subjects appeal to twice as many girls as boys. González et al. (2017) indicate that the relationship between women and technologies has historically been reduced to an image of phobia towards technology, which defames women as being against the use of technologies. These differences stem from diverse factors. Anker (2020) distinguishes between two forms of occupational segregation by gender: one horizontal and the other vertical. The first type of segregation refers to the role assignment imposed by the sex division of labour, which encourages women to join the healthcare, social, educational, administrative and commercial retail sectors (Rubio, 2008). The second type of segregation refers to the limitations that prevent women from moving upwards in the corporate hierarchy. This situation also presents itself in the Cameroon Higher Education sector especially in relation to the academic staff whereby out of 1175 teaching staff of faculties related to STI in some state universities, only 199 of them are women as seen on Table 12.

Challenges of gender participation in Higher Education

A lot of issues and factors have been identified to influence gender differentials and low participation in Science Technology and Innovation related fields worldwide and in Cameroon in particular. Literature from diverse sources has indicated that some of the causes of gender gaps and challenges in STI in Higher Education include gender stereotypes/biases, cultural believes, sex-role (gender-role) socialisation, educational, religious, psychological, individual characteristics, lack of female mentors and models. According to Home (2002), factors responsible for the low participation of females in science, technology, engineering and mathematic fields are attitudes and expectations of parents, teachers and instructional strategies. Fielding (2014) reiterates that while the attraction, education and retention of women in science, engineering and technology are deemed vital to the socio-economic development of all countries, many women and girls in sub-Saharan Africa countries such as Cameroon are excluded from participating in science and technology activities by varied factors such as poverty, lack of education and aspects of legal, institutional, political, and cultural entrapments. Research findings have indicated that gender differentials in Higher Education are invariably rooted in inequalities nursed at the primary and secondary levels where the process of scientific interest is to be established to blossom at the university (Aguele and Uhumuavbi, 2003). These inequalities include traditional and religious beliefs, remoteness, poverty, child labour, social roles required for the different sexes, argument about biological build-up of women and birth order. Some other factors that have been identified by Ifeluni (1997) include lack of support from education policy makers, different socialization patterns for boys and girls at early stages of life, early marriages, and teachers’ attitude towards girls.
Table 12. Statistics on gender gaps among the teaching staff in STI related fields in Cameroon State Universities

<table>
<thead>
<tr>
<th>Name of university</th>
<th>Institutions</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Bamenda</td>
<td>College of Technology (COLTECH)</td>
<td>12</td>
<td>37</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Faculty of science (FS)</td>
<td>19</td>
<td>54</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>National Higher Polytechnic Institute (NAPI)</td>
<td>02</td>
<td>09</td>
<td>11</td>
</tr>
<tr>
<td>University of Buea</td>
<td>College of Technology (COLTECH)</td>
<td>00</td>
<td>07</td>
<td>07</td>
</tr>
<tr>
<td></td>
<td>Faculty of Science (FS)</td>
<td>34</td>
<td>87</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>Faculty of Engineering and Technology (FET)</td>
<td>02</td>
<td>09</td>
<td>11</td>
</tr>
<tr>
<td>University of Douala</td>
<td>Faculte De Genie Industriel (FGI)</td>
<td>4</td>
<td>32</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Faculte Des Sciences (FS)</td>
<td>25</td>
<td>107</td>
<td>132</td>
</tr>
<tr>
<td></td>
<td>Institut Universitaire Des Technologies (IUT)</td>
<td>10</td>
<td>36</td>
<td>46</td>
</tr>
<tr>
<td>University of Dschang</td>
<td>Faculte Des Sciences (FS)</td>
<td>18</td>
<td>137</td>
<td>155</td>
</tr>
<tr>
<td></td>
<td>Institut Universitaire Des Technologies Fotso-Victor</td>
<td>13</td>
<td>176</td>
<td>189</td>
</tr>
<tr>
<td>University of Maroua</td>
<td>Ecole Nationale Superieure Polytechnique De Maroua (ENSPM)</td>
<td>13</td>
<td>72</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>Faculte Des Sciences (FS)</td>
<td>12</td>
<td>60</td>
<td>72</td>
</tr>
<tr>
<td>University of Yaounde 1</td>
<td>Faculte Des Sciences (FS)</td>
<td>27</td>
<td>107</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>Institut Universitaire Des Technologies (IUT)</td>
<td>08</td>
<td>46</td>
<td>54</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>199</td>
<td>976</td>
<td>1,175</td>
</tr>
</tbody>
</table>

Ministry of Higher Education 2018 Annual statistics (July 2020)

Gender role and Stereotyping
Gender stereotype contributes enormously to the low level of female representation in STI related fields in Higher Education. This stereotypical thinking creates the impression that some particular fields of study especially science and technology are good only for men. The stereotypical challenges faced by the female gender in participating and learning science courses are universal as Donaldson et al. (2008) posit. Madara and Cherotich (2016), reiterate that gender stereotypes restrain female students from incorporating into the science fields and achieving their fullest potential. Starovoytova and Cherotich (2016) on their part state that, when science-stereotype and gender-stereotype collide, females are made to see science as ‘too hard, noisy, dirty and to an extent a masculine profession’. These stereotypes limit women to some tasks like web page design, database maintenance, and computer security programming. The stereotypes therefore prevent most females from performing other professions such as those related to hardware or those with more responsibilities like computer designing, because they are considered more characteristic of the masculine gender, due to their strength (Fountain, 2000). In Cameroon a study carried out among female students of the Faculty of Arts at the University of Bamenda (UBa) indicates that some students preferred Arts oriented careers like teaching and school counselling to
science oriented careers so as to have enough time for their family businesses (Wiysahnyuy, 2020). Some of the UBa students said they were interested in certain science oriented careers but were in a state of dilemma because they believed some careers like engineering were male inclined.

**Lack of intrinsic motivation**

Another challenge related to gender participation is based on individual lack of intrinsic motivation, interest, attitude, self-confidence and perception of STI related courses or fields for female aspirers. This shows that female students have preferences for some science subjects which they perceive to be easier and void of calculations. Sánchez-Vidal (2016) confirms that the lack of confidence in one’s own competences justifies this gap given that women think they are less valid than their male counterparts. Moreover, greater resistance is observed in the use of technologies in some women, which hinders their professional learning and training compared to their male counterparts. This ‘technophobia’ translates into negative behaviour towards machines that always seem difficult to operate, bad, slow or boring. This situation is not different with female students and workers in institutions of higher learning in Cameroon, where women shy away from fields like computer science and engineering because of phobia on the operation and maintenance of the technological gadgets. In a review of students’ attitudes towards science, Osborne *et al.* (2003) state that interest and experience are important dimensions to elaborate in order to make school science more engaging for young people and to make more students to study sciences. There are important differences between girls and boys to consider, but within science-oriented education there are few studies concerned with the student perspective (Francis and Greer, 1999; Brok *et al.*, 2005; Jenkins, 2006). This is also the case in Cameroon where very scanty literature or research has been carried out on students’ perspective on Science, Technology and Innovations especially in Higher Education. It has also been realised that teachers’ expectation and teaching methods contribute to gender gap among students in Higher Education. According to Aguele and Uhumuavbi (2003), female participation and interest in STEM diminishes as they move up in the educational ladder towards the university level due to a variety of factors that are primarily related to teachers’ expectations.

**Lack of role models**

According to Botella *et al.* (2019), one of the main reasons for low representation in STI is the lack of visibility of women already working in the technological world. This discourages other women from enrolling in these fields. This trend decreases the percentage of women, which also reduces their support network and can cause workplace dissatisfaction to arise in the end. Generally, role models are always very influential in students’ choice of fields of study, therefore the fact that students do not really see females who have succeeded in some fields of sciences and technology discourages them from enrolling in these fields. The Minister of Higher Education in Cameroon indicates that women constitute only 7% of professors in Cameroon and not all of them are in the Sciences. This number may discourage female students to strive to get to these levels, though there are a few female models in STI who have been serving as models and mentors to young girls and female early career researchers. We have the example of Prof. Rose Leke who made her mark in the 1990s by investigating the immunology of parasitic infections, particularly malaria and has become an international leader and mentor to female youths and women scientists especially in Cameroon. Other female scientists who have been mentoring young female scientists in Cameroon are Prof. Theresia Nkuo-Akenji and Prof. Uphie Chinje Melo, among others. Though these female professors are sources
of inspiration to young female scientists in Cameroon, it should be noted that they are more into the biological and medical sciences.

**Lack or inappropriate career orientation**
The low representation of female students in STI in Higher Education is also related to the lack or inappropriate career orientation in secondary schools and during the admission process into the Universities. According to Wiysahnyuy (2020) in her study on Career dilemmas among female students of the faculty of Arts in UBa, some female students indicated they had interest in science subjects but due to lack of orientation, they went in for the Arts. This suggests that these students had little or no career orientation before and during their admission into the university. Cameroon graduates many School and University Counsellors annually. It is important that these counsellors are put to use appropriately rather than being posted into the classroom or appointed to unrelated services in ministerial departments as obtains currently.

**Sexism**
Sexism is also identified as one of the reasons female gender faces challenges in participating in science fields. Sexism often portrays the female gender as one made to follow and not to lead in the science fields (Seymour, 1995). It may be possible that in Cameroon, illiteracy and lack of orientation have limited parental exposure, girl child and caregiver exposure to the relevance of not only encouraging the girl child to be educated, but to undergo science studies in higher institutions. Looking at the African context, most science successful females are seemingly not dating, not engaged and definitely not married mostly because their perceived success tends to scare away the male gender (Bowman and Brundidge, 2013). This tendency discourages some girls and women especially in Higher Education not to enrol into STI fields which demand many years of education. However, with recent innovations and campaigns run by the UNESCO, their understanding of the importance of educating girls is on a rise (Kiluva-Ndunda, 2001).

**CONCLUSION**
Cameroon lacks a clear Higher Education policy on STI. As the industrial revolution enabled the countries that efficiently embraced it to grow rapidly, advancements in STI remains today the key to economic development and sustainable growth. Clearly, STI education is critical to Cameroon which seeks to become an emerging country by 2035, as STI education is the key foundation to technological development and innovation. It is only by investing in the advancement of STI through a new education strategy that focuses on the development of a highly skilled workforce that the full growth potential in Cameroonian’s Higher Education can be unleashed. It is therefore evident that for the country to attain higher middle-income status by 2035 it must actively engage in the training of highly skilled STI professionals who will power the economic transformation of the country in the foreseeable future.

Despite the importance of STI in the national development, there exists a gender gap in science, technology and innovations education; female students are underrepresented in science and technology programmes in higher institutions of learning. Cameroon, one of the countries which has a strategic development plan to mature by 2035 is faced with an endemic dearth of female actors in STI ecosystem. Extant literature has presented divergent and convergent factors that suggest reasons for the underrepresentation of females in STI fields like computer sciences, Physics, Mathematics and Engineering despite government efforts to encourage female participation in these fields. The factors that coincidentally transcend spatial settings and culture are related to parental pressure, gender role socialisation and stereotypes, interest patterns, perception motivation, societal beliefs and practices, socio-cultural practices, socio-economic conditions, school-environment
conditions and institutional policy practices. On the other hand, differences are visible between developed and underdeveloped settings or milieus where counselling services are more efficient and focused on the demands of the job market. Any efforts directed towards promoting and achieving sustainable female participation in science and Technology would require multiple perspectives and multi sector approaches including policy changes to correct these shortcomings in the society.

RECOMMENDATIONS
This review finds that many of the building blocks for fostering STI development include universities, research institutes, and a growing private sector already in place in Cameroon. However, the STI system does not focus sharply enough on Cameroon’s socio-economic needs and STI is not clearly stated in Higher Education policy. Funding allocations for STI are determined by the Government and external funding agencies and often do not relate to the priorities of research institutions and universities, and much less to those of the private sector, farmers and informal enterprises. The spirit of cooperation underpinning the STI in Higher Education represents a constructive way forward for Cameroon as it seeks to strengthen its development agenda by incorporating science, technology and innovation. From the analysis, the data showed that there is a great need for more investments in upgrading the skills of all those involved in STI. The recommendations presented in this review to strengthen STI in Higher Education in the national, regional and international levels focus on funding, human capital, capacity building and infrastructural investments, among others.

National Recommendations
1. Policy for STI in Higher Education should be designed to increase the number of students and lecturers involved in the study and application of Science, Technology and Innovation. The Ministry of Higher Education should institute regular STI scholarship and award for students, lecturers as well as all Higher Education Institutions that will stimulate scientific advances that are of national interest.

2. Cameroon needs to increase capacity support for the development of STI in Higher Education through international partnerships and linkages among researchers, academia, government, industry, and civil society actors. Higher Education Institutions in Cameroon should invest more effort in building capacity, and networking among institutions of education in STI should be intensified.

3. The Government of Cameroon through the ministries of Higher Education and that of Post and Telecommunications should ensure widespread Internet access, and where possible provide free Wi-Fi and uninterrupted power supply especially at technology hubs, university campuses and medical facilities.

4. At an early educational level, there should be the encouragement on the establishment of many STI programmes for primary school pupils and the creation of STI clubs for secondary and high school students to increase exposure to various STI careers. Various STI camps and competitions should be encouraged for secondary education students especially during the long holidays.

5. Formal partnerships should be established between the business community and higher education centers especially national polytechnics. Specifically, GICAM and the Chamber of Commerce in Cameroon should have specific roles in this process. Knowledge gained through research (either public or private) must be shared with industry to change the economy of Cameroon from a consumption economy to an economy that transforms raw material as well as ideas into refined products.
6. Cameroon should set up sustainable financing mechanisms for STI. The private sector and development partners should support and complement the Government’s efforts by providing funding, investing in critical skills (education, training and so on). The budget for Research and Innovation (related to STI) should be significantly increased over the next five years to be similar to that of emerging economies like South Africa. The research focus should include digital economy, small and medium size enterprises, agriculture and health to name but a few.

7. Technology transfer should occur in HEIs, and as such, universities must equip themselves with technology transfer offices that will help draft sound policy and contract templates, do all the paper work (contracts and files to protect any intellectual property) but also train all researchers on technology transfer related issues so as to make sure there is always a win-win contract whereby universities, researchers and industry benefit.

8. The Government should increase the quota of women in STI related fields during University recruitment. This will enable them to serve as models to young female scientists in the Universities and in their various communities. This should also be considered during the competitive entrance examinations into various teacher training colleges especially in physics, mathematics, computer sciences and engineering fields. After training, these female teachers will act as role models in secondary and high schools especially to those who perceive science and technology as male dominated fields.

9. From the review of literature, there is evidence that insignificant research has been carried out on gender participation in STI in Cameroon especially in Higher education in relation to students’ perspectives, teaching methods and teachers’ expectation. More research should be carried out in this direction. This will help to orientate the policy makers and all education stakeholders on the various strategies or actions to put in place to enhance gender balance in this sector of education. The Ministry of Higher Education should come up with action-oriented research projects on gender participation in STI, and select and sponsor researchers who will carry out these projects to enhance policy implementation.

10. The Government should ensure that school counsellors participate in the admission processes of students into the Universities. Since admission into most of the universities takes place online, students should also be provided with online counselling before they select their fields of study. When the students are eventually admitted, there should be rigorous follow up by school counsellors and mentors to make sure they do not drop out.

11. Although the mentoring programme is already going on in Cameroon, there is need for it to be extended to secondary education and to work in collaboration with the school counsellors to ensure the continuation of STI education of female students at the tertiary level. Also role model motivational talks should be given to female students in Higher Education.

12. Higher institutions of learning in Cameroon should organize workshops, seminars and conferences showcasing women in STI accomplishments as this will go a long way to imbue confidence in female students in the STI fields. Some of these could be done during the commemoration of the women’s day activities in Cameroon. The Ministry of Social Affairs, Secondary and Higher Education should come out with educative, mentoring and sensitization programmes for girls and women in STI fields.

13. Literature has shown that there are some aspects of the curriculum in relation to STI which are gender bias especially in secondary schools. If female students start perceiving the content of STI subjects to
be masculine in nature it will obviously affect their enrolment into these fields. Therefore, the Ministry of Secondary Education should modify the curriculum to make it “gender free” curriculum that attracts both sexes to the technical fields. This will enhance continuation into higher education. In addition, they should provide broader opportunities for female students to take the technical education primarily in the industrial field which has few female students. This is critical to reduce gender imbalance in the technical fields and to provide a broader non-traditional programme for female students.

