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Higher Education and Science, Technology and Innovation landscape in Africa

K. MUIR-LERESCHE
Education Consultant, Cape Town, South Africa
Corresponding Author: bandroop@gmail.com

ABSTRACT
This edition explores some of the issues facing universities as they fulfil their mandate of providing the human resources and strengthening the knowledge base of African societies. It explores the role of universities in science and technology and the links with agricultural extension and in using its post-graduate programmes to contribute to research with an overview of the evolving RUFORUM network and how it has impacted on universities relevance and quality. A review of selected country case studies shows how the sector is responding to gender inclusivity and how it could contribute better to science, technology and innovation.

Key words: Africa, gender inclusivity, Higher Education, Science, Technology, RUFORUM

Higher Education issues in Africa
African universities have faced severe challenges as they emerged from a colonial past where they were established as bastions for the elite. They were well-respected and of high quality but served only the few. They were not an integral part of society and were the quintessential ivory towers they are often referred to. They were established as clones of the universities in France, England or Portugal, and often directly linked to universities in Europe. Their institutional structures, and many of the processes and governance, remain virtually unchanged today. But with declining financial support and strong pressure on significantly increased intake, the universities had to start to adapt. Within agriculture most of the research was carried out on campus, or at best on research stations mainly serving large-scale commercial agriculture. Lynam and Mukhwana (2020) provide some historical context to the effect this had on the linkages between universities and agricultural extension. Gbamkima and Nakayiwa (2020) look at the importance of post-graduate programmes to underpin research. All universities are faced with the need to attract highly qualified staff, how to motivate them and how to strengthen and retool them to lead the universities that will drive Africa’s growth. Gbamkima and Nakayiwa (2020) consider this...
in some detail. Zinnah and Jackollie (2020) highlight the critical gap that exists in Liberia because the universities are unable to attract well qualified staff who prefer to pursue more lucrative and influential positions than those offered in education.

Waswa et al. (2020) explore the role of RUFORUM in catalysing change to encourage collaboration, strengthen the role of universities in the broader society and invest in building relevant higher education capacity to meet the growing needs.

For too many decades the very scarce highly skilled human capital has been locked up in universities. The 21st Century has seen universities increasingly take up the role of reaching out and making universities more relevant to their societies. University-led research platforms working with farmers and all the stakeholders along the value chain, RUFORUM, has shown how effectively universities can generate and scale out knowledge in sustainable ways by working in partnerships. Universities have convening power and an impartial platform where it is safe to interact. By using their students to carry out their research on such platforms, universities are able to ensure that they develop the skills and the contacts they need. Universities are able to update and upgrade their own teaching and research for relevance. Universities are increasingly playing a role in leading change, in leading development and in providing a role in advocating for greater equity: in gender, in access to higher education and in producing the research and scaling out the information, that meets the needs and demand of the majority and of the poorer quintiles in society.

Universities have a primary function of preparing students for society, of providing the skilled human capital that will drive Agenda 2063. They are also required to develop, collate and share an advanced knowledge base, to stimulate research that will meet the future and to promote development that is inclusive and sustainable.

To meet radical technological change, universities across the world, have increasingly been encouraged to change the paradigm to one of facilitating learning rather than transferring information; of producing creative, adaptable graduates with strong interpersonal skills; and of working with end-users and multiple stakeholders on research and advocacy. Universities are called on to lead the evolution of systems that are more inclusive and sustainable. To do this, they must change themselves. Universities have been grappling with this across the world. In Africa the challenges are multiplied. In some they grapple with emerging from decades of war, as explored by Zinnah and Jackollie in Liberia. In most African countries women are poorly represented at all levels in universities, and more especially in science and technology. Analysis of how to change this in three countries is explored further in this edition.

New technologies provide opportunities to overcome many of the challenges. Public and traditional universities are not easy to change. But to survive they must adapt. The future workforce needs to be educated in ways that encourage continuous learning and adaptation. We do not know what the future of employment will be and our graduates must be fully engaged with internet, big data and virtual reality if they are to succeed. Universities in Africa must find ways of integrating modern technology into all facets of their systems: teaching, research, outreach and administration. They also need to find ways to broaden their reach so that they are part of the solution to inequality, not a vehicle for driving it. How will Africa massify higher education without losing quality and relevance? What steps are needed for universities to drive sustainable, inclusive growth? These questions are looking for African solutions on how to take modern technology and fit it to local realities so that Africa can leapfrog older systems. This Edition provides ideas on how universities could be more effective and documents the situation in some of our countries and universities.
This edition opens with a paper by Lynam and Mukhwana (2020) that traces the history of agricultural extension and higher education since the colonial era. It articulates how the policy trends have affected engagement of universities in scaling out innovations and highlights the differences across the sub-regions. The pressure on time and the lack of clear targets for engagement has limited the time and resources directed at this engagement. Of particular interest for strengthening the links between agricultural extension and universities is their finding that, even with strong institutional will for collaboration, time and funds are needed to overcome the transactional costs of maintaining these relationships. Their paper also draws attention to the changing landscape in agricultural extension and the strengthening of the role played by the private sector. Lynam and Mukhwana (2020) bring to the fore how universities can improve their relevance by supporting extension. They also highlight the importance of TAE in producing graduates who have the skills and exposure to contribute. There are an increasing number of post-graduate students using modern technology to offer extension services and scale out their technologies (Mirembe et al., 2016) more effectively linking universities to farmers.

Gbamkima and Nakayiwa (2020) carry out a detailed analysis of the role of universities in producing research. They provide evidence to support the importance of investing in raising the quality of post-graduate programmes and of strengthening supervision and standards. Recent news articles on the overloading of supervisors and the undermining of quality reinforce these findings. They also focus on the issues raised by the rapid expansion of universities and the lack of faculty with advanced skills. This impacts the ability to offer post-graduate training and results in a vicious cycle. They show that Africa is under-served by universities and that the universities there are have too few qualified staff. This lack of well-qualified teaching staff is a recurring theme and is shown to be a key constraint in the paper by Zinnah and Jackollie in Liberia. However, as Gbamkima and Nakayiwa (2020) point out, it is not only the production of graduates that suffers, the role of universities in research, and more broadly in countries, is severely constrained. For Africa to take its place in the coming decades it is imperative for it to invest much more heavily in generating and adapting knowledge. In collating and sharing information to create a broad, highly-skilled locally-relevant human capital and advanced knowledge base, stimulating research, innovation and entrepreneurship.

A series of three papers explore the issue of gender in science and universities in Africa. The papers show that at all levels women are marginalised, in the student intakes, faculty and administration of universities. In Sudan although female students account for 54% of undergraduate intake, they account for only 23% enrolled in science and mathematics (Mayada et al., 2020; Muna and Mutasim Ahmed Abdelmawla, 2020). It is interesting to note that the one metric where they surpass men in science, is that once accepted, women have a higher graduation rate than men. Sokona (2020) provides a very comprehensive analysis of the situation in Mali. This description includes current data and information. In Mali only 48% of girls are enrolled in secondary school and of all staff employed in STI only 10% are women holding a Master’s degree and only 9% holding a PhD. The data show that there is a great need for more investment in upgrading the skills of all those involved in science, technology and innovation, but in particular the importance of supporting the advancement of women. Mali has allocated 15% of its budget to agriculture which is considerably more than most African countries. This paper shows that it needs to invest more in supporting tertiary agricultural education, and especially improving opportunities for women. Elhag and Abdelmawla (2020) highlight the importance of the non-government sector in Sudan for supporting improved participation by women in science and technology. Although

1There is a crisis with inadequate supervision. For example a CUE report in Kenya in 2019 showed one example where a lecturer was supervising 30 PhD and 106 Master’s students.
54% of undergraduates are women only 5% of the science students are women. The study notes further that although the new constitution emphasises the need to increase women in leadership positions, less than 3 percent of the Vice Chancellors in Sudan are women. The constitutional mandate needs to be translated into specific policies to support the advancement of women. Giva and Santos (2020) provide an interesting analysis of the role of women in higher education in Mocambique. They show that this is a particular issue for science and show that it must be addressed early; that students are making choices in mid high-school that affect their future. They recommend that more attention needs to be given to counselling children about the implications of their choices at school. They also recommend greater institutional flexibility to make enrolment more feasible for women and show that participation increases with the offer of evening classes and greater flexibility in attendance structures.

The final three papers focus on the role of higher education in the advancement of science and technology in Sudan, Ghana and Liberia. The challenges faced by Liberia are especially acute as it deals with emerging from decades of civil war, the Ebola epidemic and generations of lost education at all levels. In Sudan, Beshir et al. (2020) highlight the problems for universities addressing financial constraints by increasing fee-paying students at the expense of quality. Not only is this increasing inequality, it also decreases the quality of higher education. The study also articulates the importance of investing in upgrading the qualifications of faculty. It recommends using the network of African universities to achieve this in ways that improves not only their qualifications, but also their local relevance and their teaching and research skills. They stress the importance of investing in entrepreneurship and practical training in their TVET institutes. Sam-Amoah et al. (2020) describe the STI landscape in Ghana and highlight the importance of the role of the private sector and of how Higher Education needs to co-operate more closely with them.

They argue that investment in STI has shown some positive returns and that capacity is being built but that greater investment is required. They also note that investments and new programmes need to consult with all stakeholders while they are being developed and to have an adaptive management approach. They recommend setting up a monitoring and evaluation system to provide an ongoing assessment of the impact of that investment. Zinnah and Jackollie (2020) emphasise the very low base from which Liberia is trying to strengthen its capacity to support science and innovation. The most critical constraint is human capital with low salaries and poor conditions for research discouraging applicants. They identify areas that require investment with a focus on the need to attract, train and retain well qualified faculty for the growing tertiary education sector.

**Universities in Africa post COVID 19**

These papers were all written prior to the emergence of the Corona virus in January 2020. Everything they identify as important to build the human capital, knowledge and information sharing needed to achieve Agenda 2063, is still applicable. What this pandemic does is make the investment in producing relevant graduates and research even more critical. The requirement of physical distancing, as efforts are made to stop the spread of the virus, makes the task very much more difficult.

**Pandemics are by their nature disruptive.**

They strain not only health services but all of human and economic life. They have changed societies in their wake from 524 in Egypt to the present day. The Bubonic plague of the mid-14th century killed a third of the population in Western Europe. But it changed society and led to collective bargaining and reduced feudal obligations. Pandemics have also shifted the underlying world view from one focused on theology to one that turns to science for understanding. In 1852 the cholera epidemic led to an understanding of the relationship between disease and clean water and there are other examples of positive impacts for
humanity, albeit at heavy cost in life (John Snow in Barton, 2018). The 1918 Spanish flu, as with Covid-19 highlighted the inequality between social classes. Whitzman (2020) showed that it led to a better understanding of how important universal health care and improved low income housing is to the health of all. But societal change from pandemics will not necessarily be for the better. It depends on the structural relationships and how societies and economies respond. The Covid-19 pandemic could increase inequity between and within countries. The wealthy and professional classes have been able to adjust to social distancing while maintaining some income and their access to education. It could result in reinvestment in environmentally harmful systems. Or if we are able to provide a platform for new solutions, it could trigger real changes to institutions and result in much more inclusive and sustainable systems. Universities need to take leadership to ensure that happens.

Universities need to invest in systems that reach out across their countries, find ways to ensure that they are able to provide an education and support, even to students that are isolated. If no cure or vaccine is found, then it is more imperative than ever for Africa to rapidly increase digitisation of education. Unless we can ensure access to education across the continent, despite any ongoing, or recurring, need for social distancing, Africa will not be able to compete. It will not be able to take advantage of its youth dividend and it will not fulfil its promise. It is essential for universities to very proactively change their systems to adapt, lobby governments and private communications companies to ensure that they can reach even the most marginalised students.

To change the university systems is not easy, but the need for flexibility is imperative and there are many long term benefits that could accrue to these changes. They could benefit women by making it easier for them to participate in postgraduate education without leaving home for long periods; for mature students to be able to advance their qualifications while working; for students unable to physically access universities to be able to study. The new technologies are also able to make it easier for universities to reach even the most remote farmer, or the smallest trader in the value chain. It will allow its faculty the change to connect in meaningful ways with the best scientists in the world and to collaborate much more effectively with colleagues across the continent. But to have all these benefits, universities must adapt. They must be prepared to change their systems and to promote learning rather than try to transfer information.

Curricula need to be adapted so that universities are able to stretch their scarce human capital, making use of all the open and special licence modules already available to them. Universities need to learn how to facilitate on-line learning in ways that promotes interaction and so expose their staff to new pedagogies. The better-resourced South African universities have used Covid19 to get the telecommunications industry to zero-rate data when accessing their websites, they have made efforts to get computers and internet access to all their students and to find ways to support those still unable to fully participate in on-line learning. The less well-resourced universities are still struggling to find their way. COVID 19 is a siren call to governments and development agencies to support all tertiary education institutes to be able to use modern technology to broaden their reach and improve the quality of delivery. They need to find ways to reach out to communities and to facilitate platforms of engagement.

This requires a large investment at a time when the world is under severe economic strain. But it is an investment that has to be made. Tertiary education institutions across the continent need to collaborate. They need to work together, to share courses, to share scarce human resources and to share lessons as universities adapt differently to the pandemic. Most of all they need to work together to lobby for their governments
and the international telecommunications and development agencies to support effective internet access to all Africans, and to build the skills for Africa’s universities to produce the graduates, research and outreach which will harness Africa’s resources and catalyse sustainable and inclusive growth for the most marginalised communities.

We have to work together as a human species to be organized to care for one another, to realize that the well-being of the most vulnerable among us is a determining factor for the well-being of all of us (adapted from Snowdon, 2020). The current pandemic has shown the world how true this is. Universities need to organise and to work together to ensure that they use this moment to change themselves and to advocate for the support they need to make the change.

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The changing face of agricultural education and extension within a changing policy context in Africa

J. K. LYNAM¹ and E. J. MUKHWANA²

¹Independent Consultant, P.O. Box 72635-00200, Nairobi, Kenya
²Kenya National Qualifications Authority, P.O. Box 72635-00200, Nairobi, Kenya

Corresponding Author: Jums75@gmail.com

ABSTRACT
Tertiary Agricultural Education (TAE) institutions¹ perform a range of functions that complement their principal focus on training and human capital development. These include research, a critical component of higher degree training, outreach and community development, policy and advocacy, and increasingly product development and public-private partnerships. However, there are a range of institutions in the agricultural sector that also provide these functions, most of them specializing in a specific function, in what could be termed the organizational ecosystem within the agricultural sector. Faculties of agriculture often face dilemma in the sense that these subsidiary functions are necessary to ground faculty in a rapidly changing sector and to provide post graduate students with the skills they will need when they enter the labor market. At the same time financial resources are limited in universities to support these functions. This dilemma would argue for closer linkages between faculties and other organizations within the agricultural sector, in what is commonly referred to as agricultural innovation systems. However, such linkages require coordination, resources to support what are termed transaction costs, and mutual benefits from the arrangement. Because of these factors, institutional linkages have proven to be more the exception than the rule, even more so within a rapidly changing policy and institutional environment. This paper looks at an historical perspective in the development of the complex of institutions supporting the agricultural sector and attempts to identify the principal drivers of institutional change and change in institutional arrangements. The institutional ecosystem has varied through time, regionally, and in relation to colonial origins. The paper looks at the main trends through time, pointing out regional differences. It describes the post-independence period up to the mid-1980’s, and subsequently up to the mid 2000’s, which was dominated by structural adjustment and market liberalization programs. Finally it examines changes over the last decade and a half. Each of the periods had implications in the development of TAE and its role in the evolving agricultural innovation system.

Key words: Africa, agricultural research, extension, tertiary agricultural education, university institutions

RÉSUMÉ
Les institutions d’enseignement agricole supérieur (TAE) remplissent une gamme de fonctions qui complètent leur principal objectif de formation et de développement du capital humain. Il s’agit notamment de la recherche, un élément essentiel de la formation de niveau supérieur, de la sensibilisation et du développement communautaire, des politiques et du plaidoyer, et

¹Institutions as used in this paper refer to organizations, principally formal organizations. The more specific use of the term institutions refers to the norms, laws, and regulations that govern economic activity, as is particularly used in institutional economics.


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de plus en plus de développement de produits et de partenariats public-privé. Cependant, il existe une gamme d'insti tuitions dans le secteur agricole qui assurent également ces fonctions, à plupart d'entre elles se spécialisant dans une fonction spécifique, dans ce que l'on pourrait appeler l’écosystème organisationnel au sein du secteur agricole. Les facultés d’agriculture sont souvent confrontées à un dilemme dans le sens où ces fonctions subsidiaires sont nécessaires pour ancrer les professeurs dans un secteur en évolution rapide et pour fournir aux étudiants de troisième cycle les compétences dont ils auront besoin lorsqu’ils entreront sur le marché du travail. Parallèlement, les ressources financières des universités sont limitées pour soutenir ces fonctions. Ce dilemme plaiderait en faveur de liens plus étroits entre les facultés et d’autres organisations du secteur agricole, dans ce que l’on appelle communément les systèmes d’innovation agricole. Cependant, ces liens nécessitent une coordination, des ressources pour soutenir ce que l’on appelle les coûts de transaction et les avantages mutuels de l’accord. En raison de ces facteurs, les liens institutionnels se sont révélés être plus l’exception que la règle, encore plus dans un environnement politique et institutionnel en évolution rapide. Cet article examine une perspective historique dans le développement du complexe d’institutions soutenant le secteur agricole et tente d’identifier les principaux moteurs du changement et des arrangements institutionnels. L’écosystème institutionnel a varié dans le temps, au niveau régional et en fonction des origines coloniales. Cet article examine les principales tendances à travers le temps, soulignant les différences régionales. Il décrit la période post-indépendance jusqu’au milieu des années 80, puis au milieu des années 2000, qui a été dominée par des programmes d’ajustement structurel et de libéralisation des marchés. Enfin, il examine les changements survenus au cours de la dernière décennie et demie. Chacune des périodes a eu des implications dans le développement du TAE et son rôle dans l’évolution du système d’innovation agricole.

Mots-clés: Afrique, recherche agronomique, vulgarisation, enseignement agricole supérieur, institutions universitaires

INTRODUCTION

The institutional framework supporting agriculture in Africa has its origins in an agrarian economy facing multiple market failures and the initial design of the framework traces back to the colonial period. By the 1950’s colonial administrations had recognized the critical role played by the African smallholder in the stability of the agricultural economy and the early anthropological work argued that s(he) would respond to price incentives. The difficulty was that there was a domestic demand constraint in that urban markets were very small and local rural markets were easily saturated. On the other hand, an export orientation required an efficient assembly and bulking capacity where transport infrastructure was limited and expensive. This led to the design of institutions supporting the marketing function, with the prospect that this would shift from public control to competitive markets in the private sector. This shift would entail a restructuring of marketing institutions and institutional arrangements.

Another primary function in the development of the institutional framework was the provision of public goods, particularly research and its complement, agricultural extension services. Technologies that support growth in agricultural productivity were viewed as essential, particularly given the challenge in maintaining soil fertility on the mainly weathered soils of the continent (apart from volcanic soils) and the array of pests and diseases attacking both crops and livestock that were indigenous to the continent and on which little research had been done. The design of research and extension organizations has gone through several
structural changes in the post-independence period in significant part because funding for these public goods has primarily relied on international aid funds and many of the design changes have come from outside the continent. The lack of local participation and presence of sometimes lukewarm participation, has meant that implementation of research and extension policies and programs was always less than optimal.

Arguably the principal constraint on the functioning of agricultural institutions was the lack of adequately trained personnel to staff these organizations. University development was in an embryonic state at independence and the cadre of trained personnel was limited in relation to the need. For decades university graduates had guaranteed positions in the public sector and faculties focused on the skill requirements needed to fill these public sector positions. Universities at the same time were limited by the under investment that had been made in primary and secondary education. Both the size and curriculum of faculties of agriculture would depend on investment in the supply of potential university students, the resources then to invest in tertiary education, and the changing job market for graduates.

Eicher (1999) argues for more of a systems approach to what he calls the agricultural research triangle², namely agricultural research, extension, and university institutions. By a systems approach he argues that there is an interplay between the services offered by the three, where weakness in one constrains the provision of services by the other two. This would argue for a planned and sequenced investment in what might be thought of as the core set of institutions driving agricultural productivity growth in the sector. This idea of unbalanced development of the agricultural institutional framework, latter to be termed the agricultural innovation system, is key to understanding capacity of these institutions to support agricultural growth and transformation. This balance or lack thereof was partly influenced by government investment priorities and by the structural changes in the agricultural market economy.

The critical changes in the agricultural institutional architecture since independence have been reflected in the role and structure of the Ministries of Agriculture (MOA). The functions carried out by the MOA over this period have changed significantly, which has affected how these functions are coordinated and funded. Much of the funding of agricultural services and functions is dependent on annual budgetary allocations primarily through the MOA. With many of those functions shifting out of the MOA, this has created a tendency to underinvest in the overall agricultural institutional framework, in many cases supplemented by international aid funds, but where priorities in those have also shifted over time. At the same time funding of agricultural faculties comes through ministries of education, which has often served to isolate those faculties from principal policy initiatives in the agricultural sector and to limit the balance in the development of the agricultural knowledge triangle. The phases in the development of agricultural institution in Africa is discussed in the succeeding three sections of this paper.

Independent to the mid 1980’s: The dominance of the public sector—The colonial legacy at independence. The principal dimensions of the colonial legacy can be defined in terms of two issues, namely the development of an institutional framework in support of agriculture, which was the largest contributor to colonial economies, and the very much delayed development of universities and training of indigenous agricultural scientists, which created real constraints on institutional

effectiveness after independence. Similarly, the approach to the institutional framework varied significantly between the colonies of France and Great Britain. In the post World War II (WWII) period France developed a centralized, federated system across its colonies in West Africa while Britain supported the development of administrative capacities in each of its colonies, although there were regional approaches in agricultural research in British colonies in East and West Africa. The institutional framework in place at independence became the template for administration of the agricultural sector for the new governments, with the principal issue being how to staff these institutions.

In the British colonies up until the post WWII period, each colony was expected to support its own governmental expenditure. Those colonies that could not meet this threshold were defined as “lacking responsible government”. “The finances of some of these (colonies) - the ‘grant-aided territories’ - were under the strict control of Her Majesty Treasury” (Morgan, 1964). Most of the colonies in sub Saharan Africa (except Southern Rhodesia, today Zimbabwe) fell under this rubric which meant that all expenditure by the colonial governments came under the scrutiny of the colonial office. For agriculture the Colonial Agricultural Service staffed the agricultural departments in the colonies with British post graduate officers who spent one year at Cambridge and one year at the Imperial College of Tropical Agriculture in Trinidad. The Departments of Agriculture were headed by a Director of Agriculture, who reported to the Governor, and oversaw staff that fell into two groups, namely research staff and a field staff of agricultural officers. The latter were placed either at provincial or district level, with the district agricultural officer being the frontline officer (Masefield, 1972). Before independence in the 1950s, governance in the colonies shifted to a ministerial system based on local elections—for example, this took place in Kenya in 1954 (Trapman, 1974) which resulted in the creation of ministries of agriculture. The departments of agriculture also supported an agricultural research system in each of the colonies. Extension had also become more formalized in the post-WWII period, particularly with the large settlement and agricultural development projects, including a focus on soil conservation. However, these often involved coercive measures, which created an animosity by farmers to government extension programs, thereby greatly undermining the efficacy of these initiatives.

In many ways the more critical institution was the commodity marketing board. These differed between the settler colonies in East and Southern Africa and the smallholder-based export economies of West Africa. A principal activity of the settler community was cereal production, but in a context of limited urban demand, thin markets, and price volatility, as well as competition from smallholder production. The depression of the 1930’s led local governments pass acts to create marketing boards to set prices and regulate supplies. In particular these acts led to (1) the establishment of restrictions on grain movement from African towns, mines and other demand centers where African production could otherwise undercut European grain production; (2) the creation of monopoly state crop buying stations in European farming areas without similar investments in African farming areas; and (3) assured prices for European farmers (typically above export parity) that were financially sustained through “rake-off” taxes on maize sales by Africans to licensed private traders operating as agents of the boards (Jayne and Jones, 1996). West African economies were based on smallholder production and non-tradeable food staples but with a dynamic export production of cocoa and palm oil and kernels. During WWII in 1940
The West African Cocoa Control Board was set up to manage cocoa purchases and exports, which was extended in 1942 to palm products and groundnuts. In 1947 commodity boards were set up in each of the West African colonies to manage export products (Williams, 1985).

The last major institution to be developed in the British colonies was the university colleges. The Asquith Commission of 1945 recommended that institutions for higher education be created in the colonies, in part reflecting the need for an educated elite in getting ready for self-rule. As a result of the commission report, university colleges were founded in Nigeria (University College of Ibadan), the Gold Coast (University College of the Gold Coast) and Uganda (Makerere University College/University of East Africa), Southern Rhodesia/Nyasaland, and Sudan. These university colleges were affiliate colleges of the University of London, which designed the curriculum, set entry requirements and awarded the degrees. This went against a previous 1938 commission report which recommended a curriculum adapted to African conditions. These colleges had relatively small class sizes in relation to the need for trained manpower. In the period 1952 to 1963 university colleges in anglophone Africa produced about 150 graduates in agriculture—compared to only 4 in francophone Africa (Eisemon et al., 1985). One critique of the Asquith Commission approach focused on the over specialization and lack of relevance, the lack of linkages to the technical institutes, and too much of a focus on fundamental research (Ashby, 1966).

Managing the agricultural economy by the Ministry of Agriculture. In the anglophone countries the Ministries of Agriculture (MOA) were the central institutions that carried out the functions critical to development of the sector. These functions were aggregated into the MOA and as a result the MOA had one of the largest budgets, in general like the budget for education. The marketing boards, however, were maintained as separate entities or parastatals. Each board handled a different commodity and was given the authority to set prices and organize supply. For example, Kenya had 12 separate boards, one of which supported irrigation (Trapman, 1974) while others worked on coffee, tea, sisal, cotton, cereals, and milk, among others. The boards carried out the same functions, but were now orientated to serving smallholder farmers, particularly in the former settler colonies. This was done by expanding state buying stations into smallholder areas and with links to MOA departments, providing subsidized inputs and credit (Jayne and Jones, 1996). The MOA had departments for research and extension, for agricultural credit, for infrastructure development, and all organized at national, provincial and district levels, although
with a tendency to centralize decision making at the national level.

The MOA in francophone countries had less of an implementation role and more of a planning and coordination role. As Moris (1994) notes, the MOA “serves in a technical and advisory capacity, planning the project portfolio for publicly financed activities in the agricultural sector, which, once they have become part of the national plan and subsequently the annual budget, are usually implemented by an array of parastatal institutions dealing with individual export crops (groundnuts, cotton, cereals, and sugarcane).” These projects were usually implemented by regions and there was significant variation in project implementation depending on institutional capacity that up to the 1980’s depended significantly on expatriate staff.

**Fragmentation in agricultural research.**
A significant agricultural research capacity had been developed in most countries at independence, but it was significantly under resourced. As Rosebloom *et al.* (1998) noted, “In 1961, public (agricultural research) systems in 33 of 48 African countries employed fewer than 25 full-time equivalent (fte) researchers.” This also included a number of regional agricultural research centers. During the colonial period most countries were integrated into these regional structures. In the anglophone countries this included the East African Agricultural and Forestry Organization (EAAFRO) based in Kenya and in West Africa regional institutes for palm oil, cocoa, and rice. This also included the Empire Cotton Growing Corporation’s central station at Namulonge in Uganda. In West Africa the regional institutes were effectively nationalized at independence. EAAFRO continued to function until the collapse of the East African Community in 1977, at which point the stations were integrated into the science division of the Kenyan MOA, as was the Namulonge station into the Ugandan system. The collapse of regional structures meant that many countries lost access to research support for important crops in their economies, and a big chunk of the institutional memory that had been built over time and were saddled with a research infrastructure that did not undertake research relevant to local needs.

Different research capacities were somewhat arbitrarily incorporated in different areas of the MOA, resulting in significant fragmentation and lack of coordination of research efforts. Moreover, with the smallholder focus there was a need to shift away from a focus on export crops to food crops. This often led to competition among different research departments for funding in order to build capacities, which were sometimes duplicated. The macroeconomic mismanagement and stagnant growth of the 1980’s, with the need for improved efficiencies in the MOA, led to the restructuring of agricultural research into autonomous, parastatals with centralized management and budgeting of all or most of agricultural research in the countries, namely the creation of the national agricultural research institutes (NARIs).

The development of agricultural research institutions in francophone Africa took a very different approach. At independence in 1960 the federal system of agricultural research was jettisoned as each newly independent country assumed responsibility for its own research. However, given the shortage of personnel, these research centers continued to be managed by the eight research institutes in France up through the mid-1970’s. The agreements with France at independence included continued control of research centers in the former colonies. A continuation of French ownership or long-term rights of access to the local research infrastructure throughout Africa formed part of the cooperative agreements that France signed with nearly all the French African territories that gained independence during the late 1950s and early 1960s (Roseboom *et
al., 1998). In 1970 these centers were brought under one administrative structure, GERDAT (Groupe d’Etudes et des Recherches pour le Développement de l’Agronomie Tropical), which evolved into CIRAD and became the principal basis for French aid in agriculture. By the mid 1970’s most francophone countries had taken over control of the research centers in their countries. Because of this history, institutional development was a much slower process in French West Africa than in the former British colonies, especially in terms of the process of “Africanization” of these institutions and their ability to focus on resolving local problems.

Integrated Rural Development to T&V Extension. Agricultural extension in the anglophone countries was the preserve of the MOA and the focus was on food crop production by smallholders. There were no strict extension methodology as different approaches were used, including farmer training centers, model farms, demonstration trials, and progressive farmers. Ruthenberg (cited in Lele, 1975) summarized these different approaches in two organizational forms, namely the “take it or leave it” approach and the contract farming method. The first essentially offered advice or techniques to farmers and it was up to them to decide to adopt, thereby circumventing the more coercive methods used during the colonial period. The latter was usually associated with cash crops such as tea or cotton and was based on contractual forms of participation. Extension agents also were the front line in credit and subsidized input programs, also run through the MOA, and these also were associated with more with cash crop production programs (Mukhwana, 2000). The latter type of organization was also found in francophone countries, particularly in cotton and groundnut programs and often organized through farmer cooperatives.

Robert McNamara’s 1973 speech in Nairobi shifted the development agenda to poverty, and in Africa that meant rural poverty. This led to the World Bank’s support for integrated rural development programs—IRDP’s (Lele, 1975; Yudelman, 1976) The projects built on a range of rural development projects initiated during the colonial period (Hodge, 2007), particularly in anglophone countries. These integrated various services in particular regions and relied on the capacities in the MOA, particularly the extension departments. At this stage extension personnel were still relatively few in relation to the smallholder population and not well trained. IRDP increased the intensity of the extension capacity in program areas and increased the training of extension personnel. As the term integrated implies, technical advice was combined with credit and input delivery programs. These programs, however, were found to be too complex for the institutional capacities that were in place in that period (OED, 1992) and investment in IRDP’s essentially stopped.

The decline in support to IRDP’s coincided with the World Bank’s new initiative in Training and Visit (T&V) extension. The Bank had supported this extension model in Asia in the mid 1970’s and piloted the approach in Kenya in 1981, leading to a loan supporting a complete reorganization of extension in 1983. The Bank would go on to supporting T&V projects in 30 countries on the continent (Bagchee, 1994). Extension in these countries was organized around a single model which consisted of a hierarchical management structure, a rigid schedule of visits to pre-selected contact farmers, a focus on a few dominant crops, periodic interaction with research staff, and a significant expansion in and training of extension personnel (Anderson et al., 2006). A single methodology dominated extension departments within MOA’s in Africa through the 1980’s and into the early 1990’s and as explained in the next section, World Bank support collapsed, and with-it effective implementation of the model. The model had been heavily financed by the World Bank, and its financial sustainability was obviously in question (Mukhwana, 2000).
Expanding national universities and government management. There was at least one great weakness in the colonial approach. This was the failure to develop institutions that could produce the skilled, indigenous manpower to undertake research and to participate in the management and direction of agricultural growth (Yudelman, 1975). At independence there were five higher education facilities that provided a degree in agriculture in the anglophone countries and one in the Congo. This left a real deficit in the ability of newly independent nations to staff and manage the complex of institutions necessary for agricultural growth and development, including faculties of agriculture themselves. At independence the former university colleges affiliated to the University of London were constituted as national universities. In East Africa Makerere University was reconfigured in 1963 as one of three colleges constituting the University of East Africa, joining more recently established colleges in Nairobi and Dar es Salaam, which ended in 1970 and all became national universities. At the same time in 1963 90% of the academic staff in the university were expatriates (Court, 1991).

With the process of decolonization in the 1960’s there was a focus of American foundations, particularly Ford, Rockefeller, and Carnegie, on supporting the development of higher education in sub Saharan Africa (Livsey, 2017). This was soon followed by USAID and the World Bank. These programs had two prongs, namely higher degree training of Africans in northern universities and capacity strengthening programs for the new national universities. The result was a significant expansion of universities on the continent in the 1960’s and 1970’s, and particularly those offering agricultural and veterinary degrees in faculties of agriculture (Figure 1). However, enrollment in agricultural degree programs was not high. In 1979-81 only about 6% of all students at BSc level were enrolled in agricultural degree programs and just 7% at MSc level. For 19 countries outside Nigeria and South Africa, which had by far the largest number of students, this amounted to only

![Figure 1. Establishment dates of African universities with a faculty of agriculture or veterinary sciences](image-url)
4,102 students at BSc level and 493 students at MSc level, compared to 3,931 students at both levels in Nigeria (Bientema et al., 1998).

USAID was an early donor to the development of tertiary agricultural education on the continent and particularly focused on adapting the land grant model that had developed in the United States. One of the earliest investments was in 1953 with funding to Oklahoma State University to develop an agricultural university at Alemaya in Ethiopia. This was followed by support to Michigan State University to apply the land grant model in the creation of the University of Nigeria at Nsukka in eastern Nigeria at independence in 1960 (Livsey, 2017). Later this was followed by support to Ahmadu Bello University in the northern region and the University of Ife in western Nigeria. All together there were 11 universities that were supported in Africa, each for a decade, which is a long period by the standards of donor projects (Alemneh, 2014). The land grant model integrated three critical functions, namely education and training, research, and extension and community development, with each reinforcing the other two. Where the model succeeded, particularly at Ahmadu Bello University, there was an integration of the research institute at Zaria with the university and the creation of a research-liaison department, all supported by the Northern Ministry of Agriculture (Eicher and Haggblade, 2013). However, most failed to achieve this integration, mainly because the common ministerial separation between agricultural research (in ministries of agriculture) and agricultural higher education (in ministries of education) hampered the development of agricultural innovation systems in Africa (Eicher and Haggblade, 2013).

**Mid 1980’s to mid-2000: Structural Adjustment and Market Liberalization.**

This period market liberalization and demise of marketing boards. The 1980’s in SSA was a period of stagnant economic growth, declining per capita food production, and struggling institutions. The expansion in primary education and health services had stretched government budgets and countries tended to run large budget deficits with overvalued exchange rates. Overstaffing had significantly curtailed capital and operating budgets of public institutions, which had constrained their effectiveness. Moreover, whether farm prices were set above or below export parity depended on the country, regulations on produce movement, sales, and trade tended to limit investment incentives in the agricultural sector. This period of “African pessimism” led to the formulation by the World Bank and the IMF in the mid 1980’s of policy reforms designed to reverse these trends. These structural adjustment and market liberalization policies were implemented as conditionalities on loans provided to the countries (Woomer and Mukhwana, 2004). Because there was little in terms of private foreign investments, African countries depended on these loans. This period of policy reforms starting in the mid 1980’s and extending essentially to the turn of the century were targeted to achieve macroeconomic stability—which translated into control over deficit spending, liberalization of foreign exchange controls and trade regulation, and liberalization of agricultural markets. As a result of this period of structural reform in the economy was a major restructuring of the institutional architecture supporting the agricultural sector.

Kherallah et al. (2002) identify three basic policy and institutional features of the market liberalization process in the agricultural sector, namely: (1) liberalizing input and output prices by reducing or eliminating subsidies on agricultural inputs such as fertilizers and credit, realigning domestic crop prices, eliminating pan-seasonal and pan-territorial pricing, and reducing exchange rate overvaluation; (2) removing regulatory controls in input and output markets (for example, allowing the participation of the private sector in agricultural marketing), lifting restrictions on internal movement of food crops, and relaxing quantitative controls such
as delivery quotas and licensing arrangements; and (3) restructuring public enterprises and withdrawing marketing boards from pricing and marketing activities (such as providing market information services and maintaining security stocks). The result of these policy reforms would be to disengage the public sector from participating directly in agricultural markets and thereby encouraging the growth of private sector participation and investment (Woomer and Mukhwana, 2004).

This reordering of functions between the public and private sector in the agricultural economy would provide the rationale for redesigning the public institutions supporting agricultural development. Marketing boards were either dismantled or turned into strategic grain reserves such as ADMARC in Malawi. Significant parts of the MOA lost their role in a liberalized market economy, particularly those departments providing services that the private sector could provide. As might be expected with such a quick shift to reliance on a liberalized market economy, there was a significant lag in the entry of the private sector into the agricultural economy, especially as lack of infrastructure, uncertainty in whether the government would fully extricate itself from market interventions, and the high costs of integrating smallholders into the market economy all resulted in higher returns to investment in the urban sector (Mukhwana et al., 2004). Stepping into the breech was a major expansion of the role of civil society, as democratization surged across the continent up to the new century (Bates and Block, 2013). The NGO’s, farmer associations and cooperatives, micro credit facilities, and other forms of collective action filled the gap left by the institutional void left by the market liberalization process.

Redefining Extension. The World Bank played a dominant role in African agriculture during the 1990’s. At the same time as it was fomenting structural adjustment policies, the Bank was also increasing its loans for T&V extension. In the end, the two were incompatible in the sense that T&V extension required a significant expansion in the number of extension personnel and their mobility leading to significant increases in recurrent budgets. This occurred at the same time as other parts of the Bank were supporting macroeconomic reform particularly in terms of budgetary stringency. A uniform extension model had been rolled out in 30 countries since 1983 and by 1998 all support to T&V extension was terminated. A 1997 report by the Bank’s office of evaluation found that “the Bank had erred in the extent to which it has promoted the T&V extension management system in relatively uniform packages of investments and extension practices in large State and national programs”, and that “the increased flexibility in African T&V projects was not likely to resolve the problems encountered and therefore the T&V design was unlikely to be the most appropriate approach for improving extension in many African countries (Anderson et al., 2006).

In many respects this rather rapid withdrawal left a vacuum in agricultural extension capacity on the continent. This resulted in a period of experimentation with agricultural extension methods, primarily through NGO’s but also including the farmer field school (FFS) methodology piloted by the Food and Agriculture Organisation (FAO). This experimentation included assessing new forms of media, including local language radio, video, and FFS curricula. Similarly, farmer participation became a cornerstone of most approaches, often involving group methods and farmer associations. This provided the basis for more formal collective action by farmers, which was to be a precondition for cost effective integration of smallholders into expanding agricultural markets. This period of experimentation became the basis for what was termed pluralism in agricultural extension which rejected a uniform methodology delivered by a single agency and argued for multiple methods utilized by a range of providers, including
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an expanding private sector. The potential downside of this approach was possible bias in the coverage of the agricultural population, with a tendency for under coverage of more marginal areas or areas with higher rates of rural poverty. This experimentation as well included methods on how to link smallholders to markets, and in that sense civil society responded with integrated approaches given the vacuum in both extension and private sector market development (Woomer and Mukhwana, 2004).

Restructuring of the MOA and its changing role. In many ways the most fundamental change in institutions during this period was in MOAs. Many of the former functions were delegated to other institutions, such as research to the NARIs and market coordination to the private sector. Financing support for extension collapsed with the withdrawal of T&V extension and there were as well initial pilots to devolve extension to the districts as decentralization took hold. The implementation functions of the MOA were progressively devolved, and the role of the ministry was relegated to regulation, facilitation, and the provision of public goods. In the process budgets for agriculture were significantly pared, to the point that public spending on agriculture got to critically low levels, in some cases to 3% of the overall budget3. The African Union (AU) Heads of State meeting in Maputo in 2003 issued a declaration stating that government spending on agriculture should reach a target of 10% of overall public expenditure. In many ways this was an opportunity for the MOA to reimagine themselves and redefine their role, but in most cases the MOA retrenched staff and were unable to respond to such diverse constituencies, claims and demands, operating in an increasingly democratic but also decentralized setting. As technical line ministries they were often poorly equipped to do this (Cabral and Scoones, 2006).

At the turn of the century the World Bank and IMF realized that structural adjustment policy reform was having a negative impact on poverty rates, which led in 1999 to the additional conditionality that borrowing countries were required to produce a Poverty Reduction Strategy. Since the great majority of the poor lived in rural areas, targeted investments in rural development were a principal means of poverty reduction. This generated a debate as to whether rural development strategies were an agricultural strategy or extended to critical delivery of health and education services. In many ways it was easier for governments to direct annual budgeting to health and education than to the more complex relations between agricultural investments and poverty. A World Bank (2004) review noted the "disconnect between PRSP priorities and follow-up of the rural themes through Poverty Reduction Strategy Credits (PRSCs), other instruments, and other donors. This disconnect is most pronounced for rural finance, rural private sector development, food security, risk and vulnerability, livestock, decentralization and governance issues. On the other hand, rural education, health and water supply and sanitation, issues related to natural resource management (NRM), the incentive system, as well as agricultural support services, are followed-up in one way or another in all countries where these had been prioritized in the PRSP.

The marginalization of the MOA and the lack of public sector spending in agriculture was eventually viewed to be counter-productive given the importance of the sector in the economy and possibly as important, the weight of rural voters in the increasing democratic process. This led to the development of strategic plans for the sector viewed as critical to justifying the sector's strategic importance in the policy process. Thus, the Plan for the Modernization of Agriculture (PMA) was put in place in Uganda in 2001, with the overall goal of reducing poverty but “through a profitable, competitive, sustainable and dynamic agricultural and agro-industrial sector” (Oxford Policy Management, 2005). Similarly, Kenya developed its Strategy

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3In a Public Expenditure Review of agricultural spending in Kenya in 2004 involving the Ministry of Agriculture (MoA), the Ministry of Livestock and Fisheries Development (MoLFD) and the Ministry of Cooperative Development and Marketing (MoCDM) the findings included: (1) Sharp decline in overall public expenditure in agriculture as percentage of total government spending: 10% after Independence, an average of 7.5% in 1980-89, 3% in 1990-2000 and 3.1 percent in 2002/03 and (2) Recurrent expenditure dominated by salary payments – 70-90% of total expenditure in the three ministries.” (cited in Cabral and Scoones, 2006, p 21)
A return to regional approaches in research.

After rapid growth in funding to agricultural research in the 1960’s (6.8% per annum), the annual growth rate in spending declined from 2% in the 1970s to 1.3% in the 1980s, and to only 0.8% in the 1990s. Excluding Nigeria and South Africa, total public agricultural R&D spending in Africa actually declined by 0.3% per year in the 1990s (Beintema and Stads, 2004). Although the early reforms in agricultural research were in part supported by donor funding, this dependence increased in the turn of the century. In the early 1980’s donors accounted for 34% of expenditure which increased to 43% in 1991 (49% if Nigeria is excluded) (Pardey et al., 1995). By 2000 donor funding accounted for 35% of the research funding (Bientema and Stads, 2004). Donor funding was both volatile and accounted for much of the capital and operational budgets of NARIs. Moreover, the termination of large donor programs, such as by the World Bank, had a destabilizing effect on research effectiveness.

With such relatively large investments in agricultural research, donors had a vested interest in increasing the effectiveness of agricultural research. Much of this interest was focused on the organization of agricultural research. Up through the 1990’s the trend was a consolidation of research capacities into a unified management structure with its own budget and autonomy of decision making, namely the NARIs. Such reorganization did result in a decline in fragmentation as measured by an index (Pardey et al., 1995) and by 1991, 28 of 48 countries had adopted the NARI organizational model (Roseboom et al., 1998). With the lack of performance of agricultural research during the 1990’s and with the increasing move toward decentralization, another institutional reform process gained consensus at the turn of the century. Chema et al. (2004) summarize this reform process as follows: “A major new dimension in the overall focus of the reform agenda… is the shift from centralization to decentralization. Moreover, the new reform agenda forces agricultural research to be more outward looking, client oriented, and impact driven. It is not sufficient to produce good science: research organizations are being urged to ensure that their knowledge and technology are being applied, preferably by resource-poor, subsistence-oriented farmers in hitherto neglected areas.” Decentralization was designed to meet local farmer needs and to partner with the complex of actors in the rural areas involved in extension and integration of smallholders into markets. In many cases, the disarray in extension moved NARIs further downstream in piloting innovative farmer participation methodologies.

At the turn of the century, half the countries had less than 100 full time equivalent researchers (Beintema and Stads, 2004). The size distribution of NARIs in SSA was heavily skewed with seven (7) countries having what could be considered a robust size to manage the diversity in crops and ecologies, while the rest had to either set rigid priorities or fail to build critical mass necessary to produce research products. The logic argued for more collaborative structures in research on the continent, building on the commodity research networks managed by the CGIAR centers and the creation in 1984 of SACCAR to coordinate agricultural research in the Southern African Development Community.
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(SADC) countries of Southern Africa. With donor support ASARECA (Association for Strengthening Agricultural Research in Eastern and Central Africa) was created in 1994 in East Africa and an existing French network, CORAF was extended to anglophone and lusophone countries in West Africa. These sub regional organizations (SROs) were managed by the managing directors of the NARIs in the member countries. They did not have research capacity of their own but rather focused on mobilizing their NARS members to conduct agricultural research that is of regional interest through commissioned or competitive agricultural research grant schemes (Roseboom and Flaherty, 2016).

Fiscal autonomy and change in universities and TAE. Institutional change in TAE in this period was essentially driven by overall changes at the university level. Universities by the mid-1980’s were suffering from the same malaise as other institutions. They depended on government education budgets to meet their expenditures, and these competed with the increasing demands from primary and secondary education. Student costs were covered by government grants and graduates were guaranteed a place in the public service. Because government controlled the purse, there was in many cases political interference in the management of universities to contain student political activity. Indeed real spending per student in Africa declined from an average of $6,300 in 1980 to $1,500 in 1988 (Bientema et al., 1998). Staffing of faculty with those with post graduate degrees was also a challenge given the limited pool of talent, even as staff salaries fell by 30% during the period 1980-88 (Bientema et al., 1998). Limited budgets, low salaries, and increasing demand for university education significantly reduced institutional effectiveness. Structural adjustment programs and a reordering of spending priorities forced a severance of the reliance on government budgets, full support to students, and assured student employment. The university sector became much more responsive to market forces to meet a pent-up demand for university degrees. Tuition fees became a key source of university finances and at the same time sparked a significant expansion in private universities. The investments that countries had made in secondary education were now reflected in increasing demand for university education and given the participation of youth in the democratic process, there was an expansion in public universities. As an example, Kenya had only two public universities in 1984 and Ethiopia only two up to 1991. By 2007 Ethiopia had 22 and by 2013 Kenya also had 22, adding 15 public universities in that year. In Kenya in 1983 there was a university enrolment of about 6,800 students. This grew to 60,000 by 2002 and to 200,000 by 2012 (Lynam, 2016). Such rapid expansion had a number of effects. Firstly, faculties of agriculture with the expansion in enrollments focused almost exclusively on teaching. Moreover, with the expansion in universities there was an increasing shortage of staff, increasing class sizes and drawing in MSc lecturers. Quality of education became a key issue. Secondly, experienced researchers in the NARIs transferred over to university teaching, creating a drain on research capacity. Finally, the concentration on teaching at the expense of research and the focus on first degree students caused a drain on post graduate teaching capacity (Mukhwana et al., 2017).

At the turn of the century faculties of agriculture had gone through first a phase of consolidation and then one of expansion. Another cycle of consolidation was needed and given the number of competing faculties, a period of differentiation was also needed. Some faculties were now located in rural areas, away from the capital city, and could focus on particular ecologies. Some had the potential of developing strong post graduate programs. Others were targeting the needs of the expanding private sector. At
the same time both government priorities and foreign aid was shifting back from the PRSP focus on rural social services to investments in agriculture itself. Between 1991 and 2001, the share of aid to agriculture in Africa fell from 19 to 10 percent, while that of social services (i.e., health and education) increased from 32 to 56 percent. As agriculture lost support from among development organizations, both in absolute and relative terms, poverty in Africa has persisted, and unlike other regions that have made major advances in agricultural productivity to improve the livelihoods of the poorest, Africa has regressed (Kane and Eicher, 2004). Agriculture was poised to move back onto the development agenda but this required strong and interacting institutions.

Positioning TAE in a dynamic institutional context. This brief historical survey described above demonstrates the very dynamic changes in institutional architecture supporting agriculture and how individual institutions have responded to the emergence of different drivers over the last half century, particularly in the last thirty years the interactions of market liberalization, democratization and decentralization. At the same time there has been a significant shift in functions performed by the various institutions. Within this context the key question for this section is how TAE position does itself in this institutional framework going forward. To assess this requires an understanding of how functions are distributed within this architecture, with one institution having capacity, and in some sense responsibility, for that function but with other institutions contributing from the vantage of their specialization. Related to this last point, the other feature of this architecture is how the different institutions interact, particularly around the larger agricultural development agenda. This interaction, while not necessarily coordinated, forms what is now termed an agricultural innovation system (AIS) (World Bank, 2012) and parallels the intent of Integrated Rural Development but based on collective institutional self-interest. The history is suggestive, however, of each institution acting autonomously. TAE has the potential of fostering more interaction between institutions in an AIS (Spielman et al., 2008) given its potential contribution to key functions, namely education, research, extension and policy. This section will assess the role of TAE in these functional domains in relation to the other institutions that operate in those domains.

TAE in Education and Human Capital Development. TAE institutions train the human capital with the skills necessary to drive the agricultural growth process. From a focus on the “Africanization” of management and decision making in public institutions, faculties of agriculture now must meet the need of a highly differentiated labor market, one that is increasingly driven by the requirements of the private sector. There are few other institutions that provide this function, that is apart from universities outside Africa itself. There are some targeted training capacities, such as in business management skills for SMEs, but in general it is the faculties that provide the skilled workforce that is the critical determinant of capacity in the other institutions supporting the agricultural sector, including the private sector.

Clearly, the TAE sector is undergoing significant change, driven in large part by market forces, namely a differentiating labor market, a tuition-paying student population that can choose their course and faculty, and an increasing number of competing sources of supply. The rapid expansion in public and private universities has created a real constraint on the supply of post graduate teaching staff, especially of PhD’s, which in turn limits innovation in curriculum, pedagogy, and quality assurance. Such shortages limit the development of post graduate degree training itself, creating something of a negative feedback loop. The competitive environment eventually should lead to improved quality and differentiation across faculties of agriculture,
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but the staffing and financial constraints in the sector limit that process. This argues even more for differentiation and specialization across faculties. To a certain extent this process is being facilitated by regional network approaches (see earlier section) drawing on academic expertise where it exists in the region. The need currently is for faculty differentiation in those providing high quality post graduate education. In many faculties class sizes are too small across the range of disciplines to justify the investment to develop quality graduate programs. The World Bank’s PASIP program supports such a process by supporting centers of excellence. However, such faculties must meet the quality criteria that make them centers of excellence, and that comes from critical changes in internal development of graduate programs and the pursuit of excellence. That excellence comes from staff involvement in other critical functions beyond just teaching, which is where staff time is currently focused, particularly in research, community development, and policy.

Tertiary Agricultural Education positioning in research. Research is essential to keep teaching staff current and critical for any effective graduate program. At the same time, the NARIs have principal responsibility for research and funding for research from ministries of education are scarce. Moreover, many faculties do not have the experimental farms necessary to support ongoing research. Within faculties teaching and in turn research is organized by disciplines, when many of the key problems facing smallholder agriculture are multidisciplinary in nature. Finally, research that produces adoptable technologies is a long-term investment, which is usually not supported by funding realities. Nevertheless, post graduate students are a very effective means of carrying out dedicated research, assuming appropriate supervision and material support, and multiple students could be organized around a multifaceted, research problem. All of this argues for strong research partnerships to maintain the skills of academic staff and develop a strong graduate program.

Research in faculties of agriculture is currently driven by funding, and partnerships are usually organized around grant funding—which is little different from northern universities. Sources of such funding vary by country but include national competitive research funds, usually administered by NARIs, the grant programs of the SROs or RUFORUM (Regional Universities Forum for Capacity Building in Agriculture), a few international research support programs such as provided by foundations, and partnerships with CGIAR centers or northern universities through grants that they have received. For all these sources, faculty staff must compete with NARIs. At the same time, faculties have been hiring staff from NARIs and are increasing their competitiveness. The current situation is that research carried out in faculties of agriculture depend on those academic staff that have the network, skills, and inclination to devote time to grant development and execution and have the time beyond their teaching responsibilities.

In the differentiation process some faculties and universities are moving to branding themselves as research universities, with strong graduate programs. This requires moving from dependence on individual researchers to developing capacities that are recognized in the scientific community. One example of this is the plant breeding and molecular biology capacity at Makerere University. This has involved investment in lab, greenhouse, and experimental farm capacity, identification of skilled staff, partnerships with institutions working in the area, advanced curricula, and selective identification of graduate students. Many faculties are developing research and teaching programs in areas such as dryland agriculture, integrated soil fertility management, and livestock production systems. These centers of excellence focus on departments in developing their competitive niche and the partnerships and funding that follow. Going forward research will become a more significant part of faculties of agriculture.
focused on developing strong graduate programs and this will be led at departmental level and these programs will complement rather than displace research as undertaken in the NARIs.

Tertiary Agricultural Education role in extension and community development.

In this period of pluralism in the provision of extension and advisory services, there is a circumscribed role for faculties of agriculture in providing such services. As with research, faculty participation in extension should reinforce teaching and student education. It can also be a means of locating student research in ongoing field sites, thereby developing synergies in the work. Extension approaches involve an understanding of smallholder systems, farmer groups and community development, and partnership with other rural institutions. Extension has broadened to encompass the larger processes of rural innovation and there are now departments organized around this area, for example RUFORUM’s collaborative PhD in rural innovation between Makerere University, Egerton University, and Sokoine University. Faculties are able to test and evaluate new methodologies, such as innovation platforms (Dror et al., 2016). Piloting and evaluation in this area requires field capacity which does require resources. Moreover, choices must be made about whether the faculty identifies a community which it continues to work with or whether it limits its involvement to a particular time frame. Also, the work can be carried out just by the faculty or it can be done in partnership in something like an innovation platform. Properly designed and led, such work in rural innovation can be the point of interaction with other actors in rural development and as a bridge to farming communities. The ongoing efforts by RUFORUM to strengthen university-community engagement through especially Community Action Research and Students extension delivery approaches (Kalule et al., 2016; 2019) offer useful insights of how these could be done and scaled up to improve farming household productivities.

Tertiary Agricultural Education role in the policy arena.

For much of the post-independence period universities were marginalized from the agricultural policy process. This is partly because diverse faculties could not speak with one voice—as compared to the MOA, most faculties were also outside the capital city, and departments of agricultural economics, where much of the policy expertise resided, could not respond quickly and in a coordinated way to quickly emerging policy issues. Moreover, MOA’s had their own policy research units which supported the policy process in the ministry. This began to change with the market liberalization process in the late 1990’s and primarily with the support of the African Capacity Building Foundation which funded the creation of dedicated policy research institutes in several universities on the continent. Examples of this are the Economic Policy Research Centre at Makerere University, which works on agricultural policy, and the Tegemeo Institute of Agricultural Policy and Development at Egerton University. These research institutes could take the longer view on policy issues facing the sector, invest in their own survey and data collection, and provide independent research on policy relevant issues. Moreover, they could draw on graduate students in undertaking the research, thereby reinforcing the link back to degree training. These institutes could set their own research priorities and coordinate and fund the capacity that exist in a university around those priorities. They could also organize seminars for policy makers on their latest research, thus becoming a more pro-active voice in the policy process. These institutes reside in the capital cities, even if the university is located outside. One university tends to take the lead in developing these policy research institutes. A question going forward is whether an inter-university capacity is possible, thereby strengthening agricultural policy research across the faculties, or whether developing such capacity is part of the differentiation process.
CONCLUSIONS
Growth and development of the agricultural sector is supported by a range of institutions that provide several critical functions and deliver a range of services. Most of these are public institutions but in historical terms there are increasing numbers of private institutions as well as an expanding role played by civil society organizations. Clearly TAE institutions are a critical component of this institutional architecture and provide a key function in the training of the human capital that both staffs these institutions and increasingly supports an expanding private sector. To prepare students for these roles TAE institutions must take on some of the functions provided by these other institutions, particularly in the areas of research, extension and policy. These additional functions strengthen teaching and skill development and at the same time provide points of interaction with the other institutions supporting the agricultural sector. In many cases these potential functions and institutional linkages are latent, being overwhelmed by staff time and finances committed to an increasing student body and teaching load. Faculties have the potential of leading the process toward a more functional agricultural innovation system because they provide the knowledge and skills for those staff in other institutions within the AIS. In that regard faculties need to understand this institutional architecture, its needs, and TAE’s positioning within what is a very dynamic institutional context.

ACKNOWLEDGEMENT
This paper is as a result of many years of work by the authors on the African Continent. Our work and research have been inspired by farmers, marketers, NGOs, research institutions, Universities and Governments. It has been informed by the rich and fruitful interactions that we have had with many people. We believe that the paper will go a long way, not only in tracing the history of agricultural education and extension in the continent, but also help shape its future. We thank the 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.

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Lynam, J.K. 2017. Assessing the CGIAR’s approach to Capacity Development in R&D


LYNAM and MUKHWANA


Building a critical mass of faculty to enhance Africa’s diversity and competitiveness: opportunities and needed actions

A. GBAKIMA 1 and F.M. NAKAYIWA2

1Ministry of Technical and Higher Education, Government of Sierra Leone, New England Ville, Freetown, Sierra Leone
2Regional Universities Forum for Capacity Building in Agriculture (RUFORUM), P.O. Box 16811, Wandegeya, Kampala, Uganda

Corresponding author: f.nakayiwa@ruforum.org

ABSTRACT
The higher education sector in Africa has over the past three decades experienced a significant level of both development and turbulence. Due to the unprecedented growth in enrolment and the number of institutions, universities compete for staff to run academic programmes. This does not only limit the potential to run quality graduate and research programs, but is a hindrance to differentiation and diversity of programmes offered at national and regional levels. Governments have to invest if they are to match the national ST&I requirements. Mechanisms to leverage funding for post graduate supervision, and to fund full-time masters and doctoral scholarships will be an incentive to dramatically increase the number and quality of PhD students and thus the building blocks for academic staff in African universities and the potential for enhanced competitiveness.

Key words: Africa, Higher Education, Staffing, Universities

RÉSUMÉ
Le secteur de l’enseignement supérieur en Afrique a connu au cours des trois dernières décennies un niveau significatif de développement et de turbulence. En raison de la croissance sans précédent des inscriptions et du nombre d’établissements, les universités se disputent le personnel pour gérer les programmes universitaires. Cela ne limite pas seulement la possibilité de gérer des programmes de recherche et d’études supérieures de qualité, mais constitue un obstacle à la différenciation et à la diversité des programmes offerts aux niveaux national et régional. Les gouvernements doivent investir s’ils veulent répondre aux exigences nationales en matière de ST&I. Les mécanismes permettant de mobiliser des fonds pour la supervision des études supérieures et de financer des bourses de maîtrise et de doctorat à temps plein seront une incitation à augmenter considérablement le nombre et la qualité des doctorants et donc les éléments de base pour le personnel académique des universités africaines et le potentiel d’une compétitivité accrue.

Mots-clés: Afrique, enseignement supérieur, personnel, universités.

BACKGROUND
The higher education sector in Africa has over the past three decades experienced a significant level of both development and turbulence. Gross enrolment ratio has increased to 10% compared to 44% in Latin America and 77% in the OECD.
Building a critical mass of faculty to enhance Africa’s diversity and competitiveness: opportunities and needed actions

and the global average of 26%, (Arias et al., 2019). Correspondingly, the graduation rates have increased as the system attempts to meet the surge in demand for university education as a result of the youth bulge. The number of universities has grown from less than fifty (50) recorded by UNESCO in 1962\(^1\) to more than 1500 by 2017 (Darvas et al., 2017). Indeed, some countries including Namibia, Cabo Verde and Botswana did not have any stand-alone university until the 1980s but have expanded to more than 10 higher education institutions by 2015. While enrolment has grown from approximately 400,000 in 1970 to over 7 million in 2015 and is projected to reach 21.7 million by 2040 (Darvas et al., 2017; Calderon 2018), very few universities offer graduate programs and even fewer at the doctoral levels.

The configuration of the higher education system has changed from being predominantly public to an interface between the public and private sector that is unique to the continent. Due to the unprecedented growth in the number of institutions, universities compete for staff to run academic programmes. This does not only limit the potential to run quality graduate and research programs, but is a hindrance to differentiation and diversity of programmes offered at national and regional levels. In most countries (Table 1), the percentage of staff with PhD qualifications is still low (Hayward and Ncayiyana, 2014). Recent studies revealed that 8% of academic staff in Ethiopia have doctoral degrees, compared to 31% in Ghana, 19% in Uganda and 43% in Nigeria and South Africa (Bunting, et al., 2017; British Council 2018). Table 2 shows that the trend of PhD qualified staff in Sierra Leone in 2019 was still low, which is the case in several African countries. Clearly, greater efforts need to be put to increase significantly the pool of PhD students in Africa universities. This will be a vital step to increase proportion of PhD staff in African universities and research institutions. At the same time, cultural and gender issues have kept women in higher education at minimal levels. Only seventeen percent (17%) of vice chancellors are female, 21% are full professors, and 22% are members of the academy of Sciences (UNESCO, 2015).

Several countries do not have the research capabilities needed to combine global knowledge with national experience in support of innovation and problem solving that was articulated by Agenda 2063. In many countries, weak science, technology and innovation (ST&I) institutions encumber deployment of knowledge and technological innovations to spur socioeconomic growth (ACBF, 2017). Moreover, these institutions are inadequately staffed with evidence of shortfalls in skills, expertise, infrastructural and equipment capabilities defined as basics for world class universities (Salmi, 2009).

Based on available literature, this paper interrogates the trend of human resource capacity development for universities in Africa. There is now a consensus that Africa needs many more doctorate holders to develop the robust knowledge needed to promote development, (Hayward and Ncayiyana, 2014; Cloete et al., 2015). Proponents have argued that higher education has to be included in all development agendas, especially since science, technology and innovations are vitally important for increasing Africa’s competitiveness. The paper explores potential for diversity and provides pathways for building staff capacity through harmonisation of initiatives, differentiation of institutions and the creation of research and innovation hubs as mechanism of escalating staff capacity and access to key education resources.

**Why the sector is important.** Rapid advances

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Table 1. Percentage share of PhDs in selected countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Data /year</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
<td>% of HE staff with PhD qualifications (2016)</td>
<td>8%</td>
</tr>
<tr>
<td>Ghana</td>
<td>% of HE staff with PhD qualifications (2013)</td>
<td>31%</td>
</tr>
<tr>
<td>Kenya</td>
<td>% of HE staff with PhD qualifications (2016)</td>
<td>34%</td>
</tr>
<tr>
<td>Nigeria</td>
<td>% of HE staff with PhD qualifications (2012)</td>
<td>43%</td>
</tr>
<tr>
<td>South Africa</td>
<td>% of HE staff with PhD qualifications (2014)</td>
<td>43%</td>
</tr>
<tr>
<td>Rwanda</td>
<td>% of HE staff with PhD qualifications (2016)</td>
<td>20%</td>
</tr>
<tr>
<td>Uganda</td>
<td>% of HE Staff with PhD Qualification (2016)</td>
<td>19%</td>
</tr>
</tbody>
</table>

Source: British Council-DAAD study and Status of Higher Education (Uganda)

Table 2. Trend of PhD Qualifications as a percentage of staff in Sierra Leone

<table>
<thead>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Staff</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>770</td>
<td>919</td>
<td>1051</td>
<td>1218</td>
<td>1374</td>
<td>1467</td>
</tr>
<tr>
<td>PhD staff</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>102</td>
<td>101</td>
<td>107</td>
<td>111</td>
<td>134</td>
<td>155</td>
</tr>
<tr>
<td>% staff with PhD</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>13%</td>
<td>11%</td>
<td>10%</td>
<td>9%</td>
<td>10%</td>
<td>11%</td>
</tr>
</tbody>
</table>
in science and technology across a wide range of areas from information and communication technologies (ICTs) to biotechnology to new materials provide great potential for countries to accelerate and strengthen their economic development. The application of knowledge results in more efficient ways of producing goods and service delivery (Salmi, 2009). Unless countries build ST&I capacities to innovate and promote ST&I development, Africa risks being left behind in the race towards inclusive globalization. University education, in particular, has the potential to improve productivity and act as a catalyst for adaptation and growth in emerging high tech and other sectors.

The Higher Education rate of return average is > 20% percent compared to primary and secondary education (Montenegro and Patrinos, 2013). A one-year increase in average tertiary education levels would raise annual GDP growth in Africa by 0.39% and yield up to a 12% increase in GDP (Bloom et al., 2006). The university system has a multiplier effect on the overall Science, Technology and Innovation. Equally important is the articulation in Agenda 2063 and national development plans that have placed premium on the importance of ST&I for Africa’s development, not to mention the potential to harness the demographic dividend. The projected critical skills required to achieve Agenda 2063 as discussed by the African Capacity Building Foundation (ACBF) 2016 report is big, and needs to be urgently addressed.

Challenges in building a critical mass of faculty to enhance Africa’s diversity and competitiveness. Strong education systems are key drivers of economic growth in African nations. Cloete et al. (2015) argue that Africa needs universities which can produce both highly-skilled labour forces and new knowledge; because both products are essential to the creation of national economies that are globally-competitive. Countries in East Asia such as China, Singapore and Malaysia have demonstrated that investment in knowledge generation and the deployment of ST&I have the potential to change the development trajectory and move the population from low to middle- and high-income status. It is through a well-educated workforce that countries will create capacity to successfully integrate in, and benefit from, this 21st century knowledge-based economy. Cloete et al. (2015) however, underscore that the development of doctoral programs on the African continent should be part of the knowledge economy discourse and a broader context of how higher education can contribute to economic development. Other scholars, see for example Beintema and Stads (2017), indicate that conception, execution, and management of high-quality research is a function of high level qualifications. Africa has to generate the high-level skills and retain talent if it is to meet its schedule to grow and improve scientific output and find solutions to address local problems (Cloete et al., 2015).

In catching up with the global ST&I movement, the role of universities in the research, innovation and knowledge production ecosystem cannot be over emphasised. Moreover, for Africa, which is predominantly agrarian with a youth bulge and a population expected to be more than 2 billion by 2050, the need to think through how to mobilise the youth for meaningful livelihoods is urgent. Science, technology and innovation research has to be harnessed to generate new knowledge that will increase production and engender new forms of social and economic interaction that are essential for any meaningful advancement. There has to be a deliberate effort by governments to invest in institutions and processes that promote knowledge generation as well as development of technologies and innovations. Special focus should be made on the inputs to the higher education process especially engendering a cadre of highly qualified staff that will spur institutional advancement and sustainability. This will not only facilitate the
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African countries lack specific human and institutional capacities, critical technical skills, and resources to promote ST&I and the capacity lag in ST&I is linked to the investment priorities of African countries (ACBF, 2016). The average of African spending on research and development (R&D) stands at approx. 0.5 percent of GDP below the 1% commitment. Indeed, Africa accounts for about 5 percent of global gross domestic product, but is responsible for only 1.3 percent of global expenditure on R&D (UNESCO, 2015). And average public spending on higher education represents approximately less than 1% of GDP (Arias et al., 2019). The continent continues to experience deficits in ST&I skills and infrastructure as well as capital funding for ST&I based entrepreneurship, with limitations in ST&I deployment and uptake by both public and private agencies (ACBF, 2016).

With only 10% of Africa’s youth enrolled in universities, higher education in Africa is characterised by inequitable access and inadequate capacity to accommodate an ever increasing number of youth demanding for entry into the sector (Darvas et al., 2017). Similarly, Africa’s ST&I readiness and capacity is still significantly low compared to the rest of the world. The continent lags behind in research and development. The 2015 UNESCO Science Report indicates that Sub Saharan Africa (SSA) contributed only 1% of the global researchers with only 70 and 90 researchers per million inhabitants by 2013. The number of publications by 2014 were only 18,000, a mere 1.4% of the total global publications (UNESCO, 2015). In agriculture (Figure 1) the mainstay of the biggest percentage of the population for example, PhD qualified researchers in universities and research institutions are less than 40% (Beintema and Stads, 2014).

Other documented challenges include, excessive reliance on external funding for research and development (R&D), uncompetitive incentives in terms of pay and infrastructure have continued to promote brain drain, while several universities have an ageing professoriate (Sawyer, 2004; Salmi, 2009). In the agricultural sector specifically, by 2014, more than half the region’s PhD-qualified researchers were above 50 years, with several countries registering more than 70% of staff classified as ageing (see case of Sudan in Muna Elhag and Mutasim Ahmed Abdelmawla, 2020). By implication, the future of the agricultural research sector including universities are likely to experience critical staff shortages to lead research programs as well as mentor and train junior staff (Beintema and Stads, 2017).

The evidence of low ST&I investment is manifesting through poor science (laboratory) infrastructure, a small pool of researchers, and low patronage of science and engineering programs. Most countries have weak intellectual property frameworks, and there is minimal...
scientific output relative to the rest of the world. Research output remains the lowest in the world at less than 1% of the world share (World Bank and Elsevier, 2015) and political commitments into practical programs for ST&I-based development. As a result, there is excessive reliance of African countries on external funding for research and development, and a disconnect between the private and industrial sectors. All of these are part of the context that hinders meaningful higher education to Africa’s youthful continent.

Adequacy of human resource in the academe is one of the key challenges experienced in higher education in Africa. The total number of staff has grown from approximately 2,000 recorded in the 1962 UNESCO report to cases where most of the large universities have close to that number (Bunting et al., 2017). Several systems however, still report major shortfalls. On average there are 50 percent more students per professor at African universities when compared to the global average (African American Institute, 2015). This has resulted in unrealistic workloads, overcrowded classrooms and limited space for research and postgraduate program development (Sawyer, 2004; World Bank, 2009).

Unless key steps are taken the situation is likely to worsen. On the other side of the demographic spectrum the population trend indicates that Africa is likely to have the largest number of 18-23 year olds by 2050, these are prime candidates for higher education both within the continent and globally (Calderon, 2018). Africa is likely to see a spike in the demand for higher education. The HERANA2 programme confirmed that over a 15-year period 2001 to 2015 the average annual growth in enrolment was greater than the growth in permanent academics numbers in eight African flagship universities (Bunting et al., 2017). This is reflected in Figure 2. It is therefore important to put in place mechanisms to address the capacity bottlenecks that still hinder progression. It is urgent that governments in African countries devise strategies to facilitate institutions and higher education systems to handle the youth bulge.