**Regional Recommendations**

1. In pursuing STI-driven development, African governments must make serious commitments to develop human and institutional capacities by investing substantially in high quality universities, state of the art equipped and maintained laboratories, ICT infrastructure, and research funding mechanisms.

2. Regional bodies such as members of Central Africa States should design mobility programs for scientists and engineers, foster regional university collaborations, encourage public–private partnerships across national borders, and facilitate the adoption of regional intellectual property rights protection frameworks.

3. African countries need to enhance regional cooperation and adopt a coherent framework of cooperation between governments, scientists, universities, policymakers, the private sector, and civil society. They should increase investment in STI in higher education, and research and development, while encouraging partnerships between public and private institutions.

4. Prescription of textbooks used in teaching in Cameroon and Africa should be censored and should not only portray images of ‘White’ males as successful in science and technology fields especially in terms of mathematical sciences, operation and maintenance of machines.

5. RUFORUM (The Regional Universities Forum for Capacity Building in Agriculture) should work in collaboration with the Government of Cameroon to give scholarships to outstanding female students from diverse fields of STI to study in other African countries with better facilities.

**International Recommendations**

1. Science, Technology and Innovation and Higher Education policies in Cameroon should be aligned with long term International policies to enable the nation to attract the required support for implementation. There should be an increase in attention to the international dimension and provision of more opportunities for cross-cultural research and exchange in the learning environment. Exchange visits of female mentors and models should be used in order to encourage female students to enroll in STI related fields.

2. Cameroon must build strong partnerships with governments and organizations around the world given that the production of knowledge and technology has become increasingly global and interconnected. Universities in Cameroon need to establish new connections and strengthen existing partnerships with universities in countries such as India, China, Brazil, the Republic of Korea, United States and European countries.

3. There is a need for a coordinated collective effort (from skills surveys and diagnostic analysis) to be mounted across countries to identify the critical STI skills essential for Cameroon’s economic growth and the current gaps depending on its resource endowments and national development plans. This exercise should involve the Government, the private sector and academia. Cameroon should close the STI
investment gap with the developed world.

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STATEMENT OF NO-CONFLICT OF INTEREST
The authors declare that there is no conflict of interest in this paper.

REFERENCES


Current statistics in Science, Technology and Innovation in higher education in Cameroon


Starovoytova, D. and Cherotich, S. 2016. Female Underrepresentation in Undergraduate Education: Case study in School of Engineering. Research on Humanities and Social Sciences, ISSN 2224-5766 (Paper), ISSN 2225-0484 (Online), Vol.6, No.14


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Strengthening Higher Education and Science, Technology and Innovation in DRC

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ABSTRACT
The state and quality of education of a country is strongly and positively correlated to its economic development. It contributes to building the workforce of knowledge-based progressive societies. Sub-Saharan Africa has experienced a proliferation of Higher Education Institutions (HEIs) particularly, private HEIs in the last two decades. The quality of the private universities is variable across the continent and dependent on the existence and level of implementation of the legislative requirements, the quality of governance at the HEIs, quality of the infrastructure and student recruitment. The Democratic Republic of Congo (DRC) is a signatory to the Southern African Development Community (SADC) Protocol on Higher Education and Training, and has acknowledged the role of higher education in national and regional development and the importance of a regional higher education system. The country has experienced two decades of instability which has impacted several sectors of its economy, including its education sector. For the last two decades, limited statistics has been published concerning the status, investment and challenges facing the sector. This information is important in designing appropriate strategies for enhancing the impact of this sector to the national and regional economy. Therefore, the objectives of this study were to i) review the current statistics (including investment) available on Higher and Technical Education in DRC, with a focus on those relating to Science, Technology and Innovation; ii) establish key challenges for Higher Education; and, ii) make recommendations for strengthening the sector and to inform future initiatives in higher education to be considered by RUFORUM and DR Congo Government in engaging with partners at national, regional and international levels. The results show that there is unequal distribution of HEIs across the provinces of DRC; with high concentration of HEIs in Kinshasa, North and South Kivu. The majority of the HEIs are offering Technical training (IST) (52.1%) followed by University training (31%). Pedagogical training (ISP) only represents 16.9% of the HEIs. There is a relatively higher number of public ISP and IST compared to the private HEIs, and relatively a higher number of private HEIs than public HEIs. The majority of HEIs, particularly the private HEIs are largely dependent on family funding. Student enrolment has increased gradually in both public and private HEIs (p<0.05), diluting significantly the government per student resource allocation. The country still has very few PhD holders who are mostly localised in a few HEIs. The sector is facing various challenges including, limited academic autonomy in selecting leaders and designing programme curricula, proliferation of HEIs, and a plethora of administrative staff both in the ministry and in the HEIs. Additionally, Research and Development (R&D) is mainly conducted by HEIs and government research centres in isolation because the national
innovation system is dysfunctional. Indeed, for the last three decades, R&D and STI have been marginalised.

Key words: DRC, Higher Education Institutions, investments, students’ enrollments

RÉSUMÉ
L’état et la qualité de l’éducation d’un pays sont fortement et positivement corrélés à son développement économique. L’éducation contribue à constituer la main-d’œuvre des sociétés progressistes fondées sur le savoir. L’Afrique sub-saharienne a connu une prolifération d’établissements d’enseignement supérieur (EES), en particulier d’établissements d’enseignement supérieur privés au cours des deux dernières décennies. La qualité des universités privées est variable à travers le continent et dépend de l’existence et du niveau de mise en œuvre des exigences législatives, de la qualité de la gouvernance des EES, de la qualité des infrastructures et du recrutement des étudiants. La République démocratique du Congo (RDC) est signataire du Protocole de la Communauté de développement de l’Afrique australe (SADC) sur l’enseignement supérieur et la formation, et a reconnu le rôle de l’enseignement supérieur dans le développement national et régional et l’importance d’un système régional d’enseignement supérieur. Le pays a connu deux décennies d’instabilité qui a affecté plusieurs secteurs de son économie et notamment son secteur de l’éducation. Au cours des deux dernières décennies, des statistiques limitées ont été publiées sur les investissements et les défis auxquels le secteur est confronté. Ces informations sont importantes dans la conception des stratégies appropriées visant à renforcer l’impact de ce secteur sur l’économie nationale et régionale. Par conséquent, les objectifs de cette étude étaient de i) passer en revue les statistiques actuelles (y compris les investissements) disponibles sur l’enseignement supérieur et technique en RDC en mettant l’accent sur celles relatives à la science, la technologie et l’innovation; ii) définir les principaux défis pour l’enseignement supérieur et iii) faire des recommandations pour renforcer le secteur et informer les futures initiatives dans l’enseignement supérieur à prendre en considération par le RUFORUM et le gouvernement de la RD Congo en s’engageant avec des partenaires aux niveaux national, régional et international. Les résultats montrent qu’il existe une répartition inégale des établissements d’enseignement supérieur entre les provinces de la RDC; avec une forte concentration d’EES à Kinshasa, Nord et Sud Kivu. La majorité des EES offrent une formation technique (IST) (52,1%) suivie par les universités (31%). Les EES de formation pédagogique (ISP) ne représentent que 16,9% des EES. Il existe un nombre relativement élevé de FSI et de TSI publics par rapport aux établissements privés, et un nombre relativement élevé d’établissements d’enseignement supérieur privés par rapport aux établissements publics. La majorité des EES, en particulier les EES privés, dépendent largement du financement familial. Les inscriptions d’étudiants ont augmenté progressivement dans les EES publics et privés (p <0,05), diluant de manière significative l’allocation des ressources gouvernementales par étudiant. Le pays compte encore très peu de titulaires de doctorat, principalement localisés dans quelques EES. Le secteur est confronté à divers défis, notamment une autonomie académique limitée dans la sélection des dirigeants et la conception des programmes, la prolifération des établissements d’enseignement supérieur et une pléthore de personnel administratif tant au ministère que dans les établissements d’enseignement supérieur. La R&D est principalement menée
par les EES et les centres de recherche gouvernementaux de manière isolée, car le système national d’innovation est dysfonctionnel. Au cours des trois dernières décennies, la R&D et la STI ont été marginalisées.

Mots clés: RDC, établissements d’enseignement supérieur, investissements, inscriptions d’étudiants

BACKGROUND
It is currently recognised that sustainable economic development is positively and strongly correlated to the quality of education and training delivered in a country (UNESCO, 2006; Bloom et al., 2014). Education helps to build societies and build the workforce that will contribute to sustainability agendas (Martin and Jucker, 2005). According to Saint (2009), education institutions serve as power houses for the production of progressive work force in a country, hence prepare citizens to participate in all walks of life. According to Salazar-Xirinachs et al. (2014) “Learning builds up dynamic capabilities which are key drivers of catching up and economic development”. Education also contributes to the development of competitive, integrated and knowledge-based progressive societies (Von Tunzelmann and Wang, 2007), production of competent civil servants for effective running of the different sectors of life including government responsibility, business management, providing law and justice, banking, etc. Education has been useful in creating awareness on the concept of sustainability (Rowe, 2010; Weissman, 2012). In so doing, its role in shaping the way in which future generations will cope with the complexities of economic growth is not disputable. Higher education institutions (HEIs) contribute to providing the knowledge required for development. The HEIs are essential for design and productive use of new technologies, and providing foundations for a nation’s innovative capacity (Carnoy et al., 1993; Serageldin 2000; Pillay, 2010). However, their participation rates in developing countries has remained very low, particularly in sub Saharan Africa, where the rate of participation was estimated to be less than 5% (Bloom et al., 2006).

The higher education enrolment growth has, however, been phenomenal, with some national systems in Africa expanding more than ten-fold since 2000 (Kruss et al., 2015). Very few public universities have been created; but a proliferation of private (totally or partially) universities has been observed in several SSA countries. Three types of private universities have been operating across the SSA region. These include the State supported universities that receive some form of support from the State and regulated by State authorities. The second category are the non-profit private universities operated by trusts and relying on the students' fees. The last category are the universities which were established for profit. These universities have proliferated from the beginning of 1990s (Varghese, 2004) and are outnumbering the public universities in several countries. The quality of the private universities is variable across the continent and is dependent on the existence and level of implementation of the legislative requirements, the quality of governance at the university, the quality of infrastructure and student recruitment procedures and rates.

Any SSA nation that aspires to develop and improve the well-being of its citizens must, therefore, take its human capital investment seriously (Oketch, 2016), and support learning processes to develop dynamic technological capabilities at all levels (Salazar Xirinachs et al., 2014) for their economic development. Science and technology links and knowledge exchange with universities, research organisations
and other organisations are critical for technological capability building, but equally so are linkages to those organisations or actors that build the skills required at all occupational levels of the firm. In this regards, institutions organising Science, technology, engineering, and mathematics (STEM) programmes and/or Technical and Vocational Education and Training (TVET) are important in impacting the required scientific and technical skills. Universities involved in STEM training have remained very few in SSA, exposing the region to the dual challenge of recruiting and retaining diverse talents and ensuring that trainees receive the necessary STEM skills and resources to effectively compete and interact with their peers worldwide (Okeke et al., 2017). Also, despite the tremendous success registered in TVET training across the region, several transverse challenges affect the TVET training in SSA, including the quality of the teacher training, the curriculum of TVET schools and the adequacy of the infrastructure.

Moreover, the enrollment rates for higher education in Sub-Saharan Africa, though still the lowest in the world, have tremendously increased over the year, putting enormous pressure on public HEIs which in most cases were created during the colonial period (Bloom, 2005). The low enrollment in the region was attributed to the fact that the international development community had encouraged the African governments to put more emphasis on the lower level, as they believed that tertiary education was less important for poverty reduction (Bloom, 2005). The emergence of a highly competitive, globally integrated, knowledge-driven world economy has played a key role in reshaping this conventional belief and has boosted the enrolment in higher education across the region.

Financial investment to education in Africa, however, has remained very low. For example, between 1995 and 2005, only about 0.78% of the continental gross domestic product was invested in education, despite the fact that the enrolment had tripled (World Bank, 2010). Only about a fifth of its current public expenditure on education is dedicated to post-school education (World Bank, 2010). The mismatch between annual rate of enrolments and the public resources expenditure leads to a rapid decline in public expenditure per student. The situation is very alarming in the poorest countries and countries emerging or still in conflicts. Very limited funds are allocated per student and more resources are allocated to more compelling sectors including national security and military expenditure.

The Democratic Republic of Congo is a signatory to the Southern African Development Community (SADC) Protocol on Higher Education and Training, and has acknowledged the role of higher education in national and regional development and the importance of a regional higher education system. The country has experienced two decades of instability which has impacted several sectors of its economy, including its education sector. For the last two decades, limited statistics has been published concerning the status, investment and challenges facing the sector. Yet this information is important in designing appropriate strategies for enhancing the impact of the sector to the national and regional economy. The objectives of this study were to i) review the current statistics (including investment) available on Higher and Technical Education in DRC with a focus on those relating to Science, Technology and Innovation; ii) establish key challenges for Higher Education, and iii) make recommendations for strengthening the sector and to inform future initiatives in higher education to be considered by RUFORUM and DR Congo Government in engaging with partners at national, regional and international levels.
STUDY METHODOLOGY

Country context. DRC is geographically the second largest country in Africa and the largest in Sub-Saharan African (SSA) with its 2.345 million sq km. With an estimated population of 85 million, it is the third largest SSA population behind Nigeria and Ethiopia. The country has been subdivided into 26 administrative provinces since 2006 (Dunia and Zongwe, 2019). About 40% of the country’s population is located in three provinces namely Katanga, Kinshasa and Bandundu. The major cities include the capital Kinshasa, Lubumbashi, Mbuji-Mayi and Kisangani. The population of the DRC is dominantly young, with about 45% of its population below the age of 15. About 50% of its population is female. The fertility rate is at 6.2 births per woman, one of the highest in the world (UN, 2015). The large youth composition renders the education sector a key focus area for the development agenda of the country and in ensuring young Congolese are able to fully participate in the economy.

Humanitarian context. The country has experienced several years of armed conflicts, particularly in both Kivu provinces (South and North), inter-ethnical clashes in Ituri and Mitumba regions, the Kamunia Nsapu clashes in the Kasai region and the conflict in Mai-Ndombe. Millions of people have been internally displaced creating more pressure on existing infrastructure (schools and health related) in the host localities. In addition, the country has also faced several episodes of Ebola virus outbreak in North western and Eastern parts of the country. According to the Humanitarian Response Plan (HRP) of 2017 – 2019, about 15% of the population of DRC need humanitarian assistance, and about 60% of them are children. The situation has been aggravated by the pandemic of COVID-19 which has affected activities in most of the major cities of the country.

Socio-economical. DRC natural, mineral and energy resources potentials contrast with the scale of poverty of the majority of its population. About 16 million people are food insecure (UNDP, 2018). In 2017, the per capita income averaged US$ 458 and with a GDP growth rate of about 3.7% (Central Bank of Congo, 2016). More than 70% of the population lives below the poverty line. The multidimensional poverty indices that measure the intensity of household deprivation in the areas of education, health and standard of living, show that more than 50.8% of the Congolese population would still live in multidimensional poverty, nearly 36.7% would be in severe multidimensional poverty, and about 18.5% in a situation close to multidimensional poverty (UNDP, 2016). This shows that poverty reduction requires a strong growth-oriented economic policy (at least 10-12% per year for ten years), coupled with a satisfactory distributive policy, in order to realistically halve the poverty status by 2030.

Structure of pre-university education. Since 1990, all DRC citizens have the right to equal access to education and vocational training. Public education is “free and basic education is compulsory”. The right to establish private schools is subject to the approval by the line Ministries; namely le ministère de l’Enseignement primaire, secondaire et technique (MEPST), le ministère de l’Enseignement supérieur et universitaire (MESU) et le ministère des Affaires sociales, action humanitaire et solidarité nationale (MAS). According to the World Bank, the primary school completion rate stood at 72.8% in 2012 (World Bank, 2014).