From the governance perspective, there is incessant staff unrest and industrial action at best and a staff that is disengaged, disinterested with their services and loyalty spread across different engagements that they undertake.
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for survival. Furthermore, the reward and recognition system at institution and national level is underdeveloped and does not provide adequate motivation beyond the basic input. These factors combined have impacted on the academic productivity of staff. The capacity to undertake research and generate knowledge for development is mired by both the inadequacy of resources, a general lack of opportunities for scientific research, and the limitations of quality time dedicated to academic exploits and research. This has further manifested or resulted into limited availability of research positions and prospects for academic growth.

Current and projected Critical Training Skills (CTS) gaps. Graduate programmes are important because countries need doctoral graduates to train the next generation of academics. With an ageing professoriate (Sawyer, 2004), investments should be targeting to create an academic system with regeneration capacity. This will not only boost existing numbers for the different technical and professional skills needed, but will provide the foundation for research within universities and research institutes, as well as build capacity for the lower levels of education.

The creation of the many new universities, which is a common trend across the continent has increased the demand for PhD trained staff in Africa. Most universities experience gross shortage of staff with the requisite qualifications and capacity to influence both the higher education outputs in terms of graduates, knowledge production and research. The situation is more acute in terms of the number of women in higher academic ranks. Table 4 gives a snapshot of the staff and enrolment trend in Uganda. It reveals that while the growth of staff with PhDs has increased

![Figure 2. Enrolment and staff growth in selected African Universities](image)

Source: Extracted from Bunting et al., 2017

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Higher Education Research and Advocacy Network is an initiative tracking academic core and research activities in eight African Flagship universities.
significantly from 2006-2018, it is still below 13% of the total number of staff. This however, varies at institutional level with some universities having considerably lower percentage shares (NCHE, 2019). This is similar to the case of Sierra Leone shown in Table 3.

The challenges associated with the limitations in staff capacity among others include inadequately prepared graduates. Many employers in the various productive sectors across Africa have been critical of the lack of basic, technical and transferable skills of graduates. There is a dichotomy in the employment position on the continent where employers are looking for skilled workers while the number of unemployed graduates is steadily increasing. This is an indication that the higher education provided may not be adequate to meet the employers’ expectations and the development needs of most African countries (Arias et al., 2019).

The poor funding of institutions both by governments and private sector where the fee-paying model has been adopted generate inadequate remuneration for academic staff. Limitations in the purchasing power of the salaries of academics impact on the effectiveness and concertation of the staff.

Table 4. Trend of PhD Qualifications as a percentage of staff in Uganda

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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Staff</td>
<td>5258</td>
<td>6465</td>
<td>7785</td>
<td>8594</td>
<td>9464</td>
<td>10173</td>
<td>12845</td>
<td>13485</td>
<td>13967</td>
<td>12638</td>
</tr>
<tr>
<td>PhD staff</td>
<td>558</td>
<td>746</td>
<td>858</td>
<td>914</td>
<td>973</td>
<td>1096</td>
<td>1579</td>
<td>1755</td>
<td>1865</td>
<td>2109</td>
</tr>
<tr>
<td>% staff with PhD</td>
<td>11%</td>
<td>12%</td>
<td>11%</td>
<td>11%</td>
<td>10%</td>
<td>11%</td>
<td>12%</td>
<td>13%</td>
<td>13%</td>
<td>17%</td>
</tr>
<tr>
<td>Enrolment</td>
<td>124313</td>
<td>137190</td>
<td>173369</td>
<td>198066</td>
<td>220201</td>
<td>247473</td>
<td>257855</td>
<td>254043</td>
<td>259027</td>
<td>261087</td>
</tr>
</tbody>
</table>

Compiled by authors from the Uganda Status of Higher Education 2019
Even the highest paid earn much less than their counterparts in the western world mainly Europe and USA as well as several multilateral and national agencies (Sawyer, 2004; World Bank, 2009). Tettey (2006) affirms that the dissatisfaction with salaries is a major inhibitor that undermines commitment of academics to their institutions and careers. This has generated several key factors that deserve mention.

i) a stagnation of the academic capacity of the university as a result of national and international brain drain since well qualified staff look for alternative sources of employment. For example, apart from employment in Universities abroad, it is not uncommon to find the key program officers in the World Bank and American Foundations being headed by former university professors and in some cases vice chancellors. The African Union in 2006 estimated that there were more African scientists and engineers working in the US than in the entire continent. This combined with the freeze in recruitment and an ageing professoriate has led to an escalation of vacancy rates in university staff positions that range between 25 and 50%, being more acute in the STEM disciplines (World Bank, 2009) and gross deficit in capacities needed to drive attainment of Agenda 2063 (Figure 3).

ii) Limited diversification of the staff profile, the capacity to attract international scholars diminishes with the inability to meet the basic requirements for both social and academic needs. Equally evident from publication data is that staff from African universities usually look for research and other academic facilities such as laboratories off the continent. Implicitly, these limitations mean that there is no motivation in African universities to attract and retain international staff. As a consequence, the capacity for high level training at doctoral and post-doctoral level is curtailed. Kenya for example has 1% of PhD enrolment (see Table 5), compared to Most universities in Africa have experienced, low quality supervision; limited academic freedom; and inadequate international information-sharing leading to inadequate responsiveness to national, social and economic needs as well as weak links to industry (Arias et al., 2019).

iii) Limitations in differentiation of the higher education sector. Several of the new universities are serviced by academics from existing universities either on a full time or part time basis. This curtails the diversity in institutions, a situation made worse by the conversion of most of the tertiary institutions into universities.

Furthermore, the capacity to undertake research is limited as the few available staff are overworked and loaded with teaching responsibilities to the detriment of research and community engagements. This coupled with inadequate financial and physical infrastructure resources have ensured that Africa lags behind in knowledge production. It will be through increased research engagement that higher education and universities in particular will identify avenues for linkages with industry and private sector and create opportunities for youth to harness their productive potential in all fields as well as prospects for meaningful employment.

African potential for diversity and competitiveness. Critical for Africa’s future is strengthening educational systems and institutions for generating and applying knowledge by assuring long-term public support with emphasis on teaching and research capacity. In addition to individual skills developed in research work, research capacity includes: quality of the research environment, funding, adequate infrastructure, research incentives and time available to the researcher. In most African countries, conditions for research have been severely compromised as manifest by the generally poor remuneration, inadequate qualifications and low staff numbers mainly at the lower academic ranks, heavy teaching loads, inability to mentor young faculty, and inadequate infrastructure.
Table 5. PhD Enrolment and qualifications for academic staff in Kenya (2016)

<table>
<thead>
<tr>
<th>Category</th>
<th>PhD</th>
<th>Masters</th>
<th>Bachelor</th>
<th>Dip</th>
<th>Total</th>
<th>%PhD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Chartered Universities</td>
<td>4,215</td>
<td>5,661</td>
<td>1,004</td>
<td>530</td>
<td>11,410</td>
<td>37%</td>
</tr>
<tr>
<td>Public University Constituent Colleges</td>
<td>133</td>
<td>292</td>
<td>100</td>
<td>78</td>
<td>603</td>
<td>22%</td>
</tr>
<tr>
<td>Private Chartered Universities</td>
<td>923</td>
<td>1,936</td>
<td>168</td>
<td>43</td>
<td>3,070</td>
<td>30%</td>
</tr>
<tr>
<td>Private University Constituent Colleges</td>
<td>113</td>
<td>91</td>
<td>6</td>
<td>2</td>
<td>212</td>
<td>53%</td>
</tr>
<tr>
<td>Private Universities with LIA</td>
<td>220</td>
<td>713</td>
<td>87</td>
<td>3</td>
<td>1,023</td>
<td>22%</td>
</tr>
<tr>
<td>Total</td>
<td>5,604</td>
<td>8,693</td>
<td>1,365</td>
<td>656</td>
<td>16,318</td>
<td>34%</td>
</tr>
<tr>
<td>Enrolment</td>
<td>7,146</td>
<td>55,461</td>
<td>475,750</td>
<td>1,392</td>
<td>539,749</td>
<td>1%</td>
</tr>
</tbody>
</table>

Source: Computed from the State of University Education in Kenya 2016
Building a critical mass of faculty to enhance Africa’s diversity and competitiveness: opportunities and needed actions

One of the initiatives tracking staff capacity and development in Africa is the Higher Education Research and Advocacy Network (HERANA). The initiative tracked the growth of eight flagship universities in Africa over a 10-year period (Cloete et al., 2015). While the HERANA study focus is the academic core which had a broader scope, it emphasises the impact that academic staff have on research output, high-level knowledge production and ultimately the development impact of the flagship universities in Africa (Figure 2). The key parameters of focus for academic staff under the HERANA initiative include growth and adequacy in number with implications from the appropriate staff student ratio; the staff profile and qualifications they possess; the ranks in seniority at professorial level and capacity for mentorship; discipline focus; as well as productivity in terms of research output. When appropriately interrogated and the right mix established, these parameters provide a benchmark for investment into the potential for diversity and competitiveness derived from the higher education sector in Africa.

Beyond the need for increased public investment, institutions can improve capacity through programmatic, management and leadership adjustments. Universities and research institutes can create research excellence and communities of practice that generate ideas that link Universities to industry and other development needs. Universities can strengthen graduate programs and create an environment that will attract young faculty and stem brain drain. A collective effort that leverages comparative advantage across the continent if adopted will benefit from economies of scale and scope in investment.

Pathways for building African higher education staff capacity. The challenge of PhD programs in sub-Saharan Africa is to train professionals with the skills and knowledge for the emerging knowledge economy calls for deliberate interventions not only to address the shortfalls in knowledge generation, but to leapfrog research, science, technology and innovation to drive production systems. Governments have to explore avenues for increasing research output that will positively influence local communities as well as national and global institutions. The role of higher education and research institutions, as the most logical and cost-effective mechanism for this to be achieved cannot be over emphasised. Countries will have to invest in universities and position them to play an active role in generating the skills, the research and the policies necessary for Africa to be competitive.

A systemic approach to doctoral education is imperative for all academic systems on the continent. Noting that the next generation of academics will come from the higher education pipeline by harnessing the potential of talented students at undergraduate level and nurturing their capacity to develop academically through the postgraduate training at masters, doctoral and post doc level is therefore essential. The increase in graduate enrolment not only increases the capacity for research but is the foundation for the future of the higher education quality and quantity. The proportion of graduate students against the total enrolment will provide an indication on the potential for academic staff in the universities. There are a few enablers and institutional frameworks that will enhance Africa’s potential for capacity building and development. These among others include:

1. Strong graduate programs, indicators of which can be the percentage of graduate enrolments. The quality and number of graduate enrolments provide a talent pool for future research. It provides the basis for knowledge generation and increased level of publications. All of which have been key indicators in university rankings.

2. To create strong graduate programs there is need for an institution environment that will nurture and attract seasoned researchers to the institution. Institutional factors include:
research infrastructure, research management systems as well as a recognition and incentive system to promote the research.

3. Institutions need to develop mentorship programs and build research teams to promote learning on the job. This is especially urgent noting the age profile of professors and other academic staff as well as the ratio of senior staff to junior staff (Bunting et al., 2017). As noted by Akilagpa (2004), the skills, competencies, attitudes and values of individual researchers is developed through training and experience derived from involvement in research activity. Categorized as the active component, this is nurtured by cultivation of a positive research culture and creation of an incentive system to make the research career effective.

4. International partnerships can play a critical role in strengthening PhD provision, create diversity and enable institutions to address doctoral thesis supervision, one of the major challenges of doctoral education in Africa. It is important to build collaboration models that leverage capacity from the region and from the wider global scientific network to boost their graduate programme management and supervision capacity.

A differentiated and diversified education system especially at the higher education level ensures that institutions effectively and efficiently utilise available resources. National systems should create innovation hubs and centres of excellence in institutions that have comparative advantage for graduate programmes and research. Staff and other resources will be focused in institutions and areas where they will have a multiplier effect and maximum impact. This, not only increases access to education as different levels and institutions feed into and interact but escalates the number of doctoral students and ensures that adequate human resource capacity is created for all levels.

New pathways for capacity building for these staff characterized as third generation staff have to be adopted to increase exposure and access to international resources. Among these is incubation of new innovations and linkage with the industry and private sector and building capacity for and cooperation to promote consulting jobs. These enable staff to access additional remuneration, recognition beyond the academe as well as exposure to research problems. Universities should explore options for movement from a standard payment structure to a performance based one which will recognize highly productive staff across the three core functions. This will change the mindset of staff from the existing public support dependence for salaries and other remuneration to active engagement in research.

It is envisaged that these pathways as outlined above will attract research-oriented staff, increase research output and provide capacity for increased graduate enrolment.

Ongoing initiatives to strengthen human capacity development and staffing in African universities. There is a dearth of continent-wide information about the PhD programs and capacities created over the past few years. Recognising the need for high level doctoral training, several initiatives have come up to develop doctoral capacity for sub Saharan Africa. Most of these, are mainly collaborative research programs that target universities and other research institutions. Several are discipline specific- three categories of initiatives have emerged- institutional/national based, network based and continental policy driven initiatives. However some cut across disciplinary, institutional and cluster categories. Beyond the regional and continental initiatives, Institutional and national initiatives have played a significant role in improving staff capacities in African Universities. For example, the collaborative research program supported by the Government of Sweden under the Swedish Development
Agency (Sida) has increased the number of PhDs in public universities in Uganda, Tanzania and Mozambique. Other initiatives include the Carnegie Corporation of New York supported Next Generation of African Academics. At the national level, there are different tracks and attempts to manage the PhD shortage with partial success. Indeed, the current average estimate of 30% PhD holdings in universities has been as a result of such initiatives.

In the majority of countries, the driving force for expansion of PhD programs is the pressure for an upgrade of the academic staff qualifications. Countries such as South Africa have set the target of 75% of permanent academic staff in higher education institutions holding PhD qualifications by 2030. Similar regulations with varying targets have been adopted in Senegal, Kenya, Nigeria and Uganda (Cloete et al., 2015; British Council, 2018).

The Regional Universities Forum for Capacity Building in Agriculture (RUFORUM). Building Africa’s human capital and capacities for agricultural research and training through competitive research, innovation grants, postgraduate training and institutional support to member universities RUFORUM programmes were designed to foster co-operation in the field of agriculture within and between universities in Africa. Competitively awarded graduate research grants, scholarships for Master’s and Doctoral training and direct support to create new or upgrade and reform existing training programmes result in graduates with the appropriate skills set as well as more relevant research. Furthermore, it was assumed that institutional strengthening grants and community action research grants, given to university researchers to work more closely with industry and communities, would bring the two groups together to: solve areas of mutual interest; enhance training and mutual learning; allow industry and communities to utilize research and graduates to enhance agricultural productivity; and, increase overall productivity, performance and visibility of universities within the country, regionally and globally.

RUFORUM brings together, bilateral, multi-lateral, Foundations and other support to the higher education sector to link to agricultural and economic development. Multi-disciplinary teams and collaboration across the region provide a mentorship program and peer to peer support to improve quality and efficiency. This raises the staffing capacity in the member universities. While these initiatives have limited numbers, they represent a vital component of the support to increase in PhD capacity on the continent, and they are an indication of potential for building a critical mass of highly qualified individuals. Moreover, tracer studies have revealed that 94% of these are employed in the academia or research institutions on the continent, a departure from similar initiatives that have resulted in brain drain. Impotantly the gender focus is above average at 40% of scholarship and research grant recipients.

The Partnership for Skills in Applied Sciences, Engineering and Technology (PASET). This is an initiative by three African Governments (Ethiopia, Rwanda and Senegal) with facilitation from the World Bank. This initiative is designed to strengthen skills in the Applied Sciences, Engineering and Technology. The initiative leverages lessons from Asia, Europe and Latin America. The Initiative set ambitious targets to include boosting the PhD capacity in sub Saharan Africa by at least 10,000 in ASET fields and in addition double the number of students in ASET programs in at least 10 countries in SSA. Since its inception in 2013, PASET launched the Regional Scholarship and Innovation Fund to train quality PhD students and post-doctoral researchers at African Host Universities’ in seven African Countries. One hundred and twenty-nine students have benefited from scholarships to pursue advanced degrees.
The African Higher Education Centres of Excellence (ACE) is yet another continental initiative designed to boost the number both the science capacity and the level of PhD holders on the continent. Presently implemented in two phases, the West African as well as the East and Southern African tranches, the project supports the recipient countries to promote regional specialization among participating universities in thematic areas that address regional challenges and strengthen the capacities of these universities to deliver quality training and applied research as well as meet the demand for skills required for Africa’s development.

These initiatives although laudable require the appropriate policy environment to thrive. There is need to take stock of progress and build data systems that provide adequate information to create cohesion for a coordinated and harmonised higher education staff capacity building process in Africa. Ownership at the highest continental level will provide the legitimacy and drive implementation. That they are anchored and respond to Agenda 2063 is an indication that there is need to galvanise support at the continental level. The African Union Committee of Ten Heads of State (C10) championing Education, Science, Technology and Innovation in Africa is a beacon for continental collaborative programmes to strengthen staff capacities and increasing the pool of women scientists in African Universities and other research and development institutions. It is an opportunity to build on national and regional initiative and upscale the strategic interventions targeting graduate and postdoctoral training to bolster the capacity of universities to generate the requisite knowledge, skills and innovations. This coupled with the promotion of national higher education and research systems to establish centres of excellence for building Africa’s science, technology and innovation capacity will ensure that Africa can be an active player in the global knowledge economy space.

CONCLUSION
Collectively, the African continent has made a commitment to transition from a largely agrarian to an integrated, prosperous and peaceful Africa, driven by its own citizens and representing a dynamic force in the global arena. Agenda 2063

Figure 4. PhD Scholarship recipients 2008-2018
Source: Compile by Authors from RUFORUM documentation
in tandem with the Sustainable Development Goals has set a target that 70% of all high school graduates will proceed to have tertiary education, nominally this represents more than 20 million in the 18-23 age bracket (Calderon, 2018). For this to be realized, there has to be deliberate and substantial investment in higher education, technology, science, research and innovations capacity by national governments. This according to Agenda 2063 will lay the foundation for competitive economies built upon human capital to complement Africa’s rich endowments in natural resources. The need to build a critical mass of staff with the requisite qualification and academic environment for the advancement of the higher education is more urgent than earlier envisaged.

It is important to acknowledge that increasing the number of staff who have doctorates; providing support for female researchers; and increasing awareness around funding opportunities are some of the initiatives that will unlock the potential of African higher education systems. Education systems and universities need to devise mechanisms for providing support for postgraduate students and incentives for staff who publish and supervise postgraduate students.

Postgraduate study and especially in ST&I is quite expensive, and as such governments have to invest if they are to match the national ST&I requirements. The poor funding, the large classes and heavy teaching loads, the resultant student dissatisfaction and protests, all create a climate inimical for advanced research to flourish in the universities (Sawahel, 2018). Mechanisms to leverage funding for post graduate supervision, and to fund full-time masters and doctoral scholarships will be an incentive to dramatically increase the number and quality of PhD students and thus provide the building blocks for strong and competitive academic staff in African universities. This requires improving the expertise of supervisors and ensuring a better student to supervisor ratio.

Governments’ dedicated and long-term commitment to invest in universities and build a critical mass of highly qualified staff to drive Africa’s development process is a viable starting point. It has been argued that 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. African governments and institutions alike should commit and provide for high-level political and financial support for sustainable ST & I capacity-building solutions to accelerate Africa’s knowledge output necessary for transformation.

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Genesis, evolution and strategic thrusts of RUFORUM

M. WASWA, 1 P. OKORI, 2 A. MWEETWA1 and E. ADIPALA1

1Regional Universities Forum for Capacity Building in Agriculture, Plot 151/155 Garden Hill, Makerere University, P.O. Box 16811, Wandegeya, Kampala, Uganda

2ICRISAT, Chitedze Agricultural Research Station, P.O. Box 1096, Lilongwe, Malawi

Corresponding Author: e.adipala@ruforum.org

ABSTRACT

The genesis and evolution of RUFORUM arose out of the recognition by 10 universities in East and southern Africa of the considerable gains to be made by continuing with the formalization of the relationships established out of a donor programme-Forum for Agricultural Resource Husbandry, “the Forum” which had been established by the Rockefeller Foundation in 1992. The new African initiated and led institution was based on adapting “the Forum” strategy of linking university faculty and students with other African institutions as well as with smallholder farmers and other national innovation system actors. The new network would work together to package and market the programme to broaden donor support for intensifying efforts to improve quality and relevance and increase access to post-graduate education within Africa. The purpose of this review is to reflect on the transition processes from “the Forum” to RUFORUM so as to provide key lessons in organizational dynamics as institutions undergo transformation for continued relevance to food security and inclusive and sustainable development. In 1993, “the Forum” provided funding on a competitive basis to 10 universities1 requiring that post-graduate students work in the field with smallholder farmers and in a more participatory way on issues that were demand-driven. Universities and faculty were supported with research infrastructure and equipment support and funds allowing them to improve supervision and visit students in the field as well as support for all the 10 universities, Deans, student researchers and their lecturers were facilitated to meet annually. At these meetings relationships were strengthened, lessons shared and new approaches to both teaching and research initiated. In 2002, “the Forum” project was closed following a re-orientation of the Rockefeller Foundation. At the request of the 10 universities, Rockefeller Foundation funded discussions on the formation of an African-driven initiative that would continue some of the most successful elements of “the Forum” project. RUFORUM has used this model of networking and engagement across agricultural and educational value chains in linking universities to society and it has been successful in making them more relevant and catalyzing mutual support and collaboration between member universities. RUFORUM was established in 2004 by 10 universities in five countries (Kenya, Malawi, Mozambique, Uganda and Zimbabwe) to foster integration of universities into the national agricultural innovation systems; and provide a platform for training quality graduates and carry out research that supports development processes in Africa. The network builds relationships and allows for mobility and rationalizes resource use and enhances economies of scale and scope. It also provides a platform for networking, resource mobilization and advocacy for agricultural higher education in Africa. By 2020, it has grown to 126 universities in 38 African countries.

enable successful operations of RUFORUM, five strategic business plans were developed\(^2\) continuously guiding the operations of RUFORUM in alignment with the stated mission, mission and niche. An outcome assessment for the period 2004-2018 established that RUFORUM has positively impacted higher agricultural education in Africa; its impact has gone beyond agriculture and it is expanding across Africa. The challenge remains how to decide which ideas should become priorities for action in the face of many demands and requests for membership, orientation and cooperation.

Key words: agricultural value chains, educational value chains, food security, higher education, inclusive and sustainable development, network expansion, smallholder farmers, RUFORUM, strategic business plan, university transformation

RÉSUMÉ

La genèse et l’évolution de RUFORUM sont nées de la reconnaissance par 10 universités d’Afrique orientale et australe des gains considérables à faire en poursuivant la formalisation des relations établies à partir d’un programme de donateurs-Forum for Agricultural Resource Husbandry, «Le Forum» qui avait été créé par la Fondation Rockefeller en 1992. La nouvelle institution initiée et dirigée par l’Afrique était basée sur l’adaptation de la stratégie du «Forum» consistant à relire les professeurs et les étudiants universitaires à d’autres institutions africaines ainsi qu’aux petits exploitants agricoles et autres acteurs du système d’innovation. Le nouveau réseau travaillerait ensemble pour regrouper et commercialiser le programme afin d’élargir le soutien des donateurs à l’intensification des efforts pour améliorer la qualité et la pertinence et accroître l’accès à l’enseignement supérieur en Afrique. Le but de cet examen est de réfléchir sur les processus de transition du «Forum» au RUFORUM afin de fournir des enseignements clés sur la dynamique organisationnelle au fur et à mesure que les institutions se transforment pour continuer d’être pertinentes, pour la sécurité alimentaire et le développement inclusif et durable. En 1993, «Le Forum» a fourni un financement sur une base compétitive à 10 universités pour que les étudiants de troisième cycle travaillent sur le terrain avec les petits agriculteurs et de manière plus participative sur des questions qui étaient dictées par la demande. Les universités et le corps professoral ont été soutenus par une infrastructure de recherche, en équipement et fonds leur permettant d’améliorer la supervision et de rendre visite aux étudiants sur le terrain. Les doyens, les étudiants chercheurs et leurs professeurs ont été invités à se réunir chaque année. Lors de ces réunions, les relations ont été renforcées, les enseignements partagés et de nouvelles approches de l’enseignement et de la recherche lancées. En 2002, le projet «Forum» a été fermé suite à une réorientation de la Fondation Rockefeller. À la demande des 10 universités, la Fondation Rockefeller a financé des discussions sur la formation d’une initiative dirigée par les Africains qui poursuivrait certains des éléments les plus réussis du projet «Forum». RUFORUM a utilisé ce modèle de mise en réseau et d’engagement à travers les chaînes de valeur agricoles et éducatives pour relier les universités à la société et il a réussi à les rendre plus pertinentes et à catalyser le soutien mutuel et la collaboration entre les universités membres. RUFORUM a été créé en 2004 par 10 universités dans cinq pays (Kenya, Malawi, Mozambique, Ouganda et Zimbabwe) pour favoriser l’intégration des universités dans les systèmes nationaux d’innovation agricole; et fournir une plateforme pour la formation de diplômés de qualité et mener des recherches qui soutiennent les processus de développement en Afrique. Le réseau établit des relations et permet la mobilité, rationalise l’utilisation des ressources et améliore les économies d’échelle et de

portée. Il fournit également une plate-forme de mise en réseau, de mobilisation de ressources et de plaidoyer pour l’enseignement supérieur agricole en Afrique. En 2020, il est passé à 126 universités dans 38 pays africains. Pour permettre la réussite des opérations de RUFORUM, cinq plans stratégiques ont été élaborés en continu pour guider les opérations de RUFORUM en alignement avec la mission, la mission et le créneau énoncés. Une évaluation des résultats pour la période 2004-2018 a établi que RUFORUM a eu un impact positif sur l’enseignement agricole supérieur en Afrique; son impact est allé au-delà de l’agriculture et il s’étend à travers l’Afrique. Le défi reste de savoir comment décider quelles idées devraient devenir des priorités d’action face à de nombreuses demandes et demandes d’adhésion, d’orientation et de coopération.

Mots clés: Chaînes de valeur agricoles, chaînes de valeur éducatives, sécurité alimentaire, enseignement supérieur, développement inclusif et durable, expansion du réseau, petits exploitants agricoles, RUFORUM, plan d’affaires stratégique, transformation universitaire

BACKGROUND
During the 1960s and 1970s, several African nations were on the verge of attaining independence and these periods are branded as the “Years of Africa” and “development decade” (Ajaegbo, 1984). These periods involved establishment of new universities in most of the newly independent African nations due to the increased emphasis of the role of universities in development. During this era, escalation of higher education simultaneously served political and economic desires of the newly independent governments that zealously apportioned resources towards higher education. This role of universities in Africa was re-emphasized at the United Nations Educational, Scientific and Cultural Organization (UNESCO) conference in 1962 (UNEC, 1962) and later at the Association of African Universities (AAU) seminar in 1972. However, in the early years of independence, limited efforts were undertaken by African governments or the universities themselves to promote and actualize this pivotal role, resulting into the negative perception of universities as luxurious and non-essential. This negative perception of universities deepened during the structural adjustment programmes of the 1980s and the political dynamics in Eastern Europe. This resulted into a call for reduced public investment in education in general and a diversion of public investment from higher to primary education in developing countries in particular (World Bank, 1986). During the same period, public expenditure in the agricultural sector also averaged about half of what was being spent in other continents including Asia, where the Green Revolution was booming.

Attempts by international agricultural research organizations to import the Asian model into Africa were unsuccessful due to the very different and heterogeneous climate and soils and a much more highly dispersed population. Technocrats at the international agricultural research organizations soon realized that African problems called for targeted African solutions. However, there was no assurance that African universities were capable of producing graduates and research capable of providing solutions to the imminent challenges facing the African continent. This was partly attributed to the fact that conventional curricula often mirrored those of American and European universities; ignored the local environments and the reality of small-scale farmers who had no access to inputs, information or markets. Courses, pedagogy and research were highly academic, did not take farmer’s priorities into consideration and were inappropriate to local conditions. They were not designed to enable African universities to play a role in national or continental development (Woldegiorgis
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and Doevenspeck, 2013). Universities of the time were operating in ‘silos’; cross-faculty collaboration was non-existent; curricula did not approach learning from a holistic viewpoint; and, absence of a holistic institutional reform to enable mass production of practical, field-oriented scholars. Universities were ivory towers and had no clear impacts on social equity, economic growth, or poverty reduction. In the two tempestuous decades between the 1980s and 1990s, higher education in Africa faced a period of severely declining financial resources, financial and governance crises (Mohamedbhai, 2015). This was particularly the case for higher agricultural education and research resulting in limited, and often irrelevantly, skilled human resources that led to food insecurity and stagnating agricultural productivity.

Genesis of FORUM

The challenges facing the Africa higher education sector during the 1980s and 1990s resulted into a triple effect of producing low-performing graduates emerging out of a higher education system characterized with limited field and laboratory practical exposure and no research experience. Emigration of research and academic scientists overseas to better paying jobs, resulted into fewer scientists at the national research systems, the majority of whom were above 50 years of age. All this quagmire resulted into national agricultural research organizations supporting a few scientists to undertake post-graduate training overseas to upgrade academic levels since the majority had Bachelor degrees. However, scientists often preferred remaining to work in the countries of study due to better pay and research infrastructure (Fitzgerald and Lindow, 2013). Thus, Africa was at the verge of losing an entire generation of agricultural scientists to brain drain at a moment when scientists were most needed. This was the higher education and agriculture atmosphere at the beginning of the 1990s, when a group of persons with a unifying common interest decided there had to be more post-graduate opportunities within Africa accompanied by transformation in the way agriculture curriculum is delivered in African Universities to enhance food and nutrition security on the continent. Achieving this required rebuilding the human capital base for the agricultural sector. Core to this thoughtfulness was the Rockefeller Foundation, the humanitarian agency that was fundamental in the development of technologies and social practices that enabled farmers in the third world to increase crop yields dramatically (Perkins, 1990). The Foundation commissioned a review of the agriculture faculties of 10 universities in five southern and eastern African countries to assess the faculties’ potential for conducting applied and adaptive research on smallholder food-production systems. The review established obsolete research infrastructure incapable of attracting good students, limited opportunities for practical exposure, limited funding opportunities for students and for attracting good Professors, misalignment between students’ research with smallholders’ priorities yet Rockefeller Foundation values indigenous knowledge. To solve these predicaments, the Foundation resolved, in 1992 to support the development of quality Masters degree programmes at selected Universities in eastern and southern Africa through establishing the Forum for Agricultural Resource Husbandry (“The Forum”) with a start-up investment of US$ 350,000 (Bharati and Woomer, 2000). “The Forum” was aimed at creating graduates with a practical orientation and strong problem-solving skills to enrich the agriculture sector as trainers, extension workers and programme managers in national research organisations and development agencies. “The Forum” focused on five countries where Rockefeller Foundation had programmes: Kenya, Malawi, Mozambique, Uganda and Zimbabwe.

“The Forum” provided grants on a competitive basis to these universities supporting both faculty and students to carry out research with small-holder farmers from 1993-2003. During
that period “the Forum” had awarded 314 grants worth over US$ 14.5 million for research and post-graduate training at universities in Kenya, Malawi, Mozambique, Uganda and Zimbabwe with a focus on crop and soil improvement. They also supported the universities with research infrastructure and provided mentoring and support on the implementation of changes in pedagogy and demand-driven research in smallholder farming. In addition, by hosting an annual meeting, they strengthened student and supervisor presentation skills and encouraged the universities to learn from each other and build relationships across the region.

“The Forum” impacts
“The Forum” was instrumental in rehabilitating agriculture faculties, raising teaching standards and improving curricula. The completion rate of Masters degrees was accelerated from up to seven years in the past to an average of 2.7 years (Fitzgerald and Lindow, 2013). This was due to making programmes residential, providing stipends to students and Principal Investigators which reduced their need to supplement incomes by taking on outside consultancies thus encouraging focus on quality, engagement with farmers and early completion. By the time “the Forum” came to an end, most of its Graduates had returned to their jobs at universities or national and international research institutes. University curricula were also improved with institutions venturing into new fields such as biotechnology and biosafety. Universities were working more closely with farmers and other stakeholders. The universities were retaining their staff, expanding their programmes and forging international and regional alliances. “The Forum” had brought training back home to Africa and proved that its approach was a cost-effective and sustainable way of replenishing the continent’s ranks of scientists of international stature. National agricultural research institutions began to retain and slowly attract good scientists, and by redirecting the thrust of research to smallholders, universities were active collaborators with national research programmes (Fitzgerald and Lindow, 2013).

Key lessons learned
“The Forum” as an institution strengthened linkages amongst training, research and outreach amongst African Universities. This built the capacity of institutions and individuals native to the continent, an aspect that is important for the development of the African continent. “The Forum” further increased the enrolment rate of students as well as promotion of staff due to enhancement of research infrastructural capacities thus better quality research outputs including employers’ satisfaction with competence and attitudes of “the Forum” graduates (Blackie and Woomer, 2005). Thus, Forum benefitted both staff and students and created a culture of cooperation and collaboration within and outside the universities.

Student selection, supervision and exposure to other stakeholders are important in producing effective graduates for early success in graduate placement (Blackie and Woomer, 2005). “The Forum” was a strong undertaking due to the in-built flexibility and two-way communication with Grantees at regular intervals. It showed the importance of mentoring and supervision, the potential for graduate employment by linking the students with stakeholders and the dynamics of better resourcing lecturers so that they could focus on strengthening research for development and adapting curricula to the local situation. This project was a success but “the Forum” focused heavily on few crops and on soils and was restricted to masters-level students (Fitzgerald and Lindow, 2013). It was important to provide these opportunities more widely across disciplines and also to find ways to address farming systems in curricula, emphasizing multi-disciplinarity and practical experience. Once the Masters programmes were established and starting to graduate strong candidates, there remained the gap of
doctrinal training which was still limited within Africa. However, there were uncertainties about the capacity of African universities to produce highly qualified PhD graduates and so in 2004 reliance was still on Ph.D. scholarships opportunities overseas.

“The Forum” was a unique approach using a competitive grants programme to support MSc students to be more relevant and universities to start serving the needs of rural communities. It had the potential for replication and scaling up to other commodities, degree levels and cooperation to strengthen post-graduate training throughout sub-Saharan Africa.

Evolution of FORUM, a donor funded project, to RUFORUM, an African owned and managed organization. In 2002, the Rockefeller Foundation underwent an institutional reform that resulted into reorientation of the agricultural strategy away from “the Forum” objectives of strengthening higher agricultural education (Fitzgerald and Lindow, 2013). The project had been a success and the universities wanted to be able to continue to collaborate and support education and research that served small-scale farmers and society. The Rockefeller Foundation thus commissioned a study and provided support to the universities to develop a new African-owned and led institution. The Deans of the participating faculties of the then 10 member Universities were very keen to transform “the Forum” project into a permanent network, but the Vice-Chancellors had yet to be persuaded.

After a visit by the Deans to Eduardo Mondlane University; Kenyatta University; Moi University; Jomo Kenyatta University of Agriculture and Technology; University of Nairobi; University of Malawi; and, Makerere University, the Vice Chancellors agreed to establish a consortium to enable African Universities to work together to source support for projects and programmes that would strengthen universities role in society and provide them with a competitive edge in sourcing resources. By 2003, the final year of “the Forum” operations, the inauguration of the Regional Universities Forum for Capacity Building in Agriculture, which soon became known by its acronym, RUFORUM had ripened (Fitzgerald and Lindow, 2013).

In January 2004, the 10 Vice Chancellors from the five countries signed a Memorandum of Understanding, and by June 2004, RUFORUM was operational. In August 2005, support for RUFORUM was formalized in an endorsement signed by the New Partnerships for Agricultural Development (NEPAD) and the Ministers for education from each of the then five member countries. That same month a 10-year strategic plan (2006–2015) and a five-year business plan (2006–2010) were approved at the first annual general meeting (AGM). Both documents tailored to national needs, emphasized partnership, networking and practical results. The first governance body to be constituted was the Board of Directors consisting of one Vice-Chancellor from each RUFORUM member country plus three members representing the scientific community and the private sector. The leadership of the Board was to rotate on an annual basis. RUFORUM envisioned that members develop their own goals with the Secretariat coordinating their endeavors and mobilise resources. To facilitate this, a consultative process was undertaken with faculty of the 10 RUFORUM Member universities and established that Universities could not operate in isolation within their countries. This paved the way for the establishment of national forums that served to entrench universities into the innovation systems and to align activities with national poverty-reduction strategies and the agendas of regional bodies. This presented RUFORUM as an umbrella organization for national forums. In order to be fully representative of national development needs, the national forums included scientists from outside academia and stakeholders from the private sector and government agencies.
Figure 1. Founding of RUFORUM as an umbrella organization

Using a competitive bidding process open to the 10 founding countries, Uganda won the bid to host the Secretariat of the new organisation and established it at Makerere University as an independent unit.

**The First Strategic Plan 2006-2015: Vision, Mission and Strategic Goals.** The ten-year RUFORUM Strategic Plan (2006-2015) was developed to designate new thrusts and operational modalities to guide the Secretariat during the transition period from a donor programme to an autonomous member-based organization.

RUFORUM envisioned “vibrant agricultural innovation systems with fully integrated universities that play a leading role in nurturing the systems through high-performing agricultural science graduates who are innovative and responsive to changing demands”.

The mission was to foster innovativeness and the adaptive capacity of universities engaged in agricultural and rural development to develop and sustain high quality in education/training, in innovative and impact-oriented research, and in collaboration.

To achieve the mission and vision above, seven strategic goals were formulated from the challenges universities face and the impact that RUFORUM would like to achieve. The strategic goals determine the orientation and positioning of RUFORUM and detail the organization’s commitment to achieving outputs and impacts via a range of strategies.

RUFORUM invited the Bill and Melinda Gates Foundation to its 1st Biennial Conference in Malawi in 2007 and subsequently engaged closely with them resulting in support for the Secretariat, networking and competitive grants. This opened the path for RUFORUM to expand its operations across the eastern, central and southern Africa regions while consolidating the small grants system.
Strategic Goal 1: Masters and doctoral programmes responsive to stakeholder needs and national/regional development goals

Strategic Goal 2: Shared research and education/training facilities and capacities rationalized for enhanced economies of scope and scale

Strategic Goal 3: Innovative education/training, research and outreach activities supported by adaptive management structures in universities contributing to policy and development practice

Strategic Goal 4: Operational capacity and approaches for innovative, quality and impact oriented agricultural R4D mainstreamed in universities

Strategic Goal 5: Increased participation and voices of women in education/training, research, and production and marketing of knowledge

Strategic Goal 6: Increased use of technology to support effective, decentralized learning and sharing of knowledge

Strategic Goal 7: A dynamic regional platform for policy advocacy, coordination and resource mobilization for improved education/training, research and outreach by universities

In response to a growing need as agricultural research in Africa gained ground and more Masters students’ were graduating, it became obvious that it was time to enhance opportunities for doctoral students to be produced within Africa. Those being trained internationally were away from the continent for too long, and in some cases were not returning (Mohamedbhai, 2015). University faculty and national research institutes had very few highly qualified staff. PhD graduates were needed for expanding universities, the increasing importance of African-led research and the recognition that science-led development was essential to improving food security and livelihoods. However, there were no taught PhD programmes in the member countries at that time. As a result there was pressure from members for RUFORUM to strengthen doctoral training at member universities. Resources were very scarce and so it was decided that a regional approach would allow for better sharing of human and physical capital. A process was launched that resulted in the selection of the most critical areas to address on the continent, especially in line with the Comprehensive African Agriculture Development Programme (CAADP) adopted by African Heads of State in Maputo in 2003 and to identify which of the universities was in a position to host each degree programme (Lynam et al., 2013). These programmes were designed in response to specific capacity gaps within the jurisdiction of agriculture in Eastern, Central and Southern Africa but guided by CAADP and the FAAP (Framework for African Agricultural Productivity). The regional programmes were designed to build the teaching and research capacity of member universities. They were established to address the skills gaps at universities and research institutes and ultimately aimed at improving food and nutrition security and stimulating growth. Having doctoral students carrying out their research on the continent improves access to the knowledge generated and leads to more focus on local problems. Establishing regional programmes supports joint action towards improving the livelihoods of farmers in Africa and pools and rationalizes the use of scarce resources and expertise. Regional programmes train doctoral students in Africa and give them international exposure and build relationships and mobility across the continent. The research benefits surrounding communities and contributes to the African Agenda 2063. The regional programmes also enables mature students to upgrade their qualifications while in-service. They are cost saving - five students are supported for every one student trained abroad (Njeru, 2014). The first three regional...
Institution-wide changes have been triggered by the establishment of new training programmes, which have been successful and are now internationally recognized. These programmes include taught post-doctoral programmes in all disciplines in Kenya and Uganda, and some have been very successful and continue to attract students and faculty from across the continent. Additionally, four Regional Masters Programmes were launched to build capacity in research skills across universities and National Agricultural Research Systems in Africa, with a focus on improving information and communication capacity, middle-level plant breeding, and the capacity to track development impact (Table 2).

The general RUFORUM model for the regional training programmes as indicated in Figure 2 below was intended to enhance overall quality of graduate training programmes in the region. The model is based on the centres of leadership facilitated through networks of specialisation. This approach aimed at ensuring that courses are up to date and that experience and best practice are incorporated into graduate learning experiences (Blackie and Woomer, 2005). Accordingly, in 2005, RUFORUM set its vision of success for the Regional PhD training programmes (Figure 3) with a target of training 120 PhD graduates by 2012. A similar framework was set for MSc training with a target of 300 MSc graduates by the end of 2012.

### Table 2. RUFORUM regional training programmes

<table>
<thead>
<tr>
<th>Programme</th>
<th>Centre of leadership</th>
<th>Year of launch</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PhD programmes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dryland Resource Management (DRM)</td>
<td>University of Nairobi</td>
<td>2008</td>
</tr>
<tr>
<td>Plant Breeding and Biotechnology (PBB)</td>
<td>Makerere University</td>
<td>2008</td>
</tr>
<tr>
<td>Aquaculture and Fisheries Science (AFS)</td>
<td>Lilongwe University of Agriculture and Natural Resources, Malawi</td>
<td>2009</td>
</tr>
<tr>
<td>Agricultural and Resource Economics (ARE)</td>
<td>Lilongwe University of Agriculture and Natural Resources, Malawi</td>
<td>2009</td>
</tr>
<tr>
<td>Soil and Water Management (SWM)</td>
<td>Sokoine University of Agriculture, Tanzania</td>
<td>2010</td>
</tr>
<tr>
<td>Agricultural and Rural Innovations (ARI)</td>
<td>Makerere University</td>
<td>2012</td>
</tr>
<tr>
<td></td>
<td>Egerton University</td>
<td>2012</td>
</tr>
<tr>
<td></td>
<td>Sokoine University of Agriculture, Tanzania</td>
<td>2013</td>
</tr>
<tr>
<td>Food Science and Nutrition (FSN)</td>
<td>Jomo Kenyatta University of Agriculture and Technology</td>
<td>2013</td>
</tr>
<tr>
<td><strong>Masters programmes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant Breeding and Seed Systems (PBS)</td>
<td>Makerere University</td>
<td>2008</td>
</tr>
<tr>
<td>Research Methods (RM)</td>
<td>Jomo Kenyatta University of Agriculture and Technology</td>
<td>2009</td>
</tr>
<tr>
<td>Agricultural Information and Communication Management (AICM)</td>
<td>Egerton University</td>
<td>2008</td>
</tr>
<tr>
<td></td>
<td>University of Nairobi</td>
<td>2009</td>
</tr>
<tr>
<td></td>
<td>Haramaya University</td>
<td>2010</td>
</tr>
<tr>
<td>MSc Agrometeorology and Natural Risk Management</td>
<td>Haramaya University, Ethiopia</td>
<td>2010</td>
</tr>
<tr>
<td>MSc Monitoring and Evaluation</td>
<td>Uganda Martyrs University</td>
<td>2012</td>
</tr>
</tbody>
</table>
Genesis, evolution and strategic thrusts of RUFORUM

Figure 2. Generalized structure for a RUFORUM Network of Specialization

Figure 3. Roamap for the RUFORUM supported PhD programmes
In 2007, during the 3rd RUFORUM Annual General Meeting in Maputo, Mozambique, there was a call for RUFORUM and its universities to engage in policy advocacy; this led to the convening of the Ministerial Conference on Higher Education in Agriculture in Africa (CHEA) in 2010 in Kampala-Uganda. RUFORUM adapted its strategic plan and has become increasingly engaged in a policy advocacy role, taking advantage of its strong convening power and credibility with member universities and countries. In 2016, RUFORUM worked with the Government of Malawi to host a conference on Higher Education in Africa, at the side-lines of the 2016 United Nations General Assembly, purposely to mobilise Inter-Africa and global partnership for higher education in Africa. The Conference was attended by Government leaders in Africa and global representatives from Latin America, North America and Europe. Subsequently, this increased the RUFORUM advocacy role, including engaging with African Heads of State and Government, and together with the African Union Commission and other partners catalysed the formation by the African Union Heads of State of a Committee of Ten Heads of State (C10) championing Education, Science, Technology and Innovation in Africa in 2016 and the holding of the first Extra-Ordinary Summit of the C10, 2-3 November 2018 in Lilongwe, Malawi.

As RUFORUM established itself as a Network of Universities in Africa, with demonstrated impact at country level, demand for membership spiraled. RUFORUM agreed on a phased approach on its expansion strategy, to allow it build footprint in its operating areas while building capacity to manage an expanded network. Thus RUFORUM started slowly expanding to include other universities and in 2005 expanded to Tanzania and Zambia, thus increasing the network coverage to seven countries. By 2011, during the seventh RUFORUM Annual General Meeting in Addis Ababa, Ethiopia, the demand for RUFORUM membership created the stimulus for RUFORUM to expand its membership even more widely within Eastern, Central and Southern Africa.

To guide RUFORUM future role, a review of RUFORUM by Lynam et al. (2013) was undertaken to answer five questions including:

i. How have RUFORUM programs enhanced both directly and indirectly the capacity of faculties of agriculture in East and Southern Africa?

ii. What difference has RUFORUM made in enhancing the quality of graduate training in East and Southern Africa and how critical has a regional platform been in achieving this?

iii. How has the competitive grants program improved the research capacity and outputs within agricultural faculties and are there avenues to improve both relevance and science leadership?

iv. Is the Secretariat appropriately organized and does it have the capacity to grow and deepen the Higher Agricultural Education platform in the region?

v. How successful has RUFORUM been in achieving the balanced growth strategy of its business plan and how has it balanced resource mobilization and deepening of its core competencies?

The review established that BMGF core funding allowed RUFORUM to develop and deepen its program structure, which was essential in positioning the regional platform in agricultural policy processes in sub-Sahara Africa. During the course of the grant period, RUFORUM developed its regional MSc and PhD programs, expanded its competitive grants, launched the Community Action Research Programme (CARP) to strengthen linkage between agricultural faculties (universities) and rural communities, developed its M&E system, was
developing its management information system (MIS), and was beginning to position itself in the area of open educational resources and distance learning. RUFORUM had developed several interacting programs that addressed critical needs in higher agricultural education across the region (Lynam et al., 2013). These programs overcame the shortage of PhD academic staff in faculties of agriculture through regional approaches. RUFORUM thus complemented the efforts of regional organizations in agricultural research and agricultural extension including regional seed associations and farmer associations.

In 2014, in recognition of the acute need for upgrading the qualifications of faculty in member universities, a special session of Vice Chancellors met in Kigali, Rwanda and discussed the issue. They determined that one approach would be for the universities to support each other by sending their staff to train in PhD programmes in other Member universities. At the Fourth African Higher Education Week and RUFORUM Biennial Conference, held in Maputo, Mozambique in July 2014 RUFORUM launched the Graduate Teaching Assistantship (GTA) programme. It provided for the host university to waive fees, the sending university to continue providing salary and the staff member upgrading to PhD to assist with teaching at the host university. Mobilising resources for the research and travel would be shared by all parties, supported by the Secretariat where possible. The Biennial conference which included the African Union Commission Chair and government ministers from across Africa resulted in demand for RUFORUM to broaden its focus to include science, technology and innovation (ST&I), and a call to expand membership to West and North Africa. As such, as of 2020, RUFORUM operations cover all the five geographical regions in Africa, with a membership of 126 universities in 38 African countries (Figure 4).

**Design of second RUFORUM Strategic Business Plan (2016-2020) in 2015.** The Strategic Business Plan (SBP) for 2015-2020 built on the accomplishments and experience of RUFORUM during the ten-year period (2004-2014) as a University member-based, regional capacity-building Network. The Plan represented the strategic evolution of RUFORUM development into an established organization ready to serve a wider mandate in relation to the vision of the Africa Union Commission (AUC) for agricultural higher education and its relationship to science, technology and innovation on the continent. It was an adaptable plan that hinged on the overlapping years of the three previous RUFORUM Strategic Plans. It laid out programme choices and financial expectations that would be continuously refreshed in response to changing opportunities and circumstances on the Continent. To support the RUFORUM mission and strategic goals, the objectives of the 2015-2020 Strategic Business Plan were to ensure an effective platform for University support to smallholder farmers by enabling the University community to contribute to the productivity of small-scale producers and the value chains that serve them; to realize economies of scale and scope that link national capacities regionally; to rationalize resource use and promote international standards of excellence; to engage university actors along the whole value chain, including sister organizations and the private sector in mutually beneficial research and training to accelerate delivery of agricultural science-based innovations; to increase participation and voice of women in higher education and activity along the value chain; and to disseminate RUFORUM best practices through building lessons into academic teaching, working with partners in selected countries, including BMGF anchor countries, to spread findings through their networks both geographically and along value chains and, to take on a visionary/advocacy role at the continental level.
Figure 4. RUFORUM Expansion 2004-2020
Focus and Impact of RUFORUM up to 2017. During the period 2014 to 2017, RUFORUM consolidated its footprints in Eastern, Central and Southern Africa, including targeted support to build capacity for weaker national agricultural research systems (NARS) in Burundi, Rwanda, and Sudan with support through the Forum for Agricultural Research in Africa (FARA) that coordinated the SCARDA (Strengthening Capacity for Agricultural Research and Development) project which focused on building capacities for weaker National Agricultural Research System in Africa. The SCARDA project created high quality masters level study opportunities for African students to undertake demand-led research in more endowed universities in Africa, especially at Makerere in Uganda, Egerton and Nairobi in Kenya and Sokoine in Tanzania. The 28 graduates (15 from Sudan, 5 from Burundi, 8 from Rwanda) from the programme demonstrated that they can respond effectively to the chances and opportunities they are given, including studying in new language (Arabic and French to English). The SCARDA project represented a good case of partners who collaborate in an innovative agricultural and development research capacity strengthening programme in sub-Saharan Africa and opened the door for RUFORUM to expand its operations to the three countries (Burundi, Rwanda and Sudan) and also Botswana, Lesotho, and Swaziland in Southern Africa. Already by early 2013, RUFORUM had met its target of training 120 PhD and 300 Masters level graduates that were immediately absorbed to service agricultural sector and many joined staffing in African Universities and research institutions. The key lesson was that to strengthen research capacity, collaboration is vital as well as creating sustainable relationships among the different research actors, universities, governments and sub-regional bodies.

RUFORUM further strengthened University-Community engagement through the community action research programme (CARP). During the year 2017, three CARP projects operational in Ethiopia, Tanzania and Uganda focusing on wheat, dairy and cassava value chains respectively generated significant technologies, innovations and management practices reaching a total of more than 15,000 farmers in Ethiopia, Tanzania, and Uganda. In Tanzania, a functional dairy innovation platform integrating all actors in the value chain across Tanzania was established, and improved dairy cattle feeding practices were adopted by at least 300 smallholder dairy farmers. In Ethiopia, two new Durum wheat varieties with 14% protein content were released as well as two other high yielding varieties that were biofortified with proteins, Zinc and Iron. In Uganda, the Cassava CARP mobilized farmers and local engineers to fabricate machines for producing high quality cassava flour (HQCF) used to produce confectionaries and composite porridge flours for infants and breast feeding mothers. Cassava varieties suitable for bio-ethanol and industrial starch production were selected and production tested in partnership with Kamtech Logistics Uganda Limited (KLUL). The team produced a beer labeled “Engule” from Cassava in partnership with Uganda Breweries Limited to create more value from Cassava and make it a profitable enterprise from which farmers can benefit from. During the same year, RUFORUM awarded two new CARP+ projects focusing on the pig and potato value chains in Uganda and Kenya, respectively involving a mandatory collaboration with technical, vocational education and training institutions.

Strengthening of the Small Grants Scheme. This was aimed at supporting training of at least two Masters students by a given project in order to empower institutions of higher agricultural education and learning to train
middle-level graduates while strengthening agricultural research programs with lasting benefits for millions of Africa’s most vulnerable people. The RUFORUM competitive grants scheme demonstrated that small grants funds have the potential to efficiently link large donors and local actors and ensure that funds and other support services reach those who need it most and use it most effectively. Since experience showed that these competitive sub-granting mechanisms were indispensable in getting money to the right place and generating maximum impact, RUFORUM has been using the small grants funding to support research in African universities linked to addressing the needs of small holder farmers, strengthening agricultural value chains while using research as a mechanism to generate innovation and build human capacity for African universities and National Agricultural Research and Extension Systems. The Outcome is that over 300 technologies have been developed that are in use across Africa, and the graduates are championing research and training across the continent.

**Strengthening Regional training initiative, and supporting transformation to African Higher Education Centres of Excellence.**

In 2016, the World Bank availed an IDA credit of US$140 million to eight Eastern and Southern African countries to set up 24 centres of excellence in universities to strengthen postgraduate training and research. Eleven (11) of these were awarded to eight of the RUFORUM member universities in five countries. Some of these universities host the RUFORUM regional training programmes. For example, the Makerere University Regional Centre for Crop Improvement (MaRCCI) arose out of the PhD in Plant Breeding and Biotechnology and MSc in Plant Breeding and Seed Systems regional training programmes initiated in 2008. The AquaFish Centre of Excellence at Lilongwe University of Agriculture and Natural Resources (LUANAR) emerged from two regional PhD programmes in Aquaculture and Fisheries Science, and Agricultural and Resource Economics hosted on behalf of RUFORUM member universities at Lilongwe University of Agriculture and Natural Resources. In Kenya, Egerton University which hosted the Agricultural Information and Communication Management, now hosts the Centre of Excellence in Sustainable Agriculture and Agribusiness Management, while the Agrometeorology and Natural Risk Masters Programme now forms the core of the African Center of Excellence for Climate Smart Agriculture and Biodiversity Conservation at Haramaya University. Additionally, the Masters and PhD Programmes in Agroecology at Uganda Martyrs University, transformed to become the ACE in Agroecology and Food Systems. Thus, the regional training programmes formed the basis for the design of the Centers of Excellence to facilitate and promote scaling-up of graduate training in respective fields and strengthen linkages with the private sector in the region while increasing females and youth participation. RUFORUM is exploring this approach to establish Regional Anchor Universities/Regional Training Centres to support transformation of agricultural sector and harnessing advances in Science, Technology and Innovation (ST&I) including in emerging areas of data science and digital technologies.

**Focus on regional academic mobility.**

RUFORUM commenced facilitating academic mobility in Africa in 2009 to strengthen capacity of African universities to build their own human resource capacities and to train a new generation of African scholars who know Africa better and more widely. The overall aim is to foster inter-university collaboration in the field of higher education, promote inter-cultural and linguistic exchanges and regional cooperation across the continent. All the RUFORUM member universities committed to academic mobility through the network based on capacity gaps.
in the agricultural sector mapped in regionally accredited masters and PhD Programmes. By 2016, 521 graduate students and 110 academic and administrative staff exchanges had been supported. Students and staff benefit from exposure to diverse cultures and environments, create research networks through conferences, and are have opportunity working in different parts of the Continent. Member universities now exchange staff to deliver guest lectures and build programmes for building capacity and internationalizing their academic programmes. Success registered is attributable to institutional ownership of the programmes by the Vice Chancellors, subsidized cost of training, regionally recognized curricula and a strong coordination mechanism provided by the RUFORUM Secretariat.

**Focus on increasing the pool of women scientists.** One of the strategic objectives of RUFORUM is to enhance participation and voices of women in education/training, research, and production and marketing of knowledge. Guidelines for student recruitment, award of grants, and scholarships give special focus on support of female students. At the initiation of RUFORUM in 2004, 20% of the students trained with FORUM support at Masters level were female, while those trained at PhD level were 12%. By 2018, the ratios for both masters and PhD training rose to 45 %.

**Intensifying advocacy for higher education in Africa.** RUFORUM efforts to engage its university partners to advocate for higher education in Africa grew its network of advocates, by targeted individuals and organisations in and outside Africa that could help it in its advocacy efforts. Notable partners included Agrinatura (European Network of Universities and Research Centres), Technical Centre for Agriculture and Rural Cooperation (CTA) in Netherlands, Forum for Agricultural Research in Africa (FARA) and individuals especially David Nielsen of the World Bank, HE Prof Arthur Peter Mutharika, President of Malawi, and Prof Ameenah Gurib-Fakim, the former President of Mauritius. The culmination of this sustained advocacy for higher education was the establishment by the African Union (AU) in 2016 of the Committee of Ten Heads of State and Government championing Education, Science, Technology and Innovation in Africa (AU-C10), and subsequently the convening of the first Summit of the AU-C10 hosted by Government of Malawi at the Bingu International Convention Centre (BICC) in Lilongwe, 2-3 November, 2018. The Summit issued a C10 Declaration and Action Plan³.

RUFORUM has convened over 500 networking events including 16 Annual General Assemblies, six Biennial events over the last 15 years. These events have enabled academia-policy-development interaction, thus providing space for niching shared perspectives and visions for development with the active participation of universities.

**Expansion to West Africa.** At a convening⁴ in South Africa involving African Union Commission (AUC) and higher education actors from across the continent, RUFORUM declared a move to West Africa. This was part of a phased organizational expansion that built upon the existing shared institutional experience and collective footprint. This paved the way for the development of the new five-year RUFORUM Strategic Business Plan for 2016-2020, which confirmed RUFORUM’s role as a voice for higher agricultural education across the continent.

**Expanding RUFORUM Resource base—securing Mastercard Foundation funding.** The expanded RUFORUM expansion demands for intensified efforts to broaden RUFORUM funding base in Africa and globally. As a result of the various partnership engagements,

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RUFORUM in 2016 secured US$ 27.1 million from the Mastercard Foundation to support transformation of African agricultural universities and their graduates to better respond to developmental challenges through enhanced application of science, technology, business and innovation for rural agricultural transformation. With this funding RUFORUM was now able to ‘test new waters’. New programmes were developed that gave special emphasis to training needy but deserving students at Undergraduate and Masters levels, focus on youth skills development and entrepreneurship training, incorporation of TVETs into RUFORUM research and training with the aim to foster linkages between TVETs and universities, and piloting students extension delivery model.

RUFORUM Outcome evaluation, 2004-2018: In December 2018, RUFORUM commissioned an outcome evaluation to provide evidence about the degree to which RUFORUM has had an effect in “strengthening the capacity of African universities to deliver relevant and impact orientated research and training - producing skilled and proactive graduates, and demand driven research outputs and innovation in response to national, regional and continental agricultural development priorities”. The evaluation identified several factors that help explain RUFORUM’s success as well as other factors that pose a risk to RUFORUM performance. The outcome evaluation concluded that RUFORUM should consolidate and scale-up various successes including increasing awareness and capacities of national, regional, continental and global stakeholders in higher agricultural education in Africa through successive and successful events organized in various countries, and a strong focus on multi-institution transboundary activities; and, integration of universities with communities through student-centered extension services to meet the demand for knowledge and capacity development at the individual farmer and community levels. It further recommended that RUFORUM further consolidates its undisputed leadership as the pan-African network of higher education institutions with a passion for agriculture, using research as a powerful training tool while delivering developmental benefits. RUFORUM initiatives including establishment of post-doctoral and field attachment opportunities had been useful in helping young researchers raise their professional profiles and broaden their access to opportunities. RUFORUM through its supported programmes and engagement with member universities should continue to champion demand-driven education emerging work and learning to develop the human skills that matter, focusing on ensuring graduates are job-ready, hireable, and have access to rewarding careers over the course of their lifetime by ensuring career-long alignment between education and the job market. The evaluation recommended that while RUFORUM progresses with the policy process approach was to integrate universities into national and continental policies and strategies, measures need to be devised for RUFORUM to evolve and consolidate itself as an evidenced-based advocacy and knowledge management platform on higher agricultural education in Africa. However this would require significant investment in the RUFORUM knowledge platforms and mechanisms for monitoring.

Due to the aforementioned successes of RUFORUM, membership to the RUFORUM Network has continued to grow exponentially. However, once a connection is made, measures of ensuring a long lasting partnership need to be devised to enable RUFORUM access expertise when need arises. Measures of balancing efforts to bring in new members while staying in touch with those known before also need to be devised. Further, the expansion and diversity of the network stretches the ability of the Secretariat to manage and service the network, and meaningfully engage with the policy agenda at the national level. With diminishing resources, there is a danger of RUFORUM spreading too
thin and leaving an unremarkable footprint in the member universities and countries. The diminishing resources also call for RUFORUM to position itself as a facilitating mechanism for the universities and working with its members to design strategic initiatives attracting a more diverse array of funders, and in particular national governments committing to investing and borrowing to support higher education and research. This will curtail the risk of RUFORUM raising more funds by “doing it on behalf” of participating universities, instead of “doing it with” participating universities.

**RUFORUM Vision 2030**

The process for defining the Vision 2030 for the RUFORUM Network followed recommendations by the RUFORUM Annual General Meeting (AGM) of 2016 and organizational Business Strategy review of 2017 that demanded RUFORUM to develop a comprehensive and inclusive programme for developing Africa’s Agriculture through implementing innovative and transformative initiatives in the higher education sector. A systematically conducted 12-month consultation process with stakeholders including university faculty, staff and administrators, scientists and researchers, public officers and policy makers, the civic and private sector and community members, resulted in the development of RUFORUM Vision 2030: The African Universities’ Agenda for Agricultural Higher Education, Science, Technology and Innovation (AHESTI) (Waswa et al., 2018).

The vision, ‘vibrant, transformative universities to catalyse sustainable, inclusive agricultural development to feed and create prosperity for Africa’ comprises four strategic flagship initiatives and three strategic objectives which are (i) developing quality human resources and capacity required to intensify and increase Africa’s agricultural productivity; (ii) ensuring the products, processes and knowledge developed through university research reach down to value chain actors in the agri-food system to catalyse transformation; and (iii) marshalling resources and strategically allocating them to enable African universities to transform into viable institutional entities responsive to national aspirations and conditions through intensive knowledge-sharing and collective action. The objectives are to be achieved through four flagship programmes:

**TAGDev (Transforming African Agricultural Universities to meaningfully contribute to Africa’s Growth and Development)** is aimed at transforming African agricultural universities and their graduates, in order to respond better to developmental challenges through the enhanced application of science, technology, business and innovation for rural agricultural transformation. This is expected to be achieved through attracting and supporting youth into agricultural education to acquire skills for employability and entrepreneurship – as skilled, adaptive and proactive graduates responsive to the labour market needs.

**RANCH (Regional Anchor Universities for Agricultural Higher Education)** aims at creating African Centres of Excellence and academic leadership with high standards of conduct in a field of agricultural and ST&I education, research, innovation and learning supporting other institutions to use and facilitate application of science for development. This is expected to be achieved through facilitating and escalating setting up networks of linked universities with relevant high-level skills and strengthened integration with research as well as collaboration with professionals from the private sector.

**CREATE (Cultivating Research and Teaching Excellence)** aims at realigning universities’ research and teaching functions into a more integrated model with a focus on
problem solving and enhancing the capacity of the entire university academic practice and outreach system to contribute to inclusive sustainable development. This is expected to result into universities achieving impacts at multiple scales and shaping higher agricultural education management and delivery in positive ways.

K-Hub (Knowledge Hub for Networking, Partnerships and Advocacy) builds on RUFORUM’s convening power and facilitates the creation, capture, organising, sharing and refining of information and content across teams and geographic locations – thus increasing access to the latest, up-to-the-minute, evidence-based information and knowledge. This flagship is expected to result into RUFORUM member institutions and affiliates collaborating, using up to date information to making substantial structural changes in the way higher agricultural education and ST&I training are organized and operated.

Progress to-date
Following the development of the RUFORUM Vision 2030, a five-year Operational Plan for the period 2018-2022 was adopted. It had a new Secretariat structure following a functional analysis that was aimed at aligning Secretariat functions to the Vision 2030 aspirations. The financial Year 2018/2019 marked the first year of implementing the five-year Operational Plan.

Since the launch of the Operational Plan there is evidence which indicates that the capacity of universities and Business, Technical and Vocational Education and Training (BTVET) institutions to develop, deliver and scale innovative training curricula and new models of agricultural education has been strengthened through revising curricular of selected academic programmes at Gulu and Egerton Universities as well as BTVET institutions. There has also been an increased focus on universities attracting promising students from very remote or disadvantaged groups. These students have received mentoring and remedial and language support. The success has been remarkable with 33% timely graduation for cohort 1 Masters Students supported by the Mastercard Foundation at Gulu University. Further, there has been an increased focus on much more practical training and on entrepreneurship, for instance, student agribusiness outreach has linked refugees and their host communities to universities (University World News, 2019) and 19% of incubates under the RUFORUM Entrepreneurship Challenge Programme have established own enterprises.

As part of facilitating universities and BTVET institutions to work together to attract, recruit, train and skill Africa’s new age of development practitioners and cadres and to help speed up research-into-use, RUFORUM has facilitated relationship of universities with BTVET institutes thus strengthening a broad stakeholder intervention for the smallholder farmers and brokering stronger relationships along the education value chain. Through piloting the Technical Skills Development Program (TESDEP) and the out of school youth programme with the BTVET institutions, RUFORUM has responded to the skills gap and needs of smallholder farmers and in particular, the youth that seek to improve their livelihoods through entrepreneurial agriculture. This has increased RUFORUM’s participation in the training of BTVET students in Benin, Botswana, Ghana, Kenya, Namibia, South Africa, Uganda and Zimbabwe. The emerging evidence indicate that Youth are now prioritizing horticultural crops that have a short-term growing period and are profitable in particular to feed the growing urban market. Through the training of refugees (farmers and students), training of BTVET students and training of smallholder farmers, TAGDev supported students are serving as change agents in various communities in Uganda and Kenya. Universities and BTVET institutions have thus demonstrated increased

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5at Gulu University, Master of Science in Food Security and Community Nutrition at Gulu University, Field Attachment Curriculum at Egerton University, and non-formal Competence based curricular in indigenous micro-organisms and artificial insemination technology at Northern Uganda Youth Development Centre as well as pig production level 3 and 4 competency based curriculum at Baraka Agricultural College in Kenya.
commitment and community engagement to transform rural agricultural communities. This gives universities more practical exposure and the opportunity to speed up research into use. For the BTvET’s it provides opportunities for curriculum development and support in training staff and students. In some cases it can also result in the Universities sourcing products from the BTvET (such as in Namibia).

With support from various development partners including DAAD, Carnegie Corporation of New York, United Kingdom Research and Innovation Fund, and Mastercard Foundation, RUFORUM has escalated doctoral training on the African continent. Additional support has been through the RUFORUM Graduate Teaching Assistantship (GTA) program aimed at addressing staff capacity challenges in African universities. The GTA programme is funded by RUFORUM member Universities as part of staff capacity development within Africa for Africa (see Adidja et al., 2019).

RUFORUM has continued implementing recommendations from various policy convenings to increase the pool of women scientists in African Universities and other research and development institutions. New fellowships and research grants initiatives have adopted the 50% opportunity for female applicants. This is the initial step towards capturing the female unique attributes in research and higher education. Efforts are also ongoing to mobilise resources to increase the pool of doctoral trained academic staff in African universities and research institutions, paying particular attention to increasing the pool of women scientists and training for fragile States.

Under the K-Hub, RUFORUM online platforms including the Online Impact Portal and database, higher agricultural education capacity indicators (HAECI) portal, Management Information System (MIS), knowledge repository, website and blog, and digital communication and social media platforms have proved to be a strong outreach tool not only on the African Continent and the member universities but for different stakeholders across the globe. As part of supporting decision-making processes in the various institutions as well as for informing development partners of the status of higher education by university, 40 institutional fact sheets were generated on capacities in respective agricultural higher education institutions in Africa.

Emerging issues

i. Growth projection: Based on the past growth rate of the Network, it is projected that by 2024, RUFORUM membership will increase by 101 universities keeping all things constant. This expansion has implication for niche, possibility of disbursing efforts without solid foot prints and management and financial implications (see follow up section below)

ii. Network Management Considerations:
   With the current and projected increases, there is a need to consider the following for the effective management of the Network:
   a. Maintaining the original niches of RUFORUM as a network for capacity building in agriculture while embracing ST&I and other non-agricultural thematic areas as supporting fields
   b. Systematic maintenance of admissions into the network without causing hefty financial pressure
   c. Innovative ways of financing Network operations to appropriately respond without reducing the Network’s ethos and vibrancy
   d. Ensuring the satisfaction index for the existing members of different clusters
   e. Develop further guidance on how to encourage members to make their annual subscriptions and corresponding punitive actions for non-compliance
iii. RUFORUM’s Niches: The growth of the Network membership to 126 universities across the continent has also come with it diverse expectations that impinge into RUFORUM core niche.

Further reflection on evolution of RUFORUM and its continental expansion, impact and emerging challenges. The establishment of RUFORUM, and its continuous progressive growth in membership from 10 universities in five countries to 126 universities in 38 countries (Fig. 2), was (and still is) an expression of collective goals and shared needs, as documented in the various decisions of the Annual General Meeting and governance organs. Establishing a network of like-minded institutions is catalytic for development. But once a connection is made, measures need to be devised to continue to build the relationships. For the Secretariat it is important to maintain the collaboration functional. There is the need to balance efforts to engage new members while continuing to serve existing members. This is made more complex by the diversity of institutional capacities, cultures and policy environments. The member universities and the countries to which they belong and/or operate from are at different development levels, with differentiated capacities and needs - financial, human capital, infrastructure, scientific and technological.

RUFORUM has proved to be a functional networking system that is built on strong trans-institutional and transnational collaborative approaches that utilize Africa’s diversity, range of existing capacities and expertise, while leveraging international cooperation. Nonetheless, the expansion and diversity stretches the ability of the Secretariat to manage and service the network and meaningfully engage with the policy agenda at the national level. RUFORUM is renowned for the noticeable impact it has made and has strong ownership as is evidence both in the attendance level of its Annual General Meetings, that attract on average over 400 university representatives and other actors from across Africa and globally, and of the collaborative teaching, training, research, advocacy and resource mobilization efforts of members. With diminishing resources, there is a danger of RUFORUM spreading too thin and leaving an unremarkable footprint in the member universities and countries. RUFORUM expansion is a success that needs to be carefully managed so as not to become a risk. As a pan-African network, RUFORUM has to continue to add new members to the network in order to share learning across the continent and access as many resources (expertise and facilities) as possible. It also needs to maintain the character of the network and the continued interest of existing members by facilitating collaboration, staying in touch and activating the appropriate expertise when the network has work that needs to be done. It is increasingly difficult to raise resources to cover the networking, governance and administrative costs. Members, countries and the continent need to work towards taking full responsibility for the costs of operating the Secretariat. The RUFORUM Charter is a step in this direction.