The secondary school consists of two tracks: the long cycle and the short cycle. The long cycle is also referred to as formal secondary education, while the short cycle is the technical vocational education/training (TVET). The formal secondary education (FSE) lasts six
years and leads to higher education after the final State exam. The FSE starts with two years of common training (tronc commun) before the pupils are split into three major streams – general, teacher education, and technical of four years (Bashir, 2009). There are several options within each stream; the four-year programme is divided into scientific (biology and chemistry and mathematics-physics), pedagogical (psychology and pedagogy), literature (Greco-Latin) and technical (general mechanics, electronics, electricity, and arts).

**School enrolment in pre-University education system.** Generally, the school enrollment rate has increased in the country at all education levels. (MINEPSP/CTSE, 2013). In 2010, the gross enrolment ratio was at 41.1% for both male and female secondary school students, with male students (51.2%) having the highest enrolment ratio compared to 30.13% for female students (http://uis.unesco.org/en/country/cd). These rates have increased at 0.88% and 1.1% per year for male and female students, respectively.

**Structure of higher education system.** The higher education sector was designed by the Belgians as a copy of their system. French is the language used for instruction and the academic year runs from September to June. The Higher education system in the DRC is run by the “Ministere de l’ Enseignement Superieur et Universitaire (MESU). Private higher education in the DRC was first established in the early 1990s, when the government authorized private institutions to operate. The number of private institutions has risen significantly over the years with the proportion of students’ enrollment in institutions of higher education, growing over the years. Traditionally, the non-university HEIs were supposed to train in specific domains, however, recently, several of them have started adding new courses on their curriculum, and many have been raised to the rank of Universities. Most of HEIs offer two cycles of training, the first cycle is of three years and sanctioned by “a diplome de graduat”. The second cycle is generally for two years honored by a “diplome de licence”. The third cycle leads to “a diplôme d’études approfondies”, whose duration varies between 2 and 3 years. In principle, the third cycle is organized in the three major universities of DRC (University of Kinshasa, University of Lubumbashi and University of Kisangani). Other HEIs create linkages with these three universities, in form of doctoral schools to be able to train their staffs for the third cycle.

**Job market.** According to recent data from the Ministry of Labour, the underemployment rate exceeds 50 % and the youth unemployment rate (15-24 years) exceeds 35%. The employment structure remains dominated by informal jobs, which accounts for almost 88.6 % of employments, of which, 59.7 % are in agricultural related fields. The labour force is estimated at 65 % of which 58 % comprises of the 15-34-year age group susceptible to migration. This trend is the same in urban as well as in rural areas. The unemployment rate (in the sense of the International Labour Office – ILO) is 3.7 or 11.38 % in the broad sense. Since 2001, despite the beginning of a period of economic recovery through a revival of bi-and multilateral cooperation and the implementation of macroeconomic programmes, satisfactory economic results have not helped to reduce poverty and unemployment. The growth rate (8.9 %) has been insufficient to reduce poverty (71.3 %) and to fill jobs whose level of creation is lagging behind the growth of the national economy.

**Enabling environment.** The Development Strategy for Primary, Secondary and Vocational Education for the five-year period 2010 - 2016 is in line with the guidelines of the World Education Forum held in Dakar in April, 2000. It emphasizes equity, efficiency, dialogue, partnership, participation and learning. This strategy incorporates both the formal, and, the
technical and vocational education, and aims at strengthening the technical and vocational education. The Government of DRC planned to improve Primary Secondary Vocational Education by: (i) rehabilitating infrastructure, (ii) modernizing equipment, and (iii) updating the training programmes to better match with the national needs and the local labor market. The Government had also planned to build one Technical and Vocational school per educational province. The Government also indicated commitment to clarifying the institutional mechanisms of the Ministries in charge of education and gradually increasing the share of the education budget with a view to reaching 25% of the national budget by the year 2016.

**DATA COLLECTION AND STATISTICAL ANALYSIS.** This study was restricted to only electronically available literature, the websites of the line ministries and those which were obtained through google search. Both English and French documents were searched and selected from the google engine. The key words used were, education in DRC, investment in Education, status of science, technology and innovation, and challenges facing education sector in DRC. The findings from the selected literatures were supplemented with data from the World Bank and UNESCO database. The validity of the collected data was cross checked using key informants in the key major cities. Trends in enrolment, number of academic and administrative staff and their distribution,
and investment (personnel, equipment, maintenance, operation costs) were established using obtained secondary data. Efforts were made to obtain data covering the period between 2005 and 2020 for consistency, avoiding the period of war where the statistics are very scanty. Status of Science, Technology and Innovation was characterized based on the existing Human capacity and infrastructure at HEIs, the public investment on R&D, existing institutional arrangements for public Research and Development, technological support and regulatory agencies, technological readiness and innovation capacity and policy instruments for research and development. Data on HEIs was plotted in ArcGIS version 10.4. Data on enrolments and financial allocation were fitted to regression lines to determine their temporal trends. Correlation between enrolments and financial allocation to education was computed in order to understand if these allocations were linked to the number of students trained.

RESULTS AND DISCUSSIONS
Distribution of Higher Education Institutions (HEIs) in DRC. Figure 2 shows the distribution of HEI across the different provinces of DRC. A total of 236 HEIs were identified, but only 120 were found on the website of the line Ministry (Ministere de l’ Enseignement Superieur et Universitaire -MESU). This number is below those reported by other sources (e.g World Bank, 2005; CTSE, 2011).

All the provinces had at least an HEI, though there was wide variation in the number of HEIs across provinces. Kinshasa, South-Kivu, North-Kivu and Katanga are well endowed in terms of number of HEIs. Kinshasa, South-Kivu and North-Kivu, have more than 25 HEIs each, and Katanga falls in the category of 16-25 HEIs. This is followed by Kongo Central which is in the category of 11-15 HEIs. The provinces of Haut Lomami, Kisangani and Equateur belong to the category of (5-10 HEIs). All other remaining provinces have less than 5 HEIs. Higher education in the DRC is a mix of public and private provision (Figure 3). The majority of private HEIs are run by religious institutions/churches, a few are associated with provincial governments or are run by private individuals, trusts, or societies. The highest number of public HEIs are found in Kinshasa (>25), followed by North Kivu, South Kivu and Mongala (16-25). Haut Katanga falls in the category of 10-15 HEIs. The rest of the provinces have less than 10 HEIs each. For private HEIs, Kinshasa still had the highest number (>25), followed by South Kivu (16-25), and then North-Kivu and Mongala with (10-15). Haut Katanga and Kongo Central followed within the category 5-10. The rest of the provinces had less than 5 HEIs each. Three major HEIs (University of Kinshasa, University of Kisangani and University of Lubumbashi) have the highest enrollment rates; and the three provinces have remained the main centres of HEI training in the country.

The HEIs include, among others, Universities and non-university institutions. The non-university institutions are generally professional institutions with a wide range of training disciplines including Pedagogical, business, medical, and Rural Development. Figure 5 shows the distribution of private and public HEIs across provinces and Figure 6 shows the percentage of the different categories of HEIs per type (private or public) and type of training offered. A relatively high proportion of HEIs are offering Technical training (IST) (52.1%), followed by Universities (31%). Pedagogical training (ISP) HEIs only represents 16.9% of the HEIs. Relatively, there are more public ISP and IST compared to the private ones, but more private universities than public ones.
Figure 2. Distribution of Higher Education Institutions across the provinces
Source: Data from MESU
Strengthening Higher Education and Science, Technology and Innovation in DRC

Figure 3. Distribution of Private and Public Higher Education Institutions in DR. Congo
Source: Data from MESU

Figure 4. Percentage of private and public Higher Education Institutions in DR Congo
Source: CTSE (2011)
Number of students in the HEIs. The total number of students in the year 2014 is summarised in Figure 7. The biggest proportion of students were in public HEIs. Out of a total of 470,000 students reported across HEIs in DRC in 2014, only 30.4% were from private HEIs. The size of public establishments was larger than private establishments. There were 841 students per public institution against 323 students per private establishment. Since 2007, the total number of students have been growing gradually (gradient=31,297 students/year, \( R^2=0.81, P=0.01 \)). On average, 12083 students have been enrolled every year in private HEIs \( (R^2=0.87, P<0.01) \), and 19,214 students were registered every year in public HEIs \( (R^2=0.54, P=0.04) \). Thus, the aggregated average annual student enrolment was 31,294 for the entire country \( (R^2=0.7; P=0.01) \). This represents about 13% of the student population in 2007.

The number of students varied with provinces. Kinshasa had the highest number of students followed by Haut Katanga. The province of Maniema had the least number of students.

Number of academic and administrative staff in the HEIs. Generally, the Teacher to student ratios are relatively low in most of the HEIs. The average Teacher to students ratio for the country as a whole was about 1:34, using an enrollment estimate of about 470,000 students. DRC performance was thus better than the sub-Saharan Africa average of 44 pupils per teacher (UNESCO, 2011).

The total number of teaching staff in the public HEIs was 13, 680 in 2010. Among them, only 4.1% were Professors and 3.5% were Associate Professors. About a quarter of them were lecturers or senior lecturers. The bulk of the staff were teaching assistants. Generally, lecturers (Chef de Travaux) and the teaching assistants have a “Licence” or have a “graduat”. A greater proportion of the highly qualified academic staff were located in the public HEIs,
Strengthening Higher Education and Science, Technology and Innovation in DRC

and particularly, in the three main universities of Kinshasa, Lubumbashi and Kisangani. The majority of professors were old or close to retirement age (World Bank, 2005).

![Graph showing trends in student enrolment for both public and private Higher Education Institutions.](image)

**Figure 6. Trends in student enrolment for both public and private Higher Education Institutions**

Source: MEPSNC/MAS/METP/MESU (2015)

![Graph showing academic staff of both public and private Higher Education Institutions.](image)

**Figure 7. Academic staff of both public and private Higher Education Institutions**

Source: CTSE (2011)
Governance of Higher Education Institutions

At the level of HEIs.

The governance of HEIs is an important aspect of their operations. The governance structure of HEIs is relatively complex, with a mix of academic and administrative roles.

Academic staff in general have a higher percentage of female staff compared to administrative staff. The majority of academic staff are male, while a significant portion of administrative staff are female.

The governance of HEIs is also characterized by a lack of diversity at the highest levels. Women are underrepresented at the highest levels of governance, both at the institutional level and at the ministry level.

While there have been efforts to improve gender equality in HEIs, significant challenges remain, particularly in terms of leadership positions.

Figure 8. Administrative staff in public HEIs (left) and at the Ministry (right)

administration of education ministries argue that integration of these ministries provides more benefits in streamlining regulations and reducing operation costs—in fact, it was observed that fusion of Ministries of education always happened during periods of financial constraints. The fusion of the two line ministries coincides with the drastic decline in the country's economy in the 1980s (CENADEP, 2009). This is attributed to various reasons—external and internal. From 1965 to the mid-1970s, the country was politically stable, with low monetisation of the deficit and lower inflation (Nachega, 2005). The brutal slowdown in economic activities and the soaring of inflation in developed countries in 1973-1974, associated with the increased fuel price, affected drastically the export of raw materials from developing countries including DRC whose economy was heavily dependent on mineral exports. This was aggravated by the "Zairianisation" process in 1974, the 1979 fuel crisis and the closure of the Benguela runway because of the war in Angola (Nachega, 2005). The country then only relied on debts as the only way to obtain supplies of goods and services and to compensate for economic difficulties of the state-owned copper, coal, diamonds and coltan.


Figure 9. Periods of fission and fusion between MSEPJE and MESU (green Colour: Fusion, blue: white and orange Colour: Fission of Ministries)
et de l’industrie (ACASTI), believe that in the last three decades, R&D has been marginalised in the DRC. Researchers and innovators have access to very limited resources to engage into research and thus, innovate. According to the UNESCO data base, there is limited capacity for R&D in DRC. The country had 199.68 researchers per million inhabitant in 2009. Only 8.7% of them were female. The majority of them were government employees and/or from HEIs, and a small proportion were from Private non-profit organisations. The majority of government employees in research belong to research centres including Institut National d’Etude et Recherche Agronomique-INERA, “Conseil National de Sécurité Nucléaire-CNSN, Comité National de Protection contre les Rayonnements Ionisants- CNPRI, Conseil National du Travail, Congo Research Group, Centre de Recherches Geologiques et Minieres-CRGM, Institut de Recherche en Sciences de la Sante-IRSS, Centre de Recherche en Hydrobiologie-CRH, Centre de Recherche Agro-Alimentaire and Observatoire Volcanique de Goma-OVG. However, INERA remains by far the largest government research centre in the country, and employs close to half the country’s agricultural researchers. It operates 12 research centers and stations across the country focusing on locally relevant adaptive research covering crop, livestock, forestry, and fisheries. These institutions have suffered a lot of brain drain. Despite the facts that young people are being recruited in many of these institutions, the majority of the staff remain old, the administrative staff are plethoric, and limited retooling exercises have been conducted.

Data on public investment in R&D in the country is very scanty, since there is no mechanism of collecting and managing this information. However, UNESCO estimated that DRC spent between 0.5-1 % of her GDP on R&D in 2015. It is also important to note that there are no mechanisms to collect data on research (type, relevance, quality, effectiveness) being conducted by the different stakeholders across the country.

**Institutional arrangements for Public Research and Development.** There is generally weak linkages among the main institutional actors in the national system of innovation namely; universities, public R&D institutes, private enterprises, financial institutions, technology support agencies, and policy makers in undertaking research and development activities. This is mainly because of the dysfunctional science governance system, lack of networking and inter-sectoral cooperation, limited influence of academic and professional associations and lack of public resources allocated to R&D. In addition, research priorities are only clearly defined for Research Centres. Generally, HEIs do not have a research agenda. Students can only do what they can afford with family resources.

**Policy Instruments for Research and Development.** Different R&D and STI policy guidelines are scattered in different sectoral policy documents including the National plan for agriculture and the policy on National Education. However, a draft STI policy was developed in 2010 and is awaiting to be finalised. In addition, the 2014 policy
Framework n° 14/004, recognises that the use of Science and Technology is a sine qua none factor of the economic development of the DRC. The policy emphasises enhancing institutions governance, improvement of infrastructure, promotion of science and technology training, and strengthening collaboration between R&D institutions. The country has also ratified the agenda of the Southern African Development Community (SADC) and the Agenda 2063 of the African Union.

Technology support and regulatory agencies. One of key component of the national innovation systems are mechanisms of enhancing standard, quality and metrology (Mugabi, 2011). In DRC, control of the compliance to standard is done by the Congolese Office of Control - OCC. OCC is generally poorly equipped. However, to ensure that the OCC delivers good services to its customers, a partnership agreement exists between OCC and the Bureau Veritas BIVAC BV. The Ministry of the Environment and Rural Development (MEDR) is in charge of the implementation of the Environmental Policy, particularly the conduct of environmental and social assessments, through the Congolese Environment Agency (ACE).

Technological readiness and innovation capacity. Technological readiness represents the ability of an economy to adopt existing technologies for its industries’ productivity enhancement; while innovation capacity is the ability of a country to expand the frontiers of knowledge and create new technology (Mugabi, 2011). Indicators of technological readiness include, among others, firm-level technology absorption, laws relating to information and communication technologies, FDI and technology transfer, personal computers per 100 inhabitants, and internet users and mobile phone subscribers.

Because of a relatively long period of instability, and unfriendly taxation system, only a few firms operate effectively in the country. According to the Group Special Mobile Association (2019) report, DRC mobile connectivity score in 2019 was 25.8, while mobile coverage reached 44.58% penetration rate in the country, with just over 40% of the population covered by a 3G connection (Jenal and Cunningham, 2019). The regulatory fees was 31%. The mobile connectivity score and the penetration rate are among the lowest in the region while the regulatory fees are among the highest on the continent (GSMA, 2017). For example the penetration rate in Zambia, Rwanda and Uganda stands at 78%, 68% and 68%, respectively. Major roads connecting the different parts of the countries are damaged at several points. Electricity supply is unreliable and sporadic in several parts of the country, despite the enormous energy potential that the country possesses. Several other factors may contribute to failure of innovations in the countries. According to Jenal and Cunningham (2019), lack of adequate market-supporting institutions to overcome various market failures and trust issues, coupled with coordination and search costs, may incentivize many to mainly trade in simpler goods and services. However, it is also important to note that the telecommunication industry has the potential to strive. The mobile payment services is booming (Gilman et al., 2013) – over 37 million mobile phone have been subscribed to and the Fibre Optics network is being finalised (GSMA, 2017).