RUFORUM coming of age
The RUFORUM Vision 2030 is to engender a financially stable network by 2030. The network is expected to have significant financial and other resource input from the member universities, African governments, and regional and international agencies. Strong commitment from all stakeholders will ensure the attainment of RUFORUM Vision 2030. This is a key underpinning issue that the Network and its Board of Trustees must periodically reflect on and come up with strategies to sustain RUFORUM operations.

CONCLUSION
RUFORUM has continued to espouse the core values pursued under “the Forum” and has built
on the approaches used to strengthen the quality and relevance of universities. RUFORUM still uses competitive grants, supports students working with small farmers, communities and rural entrepreneurs in participatory action research. It has expanded the concept of linking students to all stakeholders and supports multidisciplinary, multi-agency collaborative research platforms that inform university curricula and assist in the uptake of innovations and the role of universities in society. This has ensured that the knowledge, skills and techniques emerging from universities are available more broadly to mutually benefit the network and the public. Participatory research has increased adoption rates of new methods or technologies by farmers and communities involved in the design and execution of the research programmes. It has strengthened more interdisciplinary, practical and student-centred learning and encouraged entrepreneurship, thus building competencies of agricultural graduates for the labour market landscape.

RUFORUM has also helped universities to develop regional doctoral and masters programmes and has facilitated scholarships and fellowships. Apart from much lower costs of training through fellowships and scholarships compared to international study, training in the African continent and through their research during their training, students find solutions that are applicable in the local context and thus contribute to improving livelihoods of rural communities. In this process RUFORUM has piloted systems to recruit and mentor students from very remote and disadvantaged backgrounds resulting into extending higher education to the most vulnerable populations of the African Continent. It has facilitated staff and student mobility across the continent and strengthened the mutual self-help that resulted in members waiving fees for PhD training of member university faculty through the Graduate Teaching Assistantship Programme. This has greatly contributed to rebuilding of staff numbers, skills and competencies for teaching and research at member universities; strengthening national agricultural research institutes, government ministries, departments and agencies, and non-State actors.

RUFORUM continues to emphasize building a strongly connected network with regular engagement of the 126 Vice-chancellors and over 200 Principals and Deans with lecturers and students of Agriculture and related sciences. This has enabled academia-policy-development interaction thus offering space for niching shared perspectives and visions for development with the active participation of universities. It has thus provided young faculty and students with opportunities to present their findings and develop stronger inter-personal skills and commitment to serve. This also strengthens advocacy for greater recognition of the role of universities in development and of the importance of investing in them.

RUFORUM also has a range of successful and active on-line sharing platforms that have broadened cooperation opportunities available to both faculty and students. Vast information can be accessed, transmitted and discussed at the same time using the various online portals of RUFORUM allowing for meaningful sharing of lessons, and research in new trends. RUFORUM actively encourages collaboration between members who support each other, share resources and work together to raise resources and respond to international funding calls. All the members value the role that RUFORUM plays in strengthening their links with stakeholders nationally, regionally and internationally and there is pressure from universities wanting to become members.

ACKNOWLEDGEMENT

The authors acknowledge the 10 Vice Chancellors for founding RUFORUM and the
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ABSTRACT
Availability of qualified human capital in sufficient quantity is necessary for the development and exploitation of science, technology and innovation. Mali, like many other African countries is striving to grow a requisite pool of skilled science, technology and innovation professionals but there is a dearth of information on the gender gaps at country level. Therefore, we conducted a gender-based assessment to map the status of science, technology and innovation upon which capacity development at higher education institutions will be premised. Primary and secondary data were collected and analysed qualitatively and quantitatively. The study looked at the following indicators of the status of science, technology and innovation: human capital, decision making, and research and development, while analysing the policy environment. All the indicators assessed exhibited large gender imbalance in favour of men. Within the agricultural research and training institutions, women are largely under-represented [15%]. Among women researchers, only 8% were active in 2018 compared to 92% for men. Eighteen percent of the staff involved in decision making were women compared to 82% for men. Among the active researchers, very few [6%] accessed science, technology and innovation information, regardless of gender indicating that this is a general issue that must be tackled at all level. To correct the gender gap in the agricultural training and research institutions, a capacity building program based on a countrywide policy of mainstreaming gender with incentives for girls in education, starting from the level of preschool, to primary, secondary, tertiary and high school, to higher education should be considered. Such gender mainstreaming program should be developed, implemented and must be accompanied by a strong and rigorous monitoring and evaluation program, to help inform policies on a regular basis. The gender mainstreaming programs should also provide incentives to girls that promote excellence in the short, medium and long terms.

Keywords: Agricultural training and research, gender imbalance, Mali, Science Technology and Innovation, Women

RÉSUMÉ
La disponibilité d’un capital humain qualifié en quantité suffisante est nécessaire au développement et à l’exploitation de la science, de la technologie et de l’innovation. Le Mali, comme de nombreux autres pays africains, s’efforce de développer un réservoir de professionnels qualifiés en science, technologie et innovation, mais il y a un déficit d’informations sur les écrats de genre dans les sciences, technologies, et innovation au niveau des pays. Par conséquent, nous avons mené une évaluation sexospécifique pour cartographier l’état de la science, de la technologie et de l’innovation sur lequel le développement des capacités dans les
étalissement de l'enseignement supérieur sera fondé. Des données primaires et secondaires ont été collectées et analysées qualitativement et quantitativement. Plus précisément, l'étude a examiné les indicateurs suivants de l'état de la science, de la technologie et de l'innovation: capital humain, prise de décision et recherche et développement, tout en analysant l'environnement politique. Tous les indicateurs évalués ont montré un important déséquilibre de genre en faveur des hommes. Au sein des institutions de recherche et de formation agricoles, les femmes sont largement sous-représentées (15%). Parmi les femmes chercheuses, seulement 8% étaient actives en 2018 contre 92% pour les hommes. Dix-huit pour cent du personnel impliqué dans la prise de décision étaient des femmes contre 82% pour les hommes. Parmi les chercheurs actifs, très peu (6%) ont accédé aux informations sur les sciences technologies et innovations, quel que soit leur genre, indiquant qu’il s’agit là d’un problème général qui doit être abordé à tous les niveaux. Pour corriger les écarts de genre dans les sciences, technologies, et innovations, un programme de renforcement des capacités basé sur une politique nationale d’intégration systématique de la dimension genre avec des mesures incitatives pour les filles dans l’éducation, du niveau préscolaire à l’enseignement supérieur, en passant par l’enseignement primaire, secondaire et tertiaire, devrait être envisagé. Ce programme d’intégration de la dimension genre doit être élaboré, mis en œuvre et accompagné d’un programme de suivi et d’évaluation solide et rigoureux, pour contribuer à éclairer régulièrement les politiques. Ces programmes d’intégration de la dimension genre devraient fournir des incitations aux filles qui promeuvent l’excellence à court, moyen et long terme.

Mots-clés: femmes, science, technologie et innovation, déséquilibre entre les sexes, formation et recherche agricoles

INTRODUCTION

Science, Technology and Innovation [STI] ecosystems comprise public institutions, academia, and the private sector at the local, national and regional levels, all functioning within a well coordinated policy environment and well integrated within the global context [Madar et al., 2018]. Globally, it has been recognised that Science, Technology and Innovation [STI] is a key driver of the economic and social development [United Nations 2010, 2017]. The majority of the 17 SDGs of the United Nations require technology and innovation for their implementation and achievement [Soumitra et al., 2018]. Countries that have invested in STI have benefited considerably in terms of economic growth, environmental advantages, and improved livelihoods. In the 2018 Global Innovation Index [GII], high income economies such as Switzerland and Sweden that ranked highest for their innovation input sub index also ranked highest in terms of innovation outputs and efficiency ratio [Soumitra et al., 2018]. The Kingdom of the Netherlands did better, ranking 9th for the innovation input sub index but second in terms of outputs, with high efficiency ratio. The same situation applies to upper middle income economies such as China, Malaysia, and Bulgaria, to lower middle income economies such as Ukraine, Vietnam, and Moldova and also to low income economies such as Tanzania, Senegal, and Mozambique [Soumitra et al., 2018].

Among the five pillars of innovation input sub-index (Institutions, Human capital and research, infrastructure, Market sophistication, and Business sophistication) that are used to assess the Global Innovation Index [GII],
human capital and research play an important role. Thus, availability of qualified human capital in sufficient quantity is necessary for the development and exploitation of STI. The Human Capital Index is a measurement that the World Bank uses to assess which countries are best in mobilizing the economic and professional potential of their citizens.

A linear positive and statistically significant relationship has already been reported between country population size and the GII, at least for high income economies [Soumitra et al., 2018]. Although this has not yet been confirmed for low economy countries like Mali, it is worthwhile comparing Mali’s human capital index with that of countries that are doing well in terms of GII. Such comparisons revealed that high income economies like Switzerland, Sweden, and Netherlands ranked 3rd, 6th, and 8th, respectively in terms of human capital index, compared to Mali which ranked 118th [World Economic Forum, 2015]. The same trend was observed when Mali is compared with other low income countries [Tanzania, Senegal and Rwanda]. Comparison of Mali with the above countries in terms of GII ranking and human capital index gave the same picture in 2018.

To exploit its population potential estimated at 18.3 million inhabitants among which 50.64% are women [INSTAT, 2018 and 2014] for the benefit of STI, Mali like other African countries must invest in and leverage its human resources. During this process, countries must ensure that women who represent the majority of the population are involved.

Mali has been participating in the African Science, Technology and Innovation Initiative [ASTII] since 2007. The last assessment of its STI status conducted in 2017 was mainly focused on documenting indicators such as human capital, financial resources and the innovations offered by STI stakeholders [INSTAT, 2017]. The study highlighted the weak representation of women in the STI human capital, being only 23%, indicating a two-fold increase compared to 2015. However, the study did not include gendered data for other indicators such as access to information and decision making. Nonetheless, gender is a global issue cutting across most of the 17 SDGs of the United Nations. The United Nations Conference on Trade and Development (2011) reported that the needs, concerns, and interests of men and women should be addressed in all policies related to science, technology and innovation. Therefore, applying a gender lens to STI studies is necessary to gather gender disaggregated information relevant to policy makers for the design of policies and programs that support the equitable development of men and women.

The overall objective of the study was to conduct a gender-based assessment of STI ecosystem in Mali to scientifically document the status of STI upon which capacity development at higher education institutions will be premised. Specifically, the study looked at the following indicators of the status of science, technology and innovation: Human capital, Decision making, and Research and development, while analysing the policy environment.

**MATERIALS AND METHODS**

**Population and sample selection.** Components of the STI ecosystem that were targeted included research and training institutions from both public and private sectors and private sector industries. Within the targeted STI ecosystem components, cases studies of agricultural higher education and research institutions were conducted. The National Center of Scientific and Technological Research [CNRST] which is the national coordinating body of STI in Mali, has listed 49 STI institutions among which seven (14.3%) are in agriculture and food security/safety. Out of the seven public sector institutions involved in agricultural research and/or training, three were interviewed [42.85%]. From the private sector side, and in the absence of information on the
base population, two institutions were selected for the case study.

**Data collection and analysis.** This survey used both primary and secondary data. For primary data collection, a standard questionnaire was used. The questionnaire was sent to stakeholders for filling and relayed back electronically. Three groups of indicators were measured using gender lens, these included: human capital (quantity, quality, and staff promotion), decision making, and research and development (active researchers, access to STI information). Data were descriptively analysed in Microsoft excel.

**RESULTS**

**Status of women in Mali.** In Mali, women are traditionally assigned reproductive, social, and productive roles. In their reproductive roles they are known as spouses and mothers. As such, they are in charge of all domestic tasks. In the society, they are responsible for ensuring that the traditions in the family and in the community are perpetuated generation after generation. To have a good image, women must fully accomplish the reproductive and social roles. In addition they must accomplish productive roles to contribute to the economic development of the family, the community and the country. Malian women must accomplish these roles no matter whether they are living in rural or urban settings, or have received or not received formal education (Association pour le progrès et la Défense des Droits des Femmes, 2000).

Women account for more than 50% of the Malian population. Among all government employees, only 25.6% were women (Association pour le progrès et la Défense des Droits des Femmes, 2000). Malian women are 50.4 percent of the poorest of the poor (Observatoire du Développement Humain Durable et de la Lutte contre la Pauvreté, 2006). A good 91.3% of rural women are involved in agriculture and livestock, as primary source of income and livelihoods [CPS, 2006]. They are especially found in the lowland rice (*Oryza* sp), cowpea (*Vigna unguiculata* L.), groundnut (*Arachis hypogaea*), fonio (*Digitaria exilis*), sesame (*Sesamum indicum*) and vegetable value chains and active in the production, processing and value-adding segments, and trading. However, only 3% of farm managers in Mali are women [CPS, 2006]. Women in Mali face restricted agricultural land access, with only 15 percent of the State improved lands allocated to them, as per the Law adopted by the National Assembly on April 11, 2017. When they are legally employed, Malian women are largely found in the areas of social services and human resources management (Association pour le progrès et la Défense des Droits des Femmes, 2000).

In 2015, only 49.8% of the girls were enrolled at the level of secondary education [INSTAT, 2018]. They are also found in higher education, though in lower quantity [Table 1]. Although the involvement of women in decision-making is vital for achieving tangible results for economic growth, in 2016, only, 9.5% of the parliamentarians were women [INSTAT, 2018]. According to the Institute of National Statistics, women were 23% of STI human capital in Mali in 2017. This figure corresponded to a two-fold increase compared to 2015 figure. From the present study, there are about 100 women involved in teaching and research in the STI arena in Mali. They network through Women Teachers and Researchers of Mali –REFUEMA where they communicate, share information and establish partnership with each other.

**Policy environment.** Respect of human’s rights in general and equality between men and women in particular, is a fundamental value in the country’s constitution adopted in February 25, 1992. This constitution in its article 2 prohibits all discriminations based on gender [Table 2]. A gender policy was developed, aligned with the constitutional values and
adopted in 2011. The gender policy envisions a democratic society which guarantees the development of all women and men through the full exercise of their fundamental equal rights, active and participative citizenship and equitable access to resources.

The country also adopted an Institutional Development Policy [Table 2] which emphasizes State reforms that promote investments in specific niches required for advancing gender mainstreaming as a principle of governance. The Ministry of Promotion of Woman, Child and Family is a member of the State Reform Monitoring Committee, which is chaired by the Prime Minister. A ministry for the promotion of Women, Children and Family has also been created and is controlled by women. Most sectoral and sub sectoral development policies and programs have a gender component to ensure equal representation of men and women at all levels [Table 2]. The country is signatory to many regional and international conventions that promote gender equalities at all levels [Table 2].

Mali’s policy on higher education and scientific research was adopted in 2009. This policy aims among other objectives at reducing inequalities between people and regions and promoting men and women. The country has also an STI policy adopted in 2016. This STI policy in its axis 4, intends to build and nurture an STI culture that would encourage girls and women to embrace Science Technology Engineering and Mathematics (STEM). The policy also envisioned, among others, to increase staff quantity, quality and their working conditions. However, this policy has not been particularly clear about the gender dimension of staff quality and quantity, especially how to increase the involvement of women scientists.

### Human capital involved in STI eco-system in Mali: Case of agriculture and related fields

#### Staff quantity.

The number of staff involved in STI in the field of agriculture in 2018 was 922, out of whom only 15% were women [Table 3]. The majority of agricultural sector STI human capital comes from the public sector (94.68%). However, this figure should be taken with caution, due to the fact that only two private sector institutions were involved in the study. These two institutions used as case studies had 49 staff with 36.73% being women. The two training and research institutions accounted for 194 staff out of 922 [21.04%] whereby the leading agricultural research institution – IER accounted for 679 staff [73.64].

#### Staff quality.

Large inequalities were recorded between men and women for all staff categories. Out of the 302 master degree holders, only 10% were women. When we consider the institutions individually, the number of master holders gave similar patterns. For some institutions, women

<table>
<thead>
<tr>
<th>Name of institution</th>
<th>Number of students in 2018</th>
<th>Percentage of students in 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>University of Ségou, Faculty of Social Sciences</td>
<td>649</td>
<td>1449</td>
</tr>
<tr>
<td>Polytechnic Rural Institute for Training and Applied Research</td>
<td>608</td>
<td>2298</td>
</tr>
<tr>
<td>Total</td>
<td>1257</td>
<td>3747</td>
</tr>
</tbody>
</table>

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Table 1. Gendered status of students in Higher Educational Institutions in Mali in 2018 – Case study of IPR/IFRA and the Faculty of Social sciences of the University of Ségou –US/FASSO
Table 2. National and Sectoral Policy instruments on gender and STI in Mali

<table>
<thead>
<tr>
<th>Sector / Subsector</th>
<th>Policy and year effective</th>
<th>Gender provisions</th>
<th>Year(s) revised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance</td>
<td>Constitution of the Republic of Mali (February 25, 1992) Institutional Development Policy (IDP, 2003)</td>
<td><strong>Article 2:</strong> Prohibition of all discriminations based on gender</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>IDP emphasizes State reforms that promote investments in specific niches required for advancing gender mainstreaming as a principle of governance. The Ministry of Promotion of Woman, Child and Family is a member of the State Reform Monitoring Committee, which is chaired by the Prime Minister.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>National Gender Policy (2011)</td>
<td><strong>Vision:</strong> A democratic society which guarantees the development of all women and men through the full exercise of their fundamental equal rights, active and participative citizenship and equitable access to resources.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECOWAS Gender Policy</td>
<td>This policy commits all ECOWAS member States, including Mali, to: - Create an environment conducive to gender equality and equity with a view to achieving sustainable development - Strengthen the participation and role of women as leaders in policy, governance and decision-making - Promote equitable access to quality education and address the social and cultural concerns of women - Reorient public resources to address issues of gender equality and equity, thereby promoting the formation of significant human capital and strong economic growth.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>International convention for the elimination of all forms of discriminations of women endorsed by Mali in September 1985</td>
<td><strong>Article 3:</strong> &quot;In all fields, including political, social, economic and cultural, take all appropriate measures, including legislative provisions, to ensure the</td>
<td>Additional protocol ratified by Mali in September 2000</td>
</tr>
</tbody>
</table>

68
full development and advancement of women, with a view to guaranteeing the exercise and enjoyment of the human rights and fundamental freedoms on the basis of equality with men”

Member States integrate the dimension of equals between women and men as a principle of law and good governance while focusing their efforts on 12 priority areas for action among which education and training, and decision making


A section of the SFGPR describes issues related to inequalities between women and men in the various sectors while highlighting the socio-cultural factors that perpetuate these inequalities.

MDG-3 addresses the promotion of gender equality and the empowerment of women in two points: (i) Eliminate gender disparities in primary and secondary education, preferably by 2005 and at all levels of education no later than by 2015; (ii) Reduce gender disparities in economic and
political life. The expected progress towards the MDGs requires Member States to consider the elimination of gender disparities and inequalities in development policies and programs.

**Article 6:**
AOL takes into account the sub-regional and international commitments made by Mali and these includes all the commitments related to the abolishment of all gender inequalities.

**Article 45:**
The Government promotes equity between women and men in rural areas, in particular in farming.

**Section 4.2.4**
Puts emphasis on capacity building of women and youth.

**Section on Objectives, the preamble:**
- Reducing inequalities between people and regions
- Promotion of men and women

**Section on Specific objectives:**
- Training of young people, girls, and women, in order to better ensure the equity of training and education in science is high in the agenda of the national STI policy.
- This is expected to occur at all levels of education from the primary, secondary and university levels, as well as in technical schools and institutions, and continuing education.

**Axis 4: Promotion of a culture of STI**
- Create incentives for girls to embrace Science Technology Engineering and Mathematics (STEM)
MSc holders are 30 times fewer than men [Table 4]. The PhD holders totalled 102 staff, 12% of whom were women. The number of PhD holders was almost similar for IPR/IFRA and IER, 59 and 56, respectively. Importantly, a similar trend in women representation in these two institutions where women were 29.5 and 7 times less than men was observed [Table 4].

When we considered the technical staff involved in STI, the number of women in the case studies was only 21 out of 185 [11%]. The case of IER [3.85% of women technicians] is of a greater concern, because this is the leading agricultural research institution in the country. Regarding the STI support staff at the institutions in the case studies, the situation is better with 35.54% women [Table 5].

Staff promotion per gender. Staff promotion events were hardly found in the case studies during the period concerned [2018]. The only promotion events occurred at IER which promoted 46 staff in 2018. We find these figures again below the requisite numbers for achieving gender equality, women representing only 15% [Table 6].

Staff promotion events were hardly found in the case studies during the period concerned [2018]. The only promotion events occurred at IER which promoted 46 staff in 2018. We find these figures again below the requisite numbers for achieving gender equality, women representing only 15% [Table 6]. Involvement of women at leadership positions is paramount in achieving gender equality and problem solving in a society. Nonetheless, the case studies of Mali indicated that STI and higher education institutions are far from achieving gender equality for decision making since only 22% of women were involved in decision making at their institutions [Table 7].

Research and development

Number of active researcher in 2018. Our investigations revealed that only 22 women [7.75%] were active researchers in 2018 out of a total of 284 [Table 8]. The majority of the active researchers came from IER (88%) followed by IPR/IFRA (7%) and Point Sud Centre for Local Knowledge (5%) (data not shown). When it comes to gender, IPR/IFRA did better with 40% of its active researchers being women (data not shown).

Access to STI information in 2018. Access to STI information such as financing opportunities, conferences and symposia, scientific publications, publishing partners, information on IPR issues, partnership opportunities or new technologies for all researchers [both men and women] is paramount for them to be productive and make meaningful contributions to STI. Like other indicators, parity between men and women is a must. Unfortunately, our investigations showed that out of the 22 women researchers who were active in 2018, only four [18%] accessed STI information [data not shown]. Comparison of women and men for parity check yielded a large gender gap, men being 78% and women 22% among active researchers.

Table 3. Staff quantity per institution and per gender in 2018 in Mali

<table>
<thead>
<tr>
<th>Name of institution</th>
<th>Total staff</th>
<th></th>
<th>Percentage of total staff</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women</td>
<td>Men</td>
<td>Total</td>
</tr>
<tr>
<td>University of Ségou, Faculty of Social Sciences</td>
<td>3</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>Institute of Rural Economy</td>
<td>80</td>
<td>599</td>
<td>679</td>
</tr>
<tr>
<td>Polytechnic Rural Institute for Training and Applied Research</td>
<td>37</td>
<td>136</td>
<td>173</td>
</tr>
<tr>
<td>Point Sud Centre for Local Knowledge</td>
<td>2</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>PROSLABS - Microbio Consulting</td>
<td>16</td>
<td>16</td>
<td>32</td>
</tr>
<tr>
<td>Total</td>
<td>138</td>
<td>784</td>
<td>922</td>
</tr>
</tbody>
</table>
who accessed STI information in 2018 [Table 9]. From the side of the men researchers who were active in 2018, only 14 accessed STI information, which corresponded to only 5% [data not shown]. This weak performance of men in access to STI information shows that this is a serious gap that is not gender specific and that must be addressed properly, for all genders.

DISCUSSION
Meaningful exploitation of science, technology and innovation requires among others, the availability of a critical mass of human capital skilled in Science, Technology, Engineering and Mathematics [STEM]. Similarly Murphy et al. (1991) who reported that countries with higher proportion of human capital skilled in the area of STEM tend to grow faster compared to countries with higher proportion of human capital skilled in other disciplines. This is also consistent with the UNESCO Institute for Statistics (2015) which showed that the number of researchers per capita was 117 times greater for Switzerland (a high income country) compared to Mali. The same applies to BRICS countries such as China and Brazil, where the per capita researcher head counts were 23 and 18 times greater than for Mali, respectively.

In this survey, 922 staff were involved in the design and implementation of STI policies, programs and projects. Compared to the 18.343 million inhabitants in Mali, this corresponded to 51 STI staff per million

Table 4. Number of STI staff per degree of training and gender in Mali in 2018 –Master and PhD

<table>
<thead>
<tr>
<th>Name of institution</th>
<th>MSc Holders-[Number]</th>
<th>MSc Holders [%]</th>
<th>PhD holders [Number]</th>
<th>PhD holders [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women</td>
<td>Men</td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>University of Ségou, Faculty of Social Sciences</td>
<td>0</td>
<td>13</td>
<td>0</td>
<td>4.30</td>
</tr>
<tr>
<td>Institute of Rural Economy</td>
<td>6</td>
<td>180</td>
<td>1.99</td>
<td>59.60</td>
</tr>
<tr>
<td>Polytechnic Rural Institute for Training and Applied Research</td>
<td>16</td>
<td>64</td>
<td>5.30</td>
<td>21.19</td>
</tr>
<tr>
<td>Point Sud Centre for Local Knowledge</td>
<td>1</td>
<td>6</td>
<td>0.33</td>
<td>1.99</td>
</tr>
<tr>
<td>PROSLABS - Microbio Consulting</td>
<td>6</td>
<td>10</td>
<td>1.99</td>
<td>3.31</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>273</td>
<td>9.60</td>
<td>90.40</td>
</tr>
</tbody>
</table>
Table 5. Number of STI staff per degree of training and gender in Mali in 2018 – Technicians and Support staff

<table>
<thead>
<tr>
<th>Name of institution</th>
<th>Technicians [Number]</th>
<th>Technicians [%]</th>
<th>Support staff [Number]</th>
<th>Support staff [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women</td>
<td>Men</td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>University of Ségou, Faculty of Social Sciences</td>
<td>1</td>
<td>1</td>
<td>0.54</td>
<td>0.54</td>
</tr>
<tr>
<td>Institute of Rural Economy</td>
<td>6</td>
<td>156</td>
<td>3.24</td>
<td>84.32</td>
</tr>
<tr>
<td>Polytechnic Rural Institute for Training and Applied Research</td>
<td>9</td>
<td>3</td>
<td>4.86</td>
<td>1.62</td>
</tr>
<tr>
<td>Point Sud Centre for Local Knowledge</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>PROSLABS - Microbio Consulting</td>
<td>5</td>
<td>4</td>
<td>2.70</td>
<td>2.16</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>164</td>
<td>11.35</td>
<td>88.65</td>
</tr>
</tbody>
</table>

inhabitants. This figure is slightly lower than the 64 researchers per million inhabitants reported by UNESCO (2015). When we looked at the staff actually involved in research (MSc, PhD and Technicians), this figure dropped to 34.78 staff per million inhabitants. But Mali’s population is composed of approximately 50% women. Applying a gender lens at key components of STI ecosystem in Mali showed that gender imbalance is present in all the indicators we assessed namely (i) staff quantity, (ii) staff quality [PhD, MSc, technicians, and support staff], (iii) staff promotion and access to leadership positions, (iv) staff involvement in decision making, (v) number of active researchers, and (vi) access of researchers to STI information. For all of these indicators, the survey revealed large under representation of women as compared to men.

Staff quantity has been found largely unbalanced in favour of men (85%) in our cases studies. This figure, though in agreement with respect to the pattern in gender imbalance, is slightly higher than the 77% reported by the national Institute of Statistics in 2017. It should be emphasised that the survey of INSTAT in 2017 had a much broader coverage (156 private enterprises plus all the research institutions of the country) compared to ours which was limited only to five case studies of agricultural STI institutions. Thus our survey has established that agricultural
Gendered assessment of Science, Technology and Innovation ecosystem: Case study of Agricultural Research and Training Institutions in Mali

training and research institutions have higher level of women under-representation in STI than the average of all STI fields combined across Mali. It looks like that while women farmers dominate in agricultural value-chains, women scientists fall into the minority groups at the level of agricultural training and research institutions in Mali. Many efforts are needed to correct this gender gap if the country is to meaningfully exploit the potential of women human capital to boost its economic growth and sustainable development. Leaving behind unexploited such potential is a big loss for Mali which the country cannot afford. The same situation has been observed among students enrolled in higher education institutions in 2018, with only 25% of the enrolled students being female [Table 1]. This result indicates that the gender imbalance in STI staff quantity is likely to remain for the coming or more years if nothing is done to increase the enrolment of girls in higher education institutions in the field of agriculture.

Staff quality is also important. In this survey only 10% and 11% of the staff involved in STI were women MSc and PhD holders, respectively [Table 5]. Likewise, only 11% and 26% of the staff were women technicians and support staff, respectively. Thus increasing the number of women and girls in higher education institutions is needed to fill the gap. However, this should be done under a countrywide policy of mainstreaming gender in education, starting from the level of preschool, to primary, secondary, tertiary and high school, to higher education. Such gender mainstreaming program should be developed, implemented and should provide incentives for girls and women that promote excellence at short, medium and long terms. They must be accompanied by a strong rigorous monitoring and evaluation program, to help inform policies on a regular basis.

Regarding staff promotion to access leadership position and involvement in decision making, the survey revealed that such an event hardly happens at the institutions in the case studies. Only IER had promoted its staff in 2018, and among the promoted staff, 15% were women [Table 4]. This result is not surprising, given the low representation of women at IER. Indeed, the number of promotion depends on the number of staff available. Once again a countrywide gender mainstreaming program is necessary to fill this gender gap.

Availability of research staff at an institution cannot guarantee alone the development of STI in terms of research outputs, outcomes, and impacts. The researchers must be active, and to be active they must access STI information such as financing opportunities, conferences and symposia, scientific publications, publishing partners, information on IPR issues, partnership opportunities or new technologies in their respective fields. When we looked at the number of researchers who were active in 2018 [Tables 8 and 9], the gender gap was imbalanced in favour of men (82%). The same trend was observed for the indicator “access to STI information”. Among the researchers who were active in 2018, only 18% and 5% accessed STI for women and men, respectively [data not shown]. The poor performance of men and women in accessing STI information on one hand, and the weaker performance of men compared to women in the access to STI information shows that this is a serious gap in the Malian context of STI that is not gender specific and that must be addressed properly, for all genders. Large efforts need to be made here to facilitate access of all researchers to STI information. Although access to STI information in Mali is not well documented, the need for its improvement is well known to Malian authorities since this is the focus of the national STI policy, strategic axis #7 and action #4.

CONCLUSION
Agriculture is the driving force for Mali’s economic development and growth. It is for this reason that the authorities have allocated 15% of the country’s budget to this sector.
Table 6. Status of STI staff promotion per gender in 2018 in Mali

| Name of institution                                                                 | Number of STI staff promoted | Percentage of STI staff promoted[
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>University of Ségou, Faculty of Social Sciences</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Institute of Rural Economy</td>
<td>7</td>
<td>36</td>
</tr>
<tr>
<td>Polytechnic Rural Institute for Training and Applied Research</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Point Sud Centre for Local Knowledge</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>PROSLABS - Microbio Consulting</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>39</td>
</tr>
</tbody>
</table>

Table 7. Number of staff in decision making per institution and per gender in 2018 in Mali

<table>
<thead>
<tr>
<th>Name of institution</th>
<th>Number of STI staff at a decision making position</th>
<th>Percentage of STI staff at a decision making position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>University of Ségou, Faculty of Social Sciences</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Institute of Rural Economy</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Polytechnic Rural Institute for Training and Applied Research</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Point Sud Centre for Local Knowledge</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>PROSLABS - Microbio Consulting</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>23</td>
</tr>
</tbody>
</table>
This survey has established the benchmarks for critical indicators linked to the design and implementation of STI policies, programs and projects for sustainable agricultural development. All indicators were benchmarked while applying gender lenses and agricultural training and research institutions were found to harbour in-depth gender imbalance in favour of men as compared to agricultural value-chains which generally involve more women farmers than men producers. To address the gender imbalance found in all the indicators we studied, it is recommended to develop and implement a countrywide program to mainstream gender in agricultural training and employment institutions.
ACKNOWLEDGMENTS
This research was funded by the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) through the TAGDev program. We thank the Forum for African Women Vice-Chancellors for the opportunity to share our findings in their meeting organised at the sideline of the RUFORUM Annual Meeting, 2-6 December 2019 in Cape Coast, Ghana.

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

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A gender-based assessment of Science, Technology and Innovation ecosystem in Mozambique

N. GIVÁ and L. SANTOS
Faculty of Agronomy and Forestry Engineering, Eduardo Mondlane University, Av. Julius Nyerere, Campus Universitário 3453, P.O.Box 257, Maputo, Mozambique
Corresponding Author: 3ngiva@gmail.com

ABSTRACT
Participation of women in Science, Technology and Innovation (STI) remains low, despite several initiatives globally. The African Agenda 2063 recognizes Women, Science and Technology as key tenets of the Sustainable Development Goals. This study provides a status of Mozambique’s gender based STI ecosystem to enable targeting the gaps for mainstreaming gender within higher education, enhancing the performance of higher education institutions in training the next generation of workforce. Methodology approach consisted of review of gender National policy documents and gender oriented STI initiatives, analyses of existing database to capture trends on women’s participation in STI education and research; and interviews with key informants from relevant government institutions, selected higher education and research institutions. Findings indicate an increasing trend of women participation over the years with greater preference for Arts and Humanities than Science and Technology. The gender-based STI ecosystem is weak in Mozambique, and policies and strategies are yet to be operationalized with appropriate implementation instruments. Funding opportunities are sparse, mainly secured by the public sector and international organizations. There is limited collaboration between knowledge based institutions and industry. We recommend that beyond promoting initiatives to increase women participation and access to STI, there is a need to revise the current setup of the national education system to allow students’ make better-informed decision in the selection of Higher education stream. An integrated and harmonized policy and implementation plan among responsible government sectors is needed to stimulate diversified funding through seeking solutions and technologies that are both society and market driven.

Keywords: Gender, higher education, Mozambique, Science, Technology and Innovation

RÉSUMÉ
La participation des femmes aux sciences, à la technologie et à l’innovation (STI) reste faible, malgré plusieurs initiatives à l’échelle mondiale. L’Agenda africain 2063 reconnaît les femmes, la science et la technologie comme les principes clés des objectifs de développement durable. Cette étude fournit un état de l’écosystème STI du Mozambique basé sur le genre pour permettre de cibler les lacunes pour l’intégration du genre dans l’enseignement supérieur, améliorant la performance des établissements d’enseignement supérieur dans la formation de la prochaine génération de la main-d’œuvre. L’approche méthodologique a consisté en un examen des documents de politique nationale sur le genre et des initiatives STI axées sur le genre, des analyses de la base de données existante pour saisir les tendances de la participation des femmes à l’éducation et à la recherche sur les STI; et des entretiens avec des informateurs clés d’institutions gouvernementales compétentes, de certains établissements d’enseignement supérieur et de recherche. Les résultats indiquent une tendance à la hausse de la participation...
des femmes au fil des ans avec une plus grande préférence pour les arts et les sciences humaines que pour les sciences et la technologie. L’écosystème sexo-spécifique de la STI est faible au Mozambique et les politiques et stratégies doivent encore être opérationnalisées avec des instruments de mise en œuvre appropriés. Les possibilités de financement sont rares, principalement garanties par le secteur public et les organisations internationales. La collaboration entre les institutions fondues sur la connaissance et l’industrie est limitée. Nous recommandons qu’au-delà de la promotion des initiatives visant à accroître la participation des femmes et l’accès aux STI, il soit nécessaire de réviser la configuration actuelle du système éducatif national pour permettre aux étudiants de prendre des décisions plus éclairées dans la sélection des filières d’enseignement supérieur. Une politique et un plan de mise en œuvre intégrés et harmonisés entre les secteurs gouvernementaux responsables sont nécessaires pour stimuler un financement diversifié par la recherche de solutions et de technologies à la fois axées sur la société et le marché.

Mots-clés: Genre, enseignement supérieur, Mozambique, Science, technologie et innovation

RESEARCH APPROACH

Science, Technology and Innovation (STI) has been highlighted as an important driving force for countries’ socio-economic development (Osagie and Alutu, 2016; Zavale, 2017). Initiatives promoting gender equality, Science Technology and Innovation policies targeting both men and women are recognized as fundamental to reducing poverty and ensuring equitable development (Nakayiwa et al., 2016; African Agenda 2063). However, participation of women in STI has remained low worldwide regardless of the several initiatives geared towards supporting greater engagement of women especially in research for development (UN – Interagency Task Team, 2019). Studies report an increasing access of women in academy overtime but there is still greater imbalance of male and female academics in higher rank levels (Bagilhole, 2000; Subbaye and Vithal, 2017). For instance, among UK higher education institutions, women constitute 44.5% of all academic staff (ECU, 2014), however, only 12 % of professors in science subjects are females (Howe-Walsh and Turnbull, 2016). In Europe percentage of women with professorial roles was about 20% in 2013 (Subbaye and Vithal, 2017) while in Australia and USA this figure reaches 25% (Morley, 2014). This is equally true in sub-Saharan Africa (SSA) where statistics indicate a progressive gender parity of women academic staff in higher education institutions but at a slow rate (Home-Walsh and Turnbull, 2016; Subbaye and Vithal, 2017). However, percentage of women with professorial roles remain low, particularly in key areas of STI, where figures indicates 8 % in Nigeria, in Tanzania 12 % and 15% in Uganda (Morley, 2005; Subbaye and Vithal, 2017).

Mozambique had 7030 researchers in 2016, from which only 28.9% were female. PhD trained researchers account for 14.8% of total researchers in the country of which 11.3% are male (11.3%) and only 3.5% female. There is a continuous increment of percentage of women in academia over the years; however, the gap between men and women is significant despite several policies on gender equity in higher education (António and Hunguana, 2013). Therefore, academic leaders such as The Forum for Women Vice Chancellors in Africa (FAWoVC) are devoting efforts to develop initiatives to increase participation of women in Science, Technology and Innovation in Africa. Founded in 2017, FAWoVC is an umbrella group of female university leaders in Africa created to spearhead gender responsive training in higher education institutions and
to increase the enrolment of female students in STEM, as well as galvanize women to take up leadership positions. Accordingly, FAWoVC recognizes that mainstreaming gender within higher education is of paramount importance for enhancing the performance of higher education institutions in their countries’ development through enabling them to fulfil their mandates to train the next generation of talents to drive the continent forward.

This study provides the status of gender-based STI ecosystem in Mozambique to act as the benchmark against which the impact of future gender-based STI interventions can be assessed. It expands the scope of analysis of gender parity from students’ enrolment rates to academic staff in HEIs. Specifically the study assesses the current STI ecosystem in the country, mapping key actors and their roles, interactions, policies, and partnerships. It also identifies the gender-based capacity gaps, challenges, opportunities and future prospects that are the basis to recommend strategies to increase participation of women in STI in Mozambique.

METHODOLOGY

Study methodology included review of existing gender policies and strategies and respective results and impacts in the Education, Science and Technology related sectors, of reports on gender and higher education and of STI initiatives in the country (Table 1). Analyses of existing databases in the relevant government sectors and in the HEIs were carried on to assess female participation in HEIs in STI related areas and in research. Interviews1 were conducted using different formats, face to face, skype, emails and phone call interviews. In total 11 key informants from relevant ministries, higher education institutions (HEIs) and other relevant stakeholders were interviewed (Table 1). Five HEIs geographically distributed in the country were part of this study, three public universities (Eduardo Mondlane University (UEM) in the South, Lúrio University (UniLúrio) in the North, and a higher Polytechnic Institute of Manica (ISPM) in the Center) and two private universities (A Politécnica and Higher Education Institution Dom Bosco (ISDB) both located in Maputo -South).

For the data collection and analysis of women participation in Higher Education and STI initiatives over a 10 years’ period were taken into account, however, where data were unavailable, a five year period was considered. The analysis aimed at characterizing trends of women participation in Higher Education in general and in STI related areas in particular, as well as the main actors promoting gender equity in Higher Education and initiatives to attract more women for STI related areas. Five HEIs were selected to capture institution’s leaders’ perception about how their institution is performing regarding gender equity, the initiatives undertaken to promote gender equality and STI appreciation by female students and academic staff, the kind of collaboration and partnership built and what they consider as best practices, opportunities and challenges.

Findings and Discussion

Science, Technology and Innovation ecosystem in Mozambique: Policy overview and gender perspective. Mozambique 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; Millennium Development Goals for Sustainable Development; the Sustainable Development Goals (SDGs) and the SADC Protocol on Gender and Development. The national gender policy and strategies’ framework for Human and Social Development, Higher Education (HE), Science, Technologies and Innovation (STI) Systems are informed and take into consideration these treaties.

1 with key informants from Ministry of Education and Human Development (MINEDH), from Ministry of Science, Technology and Higher and Vocational Education (MCTESTP), National Research Institutions, National Funds for Research (FNI) and five selected HEIs across the country
The Science and Technology sector was distinguished as important by the Government in the year 2000 when a new Ministry of Higher Education, Science and Technology was created. The aim of this new government unit at that time was (1) development of a skilled workforce, (2) expansion and equity of access to quality higher education, (3) development of technologies and (4) identification of Mozambican’s resources and products that could serve as development factors. Since then and during the last 20 years, this Ministry went through two reorganization processes. From 2005 to 2015 it changed its focus and was renamed Ministry of Science and Technology (MCT). The Ministry coordinated the implementation of the S&T strategy and had functions related to regulation, coordination, development, monitoring and evaluation of science and technology in the country. During this period, higher education sector was under the responsibility of the Ministry of Education. In 2015, the Ministry was reconfigured again by re-integrating the higher education and expanding it to include technical and vocational education, and as such, being renamed as the Ministry of Science, Technology, Higher and Technical-Professional Education (MCTESTP). Arguments in favor of the last reorganization include the need to deliver scientific and technological solutions for the main strategic development priorities of the Government’s Five-Year Program, the Action Plan for Poverty Reduction (PARPA), Agenda
2025, and other national development strategies and plans. The five-year government plan [2015-2019] emphasizes the need to develop human and social capital through promotion of an inclusive education system with actions and policies that promote gender equity. Along with 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. While the strategies for science technology and innovation and higher education are articulated within the MCTESTP the implementation of gender strategy for education and human development sector is coordinated by the Ministry of Education and Human Development. Current Gender Strategy for the education sector [2016-2020] broadens the concept of “education” by recognizing primary, secondary, vocational and higher levels. It also recognizes the specificities of the higher education subsystem, although does not include specific actions that respond directly to the dynamics of students, academic staff, managers and leaders in HEIs (H. Monteiro, personal comm. November 2019). A strategy for gender equity in higher education [2018-2023] has been drafted and is in process of approval. It is recognized that there is a need for greater articulation between the two ministries (MCTESTP and MINEDH) as the challenges of gender equity and women participation in science, technology, engineering and mathematics (STEM) start during primary and secondary education. Studies in the region also sustain this view, for instance, Osagie and Alulu (2016) contend that gender equity in science and technology should be nurtured in secondary levels’ students by designing training programs that stimulate confidence and assertive skills.

Women access and participation in HE and STI in Mozambique. In Mozambique higher education system is characterized by a range of HEIs, which includes public and private universities and polytechnics. In 2017 there were 52 HEIs, consisting of 19 public and 33 private ones operating in the country (MCTESTP, 2017). Mozambique’s gross enrollment ratio in higher education has been increasing in recent years from 3.9% (2.96% of females) in 2009 to 7.3% (6.5% females) in 2018. The increment has been consistently higher for males than for females (Figure 1).

This increase in gross enrollment ratio is the result of the emergence of new HEIs over the last 10 years. The introduction of evening courses

![Figure 1. Gross enrollment ratio in tertiary education from 2009 to 2018](Source: UNESCO (2019))
in the major public universities (Pedagogic University and Eduardo Mondlane University) is another factor contributing to the rise in HE students. Evening courses provide opportunity for both adult male and female citizens, already employed and who have not had the opportunity before to attend HE to enroll in HE programs (António and Hunguana, 2013; Zavale et al., 2017).

Admissions in Arts and Humanities (A&H) are consistently higher than in Science and Technology (S&T) over the last years (Figure 2), and gender equality is higher in A&H (40-50%) than in S&T (27-35%). It is also evident that there was a sharper increase over the years in A&H admissions when compared to S&T.

Despite the yearly incremental trend observed in female’s admission, males continue to dominate. Percentage of female admissions in S&T has slightly increased over time as well as the number of female students admitted. However, percentage of female admissions in A&H have remained almost the same overtime despite the fact that number of females admitted increased in the same period. Similarly, number of graduates from HE (Figure 3) are higher for both males and females in A& H than in S&T programs. Although the number of graduates in S&T related programs is relatively higher for male students, the overall number of graduates is low and the discrepancies between males and female students are high (Figure 3).

The low percentage of graduates may be a result of a significant number of dropouts due to unaffordability conditions or lack of awareness by students in high school about their preferences leading to wrong choices of areas followed. As part of the Mozambican education system students must choose between two courses of studies, S&T or A&H, when they finish 10th grade (INDE, 2007). For most students this choice process is not supported by any kind of vocational assessment or information about programs offered by HEIs. Both HEIs leaders and lecturers indicated that the choice is done too early, at a time when students have no clear idea of their professional orientation, the offering of programs or possible careers ahead. When students realize that they have done a wrong choice they are already attending an HE program and the range of choices is more limited.

![Figure 2. Admission in Arts and Humanities and Science and Technology programs by sex](image)

Source: MCTESTP – National directorate for higher education (2019)
Students in 10th grade who choose the Arts and Humanities course of study cannot transfer to a S&T related program later on.

Staff in the Ministry responsible for the HE national system are conscious about the gender differences in access to HE and stereotypes in the area preferences between males and females. During the interviews, they acknowledged the need to enhance dissemination of HE programs and the importance of establishing a mechanism for more informed choice by 10th grade students prior to their decision of taking S&T or A&H courses of study. The forthcoming gender strategy for equity in higher education [2018-2023]\(^2\) takes into account this issue. Actions listed in this strategy to increase participation of women in the higher education include allocation of quotes for females, establishment of specific programs to prepare and incentivize female students for higher education and appreciation of science, technologies and related subjects. It also includes strengthening the criteria for scholarship attribution to address gender and sex discrimination. Additionally, the strategy acknowledges the need to enhance articulation and collaboration between the MINEDH and MCTESTP in promoting initiatives that tackle the secondary schools’ students professional growth particularly for 10th graders. Nevertheless, other African countries such as Nigeria undertook a more profound reform in the educations system in order to accommodate adequate teaching and handling of science and technology subjects to allow acquisition of appropriate skills capabilities, competencies and change in students’ mindset (Osagie and Alulu, 2016). Some of our interviewees also shared this view. Interviewed key actors argued that apart from increasing dissemination of information about HE programs among students at secondary schools, more importantly there is need to establish a vocational assessment mechanism to support students in selecting HE programs. Some studies (e.g. António and Hunguana, 2013) suggest that the low preferences for S&T courses is influenced by the weak level of industrialization in the country and by an employment sector that is mainly driven by service providers. Therefore, there are expectations that the current growth of gas and mining industry will bring a different dynamic and more demand for S&T programs. Another factor mentioned as inhibiting participation

\(^2\)under revision for approval by the Ministers’ Council
of women in the S&T fields is the limited existence of role models in these areas, poorly equipped laboratories and research fields, and low incentives for researchers compared to other employment sectors.

The percentage of females is slightly higher at graduation when compared at admissions, in particular for S&T. This suggests that females perform better than males. Darvas et al. (2014) and Zavale et al. (2017) also observed a positive trend in the female students’ graduation rate. Although female students often face difficulties in accessing HE, once admitted the percentage of graduation is higher than the males, in particular in S&T courses.

When looking at women participation in S&T related programs it is clear the female preferences for health and wellness, agriculture, forestry and veterinary related programs is high (Figure 4). The number of female graduates increased more over time in health and wellness and agriculture programs. However, gender equality is worse in engineering and natural sciences related courses (less than 30% of females) compared to other S&T courses (Figure 4) while in health the numbers of female and male students is more equitable (50% of females). In agricultural sciences, female participation is around 35%.

Gender strategies and women participation in Science, Technology and Innovation.

The Ministry of Science, Technology Higher and Professional Education acknowledges that women are under-represented in different sectors of science, technology and innovation. In 2016, the country had 7030 researchers of which only 28.9% were female. Researchers with PhDs levels account for 14.8% and only 3.5% were female. Despite the continuous increment over the years, the gap between men and women is significant (Figure 5). The number of male researchers is more than two times greater than female researchers at all levels. The percentage of female PhD researchers is lower than the ones with MSc and with BSc, suggesting that males are more able to advance their academic qualifications than females. This trend is equally true in other

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**Figure 4. Number of Higher Education graduates in S&T courses**

regions of the world (Subbaye and Vithal, 2017) and some studies argue for a more inclusive promotion strategy by broadening the range of activities in promotion policies and processes beyond the focus on research. For instance, a study by Vithal et al. (2013) in the University of KwaZulu Natal advanced that including teaching in the promotion criteria contributes to equitable promotion outcomes.

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, specific policy instruments that promote female participation in S&T areas are yet to be developed. This lack of operational instruments is acknowledged (H. Monteiro, personal comm. November 2019) and has been addressed in the new gender strategy for higher education [2018-2023] yet to be approved. Along the same line and reinforced by the SADC recommendation, there is ongoing work to constitute a women’s forum for science, technology, engineering and mathematic (STEM). This forum will not only act to support dissemination of work done by women in STEM areas but is also expected to increase promotion and appreciation of STEM by women for women, thus building the role model culture (H. Monteiro, personal comm. November 2019). The National Research Fund in their gender strategy (FNI, 2016) emphasizes the need to address specific obstacles to women’s professional development in research and to eliminate the negative stereotypes and prejudices that have been rooted from the earliest times to bridge the male and female research gap. The strategy also emphasizes the need for stronger incentives to attract women to STEM related research courses. However, these objectives are yet to be transformed in systematic actions and adequate monitoring mechanisms for better and sustainable results. Some initiatives mentioned during interviews with key informants, such as the scholarship program for students interested in STEM funded by World Bank and implemented in collaboration with the Ministry of Science and Technology gives priority to women, but it ends up benefiting more men than women because a limited number of women fulfil the requirement.

![Figure 5. Number of Researchers by gender and academic degree](image)

Data Source: MCTESTP, 2017
Mapping gender and Science, Technology and Innovation ecosystem in Mozambique. Government institutions are the main actors shaping the STI ecosystem in Mozambique (Figure 6) by providing the policy framework, which in turn is informed and to some extent driven by international development agencies. Higher Education Institutions (HEIs), research institutes and technical-vocational education (TVET) are primarily responsible for the foundation of knowledge but the conditions on which these institutions operate do not allow exploration of their potential due to limited financial resources.

Contrary to in developed countries where private sector has an expressive role in funding research and development, in Mozambique most of the research money comes from the public sector and international agencies. Apart from direct funding of public HE, TVET and research institutions, government established two important mechanisms that influence directly S&T and women participation in it: National Research Fund (FNI) and Scholarship Institute (IBE).

Scholarship Institute (IBE) is a key actor in ensuring gender equity in the HE, responsible for the planning, allocation, coordination and scholarship management for academic training inside the country and abroad. In awarding scholarships, IBE considers gender by offering half of the scholarships to girls. However, this measure not always results in a desired outcome because it often happens that girls do not fulfill the scholarship requirements. Additionally, there is a government recommendation that out-of-country scholarships should be for the natural sciences related courses. This constitutes an obstacle for girls as they often graduate in social sciences and humanities. Asagie and Alutu (2017) reported similar findings in other African countries and factors associated with it includes lack of self-confidence, stereotypes, discouragements and sometimes-unclear understanding of what math and science is all about.

Research National Fund (FNI) is another key actor in STI and gender ecosystem. The FNI includes a gender dimension in the criteria for selection of fundable projects. In an interview with a key informant it was explained that the gender criteria is not yet applied in a way that gives priority to women for funds allocation. The criteria looks more in terms of the extent the proposed project takes into account gender in the team composition, the project beneficiaries and the project outcomes.

Donors and international funding agencies also play a key role in STI ecosystem in Mozambique. There are several initiatives funded by donors and international funding agencies (e.g. NUFFIC, DFID, World Bank) aiming at promoting gender strategies in higher education institutions such as universities and polytechnic institutions with the major aim of increasing women participation in science and technology. Technical and Vocational Education and Training (TVET) schools receive donors’ funds with the aim to develop and implement gender equity initiatives through programs to increase opportunities for young girls to enter TVET as well as assisting vulnerable students remain in schools and better integrate in the society.

Research expenditure by scientific area reveals that funding in STI is concentrated in a few areas. Biomedical and agricultural related areas have higher expenditure compared to engineering and technology (Figure 7).

Then the question is whether the money spent in the specific scientific area reflects the importance of the scientific area through the number of researchers or influence on attracting more researcher to the scientific area. Either way it emphasizes the need for more attention to other scientific areas. On the other hand, data about
the expenditure by sector (Figure 8) highlights that HEIs and public research institutes are the ones spending more money on research with an incremental trend, while the private sector does not spend much in research. An interesting factor to explore could be the reason influencing the decreasing trend of research expenditure in the private sector and the increasing financing to the NGO sector between 2009 and 2015.

Figure 6. Gender based STI ecosystem in Mozambique
This observation is consistent with the findings of Zavale et al. (2017) that private companies in Mozambique hardly collaborate with HEIs. Among the surveyed companies, only 20% mentioned some kind of collaboration with HEIs and research institutes and these authors suggested, “companies are more incentivized by their internal needs for short-term production than long-term innovations”. The few collaborations between companies and the few HEIs is mostly through exchange of forms of embodied knowledge, exchange of skills embodied in students, graduates or academics. The same study suggested the need to strengthening the collaboration between HEIs and private sector in curricula development and
provision of teaching to enable HEIs to better respond and provide students with skills that are relevant to companies, enabling students to spend part of their HE program time both at university and in companies. The weak collaboration between HEIs and private sector reduce the visibility and contribution from HE to science, technologies and innovations.

**STI initiatives in HEI: The case studies of public and private universities and polytechnic higher institutes.** This study zoomed on five HEIs for closer analysis of STI. These HEIs included the two public universities (UEM and UniLúrio), one private University (A Politécnica), and one public and one private higher Polytechnic Institution (ISPM and ISDB). University of Eduardo Mondlane (UEM) is the oldest public and largest university in Mozambique (founded in 1969) and has therefore the highest number of admission compared to other HEIs. Regardless of the years of existence, all studied HEIs are in process of formulating their gender policies and strategies, and only two (UEM and ISPM) have gender units aimed at coordinating gender issues within the university. Eduardo Mondlane University has an internal unit: the Gender Affairs Coordination Center (CeCaGe).This unit carries out activities in research, training and provision of gender related services to the university community (students and academic staff). The Manica Higher Polytechnic Institute (ISPM) created the gender unit in 2018, since then they have been engaged in promoting gender equity and equality at all levels of the ISPM. They are working on reinforcing and strengthening political and management will, through promoting equity and combating discrimination in access, remuneration, promotion and retention of employed women and men. A Politécnica only recently (2018) started work on gender legal instruments to better regulate the intervention and promote gender initiatives in a systematic way. As a result, they created the gender coordination group that started by systematizing all gender related initiatives which will lead to the development of a gender policy. UniLúrio is in the process of creating a gender management Unit as part of their institutional action plan, which will also coordinate the formulation of gender policy [2019-2024]. ISDB strategic plan [2017-2021] includes “Gender Sensitivity and Awareness” as one of the main values of the institution with focuses on access, diversity in staff representation and the integration of gender and social inclusion aspects into the institutional curriculum and training modules.

Gender initiatives in the studied HEI include:

- Scholarships policies and programs that target women (UEM and A Politécnica). For example UEM allocates 50% of scholarships to female students. UniLúrio has a Scholarship Program [2018-2022] funded by African Development Bank (ADB) that has 82 out of 142 scholarships being female beneficiaries.
- Promoting career training for academic staff with special quotas/attention for women. UniLúrio through African Development Bank (ADB) is funding postgraduate (MSc and PhD) training for their staff. They have awarded six Masters Scholarships (five males and one female) and 13 PhD Scholarships (six female and seven male).
- Advocacy and promotion of women leadership in academia. Ensuring women participation in collegial boards (UEM, ISPM and A Politécnica) and other initiatives such as A Politecnica ‘girls move’ initiative funded by Danida where top institution managers participate as mentors to support mentees at different university units. They provide advice and professional orientation, the idea is to select mentors that are influential in the society to serve as role model.
- Development of research projects on topics such as violence against women, women’s
economic empowerment, gender-sensitive pedagogical practices, among others (UEM, ISPM, A Politécnica).

- Promotion and facilitating access to information through training and seminars to raise gender awareness on women’s economic empowerment, gender planning and budgeting as well as life skills, for all university community at leadership level (UEM, ISPM). At ISPM some of these initiatives include gender training for teachers funded by NICHE Moz 230 project; gender-based decision-making awareness lectures for ISPM staff, seminars on Gender Equality and Equity and Women’s Empowerment in the various forums involving students, teachers, community leaders and board members.

- Offering of Psychosocial Counseling Office benefiting all HEI community (UEM). The ISPM unit assists students and other academic community on issues related to sexual and reproductive health, gender-based violence, premature marriages, among others.

- Offering of vocational assessment to support students in the selection of HE program orientation. A Politécnica offers free vocational assessment and 60% of their technical vocational education’s students are female.

- Outreach gender oriented programs with local communities offering opportunities for students engagement. ISPM offers entrepreneurship-training initiatives for young mothers and teachers; development and implementation of preparatory project for higher education entrance examinations for girls and people with special needs in secondary schools; A Politécnica final year students are involved in providing legal assistance to vulnerable people. UniLúrio adopts a Curriculum approach that favors contact with local communities. For instance, “One Student, One Family” program promotes knowledge transfer and community assistance in health and nutrition issues, sanitation, and community related issues.

- Admission systems that target increasing number of girls that enter HEI. ISPM introduced ‘affirmative action’ in the entrance examinations mechanism to benefit women and increase the number of girls in higher education courses. ISDB has a positive clearance strategy and a mandatory percentage (30%) of girls through which it facilitates the entry of more girls into the institution by making use of a subsidized credit scheme and its scholarship program targeting vulnerable families. UniLúrio, as part of the ADB project, is developing a specific program in the STEM and Portuguese subjects to support preparation of 11th and 12th grade high school girls’ students, to promote appreciation for STI areas and ensure better grades in the admission exams.

From the above HEI study cases, it is apparent that the country lacks gender and STI policies and strategies to enable concerted actions towards addressing gender disparity at both students and academic staff levels. Each HEI acted differently grabbing ad-hoc opportunities that emerged to address issues related to gender equity and increase women appreciation for STI. As advanced by Howe-Walsh and Turnbull (2016) institutions should have clear career guidance and support to help women navigate their careers to senior positions and gender affirmative actions (Tizikara et al., 2019). Other studies argue for a broader spectrum of criteria to be included in the promotions policy and processes of academic staff in HEIs beyond those focused on research for better balancing the strengths offered by both male and female in the academia (Bagilhole, 2000; Subbaya and Vithal, 2017).

CONCLUSIONS AND RECOMMENDATIONS

Gender and STI is an emergent subject in Mozambique that is slowly gaining space and more attention both at national policy and in the
HEIs. The status of Mozambique’s gender based Science Technology and Innovation ecosystem is incipient with following characteristics. First, recently created policies and strategies lack adequate implementation instruments, plans for systematic actions, and monitoring. Second, there is a weak integration and articulation between secondary, higher and technical and vocational education, i.e., between MINEDH and MCTESTP. Third, there is lack of diversified financing mechanisms oriented to gender and STI. Lastly, there is a very limited collaboration and partnerships between knowledge base institutions, industry and market of new technologies.

Actions by both HEIs and national level policies promoting gender equity and equality, stimulating and enhancing women appreciation and participation in STI are still very limited and recent, their impact and effectiveness are yet to be assessed. The current setup of the national system where students choose a S&T or A&H orientation after 10th grade, when not sufficiently prepared to take informed decision affects the appreciation and numbers of students in S&T.

The gender based STI in Mozambique is prominent in the policy and knowledge base dimensions. International agencies are the main funding source followed by the public sector while the private sector has very little contribution. Contrary to other countries where private sector has an expressive role in funding research and development, in Mozambique most of the research money comes from public sector or from HEIs and is skewed towards medical sciences and agriculture.

The prospect of constituting the STEM women’s forum is seen as an important step to enhance women visibility; increase appreciation for STEM related programs, therefore contributing to increase participation of women in HE and in STI programs in particular. It is therefore recommended to strengthen and expand already existing scholarship programs targeting females and mentorship starting in secondary school as a key strategy to be adopted. Finally there is need to establish an intrinsic collaboration with private sector find society oriented practical solutions and technologies that fit their interests and secure funding.

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

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Gender-based assessment of Science, Technology and Innovations ecosystem in Sudan

MUNA MOHAMED ELHAG and MUTASIM AHMED ABDELMAWLA
University of Gezira, P.O. Box 20, WadMedani, Sudan

Corresponding Author: munaelhag13@gmail.com

ABSTRACT
Science, Technology and Innovations (STI) play a critical role in each of the Sustainable Development Goals (SDG). Despite several STI initiatives to ensure achievement of the 5th Sustainable Development goal on gender equality, the participation of women in STI has remained low all over the world in general but particularly in sub-Saharan Africa (SSA), where women are greatly underrepresented in STI ecosystem. In Sudan, there are Policies and Strategies for STI in the Ministry of Higher Education and Scientific Research but there is no mention of gender or gender equity as separate issues. The female students at Sudanese higher education institutions form the majority (55%) of enrolment at undergraduate level and in some cases reaching 70-80% as in Agriculture and Medical fields, while enrolment of female in Science, Engineering and Mathematics is less than 23%. The numbers of females at universities and research institutes decrease in high seniority levels, with only 15 female professors out of 95 professors in research institutes in 2017. In Sudanese universities there is only one female professor in engineering in the academic year 2017/2018, while in the broader science fields there are only six female professors out of 53 professors. The women involvement in decision making in academia and industry is negligible, and overall women scientists involved in leadership and their participation in research and development is low. There are only three women Vice Chancellors out of 133 university Vice Chancellors. According to the new constitution representation of women must increase to 40% of government workforce as a general policy. The financial support of STI research in Sudan depends mainly on the public sector (more than 95%) compared to a very low contribution from the private sector. Nowadays, there are new policies at the Ministry of Higher Education and Scientific Research for partnership with the private sector by using the infrastructure of industrial companies for some STI initiatives. The overall findings from this study indicate that in Sudan the gender participation in STI issues are not well emphasized in policies and strategies of STI. However, there are some initiatives through non-governmental organization such as Sudanese Women in Science Organization and STEM Girls’ clubs project to stimulate and enhance women participation in STI programs.

Key words: Gender, STEM, STI, Sudan, women participation

RÉSUMÉ
La science, la technologie et les innovations (STI) jouent un rôle essentiel dans chacun des objectifs de développement durable (ODD). Malgré plusieurs initiatives STI pour assurer la réalisation du 5ème objectif de développement durable sur l’égalité des sexes, la participation des femmes aux STI est restée faible dans le monde en général, mais en particulier en Afrique subsaharienne (ASS), où les femmes sont largement sous-représentées dans les écosystèmes STI. Au Soudan, il existe des politiques et stratégies pour les STI au sein du ministère de l’Enseignement supérieur et de la Recherche scientifique, mais il n’y a aucune mention du genre ou de l’égalité des sexes en tant que questions distinctes. Les étudiantes dans les établissements d’enseignement supérieur soudanais constituent la majorité (55%) des inscriptions au premier cycle et atteignent dans certains cas 70 à 80% comme dans les
domaines de l’agriculture et de la médecine, tandis que les inscriptions des femmes dans les sciences, l’ingénierie et les mathématiques représentent moins de 23%. Le nombre de femmes dans les universités et les instituts de recherche diminue avec les niveaux de séniorité avec seulement 15 femmes professeurs sur 95 professeurs dans les instituts de recherche en 2017. Dans les universités soudanaises, il n’y a qu’une seule femme professeur en génie au cours de l’année académique 2017/2018, tandis que dans les domaines scientifiques plus larges, il n’y a que six femmes professeurs sur 53 professeurs. La participation des femmes à la prise de décisions dans les universités et l’industrie est négligeable et, dans l’ensemble, les femmes scientifiques impliquées dans le leadership et leur participation à la recherche et au développement sont faibles. Il n’y a que trois femmes recteurs sur 133 recteurs des universités. Selon la nouvelle constitution, la représentation des femmes doit atteindre 40% de l’effectif gouvernemental dans le cadre d’une politique générale. Le soutien financier de la recherche STI au Soudan dépend principalement du secteur public (plus de 95%) par rapport à une très faible contribution du secteur privé. De nos jours, il existe de nouvelles politiques au sein du ministère de l’Enseignement supérieur et de la Recherche scientifique pour un partenariat avec le secteur privé en utilisant l’infrastructure des entreprises industrielles pour certaines initiatives STI. Les conclusions générales de cette étude indiquent qu’au Soudan, la participation des femmes et des hommes aux problèmes liés aux STI n’est pas bien mise en évidence dans les politiques et stratégies des STI. Cependant, il existe des initiatives par le biais d’organisations non gouvernementales telles que l’Organisation des femmes soudanaises dans les sciences et le projet des clubs de filles STEM pour stimuler et améliorer la participation des femmes aux programmes de STI.

Mots clés: Genre, STIM, STI, Soudan, participation des femmes

INTRODUCTION
Science and Technology (S&T) are the key drivers of economic and social development, and this has been clearly emphasized in the recently published reports of the Scientific Advisory Board of the Secretary-General of UNESCO (SAB, 2016). Key components of the concept of innovation include the role of knowledge as a basis for novelty, utility, and value creation or preservation as the presumed goal of innovation. The Innovation can signify both an activity and the outcome of the science and technology research activities and play a vital role in determining or influencing growth and development (Sawahel, 2014; Oslo Manual, 2018). According to the United Nations (UN, 2015), sustainable and inclusive development are incomplete without a full consideration of issues of Science, Technology and Innovation (STI). Access to new and appropriate technologies promote steady improvement in living conditions, which can be life saving for the most vulnerable populations, and drive productivity gains which ensure rising incomes (Abdelmawla, 2010; and Molnár, 2015). The STI policies became the main driver in increasing the productivity, job opportunities, growth and delivering services in public and private sectors (Nour, 2012). Both Research and Development (R&D) and Innovation have the potential to significantly contribute to Africa’s economic growth and prosperity. Hence, there is a need to demonstrate the use of science, technology and innovation in poverty reduction, job creation, sustainable livelihoods and improved well-being of African citizens.

Africa is lagging behind the other regions of the world in terms of STI because of the low investment in technology in general and low expenditure on research and development (R&D) in particular. According to AIO III (2019) understanding of STI systems is important for research and innovation policy formulation and program design. In this regard
the African Science, Technology and Innovation Indicators (ASTII) initiative has made progress in supporting African countries to collect data on STI indicators and generate new indicators for better understanding of STI situation. This is particular so with focused and sustained human capital development through higher education (Borland and Dawkins, 2000; Bloom and Canning, 2006; Montenegro and Patrinos, 2013).

Sudan’s science and technology development agenda started with the establishment of the first R&D laboratory (The Welcome laboratory) in 1902 and the Agricultural Research Station in 1904. In 1924 Kitchener School of Medicine was started, as nucleus for University of Khartoum (AbuGokh, 2015). The National Council for Research (NCR) was established in 1970 as a governmental body responsible for formulating policies and plans and coordinating national efforts in respect of S&T (Beshir, 2017). The NCR was converted to the Council for Higher Education and Scientific Research in 1991-1992. The Ministry of Science and Technology (MOST) was established in 2001, leading to the formulation of the national strategy for S&T and to the centralization of the public research institutes under its supervision (MOST, 2009). In 2015, the ministry was abolished (ESCWA, 2016), on account of having failed to coordinate the various diverse fields of research to meet the needs of the various ministries and industries. This was mainly because the research institutes have their own mandates strongly related to the research needs of the technical ministries. The main four STI key players in Sudan are Agricultural Research Corporation (ARC) and Livestock Research Corporation (LRC) at the Ministry of Agriculture and livestock, National Information Centre at the Ministry of Communication and Information Technology (CIT), National Research Centre and Universities and research Institutes at the Ministry of Higher Education and Scientific Research (MOHE), and Industrial Research and Consultation Centre at the Ministry of Industry in addition to some private sector centres (Hassan, 2009).

The STI play a critical role in each of the Sustainable Goals (SDG), but despite several STI initiatives to ensure achievement of the 5th Sustainable Development Goal on gender equality, the participation of women in STI has remained low all over the world in general and particularly in sub-Saharan Africa (SSA), where women are greatly underrepresented in STI system (Tizikara et al., 2019; Zinnah and Jackollie, 2020). The under-representation of women in STI could be attributed to, among other reasons, policy, institutional and individual (cultural) factors. Many countries have gender sensitive STI policies that aim at promoting the participation of women in science at all levels, but these are rarely implemented. The institutional factors include; inflexible working hours, limited support for women in entrepreneurial development and hidden discrimination. Gender biases in the teaching of STEM subjects, family commitments and marriage, lack of confidence, fear of the unknown, lack of role model and mentoring are main cultural factors that hinder the girls and women participation in STI (SAGA, 2018; Tizikara et al., 2019).

In Sudan, female students form the majority (55%) of enrolment at undergraduate level in higher education institutions and in some cases even reaching 70-80% in agriculture fields, while enrolment of girls in Science and Mathematics is less than 40% (Statistic Unit, MOHE reports and UNESCO, 2015). The women involvement in decision making roles in academia and industry is far less, there are few women scientists involved in leadership and their participation in research and development is also low (SAGA, 2018). In Sudan there is a national STI policy and framework but it does not address gender issues significantly. Therefore efforts to ensure greater inclusion of women in the STI in Sudan are highly needed.

Within the above context, the aim of this paper is to conduct a Gender-based assessment of STI
Gender-based assessment of Science, Technology and Innovations ecosystem in Sudan

ecosystem in Sudan. The paper is organized in the following sections: Firstly Methodology approaches used to gather information and the key data assessed. This is followed by a presentation and discussion on the status of Science, Technology and Innovation system in Sudan, providing a policy overview and gender perspective. The follow up section examines the status of women participation in STI ecosystem in Sudan including women access and participation in higher education institutions and women participation in STI. This is followed by a discussion on Gender and STI strategies in Sudan including best practices (supporting bodies) at different institutions for enhancing STI performance and promoting female participation in STI, and subsequently a section on Gender and Scientific performance in Sudan. The final section presents Future prospective on Gender participation in STI in Sudan and needed action to increase women participation in STI and indeed in the broader development landscape in Sudan.