Financial investment in Education. The resources made available to the education sector as a ratio of GDP is presented in Figure 11. Public expenditure on education amounted to just over 462 billion Congolese francs (CDF) in 2012. This represented 1.8% of the country GDP, and 63.8% increase compared to the 2005 expenditure. The annual expenditure on education has been increasing annually (p=0.03) by about 40.47 billion CDF (the equivalent of 0.1% of the GDP). In 2014, the expenditure on education increased by 18.7% compared to
its value of 2010 (MEPSINC/METP/MESU, 2015).

During the process of endorsing the new sector plan, the Government committed to bringing the share of its budget allocated to education to 20% by 2018 and to maintain it at that level until 2025 (MEPSINC/METP/MESU, 2015). This will requires doubling the financial resources devoted to the sector, from 1.3 billion USD in 2016 to 2.8 billion USD, in 2025. This strategy proposes an allocation of 69% of the resources to the payroll due to the increase in staff and measures for the gradual implementation of free education, including improving the rates of support for teachers and increasing their salary level now indexed to changes in per capita GDP. The mobilisation of additional public resources for education presupposes that the ministries concerned are better equipped to negotiate more favorable budgetary decisions that are more in line with international standards.

The trend in public expenditure allocated to Ministries, including the different line Ministries of education, over the period 2005-2012 is displayed in Figure 11. Only the expenditure under MESU significantly increased during that period. Percentage expenditure under MEPSP and other Ministries (OM) has declined slightly, while under MAS, the percentage expenditure remained constant over the years. A good correlation was found only between the expenditure under MEPSP and the number of pupils ($R^2=0.62$, and $p=0.06$). It is also important to note that the percentage expenditure for MESU has been oscillating between 0.4 and 0.6% and remained at 0.5% from 2013 to 2015.

The biggest proportion of the expenditure is dedicated to paying the personnel (Table 1). Purchasing of goods and subventions and transfers accounted for about a third of the expenditure. The amount allocated on personnel has increased annually by 4.02% at the expense of all the expenditures which have been declining over the years. Since 2007, Personnel and purchase of goods costs followed a quadratic shape with opposite concavities.

![Graph](image-url)

Figure 10. The trend in the proportion of GDP allocated to education in DRC (2005-2015)
Figure 11. Percentage of expenditure allocated to Ministries for the period 2005-2012

Table 1. Operation costs in MESU

<table>
<thead>
<tr>
<th>Operational costs</th>
<th>2005-value (%)</th>
<th>Average (2005-2012)</th>
<th>Annual increment (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel</td>
<td>64.7</td>
<td>90.6</td>
<td>4.02</td>
</tr>
<tr>
<td>Purchase of goods</td>
<td>24.7</td>
<td>6.9</td>
<td>-2.59</td>
</tr>
<tr>
<td>Subventions and transfers</td>
<td>10.6</td>
<td>2.2</td>
<td>-1.07</td>
</tr>
<tr>
<td>Social expenditures</td>
<td>0</td>
<td>0.3</td>
<td>-0.42*</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>-0.06</td>
</tr>
</tbody>
</table>

* This was computed from 2007 values.
Source: UNESCO (2015)

Figure 12 below shows the percentage expenditure per type of HEIs in 2012. Relatively high percentage (35%) is allocated to pedagogical HEIs (Training teachers of secondary schools), followed by Universities, and the least was allocated to research (12%) institutions. Universities and Technical HEIs received each about the quarter of the budget. However, the country is still considered to carry a significant risk of debt distress. According to Bou-Habib and Kebede (2016), it is vulnerable to the drop in exports and the increase in borrowing costs. Since the cancelling of the US $ 7 billion, as very heavily indebted poor country in 2010, the country has continued to borrow (Lapole Kanga, 2013). The risk incurred
is that the income generated will be lower than the amount of the debt service (Essl et al., 2019). Table 2 shows the cumulative cost of operations since 2005. Between 2005 and 2012, the cumulative costs of operations amounted to 106.48 billion franc. The biggest portion of the operations costs was spent on the equipment, repair and rehabilitation and studies. Salary and construction were only allocated 0.16% and 4.3% of the total operations costs, respectively. The distribution of operations costs favored more the MEPSP compared to MESU and other Ministries.

**Figure 12. Percentage expenditure of public funds to the different type of HEIs**
Source: CTSE (2011)

**Table 2. Total operations costs from 2005-2012 (in billions of CF)**

<table>
<thead>
<tr>
<th>Operations</th>
<th>MEPSP</th>
<th>MESU</th>
<th>MAS</th>
<th>Other Ministries</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>4.56</td>
<td>0.03</td>
<td></td>
<td></td>
<td>4.59</td>
</tr>
<tr>
<td>Salary</td>
<td>0.178</td>
<td></td>
<td></td>
<td></td>
<td>0.18</td>
</tr>
<tr>
<td>Rehabilitation/repairs</td>
<td>26.92</td>
<td>5.62</td>
<td>0.01</td>
<td></td>
<td>32.55</td>
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<tr>
<td>Studies</td>
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<td></td>
<td></td>
<td>0.03</td>
<td>20.01</td>
</tr>
<tr>
<td>Equipment</td>
<td>42.61</td>
<td>6.42</td>
<td>0.07</td>
<td>0.05</td>
<td>49.15</td>
</tr>
<tr>
<td>Total</td>
<td>94.25</td>
<td>12.07</td>
<td>0.07</td>
<td>0.09</td>
<td>106.48</td>
</tr>
</tbody>
</table>

Source: UNESCO (2015)
Despite recent efforts to improve budget allocation to education, public education still is underfunded compared to most other countries in the region, with only 10.9% of the government budget allocated to education and the implementation budget of 1.8% of GDP in the sector. The SSA countries average is 17% of total budget allocation, and 4.6% as a share of GDP (World Bank, 2015). This places the DRC among the countries with the most poorly funded education sectors. Although substantial gains have been made in generation of revenue through family cost sharing, the finance of the latter are extremely stretched, particularly because of the socio-economic conditions which characterise the different households in the country. Consequently, additional resources for higher education are most likely to come from creative partnerships with private sectors, south-south and south-north collaborations and other innovative methods of revenue raising (Saint, 2009).

**Challenges facing HEIs and STI in DRC**

**Tremendous increment in student enrolment in HEIs.** Most of the public HEIs are overcrowded, because of the growing enrolments associated with both increased population and parents’ expectations. The HEI enrolment rate is among the highest in the region, and it is likely to increase as the country stabilises politically and socio-economic conditions improve. In their current state, both public and private sector HEIs cannot meet the demand, if 50% of the current population of pupils in the last year of secondary school would like to pursue their studies. Most of the public HEIs are old and poorly maintained; while the private HEIs have generally small capacity.

**Limitations of Inherited systems.** DR Congo inherited the education system from the colonialists and the Belgian’s tradition of ‘free university education for all. Universities in DR Congo have been generally charging very low tuition fees as tertiary education is widely perceived as a ‘public good’. Subsequently, several private HEIs are unable to adequately operate. This has pushed many parents to raise concerns over the quality of education provided, and thus well-resourced parents send their children outside the country. On the other hand, public HEIs are overwhelmed by the increased number of students with no proportional support from the government. Despite the fact that the Belgians have tried to overhaul and standardise their system to the European system of education, the DRC education system has remained intact, with timid attempts towards internationalisation. The mechanism for changing curricula and introducing new courses is cumbersome and is sometimes dysfunctional. The “Commission Permanente des Etudes” of the Ministry of Higher Education which finally approves changes in the curricula take a long time to meet. This was a legacy of the past when centralisation was the main objective of the DRC educational policy. As a consequence, HEIs look for shortcuts and secure temporary recognition from the line Ministry to open new programmes.

In many HEIs across the globe, programmes are revised frequently, generally every five years, to take into account the needs of the stakeholders and especially the demand from industries and the job markets. In DRC only a few public HEIs are authorised to run postgraduate programmes because of the limited HEIs capacity in the country. This coupled with brain drain, has hindered progress and building capacity for many HEIs. Most of the catholic HEIs, for example, use the institutional linkages with HEIs in Belgium and HEIs with comparative advantages to build their own capacity.

**Under-investment in Research and Innovation.** R&D has been marginalised for the last two decades in DRC. The higher education system has remained largely private but supported by extremely limited public budgets
that demoralise the personnel and can not foster growth in the system. From a system dominantly private and heavily supported by public funds at independence, the higher education in the DRC has shifted to a mixed public-private system almost entirely privately financed. The Government funds staff salaries in public HEIs and not research and the much-needed rehabilitation of R&D infrastructure is largely dependent on volatile donor support (BEFS, 2013). Private HEIs rely on students fees for salary of staff and infrastructure development. Although HEIs employ a much higher (and younger) proportion of PhD-qualified scientists compared to the National Agricultural Study and Research Institute (INERA) and other government agencies, few of them have the time or resources to focus on research. An increasing number of private HEIs and nongovernment organisations have also become involved in agricultural R&D in recent years, but their capacity is limited. Linkages with industries, financial institutions, and other key potential partners that could have promoted R&D and science, technology and innovation have remained very poor. This is attributed to the inherent poor capacity of HEIs, the dysfunctional science governance system, limited influence of academic and professional associations, lack of public resources allocated to R&D and the long period of instability which has scared potential investors (CTSE, 2010).

Gender participation in schools and work. Women in the DRC have not attained a position of full equality with men, particularly in HEIs. In spite of the different national legislative provisions and international conventions which the DRC has adopted, the level of female representation in the different HEIs governance positions is very low; and the proportion of women lecturers and professors is also very low. In fact, women occupy only 2.8% of waged jobs, which are concentrated in farming, the informal sector, and commerce (Baharanyi et al., 2014).

Confusing policy and legal framework. The mismatch between policy and sector goals is evident. There are no clear mechanisms including financial commitment for the increased number of students in HEIs. Although targeting enhancing the quality of higher education, there is no mechanisms for controlling the proliferation of HEIs which are not viable, and does not provide a clear strategy to achieve the targets. The National education policy Framework no. 14/004 of February 2014, emphasises that the country relies on the use of Science and Technology for its economic development. However, the country does not have a Science, Technology and Innovation (STI) policy, and there is no mechanism provided in terms of strategy and financial arrangements for achieving the targeted objectives. A draft STI policy was proposed by the Ministry of STI in 2010 but is yet to be finalised.

Lack of academic freedom. In most of the HEIs, the leaders are appointed resulting in jeopardising the institutional governance efficiency. HEIs do not have autonomy of the programmes they run, and to some extent, the student recruitment. Even where such institutional control is not formally in place, academic freedom is constrained by the broader political restrictions on freedom of speech, and the Government’s propensity to marginalise, arrest, or threaten those who criticise the regime. It is important to note that academics only thrive when they are given the liberty to pursue original and timely issues, and the space to provide critical analysis. Their work, in turn, challenges society to grow and improve.

Disorganised student recruitment process. DRC made a shift from elite training to mass training. During this shift, the recruitment process was significantly altered. The key university entry criteria is having at least 50% pass mark in the State examination (Examen d’Etat) and having resources to pay for tuition
Finding a student who specialised in pedagogy in secondary school doing medicine or engineering at university is not a rare case in DRC. This student will certainly experience various challenges at university.

**Limited trainings in emerging disciplines.** The lack of lecturers for new disciplines and non-availability of books in the libraries are among the major challenges. In some HEIs, lecturers develop their course modules and sell them to the students. Lack of laboratories in most HEIs has had a deleterious effect on the quality of instruction in the sciences and medicine. Fees from students are insufficient to cover the cost of laboratory materials especially in the natural sciences. Sharing of laboratory and libraries between HEIs has been the main mechanism used to improve access to laboratory facilities in several parts of the country, hence minimising the cost of investing in equipment. Sharing of human resources has also been practiced in the country; but this has contributed to lengthening the academic year in HEIs and indirectly raising the costs of education for students.

**CONCLUSIONS AND RECOMMENDATIONS**

DRC has a large and growing higher education system, which includes public institutions and private largely dependent on family funding. Due to demographic pressure, the enrolment is rapidly increasing in both public and private HEIs, reducing significantly the government resources allocated to train a student. This is likely to overwhelm the entire HEIs if preventive measures are not taken considering the socio-economic environment of the students’ families.

Despite recent efforts to improve budget allocation to education, public education has remained underfunded compared to most other countries in the region, with only 10.9% of the government budget allocated to education and the implementation budget of 1.8% of GDP in the sector. In addition, the sector is facing various challenges including, limited academic autonomy in selecting leaders and designing the curricula, proliferation of HEIs, and a plethora of administrative staff both in the ministry and in the HEIs. Congolese women and girls do not benefit from equitable representation in the HEIs in the DRC at all levels. There is inequality in access to higher education, academic careers and managerial functions as a pyramid that tapers from the bottom to the top. Overall, R&D and STI have been marginalised for the last decades, and the national innovation system is dysfunctional. Based on the above findings, there is need to:

- Ensure adequate funding of the education system and its future expansion. This funding should aim at reducing the unit cost of operations and increasing functional equipment in order to make a viable higher education system. This will also require diversification of funding sources;
- Develop medium to long term plans to resolve the HEIs structural and governance challenges that threaten to compromise the quality of the training provided by the HEIs. The quality of HEIs students not only depends on the quality of the HEIs academic staff and the quality of the learning conditions at HEIs but also the quality of the pre-university training. There is, therefore, a need to enhance the learning conditions in the pre-university schools, standardise the training at these levels, promote more practical learning than theories, and, more thinking than memorising;
- Build capacity of HEIs academic and administrative staff, through south-south and north-south partnerships. However, taking into consideration the current quasi isolation of the country at international level, there is a need to push for more south-south collaborations. There are various HEIs in the different regions of the continent which could offer adequate training to human resources in DRC. To this effect,
RUFORUM (see www.ruforum.org) as a network of universities for capacity building offers multiple opportunities for the country:

- Strengthen the capacity of the “Commission Permanente des Etudes” of the Ministry of Higher Education, to be able to perform its tasks, especially those related to programmes evaluation and accreditation;
- Create a credible quality assurance system, which would have authority over both public and private institutions;
- Strengthen the STI infrastructure and use of innovation systems approach to enhance the technological readiness and innovation capabilities of the country;
- Institutionalize the collection and management of statistics on HEIs, R&D, and Science, Technology and Innovation (STI) with a view of producing indicators for Research and Development (R&D) and Innovation;
- Strengthen the STI infrastructure in the country;
- Mount targeted programmes to increase female students recruitment at all levels of the education system; and,
- Create and strengthen partnerships between major stakeholders in the national innovations systems for enhanced R&D and STI within the country.

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STATEMENT OF NO-CONFLICT OF INTEREST

The author declares that there is no conflict of interest in this paper.

REFERENCES


Banque Mondiale. 2003. Financement et qualité de l’enseignement primaire et secondaire en RDC. Fiche d’information RDC.


Bigohe, J.B. 2014. L’intégration de l’éducation au Développement Durable dans l’enseignement primaire et secondaire en République Démocratique du Congo : Etat des lieux et perspectives d’avenir (Cas de quelques écoles dans la ville province de Kinshasa), Mémoire /Master 2, Université Blaise Pascal/École du Professorat et de


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Gender-based assessment of Science, Technology and Innovation ecosystem in Zambia

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ABSTRACT
In today’s fast changing world, science and technology are fundamental to sustainable socio-economic development of any nation. Sustainable development is anchored on the application of science and technology in the acquisition of knowledge, skills and technology that would build the capacity of the nation to meet its social and economic needs. In Zambia, over 51 percent of the population is female. Despite most of the populations in the sub-Saharan Africa having more women than men, women are underrepresented in almost all spheres of socio economic development. Worse STI, science engineering and technology has continued to record the lowest numbers of women participation. This desktop study involved review of documents from the Ministry of Higher Education, National Science Technology Council, Higher Education Authority, and Ministry of Gender. Careers in Science, Technology and Innovation (STI) and vocational training in Zambia is mostly dominated by males. Careers in engineering, agriculture, and medicine, technology and innovations continue to be male dominated. The Government of Zambia has recognized the importance of gender to promote science. Policies such as the Gender Policy, Higher Education Act, National Policy on Science and Technology, and Education Policy aim at ensuring gender based STI participation. The paper presents a STI analysis using a gender-based assessment of STI ecosystem in Zambia to gain a scientifically based understanding of the status of STI in Zambia upon which capacity development will be premised for now and in future. As of 2018, Zambia had nine public universities, 54 private universities and 29 vocational education and training institutions. The total enrolment in public universities was at 57,034, of which 55% were males and 45% female students. Public universities total enrolment stood at 34,935 students, 49% males while 51% were females. Training in STI is mostly offered in Government owned learning institutions due to the lack of capacity to buy equipment for science engineering and technology required for training.

Keywords: Gender, Higher education, Science, Technology, Innovation, Technical Education, Zambia

RÉSUMÉ
Dans le monde en évolution rapide d’aujourd’hui, la science et la technologie sont essentielles au développement socioéconomique durable de toute nation. Le développement durable repose sur l’application de la science et de la technologie à l’acquisition de connaissances, de compétences et de technologies qui renforceraient la capacité de la nation à répondre...

Mots clés: Genre, Enseignement supérieur, Science, Technologie, Innovation, Enseignement technique, Zambie

INTRODUCTION

In the recent past, Science Technology and Innovations (STI) ecosystems have made significant contribution in enhancing public investment in research and development, human resource training and access to information and communication technology (UNCTAD, 2019). An ecosystem allows the use of knowledge in the production system to create value that no single entity could have created alone (Xu et al., 2018). The quality and number of a country’s scientists and technologists are an important resource for technological development of that country. Scientists, engineers and technologists transform national economies and societies by conducting research and development work whose output contributes to industrial development and national economic competitiveness (NSTC, 2015). It is a known fact that countries that have industrialised and developed have done so by anchoring their industrialisation agenda on the use science, technology and innovation (STI).

Xu et al. (2018) indicated that an innovation ecosystem consists of a knowledge ecosystem driven by research and development, and a business ecosystem driven by market forces. However, this can be achieved by the integration of all in technology transfer including participation of a broad spectrum of key stakeholders in research, industries, and national development. The use of innovation ecosystems require that specific attention be paid to the application of science, technology and innovation in developing nations and
sub Saharan Africa in particular if they are to achieve what the developed world have achieved in terms of development. The developed world has used science, technology and innovations to foster development and production. Research and development go hand in hand for increased production.

The use of STI in Africa is generally low due to limited capacity and technological resources for implementation of STI. The education system in Africa has been primarily influenced by UNESCO principle of Education for All (EFA) and notion of economic growth (Barret et al., 2019). The focus of EFA is life skills and twenty first century skills beyond literacy and includes problem solving and critical thinking through science, technology and innovation for national development.

In sub-Saharan Africa, the pathways linking STI has included the emphasis on Science, Technology, Engineering and Mathematics (STEM) and Information Communication and Technology (ICT) in the education system. This approach is hinged on the realisation of the importance of STEM as an approach and strategy for achieving sustainable national development.

Policies and frameworks have been developed consistent with national development visions but gaps exist between policy and practice during implementation. According to Barret et al. (2019) gaps in achieving STI include inclusion, equity and equality in the education sector for science, engineering and technology in terms of access to science and technology by different gender, and equipment facilities needed to contribute to national development. As such efforts have been made through development of policies to address gender parity, equality and improvement in STEM and ICT investments.

Study setting
Zambia is a middle income State located in Southern Part of Africa. The country has a surface area of about 752, 000 km² (MNDP, 2017; World Bank, 2017). The country is endowed with abundant natural resources including copper, vast arable land, huge amount of surface water, and forestry resources. The Zambian economy is predominantly based on the exploitation of these natural resources. The major economic resource and foreign exchange has been copper since the early 1900s. The country runs a free market economy where the means of production are in the hands of the private sector. In 1991, the country embarked on privatisation of State owned mining and manufacturing industries. However, this was not a successful transition as most of the privatised industries are no longer operational or have closed.

Despite an abundance of natural resources, the country today imports most of its finished products as opposed to local manufactured products. Poor quality and limited innovation has greatly contributed to the preference for imported goods and services instead of local ones. There is little value addition and application of technology in the local industry. The Government has however come up with policies and interventions to improve the use of science and technology in the country. A major contributing cause of the poor performance of the manufacturing industry has largely been due to lack of application of science and technology, which has resulted in industries becoming uncompetitive with declining productivity (Ministry of Education, 2016; Higher Education Authority, 2017).

Zambia’s development agenda is outlined in realising the Vision 2030. Vision 2030 (2006-2030) aims to transform Zambia into a prosperous middle income nation by 2030 and to create a new Zambia which is a “strong and dynamic middle-income industrial nation that provides opportunities for improving the well-being of all, embodying values of socio economic justice.” The country aspires to build local economic growth through the education system that is capable of
transforming the natural resources through investing in science, engineering, technology investing and entrepreneurship. In order to achieve this vision education will need to play a greater role. Moreover, the growth of the industrial sector hinges on robust application of Science, Technology and Innovation (STI) and engineering.

**METHODOLOGY**

The study employed desk top review and key stakeholder discussions approach in the compilation and analysis of gender based STI ecosystem in Zambia. Key institutions targeted included science and technology based learning providers including Universities (both private and public), Technical Education and Vocational Training (TEVET) institutions and colleges, the Ministry of Higher Education, Higher Education Authority (HEA), and the National Science Technology Council (NSTC). The mapping of institutions used in the analysis is presented in Table 1. Due to the COVID-19 pandemic and restrictions prescribed in the guidelines by the World Health Organisation (WHO) and Ministry of Health, the study relied on website and online information to gather information and statistics (Table 1).

In some cases, emails and phone interviews were used to access information. National policy and legal frameworks were also referred to in the assessment. These included, National Science and Technology policy, Higher Education Act, National Gender Policy, Education Policy, Seventh National Development Plan and the Vision 2030 paper.

In this paper, data collected for female participation in higher education and STI activities to determine the trend was restricted to the period between 2014 and 2018. For the other statistics included in this paper the period covered is seven years. Some key informants from NSTC and HEA were also consulted on the status of STI situation in Zambia, women participation in decision making, challenges and opportunities.

<table>
<thead>
<tr>
<th>SN</th>
<th>Data and information collected</th>
<th>Method/activity</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gender policies, strategies and representation in higher education: challenges and opportunities</td>
<td>Literature review</td>
<td>Ministry of Higher Education, Ministry of Gender, TEVETA, Zambia Agriculture Research Institute, Peer review articles, Zambia statistics agency, National Council for Scientific Research, UNCATAD Website</td>
</tr>
<tr>
<td>2</td>
<td>Percentage of females in decision making, higher education organisations, Level of attainment, % of females enrolled and graduates in STEM fields, Education expenditure and % of women participating in STI.</td>
<td>Secondary data and descriptive statics analysis</td>
<td>Ministry of Higher Education and Ministry of Agriculture, Zambia Statistics Agency (Labour force surveys, 2014-2020) and Analysis of gender.</td>
</tr>
<tr>
<td>3</td>
<td>Mapping of existing Gender and STI initiatives, main actors and their contribution Women participation in STI initiatives</td>
<td>Documents analysis interviews</td>
<td>Annual Reports from the Ministry of Higher Education 2018 Key informants Websites</td>
</tr>
<tr>
<td>4</td>
<td>Challenges and opportunity for improving gender in STI Future for women participation in STI.</td>
<td>Compilation of secondary data and interviews.</td>
<td>Key informants from Ministry of Higher Education</td>
</tr>
</tbody>
</table>

Table 1. Summary of data collection process
Findings
Institutional setup of Science, Technology and Innovation in Zambia. Zambia got her independence in 1964. At the time the country’s economy was hinged on copper production. Subsequently, the country embarked on implementation of various macro-economic and development strategies. However, from 1964 to 1991, the economic and industrial performance in Zambia deteriorated significantly (GRZ, 1996). In an effort to revamp its economy, the country changed its economic policy framework in 1992 from a Central State controlled to a free market and liberalized economy, with greater emphasis on private sector participation in the economy. With many former State owned companies and economy in the hands of the private sector, the country’s manufacturing sector has collapsed, relying largely on imported goods and services.

The Government has realised that the major contributing factor to the poor performance of the industry has been the limited application of science engineering and technology in the utilisation of the country’s resources and wealth. Local industries had become unproductive with declining productivity under global trade and market environment. The Government has realised that sustainable economic development can be achieved through the use of science and technology guided by national policies in the education and other national development related sectors.

In 1996, the Government developed the National Science and Technology Policy to foster the use of science in the utilisation of natural resources and achieving sustainable national development. In Zambia Science and Technology work is carried out largely by the National Council for Scientific Research (NCSR), private and public universities, line ministries principally, Agriculture, Food and Fisheries, Environment and Natural Resources, Mines and Minerals Development, Health, and Science Engineering, Technical and Vocational Colleges (TEVETA) and with funding predominantly from the Government and cooperating partners including the UN agencies. Despite this set up funding for research and development by both Government and private sector has, however, been limited and this has greatly contributed to the poor performance of the application of Science and Technology in national development. There is also a weak linkage between the country’s research institutions, the Government and industry.

In the higher education sector and university education in particular, the Government created the Higher Education Authority (HEA) in accordance with section 6(h) of the Higher Education Act No 4 of 2013. The mandate of the authority is to ensure quality and standards in education to increase access to higher education in the country. The Act further ensures that institutions pursue excellence and promote the full realization of the potential of learners while creating conditions for lifelong learning. On STI, the Act envisages strengthening the effect of academic learning and scientific research so as to enhance social and economic development.

The Act aspires that higher institutions conduct critical research necessary and responsive to national needs. Such research will entail participation of both males and females. The Act has further provided for an increase in the number of universities in Zambia including both private and public (Table 1). Having an increase in number of institutions has its own challenges in ensuring full participation and access to higher education for both male and female. The cost of tuition fees has been too high and not affordable to the majority of Zambians. Further, operations cost by university management has made universities prefer social and humanities programmes to sciences and technology including engineering. This
is because training in science and technology requires significant investment in laboratory and other equipment.

**Zambia Education Framework**

The education framework in Zambia is anchored on two main Ministries, the Ministry of General Education (MOGE) and the Ministry of Higher Education (MOHE). The Ministry of General Education caters for pupils in early child education, (ECE), primary education grade 1-7 and secondary education grades 8-12. The mandate of the ministry includes promoting skills development, science, and technology and innovation education in primary and secondary school in Zambia. The education curriculum for primary education and secondary school education is developed by the Curriculum Development Centre (CDC). The development of curriculum in science related subjects is not easy and effective as it for the non-science subjects. The Zambia Education Curriculum Framework 2013 identified challenges including; limited resources for teaching of science and technology, lack of equipment, gender disparities coupled with cultural biases and attitude for female not to participate in science and technology, and few female trained teachers as role models for female in science field. (GRZ, 2013).

On the other hand, the Ministry of Higher Education was established through Government Gazzete No. 836 of 2016 to formulate policy and regulate University Education, Vocational Education and Training, as well as to promote the application of Science, Technology and Innovation for socio-economic development. Higher education in Zambia refers to any structured and systematized learning offered by formal learning institutions that award certificates, diplomas, and degrees acquired after secondary or high school (Mkandawire and Ilon, 2019). Higher education institutions includes universities, colleges, institutes, trades, seminars, and specialized job training institutions. All the Technical Education and Vocational Training (TEVET) institutions and other colleges are under the Ministry of Higher Education. Formerly, Technical and Vocational Training (TEVET) was anchored in the Ministry of Education, Science, Vocational Training and Early Education (MESVTEE).

Under the Ministry of Higher Education, there are nine public universities, 54 private universities and 29 vocational education and training institutions.

**Table 2. Number of Higher Education Institutions in Zambia**

<table>
<thead>
<tr>
<th>No.</th>
<th>Type</th>
<th>2017</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Public Universities</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>Private Universities</td>
<td>16</td>
<td>54</td>
</tr>
<tr>
<td>3</td>
<td>Colleges of Agriculture</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>TEVETA Colleges</td>
<td>284</td>
<td>295</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td>317</td>
<td>378</td>
</tr>
</tbody>
</table>

Source: [https://www.agriculture.gov.zm](https://www.agriculture.gov.zm)

According to the census of 2018, the total enrolment in public universities was 57,034, of which 55% were male and 45% female students. Public universities total enrolment stood at 34, 935 students, 49% and 51% female (Masaiti and Simuyaba, 2018). Further, in 2019, the Ministry of Finance 2019 Annual Economic Report indicated that the total student population in both public and private universities increased by 5 percent to 99,222 from 94,250 in 2018. Of the total student population, 39,689 were female students.

**National Science and Technology Policy**

The Government of Zambia developed the National Science and Technology Policy in 1996. The mission of the NSTC policy is to promote and exploit science and technology as an instrument for developing an environmentally friendly indigenous technological capacity in sustainable socio-economic development in order to improve the quality of life for Zambia.
The goals of NSTC policy include:-

- enhancing linkages between technology research institutes, the private as well as the public sector in order to encourage demand-driven research and development;
- developing and sustaining a national scientific and technological capacity and providing highly skilled human resource for increased productivity in the economy;
- fostering national and international linkages for enhanced technology transfer; and
- Facilitating the acquisition, adaptation and utilization of foreign technology.

The actualisation of this policy is done under the supervision of the Ministry of Higher Education and the implementation by various institutions including, National Science Technology Council (NSTC), Universities, Technical Education and Vocational Training Colleges (TEVET).

National Science Technology Council. The National Science and Technology Council (NSTC) is a statutory body established by the Science and Technology Act No. 26 of 1997. The main function or mandate of the Council is to “promote science and technology so as to improve the quality of life in Zambia”. The vision of NSTC is to promote the use of Science, Technology and Innovation for industrial development in Zambia. In order to realise this vision, NSTC has the following strategic objectives:

Promotion of science, technology and innovation to increase scientific knowledge, enhance product development, through increased uptake of research results by industry, in compliance to STI standards, improved science centres and development of science; and strengthen stakeholder linkages to enhance science, technology and innovation sector coordination for national developmental sectors.

Figure 1. Selected African countries with women representation in politics by 2018. Source: Okedele (2020)
Status of STI ecosystem and women participation

Women participation in decision making and political arena. In order to foster participation of women in STI, decision making organs, the Government plays a critical role in encouraging gender mainstreaming. Some African countries have adopted the quota system with a minimum of 30% of women representation in political positions as stipulated by the Southern African Development Community (SADC) Protocol of 2008 (Okedele, 2020). The Protocol aims to provide for the empowerment of women, to eliminate discrimination and achieve gender equality by encouraging and harmonising the development and implementation of gender responsive legislation, policies and programmes and projects. Gender quota system focus on women engagement into politics and decision making in member (SADC) countries. The protocol advocates for the representation of women in parliament to be at least 30%. Women participation has been recognised and achieved at national policy level in Angola, Mauritius, Mozambique, Namibia and Zimbabwe whereby an affirmative action has been taken to increase women representation (Figure 1) to a minimum of 30%. In Zambia, the governance system does not follow the quota system hence women representation has been under represented.

By the end of 2018, Rwanda had the highest representation of women in parliament at 63.8%, South Africa 41.8%, Mozambique 39.6%, and Angola 36.8% while Zambia had 18% representation (Gender Links, 2017: Okekedel, 2020).

Based on the August 2016 general elections, Zambia is ranked the 4th lowest performing country in the region with slight improvement in women representation in parliament, 18 in 2011 to 25 in 2016 (Figure 2). At cabinet level, there was more than 50% improvement with 12 women in cabinet in 2010 and to 25 in 2016. This is an indication that Zambia can do better in this area if the quota system is applied.

The low participation of women in decision making can be attributed to a number of factors such as:

- Low education level
- Low literacy levels and society’s perception of the role of men and women,
- Lack of financial resources as most women in Zambia depend on male counter parts,
- Traditional work burden despite some of the women being in paid formal employment,
- Religiously, power and authority is believed to belong to men hence hindering women from participating in decision making

However, in order to sustain equality in decision making, the Zambian Government has proposed the inclusion of a minimum of a 30% quota system and proportional representative. Political parties have been tasked to develop and adopt gender policies and action plans that will increase women participation in decision making (GSWLG, 2018).