METHODOLOGY AND ACTIVITIES
The methodology adopted relied on a cross section of information sources using quantitative and qualitative methods. Gender policies and strategies of STI in Ministry of Higher Education and Scientific Research (MOHE) and other related institutes as well as reports on gender initiatives in the country were reviewed to assess the gender gap in STI. Data on female enrolments and graduation in the Higher Education Institutions (HEIs) were analyzed to provide an overview of female participation in higher education and STI. Additional information was collected through interviews using different formats, face to face, emails and phone call interviews with key informants from the Ministry of General Education, Ministry of Higher Education and Scientific Research, University of Khartoum, AlNeelain University, University of Gezira, Kordofan University, Africa City of Technology, National Council of Research, Agriculture Research Cooperation, Sudanese Women in Science Organization (SWSO), UNESCO Chair for Women in Science and Technology-Sudan University of Science and Technology, in addition to 20 experts in the government and private sectors and samples of postgraduate students in STEM fields (Table 1).

For the analysis of female participation in HEIs and STI initiatives, data from 1990 to 2018 were collected to characterize the trends of female participation in HEIs and STI ecosystem. The paper is confined to the last 10 years as of December 2019. From the interviews with different actors the paper captured their perception about the STI situation in Sudan, women participation and gender equity and the opportunities and challenges faced by Sudanese women in the STI ecosystem.

FINDINGS
Science, Technology and Innovation system in Sudan: policy overview and gender perspective. In 2016 the Council of Ministers of Sudan approved a new STI policy which is being translated into strategies and plan of actions with clear priorities. Subsequently, the Ministry of Higher Education and Scientific Research was mandated by government to lead the STI issues for the future sustainable development in Sudan. Government also supported this mandate by attaching all research, development, technology transfer and innovation institutes under MOHE administrative structure, which were previously under MOST. The MOHE created new units for Scientific Research and Innovation Commission as a body for Sudan STI policies, plans and strategies and to coordinate STI initiatives. Accordingly, the structure of STI is categorized at four main ministries, i.e., MOHE, Information and Communication Technology (ICT), Industry (including private sector), and Agriculture and Livestock ministries. At the ministerial level, most of the funding bodies were allocated a clear distinction between each other and the coordination between and cross entities are usually done at ministries council level.
Table 1. Summary of data collection process

<table>
<thead>
<tr>
<th>Data and information collected</th>
<th>Method/activity</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender policies and strategies in higher education; Priorities and interventions National debate about national education system and S&amp;T</td>
<td>Literature review</td>
<td>Ministry of Higher Education, National Research Council, Ministry of Information and Communication Technology, Africa City of Technology, other related STI institutes, UNESCO Chair for Women in Science and Technology-Sudan institutes, UNESCO Chair for Women in Science and Technology</td>
</tr>
<tr>
<td>Admissions and graduates by sex (% of female enrollment and graduates in STI); Number of researchers by sex Number of academic staff by sex Share of GDP devoted to STI research Indicators for STI situations</td>
<td>Secondary data and Descriptive statics analysis</td>
<td>Ministry of Higher education and Scientific Research (Statistic Unit) Annual reports (2009-2018) Data provided by HEIs, SWSO, UNESCO Chair for Women</td>
</tr>
<tr>
<td>Mapping of existing Gender and STI initiatives, main actors and their contribution Women participation in STI initiatives</td>
<td>Documents analysis and interviews</td>
<td>Annual Reports Key informants, Websites</td>
</tr>
<tr>
<td>Best practices, challenges and opportunities for improving gender in STI Future for women participation in STI</td>
<td>Compilation of secondary data and interviews.</td>
<td>Key informants from relevant ministries, HEI, relevant stakeholders from government and private sector were interviewed.</td>
</tr>
</tbody>
</table>

For this paper, the STI Policies for Ministry of General Education, Ministry of Higher Education and Scientific Research, Ministry of Security and Social Development, and Ministry of Information and Communication Technology (ICT) were reviewed. It is observed that there is no STI national policy or framework in the Ministry of General Education and Ministry of ICT. However, the MOHE developed an STI framework “Policies and Strategies of Science, Technology and Innovation” but there is no mention of gender or gender equity as separate issues. The gender equity appeared in the framework of Ministry of Security and Social Development (National Policy of Women Empowerment 2007, updated in 2018) but there is no clear focus on STI issues in general and gender issues in particular.

**Status of STI ecosystem and women participation in Sudan.** For this section data from the different ministries involved in STI were collected and interviews with the experts in the government and university staff in public and private universities, research institutes and private sectors were conducted to assess the situation of women participation in STI.

**Women access and participation in higher education institutes.** The Government of Sudan has made remarkable progress in higher education during the last three decades. The
The number of universities increased significantly from five public universities in 1989 to 59 universities (38 private and 21 public) and an additional 74 (up from 2) private colleges and HEI in 2019 (Table 2). This led to significant increase in both students’ enrolment and graduation rates in higher education and universities by 73.78% and more than 200%, respectively. The number of students’ intake at bachelor level jumped from 6,080 in 1989 to 43,477 in 2007 and to more than 180,000 in 2019. The number of female students rose from 40% of enrolment in 1995 to more than 70% in some colleges in 2019 (Statistics Unit, MOHE).

In Sudan, despite the significant expansion of higher education institutes and graduate training from 1990 to 2019, still the Sudanese universities produce significantly more graduates in social sciences and humanities than graduates from engineering and other sciences. In the year 2016/2017 about 67,357 students graduated in social sciences, while only 15,958 graduated from science and 13,434 from engineering fields at the undergraduate level. There are many reasons behind this gap in graduation in different disciplines. In the first place it has to be realized that there is an equal chance for students to choose the subjects for Sudanese Secondary exam but some public universities offer some engineering fields for boys only (e.g. Surveys, Petroleum and Excavation Engineering) and most of the private universities and colleges do not offer studies in engineering or science fields. In 2018 the number of faculties for Engineering and Science in public and private institutes were 56 and 70, respectively which is far below the Humanities and Social Science faculties, which had about 150 and 85, respectively.

The graduates available at the country level to enter the workforce, including R&D staff numbers, particularly in S&T fields is considered a good human resources indicator to measure the status of the STI in the country. In Sudan, the number of the postgraduate students increased from 1,074 (85 PhD and 989 MSc) in 1991 to 32665 (6,194 PhD and 26,471 MSc) in 2017 (AbuGokh, 2015; Statistics Unit, MOHE, 2018). However, only 2,064 postgraduate students carried out research work in the field of science and 2,292 in the field of engineering, which represented only 13.3% of students. From the interviews with Sudanese experts and policy makers they mentioned that many graduates lack skills of using modern tools and equipment due to many reasons including low investment by the government and private sector in R&D in addition to the American sanctions, which hindered the development and upgrading of laboratories and other research facilities.

The number of female students at the Master’s level during 2010 to 2017 ranged from 41% to 52% of students in the field of Science and 31% to 46% of students in the field of Engineering. However, female students outnumbered male students in Medical field, where they represented 44%-66% of the students, while in the Agricultural field, female students at the master level increased during 2014/2015-2017/2018 to 58% of the students enrolled and this is due to the fact that more than 70% of research assistants are females in the Agricultural Research Corporation (Figure 1).

**Table 2. Higher Education Organizations**

<table>
<thead>
<tr>
<th>Type</th>
<th>1989</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Universities</td>
<td>5</td>
<td>38</td>
</tr>
<tr>
<td>Private universities</td>
<td>-</td>
<td>21</td>
</tr>
<tr>
<td>Private colleges and institutes</td>
<td>2</td>
<td>74</td>
</tr>
</tbody>
</table>
At the doctoral level, the number of female students increased only in the medical field from the academic year 2010-2011 to 2016-2017 by 40% -63%. However, male students outnumbered female students in the agricultural field. In the field of science, the number of female students increased from the academic year 2010/2011 to 2016/2017 where they represented 21%-43% of the students’ population. The percentage of female students at the doctorate level in the engineering field was far below that of male students, where they constituted only 11%-26%. Overall, more male students are enrolled in postgraduate studies in the fields of agriculture, science and engineering and the number of female students is decreasing with ascending steps in the ladder of higher education (Figure 2).

**Women in the STI workforce and professional practice.** Despite the growth in the number of university staff members, researchers and development personnel, the data from MOHE indicated that males still dominate positions with virtually no female representation at some institutions in general and at high-ranking positions in particular. During the period from 2009 -2018, the female university staff members represented 24% to 36% of the staff in the Sudanese universities. The number of male staff members at all staff levels (lecturer, assistant professor, associate professor and full professor) exceeded those of female staff (Figure 3). The same situation is true for research institutes. The number of females decrease in high seniority levels. There are only 15 female professors out of 95 professors in research institutes. The numbers of female staff decrease in higher level positions with only one female professor in engineering in the academic year 2017/2018. Similar results were observed in the science fields with only 6 female professors out of 53 (Figure 4). Generally, universities located in Khartoum, Sudan capital, have higher number of professors and associate professors compared with universities located in other states. For
example, in Kordofan University which is located in Kordofan State in Western Sudan, the total number of female staff members was 320 out of 740. There was no female professor and only one female associate professor in the Faculty of Agriculture (Figure 5).

As shown in Figures 3-5 and the information from the interview with key informants, there are few women in high seniority levels mainly due to cultural factors (women not allowed to travel abroad on their own in some areas), family commitments and marriage, lack of confidence, fear of the unknown, hidden discriminations and lack of mentoring and coaching. In the last five years the situation of employing women in higher positions improved. After the December revolution in 2018, the representation of women in STI high ranking positions increased to three Vice Chancellors, while the number of Deans increased to nine in AlNeelain University and eleven in Sudan University of Science and Technology. This was made possible through the new constitution, which demands that the representation of women must increase to at least 40% of government workforce as a general policy.

**STI strategies and gender incorporation in Sudan.** Sudan as the other African countries allocated only a small percentage of its GDP for the STI. Before 2000s, the rate of spending on R&D in Sudan as a percentage of GDP was only 0.04%. In 2006, the share increased to 0.1%, which fell behind the average rate of the World and Arab countries, which spent on R&D as a percentage of GDP about 2.3% and 0.6%, respectively (Nour, 2012). Based on the Sudan Presidential Initiative for STI, which was proposed to UNESCO in 2009, issuing legislation required increasing spending on R&D to 0.5% of GDP in 2017-2019 and then up to 1% of GDP by 2020. This has not been achieved.

![Figure 2. Percentage of female and male students at the doctorate level in agriculture, medical, science and engineering faculties](image)

Figure 2. Percentage of female and male students at the doctorate level in agriculture, medical, science and engineering faculties
Figure 3. Number of female staff members in the various fields

Figure 4. Number of female staff members in Sudanese universities and research institutes

Figure 5. Number of female staff members in Kordofan University
The financial support to STI depends mainly on the public sector compared to a very low contribution of the private sector. According to Nour (2013) about 95% of total financial support to S&T is provided by government, mainly from MOHE and Ministry of Finance for some research institutes, compared to a very low contribution of the private sector in Sudan (only 5% of total financial support to S&T). Nowadays there are new policies for partnership with the private sector by using the infrastructure in some industries for some STI initiatives. The impressive growth in communication and information technology sector is considered a great lever for STI implementation.

As an indicator of research activities in universities, the MOHE started funding a large number of research projects for university staff members, and since 2004, the amount of fund 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. The number of projects varies depending on funds availabilities to MOHE from the Government and the quality of the projects submitted to MOHE (Figures 6 and 7). This funding supported the research work of many staff members and resulted in some useful technological packages. The Government expenditure (GOVERD) on R&D in Sudan compared with other African countries is relatively low, where for example, countries like South Africa and Egypt spent more than 1$ billion on R&D performed by public institutions (Cloete and Barley, 2011; Bunting and Cloete, 2014). The proportion of GOVERD as a percentage of GDP in Sudan is about 0.02% in 2019 which is far below the share suggested by Sudan Presidential Initiative for STI. This is low compared to other African countries. According to AIOIII (2019) the GOVERD for the Republic of Tanzania, Egypt and South Africa was 0.27%, 0.26% and 0.16%, respectively. The low contribution of the private sector in R&D expenditure might be due to the fact that the size of the business sectors in Sudan is small, which may not have enough financial resources to invest in R&D activities. It could also be due to the mind-set of the businessmen in Sudan who are not motivated to invest in research, and the low awareness of the role of R&D because the business sector is looking for short-term profit.
Data presented in Table 3 show that 432 research projects were funded by MOHE during 2017-2018, of which only 65 projects were led by female researchers which represent only 15% of the total number. This indicates that the number of research grants obtained by female researchers is very low compared to the male researchers. This is mainly due to the fact that the criteria for application and awards of the grants require that the team leaders must be full professors or associate professors. As shown in Figure 5 there are few female professors and associate professors in research institutes and universities.

**Supporting bodies for STI in Sudan.** From the last decade many non-profit organizations were established to enhance and promote the STI system in Sudan. Some of these are highlighted below.

**Sudanese Researchers Initiative (SRI).** Founded in 2009, the main aim of the group is to establish a hub for the Sudanese researchers in a web-based platform, to motivate the Sudanese folks to share knowledge and to be involved in R&D. This platform helps young and junior researchers to discuss their ideas openly. The SRI is a research community oriented initiative; it has about 92,403 researchers from different disciplines and various backgrounds. It is a forum and pool for innovative ideas, publications, seminars, awareness and other related topics (http://www.saec.gov.sd).

**Incubators.** Incubators constitute a vital component in STI schemes, aiming to support technology-based and innovation-oriented entrepreneurs. They also provide a flexible environment that helps and makes sure the business will survive and be protected, and offer many services such as workspace (on preferential and flexible terms), shared facilities, management training and a range of business support services. Being one of the government initiatives for STI, Sudan University of Science and Technology (SUST) has six incubators. Also Africa City for Technology has nine incubators. the main ones being: Leather Incubator; Cement Incubator; Poultry Incubator; Goat Production; Furniture Incubator; Oil Seeds Processing; and Solar Energy.
Table 3. Amount of funds released from MOHE during 2017 - 2018 for male and female researchers

<table>
<thead>
<tr>
<th>Field</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of projects</td>
<td>Amount of fund (SDG)</td>
</tr>
<tr>
<td>Medical Sciences</td>
<td>93</td>
<td>23,345</td>
</tr>
<tr>
<td>Agriculture Sciences</td>
<td>134</td>
<td>34,921</td>
</tr>
<tr>
<td>Sciences</td>
<td>56</td>
<td>12,346</td>
</tr>
<tr>
<td>Engineering</td>
<td>84</td>
<td>22,067</td>
</tr>
</tbody>
</table>

STEM Girls’ Clubs project. For enhancing the gender participation in STI, UNESCO ISESCO Chair for Woman in Science and Technology at Sudan University for Science and Technology launched STEM Girls Club in November 2018, with the objectives to encourage students to join science courses, awareness-raising that helps students to choose the science courses, bridging the gap in curriculum and courses, encourage students to follow technological developments, encourage discovery and innovation, contribute to the development of scientific research, and create partnerships between educational institutions.

Sudanese Women in Science Organization (SWSO). Started in 2013 as an arm of Organization for Women in Science for Developing World, its objectives are to support capacity building programs, community development programs, awareness campaigns, and establish central laboratories.

Innovation and Entrepreneurship Community (IEC). Started as an arm of IEEE Sudan subsection, which was known as IEEE Sudan entrepreneurship Centre (ISEC), IEC was launched in April 2013, with an objective to support the entrepreneurial activities in Sudan.

Gender and Scientific performance in Sudan. In this section, the STI output indicator is measured using scientific performance (in terms of publications and direct research output that has direct impact on economic growth of the country) and number of patents.

Scientific performance. There are many limitations concerning the data availability that address the scientific publications in Sudan, specially locally published research papers and articles. This could be attributed to the fact that most of Sudanese universities and research institutions lack electronic journals. Table 4 shows the publication outputs of some research institutions during the period from 2015 to 2018 that published in peer reviewed journals available at Scimago.com and Pubmed.com. Currently in Sudan, the output 0.03, reflects the low number of publications per researcher per year compared to the international rate of 2 papers for each researcher.

The success of R&D findings that contributes to development and economic growth of the country is used for measuring the impact of

Table 4. Number of Scientific Publications 2015-2018

<table>
<thead>
<tr>
<th>Field</th>
<th>No of research papers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>2380</td>
</tr>
<tr>
<td>Science</td>
<td>2300</td>
</tr>
<tr>
<td>Engineering</td>
<td>1253</td>
</tr>
<tr>
<td>Medicine</td>
<td>3669</td>
</tr>
</tbody>
</table>

*Scimago.com, Pubmed.com*
STI output. During the last decades, there were successful applications of research results and technology in Sudan, which include the following: a) success in cultivation of wheat south of latitude 15°N by breeding heat-tolerant varieties, b) reduction of Belharziiasis in the Gezira Scheme from 80% to 20% by applying appropriate control methods, based on research strategies and protocols at Blue Nile National Institute for Communicable Diseases, University of Gezira, c) production of new animal vaccines by the Faculty of Veterinary Medicine, University of Khartoum, and d) treatment of Hepatitis and cancer using camel milk and urine at University of Gezira. Besides the above mentioned outputs, there are many research findings produced by universities and research institutes still in the shelves and libraries which need to be applied at a large scale to maximize the benefits from research to the country’s development.

**Number of patents.** Patents number can only be meaningful, if there is adequate knowledge of the criteria and methodologies used to register them. The patents reflect the inventive performance of a country (IPO, 2019). Before 2005, the number of patents registered in the Registrar of Intellectual Property in Sudan was only 12. This number increased to 426 by the end of 2013, which is still very low compared with other countries in Africa, e.g. there are 3694 patents in South Africa during the same period. This low number of registered patents is probably because Sudan has insufficient science and technology infrastructure and only 0.01% of GDP is spent on R&D during the period before 2005. There is however an increase in the number of patents during the period 2013-2018 (Table 5). This is largely due to the increase in the fund received from MOHE (25 folds during the last five years) and also the share of R&D to GDP increased. The contribution of female researchers with registered patents is very low compared with that of male researchers (Figure 8).

**Future perspective on gender participation in STI in Sudan.** The various Sudan Governments have been aware about the gender disparities in the HEI and STI system. The Mistry of Higher Education and Scientific Research and the HEIs also acknowledge the need to enhance participation of males and females in STEM courses and the need to put in action gender strategy for equity in higher education policy, bearing in mind that the Sudan constitution and academic regulations for higher education admission system give equal rights for both males and females in education. The MOHE may need to adopt some mechanisms to increase female participation in STEM programs like using quota system, providing incentives and scholarships for females to choose science and technology related subjects. In addition to revised recruitment policies at the Universities and research institutes, women working environments, including flexible work schedules that guarantee equal opportunity for retention and progression are needed. In some Sudanese universities, the vision and mission statements are developed to focus on STI goals, such as at Sudan University of Science and Technology (SUST), University of Medical Science and Technology (UMST), Future University, and University of Science and Technology (UST).

**Table 5. Number of registered Patents in Sudan (2015-2018)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>169</td>
<td>17</td>
<td>186</td>
</tr>
<tr>
<td>2016</td>
<td>159</td>
<td>19</td>
<td>178</td>
</tr>
<tr>
<td>2017</td>
<td>176</td>
<td>33</td>
<td>209</td>
</tr>
<tr>
<td>2018</td>
<td>116</td>
<td>14</td>
<td>130</td>
</tr>
</tbody>
</table>
Also University of Gezira and University of Khartoum have Scientific Research strategies but gender issues are not considered. Most of the male students prefer to choose mathematics and engineering subjects because according to the Ministry of General Education, job markets are available making it easier to find work after graduation especially for mechanical and civil engineers. There are also opportunities for self-employment.

From the interviews with key actors and Ministry of General Education report there are arguments that the education system is not well equipped to facilitate the participation of both males and females, but more especially females in STEM programs. Most of the available STEM instructors are males specialised in mathematics and engineering subjects and are mostly in the boys’ schools; about 74% of them are found in boys’ schools and only in the big cities, while in rural areas the percentage decreased to less than 20%.

Some initiatives such as Sudanese Women in Science Organization, Sudanese Researchers Initiative, STEM Girls’ Clubs aiming at stimulating young researchers in general and women researchers in particular to participate in STI are encouraging students to join science courses. They undertake awareness-raising that helps students to choose the science courses, bridging the gap in curriculum and courses, encourage discovery and innovation, sharing knowledge and help young and junior researchers to discuss their ideas openly.

The Republic of Sudan has potential for establishing strong and concrete STI structures, which are currently distributed over many ministries that give the STI system a unique diversity. The Government distributes roles, responsibilities and hierarchy among STI organizations, but there is need to identify the steps and actions that lead to increased participation and enrolment of women in STI. These include, amongst others:

a. Balance between working life, motherhood and other family obligations
b. Stimulating women’s self confidence
c. Creation of a Network of Women Researchers
d. Building the role model culture
CONCLUSIONS AND RECOMMENDATIONS

In Sudan, female students form the majority (55%) of enrolment at undergraduate level in higher education institutions and in some cases even reaching 70-80% like in Agriculture and Medical fields, while enrolment of girls in Science and Mathematics is less than 23%. However, the majority of these female graduates are unemployed. The women involvement in decision making roles in academia and industry is very low, with very few women scientists involved in leadership and their participation in research and development is also low.

In Sudan, there is no existence of STI national policy or framework in the Ministry of General Education and Ministry of Information and Communication Technology. However, the MOHE developed an STI framework “Policies and Strategies of Science, Technology and Innovation” but there is no mention of gender or gender equity as separate issues. The gender equity appeared in the framework of Ministry of Security and Social Development but there is no clear focus on STI issues. Therefore, efforts to ensure greater inclusion of women in the STI ecosystem in Sudan are highly needed and should be embedded in national and institutional frameworks. The number of females decreased significantly in high seniority levels. There were only 15 female professors out of 95 professors in research institutes. After the December revolution in 2018, the representation of women in STI high ranking positions increased to three Vice Chancellors, while the number of Deans increased to nine in AlNeelain University and eleven in Sudan University of Science and Technology. This positive development has been made possible as a result of the conditionality in the new constitution to ensure at least 40% female representation in government labour force as a general policy guideline.

The financial support to STI depends mainly on the public sector (financing from Government), compared to a very low contribution from the private sector. Nowadays, there are new policies for partnership with the private sector by using the infrastructure of industries for some STI initiatives. In Sudan, the gender participation in STI is not emphasized in policies and strategies of STI. However, there are some initiatives through non-governmental organizations to stimulate and enhance women participation in STI programs.

Arising from the above analysis, the following recommendations should be considered:

• Increase funding from public and private sector for the different research institutes and universities, including creating an Innovation Fund to be accessed competitively;
• Offer incentives and motivation for researchers with especial consideration for female researchers
• Creation of more favourable conditions for females and offering the necessary facilities and improvement of R&D culture.
• Increase availability of sufficient human resources and adequate research infrastructure
• Enhance technical competencies of human resources through capacity building training and curriculum reforms
• Offer incentives and motivation for females to join the STEM fields
• Improve management, coordination and networking between the related institutes including ministries
• Build the role model culture, mentoring and coaching for female students and researchers
• Create partnerships between Sudan educational institutions and related institutions in Africa and globally
• Establish education fund to train Sudan masters and PhD students in Sudanese and other African universities
• Establish initiative to build capacity in emerging areas related to digital technologies and data science
• Establish STI centres of excellence in Sudan

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

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Higher Education and Scientific Research in Sudan: Current status and future direction

M. M. BESHIR1, N. E. AHMED2 and M. E. MOHAMED3

1Biotechnology and Biosafety Research Centre, Agricultural Research Corporation, P.O. Box 30, Shambat, Sudan
2Integrated Pest Management Centre, Agricultural Research Corporation, P.O. Box 126, Wad Medani, Sudan
3Water Management and Irrigation Institute, University of Gezira, P.O. Box 20, Wad Medani, Sudan

Corresponding author: mayadabeshir2015@gmail.com

ABSTRACT

Higher Education (HE) is an essential resource for Sudanese who hope to escape the painful transition to independence, its violent attempts to forge a common national identity, and its decades of war and military rule. The year 1990 witnessed the birth of HE revolution which is considered as a revolving point for HE in Sudan. Since then, however, considerable discrepancy between the output of graduates in different specializations and the absorptive capacity of the labour market has been noticed leading, in turn, to unemployment, underemployment and to scarcity of graduates. The purpose of this study was to examine the status and future direction of higher education and scientific research in Sudan. Study methodologies combined use of qualitative and quantitative data. The findings indicate that the regulation of HE institutions and oversight of scientific research in the country are managed by Ministry of Higher Education and Scientific Research (MOHE), but formulating policies, plans, objectives, funding, and scientific research priorities are handled by the National Council for Higher Education and Scientific Research since 1972. Today, there are 128 Higher Education Institutions (HEIs), of which 36 are public and 20 private universities, 53 private colleges and 19 technical university colleges. Disciplines in HE include education, humanitarian, social, administration and law, agriculture, health, science, information technology, engineering and others as services. In 2018, the number of enrolled students was 300,000, with 54% female and 46% male students. The highest total numbers of students’ enrolment were in education and social studies, which accounted for 20% and 19%, respectively, of the total enrolment, followed by health and Administration and law studies with 14% and 13%, respectively. Agricultural studies, science and information technology had the lowest numbers of students, representing only a total of 3%, 5% and 5%, respectively. The Government of Sudan needs to expand HEIs to promote growth and take advantages of new technologies for agriculture, science and information technology education. This would spur economic growth and development in Sudan which in turn would enhance food security and livelihoods improvements in the country. In 2018, the number of affiliated staff was 21,584 professors, associated and assistant professors, lecturers and assistant lecturers and 51% were PhD holders consisting of 27% female and 73% male. The highest total numbers of employed staff were in health studies followed by social and
education studies. Also data show that employed male staff (64%) were significantly more than female staff (36%) especially in disciplines like information technology and engineering studies. The highest numbers of employed staff were the assistant professors followed by lecturers and the teaching assistants while the lowest numbers of employed staff were professors and associate professors. However, the rapid expansion of higher education was not accompanied by increase in staff quantity and quality. There is accordingly urgent need to help young staff to pursue postgraduate studies in order to upgrade the proportion of doctoral trained faculty. The consistent low number of females staff compared to males is explained by the history of education in Sudan, which focused on training male students. It is time to narrow the academic gender gap in HEIs and give females equal opportunities for training and promotion. During the academic year 2017/18, there were 32 students for every staff member which is almost double the averaged world ratio of 16.5 students for one staff member. To achieve the Government’s desired goals of 2030, the teacher-student ratio should be similar or near to the averaged world ratio. Like many HE systems in Africa, the higher education sector in Sudan is currently experiencing substantial challenges. This paper raises issues and challenges that need to be addressed at policy level. For example, the Council in 1997 gave permission to each public university to admit additional 25% of the qualified fee-paying students, as determined by each university, and such students may be admitted with as low as with 12% less than the minimum corresponding score for the general admission determined by general competition. In this regard it seems that the Government is supporting rich families at the expense of the poor ones. This will create research and knowledge divide within the country between those who have access and benefit from HE and those who lack it. Overall, there is need for Sudan Government policy makers to take advantage of the role HEIs could play in development of the country, not only for capacity building and research, but also for preparing leaders in development and policy analysis. Accordingly 1) There is need for strategic investment in infrastructure and human resource capacity development to support higher education and research in Sudan. As part of this effort, the Government of Sudan should invest in strengthening postgraduate training so as to build capacity for HEs, research and various sectors of the economy. In this regard efforts need to be made to strengthen integration of Sudan Higher Education and research into Africa Higher education space. Accordingly, Sudan Government needs to put in place mechanisms for training her Postgraduate students in different African universities, while at the same time bringing in students from other African countries to train in Sudan; 2) It is also recommended that Sudan Government through well-structured independent review processes establishes 5-7 HE Centres of Excellence in the country that respond to strategic areas of the country such as strengthening Agri-food systems, building climate change resilience, management of dryland ecosystems and water resources, strengthening health services, and developing capacity in data sciences and digital technologies; 3) There is also need to create and expand opportunities and facilities for Technical and Vocational Education and Training for skilling Sudan youth in both existing and emerging economic sectors. These TVET institutes should offer various technical programmes to provide human resource training to meet the needs of the country and self-employability. Likewise there is need to set up programmes to build entrepreneurial skills of Sudan youth, so as to enhance their employability; 4) While there is gender balance at undergraduate level, deliberate steps need to be made to increase the pool of female students undertaking postgraduate training
so as to increase female staffing in HEs, research institution, and leaderships at various levels; and 5) Finally, to promote research excellence and innovativeness in the country, there is need to establish a Research and Innovation Fund for generating research outputs and innovations, and for supporting linkage with industry.

Key words: Gender participation, higher education institutions, public and private education, students enrolment, students staff ratio, Sudan, TVET

**RÉSUMÉ**

L’enseignement supérieur (ES) est une ressource essentielle pour les Soudanais qui espèrent échapper à la douloureuse transition vers l’indépendance, ses tentatives violentes de forger une identité nationale commune et ses décennies de guerre et de régime militaire. L’année 1990 a vu la naissance de la révolution de l’ES qui est considérée comme un point tournant pour l’ES au Soudan. Depuis lors, cependant, un écart considérable entre la production de diplômés dans différentes spécialisations et la capacité d’absorption du marché du travail a été observé, entraînant à son tour le chômage, le sous-emploi et la rareté des diplômés. Le but de cette étude était d’examiner le statut et l’orientation future de l’enseignement supérieur et de la recherche scientifique au Soudan. Les méthodologies d’étude combinaient l’utilisation de données qualitatives et quantitatives. Les résultats indiquent que la réglementation des établissements d’enseignement supérieur et la surveillance de la recherche scientifique dans le pays sont gérées par le Ministère de l’Enseignement supérieur et de la Recherche scientifique, mais la formulation des politiques, des plans, des objectifs, du financement et des priorités de recherche scientifique est gérée par le National Conseil de l’Enseignement supérieur et de la Recherche scientifique depuis 1972. Il existe aujourd’hui 128 établissements d’enseignement supérieur (EES), dont 36 universités publiques et 20 privées, 53 collèges privés et 19 collèges universitaires techniques. Les disciplines de l’enseignement supérieur comprennent l’éducation, l’humanitaire, le social, l’administration et le droit, l’agriculture, la santé, la science, les technologies de l’information, l’ingénierie et autres en tant que services. En 2018, le nombre d’étudiants inscrits était de 300000, dont 54% de femmes et 46% d’hommes. Les effectifs totaux les plus élevés étaient inscrits dans les domaines de l’éducation et des sciences sociales, qui représentaient respectivement 20% et 19% de l’effectif total, suivis des études en santé et administration et en droit avec 14% et 13%, respectivement. Les études agronomiques, les sciences et les technologies de l’information comptaient les effectifs les plus faibles, représentant seulement un total de 3%, 5% et 5% respectivement. Le gouvernement du Soudan doit élargir les établissements d’enseignement supérieur pour promouvoir la croissance et tirer parti des nouvelles technologies pour l’enseignement de l’agriculture, des sciences et des technologies de l’information. Cela stimulerait l’économie la croissance et le développement au Soudan qui, à leur tour, amélioreraient la sécurité alimentaire et l’amélioration des moyens de subsistance dans le pays. En 2018, le personnel affilié était de 21 584 professeurs, professeurs associés et assistants, chargés de cours et assistants et 51% étaient titulaires d’un doctorat, dont 27% de femmes et 73% d’hommes. Les effectifs totaux les plus élevés se trouvaient dans les études de santé suivies des études sociales et éducatives. De plus, les données montrent que le personnel masculin employé (64%) était beaucoup plus que le personnel féminin (36%), en particulier dans des disciplines comme les technologies de l’information et les études d’ingénierie. Les effectifs les plus élevés étaient les professeurs assistants suivis des chargés de cours et des assistants pédagogiques, tandis que les effectifs
les plus faibles étaient les professeurs et les professeurs associés. Cependant, l’expansion rapide de l’enseignement supérieur ne s’est pas accompagnée d’une augmentation de la quantité et de la qualité du personnel. Il est donc urgent d’aider les jeunes à poursuivre des études de troisième cycle afin d’augmenter la proportion de professeurs formés au doctorat. Le faible nombre constant d’employés féminins par rapport aux hommes s’explique par l’histoire de l’éducation au Soudan, axée sur la formation d’étudiants de sexe masculin. Il est temps de réduire l’écart entre les sexes dans les établissements d’enseignement supérieur et de donner aux femmes des chances égales de formation et de promotion. Au cours de l’année académique 2017/18, il y avait 32 étudiants pour chaque membre du personnel, soit presque le double du ratio mondial moyen de 16,5 étudiants pour un membre du personnel. Pour atteindre les objectifs souhaités par le gouvernement à l’horizon 2030, le ratio enseignant-élèves doit être similaire ou proche du ratio mondial moyen. Comme de nombreux systèmes d’enseignement supérieur en Afrique, le secteur de l’enseignement supérieur au Soudan connaît actuellement des défis importants. Ce document soulève des problèmes et des défis qui doivent être traités au niveau politique. Par exemple, le Conseil en 1997 a autorisé chaque université publique à admettre 25% supplémentaires des étudiants payants qualifiés, selon la détermination de chaque université, et ces étudiants peuvent être admis avec aussi peu que 12% de moins que le minimum correspondant. score pour l’admission générale déterminé par le concours général. À cet égard, il semble que le gouvernement soutienne les familles riches aux dépens des pauvres. Cela créera un partage de la recherche et des connaissances au sein du pays entre ceux qui ont accès et bénéficient de l’enseignement supérieur et ceux qui n’en ont pas. Dans l’ensemble, les décideurs politiques du gouvernement soudanais doivent tirer parti du rôle que les EES pourraient jouer dans le développement du pays, non seulement pour le renforcement des capacités et la recherche, mais aussi pour préparer les chefs de file en matière de développement et d’analyse des politiques. En conséquence 1) Il est nécessaire d’investir stratégiquement dans les infrastructures et le développement des capacités des ressources humaines pour soutenir l’enseignement supérieur et la recherche au Soudan. Dans le cadre de cet effort, le gouvernement du Soudan devrait investir dans le renforcement de la formation postuniversitaire afin de renforcer les capacités des établissements d’enseignement supérieur, de la recherche et de divers secteurs de l’économie. À cet égard, des efforts doivent être faits pour renforcer l’intégration de l’enseignement supérieur au Soudan et la recherche dans l’espace de l’enseignement supérieur en Afrique. En conséquence, le gouvernement du Soudan doit mettre en place des mécanismes pour former ses étudiants de troisième cycle dans différentes universités africaines, tout en faisant venir des étudiants d’autres pays africains pour qu’ils se forment au Soudan; 2) Il est également recommandé que le gouvernement du Soudan, par le biais de processus d’examen indépendants bien structurés, établisse 5-7 centres d’excellence dans le pays qui répondent aux domaines stratégiques du pays tels que le renforcement des systèmes agroalimentaires, le renforcement de la résilience au changement climatique, la gestion des écosystèmes des terres arides et les ressources en eau, le renforcement des services de santé et le développement des capacités en sciences des données et technologies numériques; 3) Il est également nécessaire de créer et d’étendre les opportunités et les installations d’enseignement et de formation techniques et professionnels (EFTP) pour la qualification des jeunes Soudanais dans les secteurs économiques existants et émergents. Ces instituts d’EFTP devraient proposer
INTRODUCTION
Higher Education (HE) is an important trend that has gained considerable attention from different stakeholders and customers of education systems, including policy makers, management of HE institutions, accrediting organizations, governments, funding agencies, affiliated staff members, employers, students, and their families (Abdalla, 2016). This is largely due to a global awareness of the significant impact HE quality can play in the development processes (Siegfried et al., 2007). African HE service provision has been diversified and the number of Universities increased and also enrolments have soared amidst funding and quality challenges (Nakayiwa et al., 2016). In this context higher education encompasses all post-secondary education including both public and private universities, institutes, colleges, diploma and research centres in a country (Africa Union, 2015). From 2000 students in 1970 enrolment had expanded to more than 4.5 million by 2008 and to 9.54 million by 2012 of which 66% are in Sub Saharan Africa (Nakayiwa et al., 2016). Where most countries had a single public institution in 1970, the number of institutions has grown to more than 600 by 2012; and the private sector’s role has developed considerably (UNESCO, 2010). In Sudan, there are tents of public and private universities, private colleges, and technical university colleges that have been established thereby doubling the number of graduates by many folds than their numbers 30 years ago. This is attributed to the HE policy implemented in 1990 by the regime of the former Governments as part of Sudan’s Cultural Revolution (MOHE, 2020).