Zambian STI development and gender mainstreaming

According to the Vision 2030 agenda for Zambia, the nation’s ambition to become a middle income and industrialised economy, there is need to invest in science and technology. In addition, Zambia’s Seventh National Development Plan 2017-2021 is a roadmap which has also recognised the cardinal role of science, engineering and technology in national development (GRZ, 2017). The Seventh National Development Plan includes strategies to enhance science and technology by developing programmes to prioritise research in education institutions to promote productivity, innovation and
competiveness in the economy. Additionally, there is need to promote research and innovation to steer the creation of new products and new ways of producing existing products efficiently by the industry and agriculture sector. Science and technology therefore becomes of paramount importance. The National Science and Technology Council is one of the key mandated institutions to promote science and technology development in the country.

In the National Science and Technology Council of Zambia 2019-2021 Strategic Plan, Zambia aspires to transition from being raw material producer and exporter to a value-adding, knowledge-intensive and industrialised economy (NSTC, 2019). The adoption of science, engineering and technology plays a critical role in achieving this aspiration. The Government of Zambia has developed many legal frameworks and policies. In general this starts with the education policy and higher education policies.

Recognising gender imbalances in Zambia, the National Gender Policy was developed. It aims at ensuring the attainment of gender equality in the development process by redressing the existing gender imbalances including in education and socio-economic opportunities. It also provides for equal opportunities for women and men to actively participate and contribute to their fullest ability and equitably so as to benefit from national development (GRZ, 2014). The policy is an overall benchmark for gender mainstreaming in national development. The decisive intention of this Policy is to create a Zambian society which has achieved the Vision of ‘A nation where there is gender equity and equality for sustainable development’. The Government has realised the cardinal role of Science and technology for girls as opposed to the usual trend whereby this has been dominated by their male counterpart. The Government has since built Technical Schools for Girls in each of the country’s 10 provinces since 2016.

![Figure 2. Comparison of numbers of women elected to parliament and serving as cabinet Ministers in Zimbabwe](Source: CSO. 2018)
STI in Higher Education Institutions in Zambia
The number of tertiary STI education institutions in Zambia between 2017 and 2020 is presented in (Table 2). The number of higher education institutions in Zambia increased from 317 in 2017 to 378 in 2020. Currently, Zambia has nine public universities, 54 private universities, 15 colleges and schools of agriculture and 295 TEVETA colleges. The general enrolment in these institutions is provided in Table 3. The University of Zambia is the leading public university in the country with a total enrolment of over 24,676 students segregated by gender as 13,406 males and 11,270 females, respectively as of 2018 (Masaiti and Simuyaba, 2018.)

Private universities on the other hand have low enrolment but with numbers steadily on the rise (Table 4). It should be observed that the number of females in public universities is generally lower than that of their male counterpart. As for private universities offering science and technology, City University of Science and Technology as well as Africa Research University have more female students.

Table 3. Student enrolment by gender and university institution (Public Universities)

<table>
<thead>
<tr>
<th>University Name</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Zambia</td>
<td>13,406</td>
<td>11,270</td>
<td>24,676</td>
</tr>
<tr>
<td>Copperbelt University</td>
<td>8,010</td>
<td>3,650</td>
<td>11,660</td>
</tr>
<tr>
<td>Nkrumah University</td>
<td>4,710</td>
<td>4,173</td>
<td>8,883</td>
</tr>
<tr>
<td>Mulungushi University</td>
<td>2,644</td>
<td>2,107</td>
<td>4,751</td>
</tr>
<tr>
<td>Chalimbana University</td>
<td>1,442</td>
<td>3,279</td>
<td>4,721</td>
</tr>
<tr>
<td>Mukuba University</td>
<td>1,023</td>
<td>1,320</td>
<td>2,343</td>
</tr>
<tr>
<td>Total</td>
<td>31,235</td>
<td>25,799</td>
<td>57034</td>
</tr>
<tr>
<td>Percent</td>
<td>55%</td>
<td>45%</td>
<td></td>
</tr>
</tbody>
</table>

Levels of qualification attainment by gender.
The levels of attainment in the education system from secondary to higher education is dominated by more males than females (Table 5). In 2017, at secondary level, half (32.7%) of females compared to 67.3% of males attained secondary school qualification certificates. The trend is not different at higher levels of education. However, at Postgraduate level, the number of females has been significantly lower (22%) compared with that of male counterparts (77%) of who graduated with master’s degrees. Most recently in 2019, 26% of females compared with 74% attained master’s degrees.

Gender in STI for Higher Education Institutions in Zambia. During the period 2017 and 2019, Zambia had about 317 and 378 STI oriented institutions of higher learning offering sciences, engineering, agricultural and technological courses.

Table 4. Student enrolment by gender and university institution (Private Universities)

<table>
<thead>
<tr>
<th>University Name</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lusaka Apex University</td>
<td>2,834</td>
<td>4,299</td>
<td>7,133</td>
</tr>
<tr>
<td>University of Lusaka</td>
<td>3,454</td>
<td>3,295</td>
<td>6,749</td>
</tr>
<tr>
<td>DMI St. Eugene University</td>
<td>2,754</td>
<td>2,244</td>
<td>4,998</td>
</tr>
<tr>
<td>Rusangu University</td>
<td>2,052</td>
<td>2,027</td>
<td>4,079</td>
</tr>
<tr>
<td>Zambia Open University</td>
<td>1,595</td>
<td>1,925</td>
<td>3,520</td>
</tr>
<tr>
<td>Cavendish University</td>
<td>1,579</td>
<td>1,270</td>
<td>2,849</td>
</tr>
<tr>
<td>Chreso University</td>
<td>636</td>
<td>970</td>
<td>1,606</td>
</tr>
<tr>
<td>LIUTEB</td>
<td>766</td>
<td>707</td>
<td>1,473</td>
</tr>
<tr>
<td>Northrise University</td>
<td>434</td>
<td>291</td>
<td>725</td>
</tr>
<tr>
<td>Zambia Catholic University</td>
<td>288</td>
<td>419</td>
<td>707</td>
</tr>
<tr>
<td>City University of Science and Technology</td>
<td>371</td>
<td>159</td>
<td>530</td>
</tr>
<tr>
<td>Africa Research University</td>
<td>183</td>
<td>98</td>
<td>281</td>
</tr>
<tr>
<td>Trans-African University</td>
<td>132</td>
<td>60</td>
<td>192</td>
</tr>
<tr>
<td>Evangelical University</td>
<td>28</td>
<td>28</td>
<td>56</td>
</tr>
<tr>
<td>Southern Valley University</td>
<td>17</td>
<td>9</td>
<td>26</td>
</tr>
<tr>
<td>African ChriSTIlan University</td>
<td>7</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>17,130</td>
<td>17,805</td>
<td>34,935</td>
</tr>
<tr>
<td>Percent</td>
<td>49%</td>
<td>51%</td>
<td></td>
</tr>
</tbody>
</table>

Source: Masaiti and Simuyaba (2018)
Table 5. Attainment of qualifications from Secodary to Tertiary Education level 2017 -2019

<table>
<thead>
<tr>
<th>Education Qualification attained</th>
<th>2019 Male</th>
<th>2019 Female</th>
<th>2018 Male</th>
<th>2018 Female</th>
<th>2017 Male</th>
<th>2017 Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary School Certificate</td>
<td>67%</td>
<td>33%</td>
<td>69.5%</td>
<td>30.5%</td>
<td>67.3%</td>
<td>32.7%</td>
</tr>
<tr>
<td>Certificate/diploma</td>
<td>58%</td>
<td>42%</td>
<td>59.3%</td>
<td>40.7%</td>
<td>60.4%</td>
<td>39.6%</td>
</tr>
<tr>
<td>Bechelors Degree</td>
<td>62%</td>
<td>38%</td>
<td>67.8%</td>
<td>32.2%</td>
<td>68.2%</td>
<td>31.8%</td>
</tr>
<tr>
<td>Master’s Degree</td>
<td>74%</td>
<td>26%</td>
<td>81.8%</td>
<td>18.2%</td>
<td>77.5%</td>
<td>22.5%</td>
</tr>
</tbody>
</table>


With regards to STEM field’s programmes, the enrolments are still dominated by male students. As indicated in Figure 3, only 37.3% of the female students were enrolled in Natural Sciences, Mathematics and Statistics, 25.2% in Information and Communication Technologies and 29.5% in Engineering, Manufacturing and Construction in 2018. These numbers were significantly lower compared to those of males. This imbalance is a reflection of what occurs in industries once these graduates.

In the management of higher education institutions, women are also underrepresented at Vice Chancellor and Deputy Vice Chancellor level. From 2015 to 2020, only 8% and 14% of women held the position of Vice Chancellor and Deputy Vice Chancellor, respectively, in both private and public universities. This shows the level of women under-representation at the higher education level management level. The numbers of females graduating in STEM programmes have not been consistent. Information and Communication Technology (ICT) has been low compared to in natural sciences, mathematics and statistics. However, engineering, manufacturing and construction has attracted more females, followed by natural sciences, mathematics, while Information and Communication Technologies attracted the lowest. Figure 4 shows the numbers of female graduates in (STEM) related fields during the period 2014 to 2018 in Zambia.

Higher Education Enrolments by Gender. In general terms enrolment between males and females at various levels of education differ significantly whether at secondary school, certificate and diploma, bachelor’s degree and postgraduate qualification. Overall, Science, Technology, Engineering and Mathematical Sciences (STEM) have very low female participation. Further, the number of women

Figure 3. Percentage of females enrolled in STEM fields
Source: ASTI (2020)
who attained Higher Education - Masters and PhD in this field is quite low. Similarly, only 14%, 25% and 29% respectively were female. This was not quite the case in fields like education and business-related programs where females constituted 48% and 49.2% respectively. In technical education sector, TEVET institutions admit less than 2% of the output from basic and secondary education and the Government plans to increase it to above 15% (AfDB, 2013).

Government Investment in Science Technology and Innovation (STI). The Government of Zambia plans to increase investments in science, technology and innovations through budgetary allocation in the education sector. As an example, the 2016 Higher Education expenditure stood at 93% for University Education, 51% for Skills Development and another 51% for Science, Technology and Innovation (Figure 5).

The 2018 budget for the Ministry of Education had an approved total budget of K1.9 billion (Ministry of General Education, 2018 Annual Report). The major funded activities in the ministry included University Education (72.6%), STI (6.4%) and 18.3% for skills development (Figure 5 and Table 6).

![Figure 4. Total Number of female graduates in STEM fields 2014 -2018](source: Ministry of Higher Education 2018)
in the education sector. As an example, the 2016 Higher Education expenditure stood at 93% for University Education, 51% for Skills Development and another 51% for Science, Technology and Innovation (Figure 5).

The 2018 budget for the Ministry of Education had an approved total budget of K1.9 billion (Ministry of General Education, 2018 Annual Report). The major funded activities in the ministry included University Education (72.6%), STI (6.4%) and 18.3% for skills development (Figure 5 and Table 6).

**Zambian Labour force in STI.** The low participation of females in STI does not only end at tertiary level education but is further reflected in the labour market. Science, engineering and technology oriented careers are male dominated. There are however more females (52 percent) than males (48 percent) employed in the Agriculture, Forestry and Fisheries Industry (Gender Status Report 2014). Overall, the number of females working in the fields of STI in Zambia still remains very low below levels. (Figure 6).

In the agriculture sector, males dominate agriculture staffing, trained agriculture extension officers, fisheries officers, among others, constituting 64% compared to 35% for females in 2019 (Figure 6). However, the participation of non professional females or women accounts for over 70% of agriculture production labor force in the Zambia.

According to the Labour force Survey of 2014, out of 2,864 skilled employees in the agriculture, forestry and fisheries sectors, about 56% employed were women compared to 41% men (CSO, 2014). Despite this gender positive statistic, only a small percentage of females are in managerial positions.

According to Beintema and Di Marcantonio (2009), female farmers play a significant role in African agriculture representing between 60 and 80 percent of the labor force. Contrustingly on the scientific front, such as in agricultural scientific research and technology, men dominate. There are few female scientists, professors, and academicians in scientific research and technology. There is unfortunately limited information about female’s participation in science and technology in Zambia. Much of the concern of the policy focus has been on issues of women empowerment, gender based violence and victim support. Gender diaggregated data are needed in various aspects and sectors for sound policy information.

Source: Estimates of Revenue and Expenditure for 1st January to December 2017 (Volume 2)
Information Communication and Technology in Zambia

In the 21st century, the use of information and communication technology is very critical. Computers and technology are no longer a luxury but a necessity for national development. Like in other STI fields, females’ participation in ICT in Zambia still lags behind significantly in comparison to men. This is despite that ICT is considered an important mechanism in delivering the socio-economic needs of both men and women (ZICTA, 2014). The use of ICT in socio-economic activities, which seek to encourage and enhance equal participation of men and women, is crucial in national development. Although Zambia adopted the Information and Communication Technology (ICT) Policy in 2007, which provided for mainstreaming of ICT usage in developmental programmes, very few women and girls have adequate access to ICTs especially in rural areas mainly due to limited ICT literacy and funding. Statistics for 2013 indicated that out of a total of 8,240,753 mobile phone subscribers, only 40 percent were women.

Government effort on mainstreaming STI in Tertiary Education. In the bid to increase access to higher education including in STI fields in the country, the Government of Zambia in 2016 established the Higher Education Loans and Scholarship Board (HELSB). The board was established through the Act No. 31 of 2016 to provide loans and scholarships to students who require financial assistance or who are recognised for academic excellence. The criteria of the loan is that the applicant must be admitted to, or registered as a student at a higher education institution within Zambia for a course of at least one academic year’s duration. Further, a student is eligible for consideration for a scholarship if the student satisfies such conditions as the Minister may prescribe by statutory instrument. Before 2016, the Bursaries Committee was responsible for offering scholarships to students at the University of Zambia and Copperbelt University. The demand for financial support has always been on the increase as indicated in Table 7.

By 2018, a total of 20,649 loans were awarded to students in universities, out of which 12,212 (59%) went to males and 8,437 (41%) went to females out of over 35,000 applicants (MOHE, 2018).

By 2019, the higher education loans were restricted to public universities namely, Copperbelt University, Kapasa Makasa, Mulungushi University, Mukuba, Kwame Nkuruma and University of Zambia.
Challenges of mainstreaming Gender in STI

The low participation of women and girls in science and technology in Zambia is of great concern. Some of the identified challenges hindering participation of women STI include the following:

Access to tertiary education. The low number of females accessing tertiary education has been a challenge. This is depicted in Figure 3 as well participation in STI in Figure 6.

Lack of financial support. Generally a higher percentage of female students drop out from the education system compared to their male counterpart. According to CSO (2018), 39%

Table 7. Award of students loans in Higher Education Institutions

<table>
<thead>
<tr>
<th>Year</th>
<th>Awards</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>3884</td>
</tr>
<tr>
<td>2013</td>
<td>4437</td>
</tr>
<tr>
<td>2014</td>
<td>5741</td>
</tr>
<tr>
<td>2015</td>
<td>4585</td>
</tr>
<tr>
<td>2016</td>
<td>6499</td>
</tr>
<tr>
<td>2017</td>
<td>5723</td>
</tr>
<tr>
<td>2018</td>
<td>6106</td>
</tr>
</tbody>
</table>

Source: Higher Education Loans and Scholarship 2019-2021 Strategic Plan
females drop out of the education system in urban areas while in rural area 45% of female students drop out. This is due to a myriad of factors such as, early marriages, preference for males by parents and sponsors, and cultural attitudes that women focus on house and family chores rather than career progress.

**Limited job opportunities for STI graduates.** Currently Zambia has few manufacturing and processing industries. This has negatively affected the prospects for employment in engineering, construction, agriculture and energy sectors. A few opportunities are prioritized for male applicants such as work in rural areas where females would not prefer to work in.

**Inadequate gender statistics and few role models in STI Careers.** Currently women representation in parliament stand at 19%, with even fewer women employed as engineers and Vice Chancellors in Universities. This in away has contributed to girls to opt for service based careers such teaching, nursing, commerce and hospitality sectors. In addition, there is inadequate sex disaggregated data to capture the status of women in various STI fields. Most information is focussed on negative effects of Gender based violence rather than the positives on empowerment and improvements in female participation. This gives females a perception of being victims and vulnerable rather than having the potential to lead and contribute to national development.

**Negative attitude of females to science and technology courses and programmes.** Female students have negative perception about taking courses in mathematics, science and engineering. Moreover, limited laboratory infrastructure, places and programmes implies only few students will be enrolled in science and technology programmes which invariably results in fewer places for female students. Pure science classes and technical subjects have been perceived as male oriented (NSTC, 1996). Further, limited numbers of female role models as teachers and lecturers have promoted this myth about science as a male dominated career options.

**STI Strategies and Gender mainstreaming in Zambia**

Affirmative action by the Government of Zambia led to the creation of the Ministry of Gender to promote gender related issues in development. In promoting science, technology and innovations, the Government of Zambia is implementing the following strategies:

- Reviewing of educational curricula in schools, colleges and universities to make it gender sensitive for female participation.
- Establishment of special funds and scholarships for female education in the science and technical fields through the High Education Loans and Scholarship Board (HELSB)
- Promotion of science and technology subjects in girls’ schools such as making the subjects compulsory, and girls’ technical secondary schools have been created in all provinces of the country.
- Establish and/or strengthen career counselling programmes to address problems which hinder girls’ progression in Science and Technology.
- Provision of incentives to female teachers in science and technology and those willing to work in rural areas to work as role models.

**CONCLUSION AND RECOMMENDATIONS**

Science, Technology and Innovation plays a crucial role in meeting the internationally adopted Sustainable Development Goals (SDGs), approved by the United Nations General Assembly in 2015. In Zambia, STI gender ecosystem shows that the participation of female in science technology and innovation is still low as in other SADC countries and Africa in general. Starting from the lowest
position of secondary school to higher education university level and in political leadership, females are grossly underrepresented. However, there are on-going efforts through the National Science and Technology Council to encourage participation of females in STI. Also, the Ministry of Higher Education through the Higher Education Loans and Scholarships Board encourages participation of females in STI by sponsoring more female applicants for science, technology and engineering programmes. The Government of Zambia has in fact developed policies and strategies to encourage female participation such as through constructing girls’ technical schools throughout the country and giving incentives for female participation in STI subjects, and appointing females into Government positions.

**Recommendations**

- The Higher Education Lands and Scholarship Board (HELSB) should come up with strategies to promote female applicants secure scholarship and loans in science, technology and engineering programmes. This would increase female students’ enrolments and number of females in tertiary education sector and labour force.
- Gender mapping and statistics in STI systematically compiled and used to promote quality in Higher Education instead of focusing on gender based violence (GBV) which is currently the main focus of gender mainstreaming. Therefore participation of females in Science, Technology, Engineering and Mathematical Sciences (STEM) and STI should be prioritized.
- Promote more women leadership in science and technology and innovation oriented careers so that women act as role models for young females, i.e., as Vice Chancellors, Professors, Principals and in Industry, etc. Currently, the census for staffing in Higher Education is underway to provide capacity and status of staff and qualifications in tertiary education.
- Promote the Science-Policy interface. While many policies have been developed on gender, there is little effort in actualising such interventions on the ground. Government should come up with additional STI instruments to actualize the needed interventions, for example, creating small STI pilot projects to solve community problems and to promote the science-policy interface in national development.
- Create platforms for STI disseminations such as National workshops, seminars, conferences and create opportunities for dialogue with the female scientific community.
- Enhance transnational/regional and multidisciplinary approach on integrating STI in socio-economic development aspects including policy formulation. Additionally, encourage intra-Country scientific cooperation and collaboration across African region and developed world to promote technology transfer and knowledge exchange.
- Harness regional and and continental platforms to build capacity in STI in Africa.

**ACKNOWLEDGEMENT**
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**STATEMENT OF NO-CONFLICT ON INTEREST**
The authors declare that there is no conflict of interest in this paper.

**REFERENCES**


National Science and Technology Council. 2015. Directory of Scientists and Technicians in Zambia


A theoretical analysis of public expenditure on education and agriculture sector growth nexus: Case of Uganda

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ABSTRACT
Uganda’s economic development prospect is intertwined with agriculture sector growth. The country has 80% of the land, which is arable, but only 35% is being cultivated majorly using subsistence suboptimal methods. On the other hand, the country’s population age structure is a paradox of its own. Census data indicates that close to 63% of the total population is below the age of 24 years and 50% below the age of 15 years. It is therefore imperative that the education expenditure as a proxy for human capital development should underpin policy and public investment choices. At the sector level, growth and prosperity are positively correlated to a reduction in rural poverty that is still a characteristic of rural households. This paper seeks to deepen the theoretical understanding of agriculture and education nexus and the low transformation of the agriculture sector in Uganda.

Key words: Agriculture Sector, economic development, education investment, human capital, Uganda

RÉSUMÉ
Les perspectives de développement économique de l’Ouganda sont étroitement liées à la croissance du secteur agricole. Le pays possède 80% des terres arables, mais seulement 35% de ces derniers est principalement cultivé en utilisant des méthodes de subsistance sous-optimales. En revanche, la structure par âge de la population du pays est un paradoxe en soi. Les données du recensement indiquent que près de 63% de la population totale a moins de 24 ans et 50% a moins de 15 ans. Il est donc impératif que les dépenses d’éducation en tant qu’indicateur du développement du capital humain sous-tendent les choix politiques et d’investissement public. Au niveau sectoriel, la croissance et la prospérité sont positivement corrélées à une réduction de la pauvreté rurale qui est encore une caractéristique des ménages ruraux. Cet article cherche à approfondir la compréhension théorique du lien existant entre l’agriculture et l’éducation ainsi que la faible transformation du secteur agricole en Ouganda.

Mots clés: Secteur agricole, développement économique, investissement dans l’éducation, capital humain, Ouganda

INTRODUCTION
Agriculture occupies conspicuous space in Uganda’s development agenda due to increasing food insecurity and poverty that requires finding viable solutions to a number of complex technical, institutional, and policy issues. On the other hand, education raises people’s productivity, creativity, promotes entrepreneurship and technological advancement of humanity (Bloom et al., 2020). However, the lack of clarity on the interconnection between investment in education and agriculture sector growth is compelling. There is a firm consensus that education drives economic growth as well as fostering intellectual, cultural and trade links in an increasingly developing knowledge ecosystem and multi-lateral thinking (Attanasio, 2015; Ali et al., 2018). Burgess, (2016) identifies critical policy domains through which education as a means of building human capital is critical. First, a country’s stock of skills is central to its potential for economic growth in a highly competitive international environment. Second, the distribution of that human capital is a key determinant of income inequality, ever more important with a high wage premium for skills. Third, the link between a person’s human capital and their background is a fundamental determinant of social mobility. In the agriculture sector, investment in human capital development contributes to generation of skilled labour force that provides the prerequisite knowledge for production and activation of critical value chains that have the potential to advance the vibrancy of the entire national agricultural innovation system and spur growth (Bashir et al., 2018).

The new Growth Theory” considers technological progress as an endogenous variable of economic growth and this is the real driving force of long-term economic development (Banerjee and Duflo, 2004; Chandra and Islamia, 2010). Economic development is a multidimensional process characterized by growth of systems that generate economic, technological, social and institutional changes to support wealth of nations and wellbeing of a society (Coccia, 2018). Recent studies reveal that most of sub-Saharan African countries are experiencing unprecedented growth underpinned by favourable macroeconomic trends that are likely to contribute to the much-needed economic transformation (AUC/OECD, 2019). The Rostow’s stages and Harrod-Domar model of classical theories of economic growth have failed to clarify the economic development of poor nations, as the returns to high investments in physical capital are dismal (Osiobe, 2019). This is attributed to lack of other socioeconomic factors such as efficient higher education system and good governance (Jiranyakul, 2014).

Fundamentally, there is a plethora of evidence that alludes to the fact that investment in education enhances factor productivity, stimulates economic growth and promotes socio-economic development (Barro and Lee, 2013; Patrinos and Montenegro, 2014). Indeed, the registered improved economic performance in sub-Saharan Africa has been to some extent attributed to the rapid expansion of the tertiary education sub-sector (Darvas et al., 2017). More specific to the agriculture sector, investing in education through training and research generates new technologies and innovations that potentially increase agricultural productivity and help solve some of the world food crisis and mitigate natural resources degradation (World Economic Forum, 2015). According to Mogues et al. (2015), the consistent and significant public investments in technology, infrastructure, and services supportive of agriculture sector growth, led to sustained and impressive agricultural productivity that we now refer to as the “Green Revolution” in Asia. Sadly, Africa is yet to witness such a transformation of its agri-food system.

METHODOLOGY
This paper, therefore, seeks to provide insights into the education and agriculture growth nexus and stimulate policy conversations around education investment and agriculture sector growth. The synthesis applies a theoretical review of existing literature and take a descriptive reflection on longitudinal national statistical data for the period 1982-2017.
We hope that the synthesis provided will be relevant to emerging economies in sub-Saharan Africa that have a significant proportion of their population dependent on agriculture as well as contribute to the policy debates on agriculture transformation.

**Theoretical Findings**

**Rationale for country specific analysis.** There are underlying characteristics that are country-specific such as the prevailing policy framework, labour market dynamics and brain drain that render cross-national comparisons inaccurate and misleading to inform specific recommendations (Hamilton et al., 2009; Kwon 2009; Liu, 2014). According to Von Brockdorff and Amaira (2017) this cross-sectional estimation of determinants of productivity fails to reflect the existing heterogeneity and differential effects in countries. The State superstructure is quite diverse across countries and has implications on productivity performance. This is the rationale for deeper theoretical investigation at country specific level as opposed to comparative study across countries.

**Economic returns to education investment**

Economic returns to education investment are significant. Recent evidence suggests that indeed education is a determinant of individual income and can produce public and private benefits, which are also termed as social returns (see Gyimah-Brempong et al., 2006; Pegkas, 2014; Shao and Wang, 2018). According to Bloom et al. (2014) using data from UNESCO, sub-Saharan Africa’s production level is about 23% below its production possibility frontier due to capacity gaps. They also established that a one-year increase in the tertiary education stock would raise the long-run steady-state level of African GDP per capita by 12.2% due to factor inputs. However, there is growing concern that returns to investment in education are diminishing in view of increased unemployment among the educated workforce, as a result of limited placements in public service and private sector to absorb the existing human capital. There is a negative relationship between unemployment and labour productivity growth rate (Doppelt, 2018). This comes amidst fiscal difficulties facing national governments with the implication that education, as a factor of human capital will decrease returns.

The two recent Uganda National Household Surveys (UNHS) on labour market indicators of the working population aged between 14-64 years revealed that unemployment statistics are higher in urban than rural areas (Table 1). For instance, between 2013 and 2017, the proportion of the population employed in urban areas grew marginally from 23% to 24.3%, an increase of less than two percentage points over a period of five years. Whereas over the same period, there was a drop in the working population in rural areas from 77% to 75% of which 47% were employed in the agriculture sector. Similarly, the proportion of the working population in the agriculture sector among males declined from 37% to 31% while the employment rate for women remained stable at 47% on average. Overall, there is a high unemployment rate in urban areas approximated at 75% that need a critical reflection on despite the consistent upward trajectory of economic and wellbeing indicators. This level of economic exclusion poses a dilemma and may even reverse the gains made towards achieving the objectives of the Sustainable Development Goals (SDGs). Uganda’s unemployment status cannot be looked at in isolation without looking at the trends in the education sector policy environment and performance metrics.

**Education policy environment in Uganda**

Prior to the advent of full implementation of the World Bank’s Structural Adjustment Programme (SAP), the education sector like any other form of public service was free. The SAP consisted of conditional loans provided by the International Monetary Fund (IMF) and the World Bank (WB) to countries that experienced economic crises on condition that they put in place policies and reforms towards a market-oriented economy. These policy changes led the Uganda Government to abolish tuition subsidies in all tertiary education institutions and equally introduced private student sponsorship schemes in all public institution
of higher learning to support the resource allocative policy of realising universal primary education objectives (Bakkabulindi, 2006; Katunguka, 2015). Thus, the Government of Uganda introduced the Universal Primary Education (UPE), which almost tripled the net primary school enrolment, but with a catastrophic change in the public investment, landscape at both secondary and tertiary education levels whose effects are still being felt today (Figure 1). The same policy led to increased investment in the education sector by the private sector. According to the latest Annual School census of 2016, there is a total of 6,798 pre-primary schools 19,718 Primary schools and of these, 12,109 (61%) are government-owned whereas the rest are privately owned (UBOS, 2018).

Despite the increased enrolment, rates that were sustained beyond grade five with effects much large among girls in poor households; the education system is still facing challenges in terms of low internal efficiency and unequal quality of education (Huylebroeck and Titeca, 2015). Figure 2 shows education public expenditure for primary, secondary and tertiary education levels, respectively. The universalisation of primary education in the mid-nineties led to irreversible increase in primary education expenditures and for the first time surpassing allocations to secondary education level which trend has remained so to date. The spike in secondary education expenditure from 2007 onwards was due to the introduction of Universal Secondary Education (USE), a new policy that introduced free secondary education in selected secondary schools whether private or public. The objective of USE was to support the poor but academically promising students to access secondary education.

According to the 2016 Ministry of Education and Sports, Annual School Census (2016), Uganda has 3,070 secondary schools of which 1592 (51.9%) are USE out of which 690 schools were private USE schools (Uganda Bureau of Statistics, 2017). The increase in resource allocation to tertiary education universities is largely attributed to an increase in the number of public tertiary institutions from four in 1982 to the current eight. The level of funding at tertiary education level does not reflect the aspirations of the second National Development Plan (NDPII). The NDPII demands that higher education funding through government should

---

Table 1. Key Labour Market Indicators of Working Population (14-64 years) by sex and residence in Uganda

<table>
<thead>
<tr>
<th>Selected Labour Market Indicators</th>
<th>Male</th>
<th>Female</th>
<th>Rural</th>
<th>Urban</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNHS 2016/17</td>
<td>8,965</td>
<td>10,139</td>
<td>13,803</td>
<td>5,301</td>
<td>19,104</td>
</tr>
<tr>
<td>Working age population ('000)</td>
<td>7,397</td>
<td>7,656</td>
<td>11,395</td>
<td>3,658</td>
<td>15,053</td>
</tr>
<tr>
<td>Working population ('000)</td>
<td>49.1</td>
<td>50.9</td>
<td>75.7</td>
<td>24.3</td>
<td>100</td>
</tr>
<tr>
<td>% of working population</td>
<td>2,310</td>
<td>3,604</td>
<td>5,373</td>
<td>541</td>
<td>5,915</td>
</tr>
<tr>
<td>Subsistence agriculture ('000)</td>
<td>31.2</td>
<td>47.1</td>
<td>47.2</td>
<td>14.8</td>
<td>39.3</td>
</tr>
<tr>
<td>Percentage working in subsistence agriculture only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| UNHS 2012/13                     | 7,850      | 8,652       | 12,289    | 4,213     | 16,502   |
| Working age population ('000)    | 6,827      | 7,069       | 10,732    | 3,164     | 13,896   |
| Working population ('000)        | 49.1       | 50.9        | 77.2      | 22.8      | 100      |
| % of working population          | 2,517      | 3,493       | 5,345     | 664       | 6,009    |
| Subsistence agriculture ('000)   | 36.9       | 49.4        | 49.8      | 21        | 43.2     |
| Percentage working in subsistence agriculture only | | | | | |

Source: UBOS, UNHS 2012/13 and 2016/17; UNHS= Uganda National House Survey
be at least 1% of GDP, but the current funding level has stagnated at 0.3%. Further, the then envisaged revenue from the privatisation of higher education did not improve the balance sheet of most of the tertiary institutions. According to the Uganda budget monitoring and accountability unit under the Ministry of Finance, Planning and Economic Development, on average all public universities receive less than 50% of their budgeted capital development fund.