Sudan, the third largest country in Africa with an area of about 1.88 million km², has a special geopolitical location bonding the Arab world in Northern Africa to Africa south of the Sahara (FAO, 2018). The current population of Sudan is more than 43 million which is equivalent to 0.56% of the total world population and 50.2% are male and 49.8% are female based on Worldometer elaboration of the latest United Nations data (www.worldometers.info/world-population/sudan-population/). More than 40% of Sudan’s population is below 15 years of age representing a typical feature of a developing country. Sudan is characterized by geographical diversity, reflected in its multicultural, multiethnic, and multilingual population (Ahmad, 2010). High population growth in the country (2.6%) implies challenges in terms of provision of services, acceleration of economic growth as well as environment sustainability, resource management and social equity. Sudan is lagging behind on the overarching Sustainable Development Goals (SDGs) for poverty reduction with 46.5% of the

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Sudanese living below the poverty line and on access to safe water and improved sanitation. Also disparities are significant in the incidence of poverty between urban and rural areas, with the hardest hit being in rural areas.

Since the Independence in 1956, Sudan has been burdened with many conflicts which have hindered its economic, social and cultural development (UNEP, 2007). While some of these problems can be attributed to colonial policies within the country, many have been created by the post-independence governing elite. Two rounds of north-south civil war has led to loss of lives of 1.5 million people, and the continuing conflict in the western region of Darfur has driven two million people from their homes and killed more than 200,000 (FAO, 2018). These ongoing conflicts in marginal States, lack of basic infrastructure in large areas, and reliance by much of the population on subsistence agriculture, have resulted in almost half of the population living at or below the poverty line (UNEP, 2011). In 1999, the economy boomed on the back of rising oil production, high oil prices, and significant inflows of foreign direct investment. Since the economic shock of South Sudan’s secession in 2011 and the consequent loss of two thirds of oil reserves, Sudan has struggled to stabilize its economy and make up for the loss of foreign exchange earnings. In addition, the interruption of oil production in South Sudan in 2012 for over a year and the consequent loss of oil transit fees further exacerbated the fragile state of Sudan’s economy. Since then, Sudan has attempted to develop non-oil sources of revenues, such as gold mining and agriculture, while carrying out an austerity programme to reduce expenditures (Mahgoub, 2014; Beshir et al., 2017).

Mostly, due to armed conflicts and civil wars, Sudanese women have been suffering from the lack of basic services, especially healthcare. Maternal mortality, for example, stands at 509 per 100,000 live births. In addition, social and cultural norms, beliefs and traditional practices continue to hinder women from engaging actively in all walks of life. However, female enrolment in primary education increased from 64.4% during 2006-2007 to 69.9% in 2009, while female enrolment in secondary education increased from 30% in 2005 to 35.5% in 2009. In addition, Sudanese women have made progress in terms of representation and political participation. For example, in the 2010 elections women won 28% of parliamentary seats.

In spite of the rapid pace of urbanization (from 8.3% in 1956 to approximately 40% in 2008) Sudan remains rural in its social, economic and cultural outlooks with the majority of the country’s total population living in rural areas (African Development Bank Group, 2010). The gross domestic product (GDP) in Sudan was worth 55 billion US dollars in 2019, according to official data from the World Bank and projections from Trading Economics. The GDP value of Sudan represents 0.05% of the world economy (www.tradingeconomics.com/sudan/gdp). Since independence in 1956, Sudan has been keen to promote agricultural education and qualifying managerial agricultural scientists, as the country is primarily an agricultural country (Mahgoub, 2014). About 90% of Sudan’s exports are agricultural products such as Cotton, Gum Arabic, Cattle, Meat, Oil seeds, Sorghum, Vegetables and Fruits (ARC, 2007; World Bank, 2012). Also, more than 60% of Sudanese graduates of HEIs who are employed in government are males (MOHE, 2020).

It has been documented that within the twenty first century, eradication of extreme poverty as elucidated in the Sustainable Development Goals (SDGs) is a function of knowledge generation and exploitation (Nakayiwa et al., 2016). As such, available evidence suggests that education, health, gender equity, social protection and standards of living have expanded
significantly in spite of the numerous challenges facing Sudan internally and externally (Sudan National Voluntary Report, 2018). Worthy to explore in Sudan therefore, is the role of Higher Education (HE) and its contribution to the knowledge economy and how it impacts on appreciation, adoption and implementation of initiatives that will actualize sustainable development as articulated in the SDGs.

This paper highlights the status and future direction for Higher Education and Scientific Research in Sudan. It provides information on scientifically based understanding of the status of HE in Sudan, its achievements and challenges; an assessment of the contributions of the national, regional and international organizations to Higher Education in Sudan context; and identification of the Higher Education prospects in Sudan including strategic investments for the future such as establishment of Centres of Excellence for Higher education and research in the country. Study methodologies include field work through interviews and observations; and review of existing literature and extensive internet searches. The study covers the history, practices, and status as well as link between higher education and agricultural development. It ends with recommendations for guiding future direction of higher education and research in Sudan.

RESEARCH AND DEVELOPMENT

History of Higher Education in Sudan. Education remains a basic human right. Its function is to develop the talents of individuals to the fullest extent possible so as to enable them participate freely in a society. On the other hand, higher education, also called third-level, post-secondary or tertiary education leads to an academic degree or qualification. Higher Education is an optional final stage of formal learning that occurs after completion of secondary education. The right of access to Higher Education is mentioned in a number of international human rights instruments. The UN Economic Social and Cultural Rights of 1966 declares, in Article 13, that “Higher Education shall be made equally accessible to all, on the basis of capacity, by every appropriate means, and in particular by the progressive introduction of free education” (www.en.wikipedia.org/wiki/). Higher Education is important to national economies, both as an industry and as a source of trained and educated personnel for the rest of the economy. College educated workers have commanded a measurable wage premium and are much less likely to become unemployed than less educated workers.

Formal education in Sudan was started by the British Colonial Administration after their re-occupation of the country in 1898. Previously education was limited to Quranic and other religious schools and the few Sudanese who enrolled in any activity which could be classified as modern or HE were those who enrolled in Al-Azhar University in Egypt. Gordon Memorial College, which later became the University of Khartoum (UofK), was established in 1902 by the British in order to provide the administration with its needs of indigenous manpower in the fields of education and administration. The College had experienced different phases of change which mirrored the economic and social development in Sudan. Through all these phases, the changes were gradual and adequate resources were normally provided. This small scale but balanced pattern continued after independence with the creation of new departments and widening of the range of disciplines offered until 1969. The establishment of the medical, agricultural and engineering schools was in response to the changing realities and needs as well as the aspirations of the population. In 1951, the establishment of technical colleges was closely related to necessity where colleges such as Shambat Agricultural College and Khartoum Technical College helped provide the much needed technical skills on which development projects and municipalities depended.
Inspired youths travelled abroad to gain higher qualifications especially in disciplines where local institutions were not able to train such as medicine and engineering in Egypt and Eastern Europe. The ambitious development plans of the early 1970s were catalyst for HE proliferation, albeit at small scale. A number of technical colleges and new universities were established to provide skilled personnel for the different projects undertaken as well as to fill the gaps created by migration to rich Gulf States in the wake of the oil boom.

Higher Education in Sudan has a long history of interaction with politics. Institutions were affected by the political climate as well as being instigators of political changes. Gordon Memorial College graduates were the force which established the Graduates’ Congress in 1902 that led to the creation of the main political parties in Sudan either directly or as a reaction. The Graduates’ Congress was the focus of the independence movement and its leaders formed the new administration when self-rule became a reality. The involvement of the graduates in politics continued unabated after independence and the influence of University of Khartoum was remarkable in the popular uprising of October 1964 and the demise of the first military regime of General Ibrahim Aboud.

The University of Gezira and University of Juba were established in 1975 at Wad Medani City in Central Sudan and Juba City in South Sudan, respectively, as the first universities in the country to be built outside the capital Khartoum. The University of Gezira is close to the Gezira scheme, one of the biggest agricultural projects in Africa, with main objective being to supply the project with high caliber graduates (Ahmed, 2011). In 1990, other universities were established to serve agricultural development among other needs in specific regions of Sudan. For example University of Kordofan, one of the biggest universities in Sudan, is located in El-Obeid City in North Kordofan State; the university has a Centre for Intermediate Technology in Agriculture. Currently, mandates of Sudanese universities as is the case for other African universities have considerably changed from their traditional teaching and research roles, to greater active involvement in the development agenda of their countries (Beshir et al., 2017). The Khartoum Branch of Cairo University was the eventuality of Egyptian quest for influence among the emerging classes of modern forces and it became the fore-runner for mass HE in Sudan. The range of disciplines offered was crucial in reducing the gap in office skills which University of Khartoum with its elitist nature and budgetary constraints that curtailed expansion failed to deliver. The graduates of this university were disadvantaged because of prevailing prejudices which saw the Cairo University Branch as a quantity institution, in contrast to the University of Khartoum which safeguarded the quality of its courses and graduates.

Later on Omdurman Islamic University helped provide the education system with teachers and later, after expansion and modernization, became another source for manpower in different fields. The conservative nature of the university helped to shelter it from HE upheavals except for a short period of its history.

Role of Ministry of Higher Education and Scientific Research (MOHE). In Sudan, the Ministry of Higher Education and Scientific Research focuses on the provision or regulation of institutions of HE and the oversight of scientific research (MOHE, 2020). The MOHE was initiated in 1971 to carry out the task of setting policies, plans and programmes for HE and scientific research and providing coordination between its institutions. Higher Education and scientific research institutions consist of universities, government and private institutions, research centres and institutes that are established under their own laws and founding orders. These
institutions have scientific, administrative, and financial independence and are supervised by their boards and administrative bodies.

The period of 1970s witnessed the issuance of laws and regulatory bodies of HE in Sudan and therefore is considered a major transformation stage for HE in Sudan. Some of these issuance of laws and regulatory bodies were: establishment of a National Council and a Ministry of Higher Education and the promulgation of the National Council for Higher Education in 1972 (MOHE, 2020); establishment of the University of Gezira in Gezira and University of Juba in Juba as the first two universities to be established outside the Capital in 1975 with the aim of linking university studies with the environment and community needs and meeting the needs of those societies (Beshir et al., 2017); inclusion of all institutes and colleges that were affiliated with departments of MOHE were encompassed after issuance of founding orders for them; and establishment of technical colleges and university colleges, with the assistance of the World Bank. Abu Haraz Agricultural Institute, Abu Naamah Agricultural Institute and Atbara Faculty of Mechanical Engineering were founded in the academic year 1977-1978 to partially meet the country needs for technicians in agriculture and engineering.

The Engaz regime declared that the situation of HE in Sudan had severely deteriorated in all aspects and there was an urgent need for revolutionary reforms (Elhadary, 2016). The year 1990 is considered as a turning point for the HE situation in Sudan. This year witnessed birth of HE revolution and expansion in the establishment of State universities which was adopted by the National Salvation Revolution that came to power in June 1989. The major objectives of this revolution in HE were: to increase student intake at all institutions and reform admission policy; geographical distribution of universities in different States of Sudan; encourage formation of private Higher Education institutions and relate educational programmes with the local environment and the needs of society; abolish student boarding and subsistence schemes; encourage all students studying abroad to come back and continue their studies at Sudanese institutions; and use Arabic language as the only language of instruction at the undergraduate level.

**National Council for Higher Education and Scientific Research.** The Council is the responsible body for formulating policies, plans, objectives, funding, scientific research priorities and all matters regarding Higher Education within the framework of national policy. It grants licenses for establishment of HEIs besides determining the educational and research plans. The Council also helps in universities planning and supervision, defining institutional relations, setting educational plans, defining curricula, and policies implementation. The Council holds its meetings periodically, twice a year at most. It consists of 86 members including the Minister, heads of boards and directors of public universities, heads of boards of trustees and directors of private universities, three private colleges, six deputy ministers of relevant ministries, five members interested in HE scientific research, with the Secretary General of the Ministry of Higher Education and Scientific Research as a Rapporteur. The National Council for Higher Education and Scientific Research has established ten scientific advisory committees specialized in Agricultural and Veterinary Studies, Natural Resources and Environment, Engineering Studies, Educational Studies, Medical Sciences, Economic and Social Studies, Basic Sciences, Legal and Sharia Studies, Computer Studies, Humanitarian Studies, and Scientific Research. These committees advise the council to conduct studies and research, hold seminars, conferences and workshops, study curricula and programmes, establish colleges in governmental and private universities, and submit recommendations to
the Council to authorize them (MOHE, 2020).

**General levels of education in Sudan.** The Anglo-Egyptian condominium in 1898 insisted that education policy should concentrate on a basic elementary education for the masses. With this in mind, in 1900 the colonial authorities started to create a school system, geared to provide Sudanese officials for the lower grades of the administration, and decided to appoint as many Sudanese as possible to posts not requiring education. They made efforts to reopen as many kuttabs (primary schools) as possible, by giving subsidies to teachers. Instructional workshops were set up at Kassala, Omdurman, and at the Gordon College. Later, four government primary schools were created. By 1914 the policy was working, and the students from these schools were filling the lower ranks of the administration. However, this all concerned education for boys. It was in 1907 that education for girls began on the initiative of Babiker Badri. In the 1930s and 1940s there was an expansion in secondary schools in northern Sudan. In 1938 the decision was taken to provide post-secondary schooling, leading towards the establishment of a university. In 1944 these schools were amalgamated to form a university, offering degrees equivalent to a United Kingdom degree. Between 1898 and 1930, the government policy in the South of the country was simply to maintain a basic military control of the area, which otherwise remained undeveloped. Education was in local languages at primary level, and in English at higher level.

The school system was in good shape at independence in 1956, and the new government continued to create new schools and universities. In 1989 there were five public universities and two private universities in Sudan. In September 1990, the Engaz regime islamicized the schools and HEIs were backed by the leaders of the Muslim Brotherhood and Islamic teachers and administrators, who were the strongest supporters of the regime. Within a year the government ordered that Arabic should be used as the language of instruction, replacing English. This decision has made the Sudanese students and graduates less competitive to work outside Sudan.

**Scientific writing in Sudanese HEIs.** Writing is an essential means of communication and the act of creating written work or putting something in written form (Zakaria and Mugaddam, 2013). It may well be considered as one of the most difficult and productive skills. Academic writing is commonly known as scientific writing which is portrayed as organized research practiced and utilized by researchers at HE level. Dynamic and quality research has been the keystone of HE. Research is primarily integrated with academic writing as genre based pedagogies that acknowledge the writing procedure as a necessity arranged with social and cultural response to specific contexts and communities (Al-Mubarak, 2017). Considerable amount of research has recommended that writing in a second language learning context is a difficult and demanding task. Alsamadani (2010) mentioned that the difficulty and complexity of academic writing arise from the fact that it includes discovering a thesis, developing support, organizing, revising, and finally editing it to ensure an effective, error free piece of writing.

The introduction of learning outcomes represents a broader set of expectations about what students should acquire from their studies. This will affect not only teaching in HE, but also the assessment of students’ learning. Assessment methods and assessment criteria must be related to the aims of students’ learning, and crucial for assessment is to decide what is to be assessed. The MOHE helps the HEIs to advance understanding of assessment and evaluation practices and processes, particularly in the contribution they make to student learning, and of course, staff
and institutional development. Generally, this could be done, irrespective of discipline, with setting out to provide readily accessible, up to date information about significant developments within the field, with a view to the sharing and extension of evaluated and innovative practice.

**Education and gender equality in Sudan.**

Female gross enrolment rate (GER) at the pre-school and Higher Education levels has always been and is still higher than for the male GER (UNESCO, 2018). Once enrolled, girls have a good survival rate, of 79.10% at primary level and 97.51% at secondary level according to the 2012 data (UIS, 2017). The high retention rate for girls in the education system may be explained by strong incentives for them to stay in school to delay marriage and entrance into an uncertain labour market. Boys may have better opportunities in the labour market and therefore fewer incentives to stay in school. Additionally, the World Bank (2017) suggests that girls are at a greater disadvantage among marginalized or vulnerable population groups in the population as a whole.

Although some attempts have been made to enhance women’s education, women continue to be generally less represented than men in the labour market. This could result largely from an interaction between social structure, traditional beliefs, family economic conditions, and State policies. According to UNICEF (2020), 49% of girls are missing out on primary education in Sudan. As a consequence of unequal views towards women, educators can easily implement their views on who they allow to enroll in schools, and the large numbers of families who struggle with the cost of education generally choose to give boys educational opportunities.

Indeed, women and girls account for 76% of enrolments in literacy classes and adult education (World Bank, 2012). In addition, the capacity of teachers is low in the country and the severe lack of female teachers often creates a learning environment that is hostile to girls. This can be attributed to the lower rates of schooling for girls in past generations, resulting in lower literacy rates for women and a greater need for catch-up education. To improve education in targeted areas, GPE is investing in initiatives like the Basic Education Recovery Project, to the tune of US$76 million, which significantly helps girls’ education in Sudan (UNESCO, 2018). Despite this discrepancy in number of elementary and high schools for girls, they manage to occupy 54% of the university enrolment in the last ten years (MOHE, 2020).

**Status of Higher Education in Sudan, its achievements and challenges**

**Overview of students enrolment in the HEIs.**

Higher Education institutions statistics in Sudan from 1975 to 2018 based on MOHE (2020) are presented in Figure 1. The HE system is characterized by a range of HEIs including public, private universities, private colleges and technical university colleges. Statistics from 1975 to 2018 indicate a total of 128 HEIs from which 36 are public and 20 are private universities, 53 private colleges and 19 technical university colleges (MOHE, 2020).

Names of the universities, their locations and dates of establishment for the Sudanese public and private universities across the country are presented in Tables 1 and 2, respectively. There are 36 public universities distributed in 26 cities across Sudan, and 20 private universities distributed in six cities, namely, Barbar, Khartoum, Omdurman, Wad Medani and Kosti.

Student enrollment in HEIs from 1980 to 2018 is presented in Table 3. The number of students in HEIs increased from around 26,000 in the early eighties to more than 300,000 in 2018. The rate of student gross enrolment in the Sudanese universities has been increasing for the last 38...
years from 1980 to 2018.

Comparison between male and female registered students in Sudanese HEIs from 1980 to 2018 is presented in Table 2. On average, the data show higher number of female students than male students. Before 1990, the number of male students was higher than females and after 1990 the number of female students increased drastically and consistently.

Summary of students enrolled in HEIs by fields in academic year 2017-2018 is presented in Figure 2. The HEIs offered various disciplines including education, humanitarian, social, administration and law, agriculture, health, science, information technology, engineering and others as services studies. The highest total numbers of students’ enrolments were in social studies followed by education and health.

Figure 1. Higher Education institutions statistics in Sudan from 1975 to 2018
Source: MOHE (2020)
Table 1. Public universities, location and year of establishment in Sudan ranked by the year of establishment

<table>
<thead>
<tr>
<th>Public University</th>
<th>Location</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Khartoum</td>
<td>Khartoum, Khartoum State</td>
<td>1902</td>
</tr>
<tr>
<td>Omdurman Islamic University</td>
<td>Omdurman, Khartoum State</td>
<td>1912</td>
</tr>
<tr>
<td>Neelain University</td>
<td>Khartoum, Khartoum State</td>
<td>1956</td>
</tr>
<tr>
<td>University of Gezira</td>
<td>Wad Medani, Gezira State</td>
<td>1975</td>
</tr>
<tr>
<td>Sudan University of Science and Technology</td>
<td>Khartoum, Khartoum State</td>
<td>1975</td>
</tr>
<tr>
<td>Kordofan University</td>
<td>El-Obeid, North Kordofan State</td>
<td>1990</td>
</tr>
<tr>
<td>The University of Holy Qur’an and Islamic Sciences</td>
<td>Omdurman, Khartoum State</td>
<td>1990</td>
</tr>
<tr>
<td>Nile Valley University</td>
<td>Atbara, Nile State</td>
<td>1990</td>
</tr>
<tr>
<td>The University of Holy Qur’an and the foundation of science -</td>
<td>Wad Medani, Gezira state</td>
<td>1991</td>
</tr>
<tr>
<td>Gezira State</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alfashir University</td>
<td>Elfashir, Darfur State</td>
<td>1990</td>
</tr>
<tr>
<td>Al-Zaieem Alahari University</td>
<td>Khartoum North, Khartoum State</td>
<td>1993</td>
</tr>
<tr>
<td>Dalanj University</td>
<td>El-Dalanj, South Kordofan State</td>
<td>1993</td>
</tr>
<tr>
<td>Sinnar University</td>
<td>Sinnar, Sinnar State</td>
<td>1993</td>
</tr>
<tr>
<td>Imam Mahdi University</td>
<td>Kosti, White Nile State</td>
<td>1993</td>
</tr>
<tr>
<td>Zalingei University</td>
<td>Zalingei, Central Darfur State</td>
<td>1994</td>
</tr>
<tr>
<td>Nyala University</td>
<td>Nyala, Darfur State</td>
<td>1994</td>
</tr>
<tr>
<td>Gadarif University</td>
<td>Gadarif, Gadarif State</td>
<td>1994</td>
</tr>
<tr>
<td>Kassala University</td>
<td>Kassala, Kassala State</td>
<td>1994</td>
</tr>
<tr>
<td>Shendi University</td>
<td>Shendi, Nile State</td>
<td>1994</td>
</tr>
<tr>
<td>Dongola University</td>
<td>Dongola, Northern State</td>
<td>1994</td>
</tr>
<tr>
<td>Red Sea University</td>
<td>Port Sudan, Red Sea State</td>
<td>1994</td>
</tr>
<tr>
<td>Blue Nile University</td>
<td>Damazin, Blue Nile State</td>
<td>1995</td>
</tr>
<tr>
<td>West Kordofan University</td>
<td>El-Nuhood, West Kordofan State</td>
<td>1997</td>
</tr>
<tr>
<td>BakhtElrida University</td>
<td>El-Dowaym, White Nile State</td>
<td>1997</td>
</tr>
<tr>
<td>Albutana University</td>
<td>Rofaa, Gezira State</td>
<td>2001</td>
</tr>
<tr>
<td>Peace University</td>
<td>El-Foola, West Kordofan State</td>
<td>2003</td>
</tr>
<tr>
<td>Sudan Opened University</td>
<td>Khartoum, Khartoum State</td>
<td>2004</td>
</tr>
<tr>
<td>Abdul Latif Al-Hamad University of Technology</td>
<td>Merowe, Northern State</td>
<td>2009</td>
</tr>
<tr>
<td>Bahry University</td>
<td>Khartoum North, Khartoum State</td>
<td>2011</td>
</tr>
<tr>
<td>Islamic Institute for Translation</td>
<td>Khartoum, Khartoum State</td>
<td>2013</td>
</tr>
<tr>
<td>Giniena University</td>
<td>Elginiena, West Darfur State</td>
<td>2014</td>
</tr>
<tr>
<td>University of Managil for Science and Technology</td>
<td>Managil, Gezira State</td>
<td>2016</td>
</tr>
<tr>
<td>Sudan Technical University</td>
<td>Khartoum, Khartoum State</td>
<td>2016</td>
</tr>
<tr>
<td>Technology University</td>
<td>Khartoum, Khartoum State</td>
<td>2016</td>
</tr>
<tr>
<td>East Kordofan University</td>
<td>Kadogly, South Kordofan State</td>
<td>2016</td>
</tr>
<tr>
<td>Eldaein University</td>
<td>Eldaein, East Kordofan State</td>
<td>2016</td>
</tr>
</tbody>
</table>

Source: MOHE (2020).
Table 2. Private universities name, location and year of establishment in Sudan ranked by the year of establishment

<table>
<thead>
<tr>
<th>Private University</th>
<th>Location</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahfad University for Women</td>
<td>Omdurman, Khartoum State</td>
<td>1966</td>
</tr>
<tr>
<td>International University of Africa</td>
<td>Khartoum, Khartoum State</td>
<td>1977</td>
</tr>
<tr>
<td>Omdurman Ahlia University</td>
<td>Omdurman, Khartoum State</td>
<td>1986</td>
</tr>
<tr>
<td>Sudan International University</td>
<td>Khartoum, Khartoum State</td>
<td>1990</td>
</tr>
<tr>
<td>Future University</td>
<td>Khartoum, Khartoum State</td>
<td>1991</td>
</tr>
<tr>
<td>Wad Medani Ahlia University</td>
<td>Wad Medani, Gezira State</td>
<td>1992</td>
</tr>
<tr>
<td>Karary University</td>
<td>Omdurman, Khartoum State</td>
<td>1994</td>
</tr>
<tr>
<td>University of Science and Technology</td>
<td>Omdurman, Khartoum State</td>
<td>1995</td>
</tr>
<tr>
<td>University of Medical Science and Technology</td>
<td>Khartoum, Khartoum State</td>
<td>1996</td>
</tr>
<tr>
<td>IbnSina University</td>
<td>Khartoum, Khartoum State</td>
<td>1999</td>
</tr>
<tr>
<td>White Nile University</td>
<td>Kosti, White Nile State</td>
<td>1999</td>
</tr>
<tr>
<td>Ribat National University</td>
<td>Khartoum, Khartoum State</td>
<td>2000</td>
</tr>
<tr>
<td>Elrazi University</td>
<td>Khartoum, Khartoum State</td>
<td>2001</td>
</tr>
<tr>
<td>Arab Open University</td>
<td>Khartoum, Khartoum State</td>
<td>2002</td>
</tr>
<tr>
<td>Elsheikh Abdallah Elbadri University</td>
<td>Barbar, Nile State</td>
<td>2002</td>
</tr>
<tr>
<td>Mashreg University</td>
<td>Khartoum North, Khartoum State</td>
<td>2003</td>
</tr>
<tr>
<td>Garden City University</td>
<td>Khartoum, Khartoum State</td>
<td>2003</td>
</tr>
<tr>
<td>National University</td>
<td>Khartoum, Khartoum State</td>
<td>2005</td>
</tr>
<tr>
<td>Al-Mughtaribeen University</td>
<td>Khartoum, Khartoum State</td>
<td>2010</td>
</tr>
</tbody>
</table>

Source: MOHE (2020).

Table 3. Students enrollment in HEIs from 1980 to 2018

<table>
<thead>
<tr>
<th>Year</th>
<th>Bachelor</th>
<th>Diploma</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>1980*</td>
<td>17753</td>
<td>10357</td>
</tr>
<tr>
<td>1990*</td>
<td>13954</td>
<td>12174</td>
</tr>
<tr>
<td>2000</td>
<td>106046</td>
<td>121236</td>
</tr>
<tr>
<td>2010</td>
<td>167718</td>
<td>204627</td>
</tr>
<tr>
<td>2018</td>
<td>266005</td>
<td>308748</td>
</tr>
</tbody>
</table>

Source: MOHE (2020)

*: Data not available for the Diploma students and graduates
Table 4. Comparison between male and female registered students in Sudanese HEIs (Bachelor and Diploma) from 1980 to 2018

<table>
<thead>
<tr>
<th>Year</th>
<th>Total number of male students*</th>
<th>Total number of female students*</th>
<th>Total number of students*</th>
<th>Percentage of male students* (%)</th>
<th>Percentage of female students* (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>17753</td>
<td>10357</td>
<td>28110</td>
<td>63</td>
<td>37</td>
</tr>
<tr>
<td>1990</td>
<td>13954</td>
<td>12174</td>
<td>26128</td>
<td>53</td>
<td>47</td>
</tr>
<tr>
<td>2000</td>
<td>112917</td>
<td>128479</td>
<td>241396</td>
<td>47</td>
<td>53</td>
</tr>
<tr>
<td>2010</td>
<td>214973</td>
<td>249135</td>
<td>464108</td>
<td>46</td>
<td>54</td>
</tr>
<tr>
<td>2018</td>
<td>310568</td>
<td>358918</td>
<td>669486</td>
<td>46</td>
<td>54</td>
</tr>
<tr>
<td>Average</td>
<td>134033</td>
<td>151813</td>
<td>285846</td>
<td>51</td>
<td>49</td>
</tr>
</tbody>
</table>

Source: MOHE (2020)

*: The total was calculated by adding Bachelor and Diploma students

It is now argued that Sudan needs high numbers of graduates since there must be enough to assist in community transformation and to face challenges and opportunities of the twenty-first century. Taking into account the number of graduates annually produced by Sudanese HEIs and the disconnect between the industry and the knowledge and skill base of these graduates, the relevance of establishing these universities has been brought to question. Also, the high number of graduates with no jobs shed doubt on the relevance and significance of the established HEIs and industrial and societal needs.

Overview of affiliated staff enrolment in the HEIs. Summary of number of affiliated staff employed in HEIs by discipline in 2017-2018 is presented in Figure 3. The highest total numbers of employed staff were in health studies followed by social and education studies, while the lowest total numbers of employed staff enrolment were in information technology followed by administration and law and other disciplines like service studies. Agricultural studies discipline has also moderate number of employed staff. Generally, lecturers and the teaching assistants are more than the rest of affiliates like assistant and associate professors.

Summary of total number of employed affiliated staff by disciplines and gender in HEIs is presented in Table 5. This data clearly show that employed male staff being more than female staff especially in disciplines like information technology and engineering studies. Generally, both disciplines have the least number of employed affiliates across all disciplines. Agricultural studies has few employed staff even though, more than 80% of the population are working in agriculture. Qualified staff often terminate their jobs at the HEIs and join private companies that often offer better opportunities. On the other hand, the number of employed professors and associate professors in the HEIs is fewer compared to the rest of the affiliates. This could be attributed to the fact that many experts and high caliber professors and associate professors left the HEIs to join private jobs or departed the country to other countries for better earning and lifestyle.
Figure 2. Summary of students enrolment in HEIs by fields during the academic year 2017-2018
Source: MOHE (2020)

Figure 3. Gross affiliated staff employment by discipline in 2019
Source: MOHE (2020)
The number of male and female affiliated staff employed by HEIs in academic year 2017/18 is presented in Figure 4. The highest numbers of employed staff were the assistant professors followed by lecturers and the teaching assistants while the lowest numbers of employed staff were professors and associate professors. From the gender perspective, the number of male staff is higher than female in all affiliates categories. This is despite the fact that there have been more women than men students enrolled in universities since 2000. There is need to help the young staff to pursue their postgraduate studies so as to be promoted to associate professors and professors. The consistent low number of females staff compared to males is explained by the history of education in Sudan which did not promote female education. It is time to narrow the academic gender gap in HEIs and give females equal opportunities for promotion.

The shortage of employed staff is challenging to the capacity of the national institutions particularly the research and educational public institutions. This situation has led to a significant deterioration of academic and research infrastructures, a reduction in the capacity of students’ supervision, lack of learning materials and in the final analysis a decline in the quality of teaching and research. There is thus an urgent need for strengthening the quality of HE and scientific writing in the country. In addition, the quality of teachers is low and the lack of female teachers often creates a learning environment that is hostile to women.

The Ministry of Higher Education and Scientific Research has paid great attention to the shortage of teaching staff in Sudanese universities. The Ministry formed a specialized technical committee that prepares direct online classes chaired by a number of specialists and technicians. The Ministry is focusing attention on developing a hybrid conception that provides services for direct electronic classes (lectures).
which includes teaching components (exercises, lectures and quizzes), and set a schedule for examinations, in cooperation and coordination with the professors’ initiatives abroad. The Ministry indicates that there are programmes and plans the Ministry is striving to prepare in order to bridge the shortfall and facilitate the teaching process for university students.

In 1997 the National Council for Higher Education and Scientific Research introduced a new admission policy to public universities. Each public university was given permission to admit additional 25% of the competing, fees paying students. These students share the same facilities with students entering through normal admission. However, other private HEIs students are given incentives of up to 12% less points than the minimum corresponding score for the general admission determined by general competition. These fees paid by private students are determined by the respective universities, are compulsory and not subject to any negotiation. The annual private fees range from USD1,000 for social studies, to USD6,500 for engineering electricity and up to USD8,500 for medicine. Public universities use this money to pay their lecturers and help public students who are not able to pay their tuition fees. It is now seen that these paid fees are not enough for these public universities to retain their staff and advance their education facilities and learning environment.

Comparison between affiliated staff and enrolled students in the HEIs. The percentage number of affiliated staff compared to enrolled students per discipline in Sudan HEIs is presented in Table 6. In general the average number of registered students in HEIs is 68,0696 while the number of affiliated staff is 21,584 during the academic year 2017/18. The highest number of students (19% of total students) was in social studies while the lowest number of students (3% of total students) was in agricultural studies. However, social studies and agricultural studies had 14% and 10%, of the total affiliated staff in HEIs. The highest number of affiliated staff was in health studies and the lowest was in services and other studies.

![Figure 4. Total number of male and female affiliated staff employed by HEIs during the 2017-2018 period](source: MOHE (2020))
The students - affiliated staff ratio was calculated based on OECD (2020) (Table 4). It is evident that the staff number compared unfavorably to enrolled students in all disciplines. The availability of one affiliated staff ranged from 9 to 128 registered students. One affiliated staff teaches 9 registered students in agriculture, 14 registered students in science, and 17 in health studies. This ratio deteriorates to 1:77, 1:43 and 1:43 in administration and law, education and social studies, respectively. The MOHE (2020) reported that the averaged ratio of affiliated staff to enrolled students was 1:32 based on academic year 2017/18 registered students and affiliated staff. It is apparent from the data that the staff number has not kept pace with students number and there is the need therefore to employ more trained staff. In addition, more rewarding recruitment salaries will undoubtedly stop migration of high caliber staff.

**Higher Education contribution to national and regional development.** Distribution of HEIs in all regions has highlighted the productive role of education in economic growth and development in the country. The positive side of the revolution of 1990 was the increase in the number of students, especially females, enrolled in HEIs. The distribution of HEIs in the States has helped to reduce cost of travelling and accommodation in towns especially in the Central region where 66.4% of the total HEIs are located. In conflict regions like Darfur and Blue Nile and Sinnar regions there are few HEIs, however these HEIs have focused on

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**Table 6. Registered students and affiliated staff, their percentages by discipline and students affiliated staff ratio in Sudan Higher Education Institutions during 2017-2018**

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Registered students</th>
<th>Percentage of registered students per discipline (%)</th>
<th>All Staff</th>
<th>Percentage of all staff per discipline (%)</th>
<th>Students-affiliated staff ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational studies</td>
<td>115193</td>
<td>17</td>
<td>2686</td>
<td>12</td>
<td>43</td>
</tr>
<tr>
<td>Humanitarian studies</td>
<td>65486</td>
<td>10</td>
<td>2194</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Social Studies</td>
<td>132117</td>
<td>19</td>
<td>3090</td>
<td>14</td>
<td>43</td>
</tr>
<tr>
<td>Administration and law</td>
<td>76207</td>
<td>11</td>
<td>987</td>
<td>5</td>
<td>77</td>
</tr>
<tr>
<td>Agricultural Studies</td>
<td>19507</td>
<td>3</td>
<td>2070</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Health studies</td>
<td>82797</td>
<td>12</td>
<td>4957</td>
<td>23</td>
<td>17</td>
</tr>
<tr>
<td>Science</td>
<td>30910</td>
<td>5