Higher education output

The data on the number of graduate exit the higher education system for selected years are shown in Table 2. The data indicates there is disproportionate lack of skilled human capital to fully service the sector. Between the period 2004 -2011 less than 2% of all graduates enrolled in tertiary institutions in the country pursued agriculture as a discipline. (see Table 2). This percentage has remained the same despite an increase in tertiary education enrolment and the expansion of post-secondary education system to cater for a large number of students that are annually qualifying to join tertiary institutions. This lack of adequate human capital makes all attempts by the public sector to implement policies supporting rural economic and institutional transformation processes led by local rural actors themselves to be ineffective, as the key actors do not have the prerequisite knowledge and skills to harness the dividends of technology and innovation in the sector (Ambrosio-Albalá and Bastiensen, 2010). Higher education plays a crucial role as part of the triple helix model for innovation. Therefore, the future of productivity growth in the agriculture sector is dependent on abilities to maximise productivity gains, anchored on innovation and technical capacities of the citizens. The underpinning factor is the vital role agricultural graduates play as innovators to stimulate improvements and unlock the untapped potential in the respective value chains (OECD, 2016; Asadullah and Ilah, 2018).

![Graph showing school enrolment between 1982-2018](image-url)

**Figure 1. School enrolment between 1982-2018**
A theoretical analysis of public expenditure on education and agriculture sector growth nexus: Case of Uganda

Figure 2. Public Expenditure in primary Secondary and tertiary Education, 1982-2018

Table 2. Number of graduates disaggregated by discipline

<table>
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<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Universities and University Colleges</td>
<td>84658</td>
<td>45584</td>
<td>73204</td>
<td>19401</td>
<td>140,087</td>
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<tr>
<td>Technical Colleges</td>
<td>0</td>
<td>2941</td>
<td>0</td>
<td>1980</td>
<td>3250</td>
</tr>
<tr>
<td>Teachers Colleges</td>
<td>5542</td>
<td>2375</td>
<td>7757</td>
<td>3240</td>
<td>7842</td>
</tr>
<tr>
<td>Commerce/Business</td>
<td>14060</td>
<td>8617</td>
<td>11347</td>
<td>6834</td>
<td>348</td>
</tr>
<tr>
<td>Management/Social Development</td>
<td>5173</td>
<td>106</td>
<td>3841</td>
<td>315</td>
<td>5472</td>
</tr>
<tr>
<td>Health</td>
<td>0</td>
<td>6274</td>
<td>0</td>
<td>3132</td>
<td>7488</td>
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<tr>
<td>Agriculture/Fisheries/Forestry</td>
<td>0</td>
<td>1293</td>
<td>0</td>
<td>1651</td>
<td>1625</td>
</tr>
<tr>
<td>Theology</td>
<td>1580</td>
<td>0</td>
<td>1098</td>
<td>0</td>
<td>1597</td>
</tr>
<tr>
<td>Art and Design</td>
<td>175</td>
<td>20</td>
<td>0</td>
<td>0%</td>
<td>195</td>
</tr>
<tr>
<td>Media</td>
<td>729</td>
<td>891</td>
<td>472</td>
<td>1004</td>
<td>1620</td>
</tr>
<tr>
<td>Hotel and Tourism</td>
<td>23</td>
<td>203</td>
<td>0</td>
<td>143</td>
<td>226</td>
</tr>
<tr>
<td>Study Centres</td>
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<td>0</td>
<td>604</td>
<td>0</td>
<td>640</td>
</tr>
<tr>
<td>Survey and Land Management</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Law Development</td>
<td>800</td>
<td>0</td>
<td>800</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Aviation</td>
<td>0</td>
<td>147</td>
<td>0</td>
<td>0</td>
<td>147</td>
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<tr>
<td>Meteorology</td>
<td>0</td>
<td>39</td>
<td>0</td>
<td>39</td>
<td>39</td>
</tr>
<tr>
<td>Petroleum</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cooperatives</td>
<td>443</td>
<td>23</td>
<td>328</td>
<td>0</td>
<td>348</td>
</tr>
<tr>
<td>Research Centres</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Data source: Uganda National Council of Higher Education (NCHE). Reconstructed by the author
Table 3. Number of Bachelor graduates in agriculture and related courses from Makerere University for the period 2004-2018

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</tr>
</thead>
<tbody>
<tr>
<td>BSc. Agribusiness Management</td>
<td>74</td>
<td>47</td>
<td>52</td>
<td>68</td>
<td>70</td>
<td>57</td>
<td>64</td>
<td>71</td>
<td>72</td>
<td>85</td>
<td>12</td>
<td>45</td>
<td>36</td>
<td>45</td>
<td>18</td>
</tr>
<tr>
<td>BSc. Agriculture and Rural Development</td>
<td>86</td>
<td>47</td>
<td>39</td>
<td>56</td>
<td>51</td>
<td>41</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSc. Agricultural Engineering</td>
<td>17</td>
<td>23</td>
<td>25</td>
<td>18</td>
<td>27</td>
<td>19</td>
<td>16</td>
<td>25</td>
<td>15</td>
<td>21</td>
<td>17</td>
<td>7</td>
<td>9</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>BSc. Agricultural Land Use and Management</td>
<td>37</td>
<td>22</td>
<td>15</td>
<td>19</td>
<td>30</td>
<td>34</td>
<td>39</td>
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<td>7</td>
<td>22</td>
<td>21</td>
<td>34</td>
<td>21</td>
</tr>
<tr>
<td>BSc. Agriculture</td>
<td>54</td>
<td>50</td>
<td>35</td>
<td>57</td>
<td>61</td>
<td>47</td>
<td>47</td>
<td>95</td>
<td>64</td>
<td>99</td>
<td>25</td>
<td>49</td>
<td>78</td>
<td>70</td>
<td>82</td>
</tr>
<tr>
<td>BSc. Animal Product Technology</td>
<td>28</td>
<td>21</td>
<td>17</td>
<td>6</td>
<td>13</td>
<td>21</td>
<td>27</td>
<td>12</td>
<td>16</td>
<td>10</td>
<td>2</td>
<td>15</td>
<td>13</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>BSc. Development Economics</td>
<td>164</td>
<td>182</td>
<td>172</td>
<td>229</td>
<td>206</td>
<td>229</td>
<td>185</td>
<td>227</td>
<td>235</td>
<td>126</td>
<td>4</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>BSc. Development Studies</td>
<td>377</td>
<td>399</td>
<td>410</td>
<td>340</td>
<td>272</td>
<td>183</td>
<td>211</td>
<td>205</td>
<td>263</td>
<td>310</td>
<td>204</td>
<td>85</td>
<td>283</td>
<td>613</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>837</td>
<td>791</td>
<td>765</td>
<td>793</td>
<td>730</td>
<td>631</td>
<td>629</td>
<td>684</td>
<td>709</td>
<td>709</td>
<td>271</td>
<td>239</td>
<td>440</td>
<td>800</td>
<td>169</td>
</tr>
</tbody>
</table>

Data obtained from the Directorate of Quality assurance Makerere University

As such, there is growing emphasis to invest in human capital development through training and research to generate technologies and innovations that will increase agricultural productivity to help solve some of the world food crisis and natural resources degradation (World Economic Forum, 2015). There are indications that this is in fact a viable public investment option (see Olowa and Olowa, 2014; Mogues et al., 2015). This is the human capital stock that should be harnessed to cause desirable changes in the agricultural sector (Fox, 2015; Ragasa, 2016). Therefore, both human capital and knowledge systems are critical in improving the productivity of agri-food systems while ensuring environmental sustainability (Zheng and Jun, 2013). Ummadda's Higher education output

Uganda's economic development cannot be separated from the agriculture sector. The fertile agricultural land has the potential to feed 200 million people if it is fully exploited. The sector contributes close to half of all exports earnings, and about one-quarter of gross domestic product (GDP). The agri-food system remains largely untapped, yet the demand for high-quality labour is increasing. Therefore, human capital stock should be increased to meet the demand.
agriculture commodities is on the increase as a result of urbanisation and changing dietary preferences that come with improvement in income and the associated lifestyle. According to the World Bank estimate, during the year 2050, Uganda will have a population of 102 Million people which is a huge market that will provide massive opportunities for the country’s agriculture sector and wider agri-food system. Recent estimates argue that the value add of agriculture to GDP will increase if investments are in made higher-end value chain activities that include manufacturing and food processing (OECD, 2016).

The agriculture sector is of particular interest in growth analysis. The reasons are relevant both for practical relevance and theoretical arguments as permanent increases in agricultural output are of macroeconomic relevance (Bahiigwa et al., 2005; Diao et al., 2010). In Uganda, the agriculture sector employs close to 70% of the population and growth in the sector is key to poverty reduction. The share of employment has consistently remained at close to 70% mark for the over the past two decades despite the doubling of the total force during the same period. This employment rate distribution across sectors has been stagnant for the entire period of post-independence Uganda that is coming close to 60 years. The remaining 30% of the employed population is split between the service and industry sectors at 25% and 5%, respectively (Figure 1). The share of employment has consistently remained at close to 70% mark for the over the past two decades despite the doubling of the total force during the same period. This employment rate distribution across sectors has been stagnant for the entire period of post-independence Uganda that is coming close to 60 years. The remaining 30% of the employed population is split between the service and industry sectors at 25% and 5%, respectively (Figure 3).

Therefore, growth in the agricultural sector is key to poverty reduction and there is no doubt this growth can be stimulated from innovations emanating from the country’s agricultural training and research innovation system. Based on the above, it can as well be argued that under-investment in higher education by many governments thus has been constraining development through lack of innovation and technological advancement contributing to increased youth unemployment, inequality and limiting inclusive economic growth (Mogues et al., 2012).

Figure 3. Number of employed in Uganda by economic Sector 1982-2018
Education and Agriculture Sector growth pathways

Whereas Gashu et al. (2019) argue that failures in agricultural policies, weak institutions, and poor governance are the root cause of growth stagnation of agriculture in Africa, there is a need for significant investment in creative innovation. A vibrant agriculture innovation system emerges from conscious integration of multi-disciplinary approaches to gain full understanding of the rural development challenge in low to middle-income countries. For instance, advances in the study of mind, neurological sciences, brain and cognition have significantly contributed to a better understanding and orientation of the teaching-learning process and a more effective organization of educational activities. Similarly, economists, sociologists and political scientists, too, have contributed substantially to the issues related to prioritizing investments and maximizing outputs of the system (Varghese, 2009). There are three major pathways to which higher education impacts on development, namely, that of teaching, research and innovation. The notion of teaching empowers individual leaners to gain capabilities to be more innovative and productive and directly earn more. Despite the growing massification and differentiation of agriculture higher education as a factor of human capital development, Uganda’s agricultural sector has dismally grown at a rate of 2% which is comparable to 1.8% growth rate across the sub-Sahara Africa and yet the sector accounts for over 70% of the labour force in agriculture (Diao et al., 2010). It is argued that improvements in the stock of human capital will result in the generation of new technologies, innovations and new knowledge to unlock the current bottlenecks in value chains and would significantly increase agricultural productivity. Despite the concerted effort by the public to invest in the education as part of human capital development, the education pipeline is a very tightly funneled pyramid with less than 2% of the annual total multi-level school enrolment accessing tertiary education (see Figure 2). Of these, on average less 20% complete secondary with over 75% not going beyond the primary level. According to the World Bank gross school enrolment at secondary level was reported at 23.24 % in 2015.

Bloom et al. (2014) argue that physical capital fails to flow in poor countries because of relatively poor endowments in complementary human capital, and factor accumulation. In the long-term, increases in agricultural productivity in the developed countries have been attributed to advances in knowledge and technology derivatives of human capital (Kassie et al., 2011; Li et al., 2013). Therefore, the extent to which the existing agricultural knowledge systems and human capital contribute to agricultural development need to been extensively studied. This argument has advanced by various authors, for instance, in China (Liu and Jiang, 2001), European regions (Sterlacchini, 2008) and Latin America (Torres and Schugurensky, 2002).

Uganda Human Development Complexities

Uganda is experiencing rapid population growth and there are concerns of the dilution effect of population growth and unemployment rate on returns to human capital development especially as being experienced in most of sub-Saharan Africa (Adil et al., 2014; Bucci et al., 2018). Further, long-run growth as a result of human capital accumulation is dependent on the efficiency with which resources available are deployed and utilised within the various sectors of the economy (Opeyemi et al., 2017). Marginson (2017) perhaps provides the most controversial narrative that human capital theory fails the test of realism, due to weaknesses of method: use of a single theoretical lens and closed system modelling, inappropriate application of mathematical tools, and multivariate analysis of interdependent variables that imposes a single linear pathway on the complex passage between heterogeneous education and work.

Uganda’s education sector has been overly
criticised for compounding the problem of unemployment, with antiquated curricular that churns out not fit-for market graduates. Because of this realisation, there is emerging interest and attention to Vocational training. This education subsector is witnessing increasing public allocation of resources ostensibly to avert the current youth unemployment, which burden is afflicting the majority of countries in sub-Saharan Africa with potentially catastrophic outcomes for sitting regimes. As a result, the Government of Uganda developed the Business, Technical and Vocational Education and Training (BTVET) Strategic Plan 2011 – 2020 with a paradigm shift for skills development in Uganda. The strategy is embedded in the overall education policy framework and underpinned by the Government white paper (GWE, 1992) on education as well as the insufficient skills to propel the informal sector especially the non-farm informal sector. The non-farm informal sector, comprises mainly micro-enterprises, own-account workers and unpaid family workers, and has declined in recent years, but still accounts for 18% of total employment, and 58% of the non-agricultural employment. Hanushek and Woessmann (2016), observes that there are significant gains that accrue from providing universal basic skills. Returns to such investment is projected to be six times those of just providing universal access to schools. Datzberger (2020) in his quest for why education is not helping the poor in Uganda, observed that assimilative approaches as outlined in the policy implementation strategies of (a) increased access to education and retention; (b) improved quality of education; and (c) employment generation through education, had little impact on the political, economic and social structures that are the underlying causes of poverty.

CONCLUSION AND POLICY RECOMMENDATIONS

Based on enrolment data at tertiary education level, the study recognises that there is still a challenge of attracting students to study agriculture as a discipline. As a result, the sector has a deficit of critical mass of skilled and appropriate human capital to apply skills technology and innovation to unlock the critical value chains. Therefore, for the country to fully reap human capital dividends for the benefit of the agriculture sector, it will require a multifaceted approach with a sustained public investment, institutional reforms and policy implementation devoid of ambiguous and narrow-minded interventions such as the civil-military operation, the so-called operation wealth creation.

The current public finance model should take into account the returns to the investment approach and not merely look at as provision of social services. The fact that education improves people lives coupled with the increasing role of the service and industry sector economic output, this should be a rationale for investing in education to build a stock of sector-specific demanded skills that can be attained through individuals attaining formal education. Uganda like all countries, uses the cash-based national budget as a planning tool for public expenditure showing projected overall resource envelope for the medium and overall priority interventions including investment in the education sector. However, the cash-based budgeting system undermines the efforts to improve macroeconomic performance and commitment to budget discipline amidst competing for short term political gains versus long-term development goals. The protracted process of human capital development involves learning in a structured environment, which is only attainable in a formal education system. The emerging knowledge-based competition within a globalizing economy is indeed prompting a fresh consideration of the role of education in development and growth.

A country’s human capital development success is dependent on policy and public investment choices underpinned by the demographic structure of its population. Uganda’s age structure is a paradox of its own. Census data
indicates that close to 63% of the total population is below the age of 24 years and 50% below the age of 15 years. This young population demands purposive skilling and knowledge formation to enable them to find meaningful and inclusive engagement in the economy to circumvent potential unrest that is often a manifestation of exclusion of young and ambitious segment of the population from economic activity. Based on these demographic statistics, the country is characterised as “young”. Conventional wisdom dictates that countries with young populations with a significant proportion of the population under the age of 15 years, as for the case of Uganda, need to invest more in human capital development. In fact, for Uganda, developing human capital is critical if the country is to achieve the aspirations of vision 2040 “A Transformed Ugandan Society from a Peasant to a Modern and Prosperous Country within 30 years”. It will be a futile attempt to realise this vision without according high priority to human capital development.

ACKNOWLEDGEMENT
Our appreciation goes to the Regional Universities’ Forum for Capacity Building in Agriculture for sponsoring this study.

STATEMENT OF NO-CONFLICT ON INTEREST
The authors declare that there is no conflict of interest in this paper.

REFERENCES
Bloom, D. E., Canning, D., Chan, K. and


The International Bank for Reconstruction and Development / The World Bank and Fox, S. 2015. Accelerating catch-up:


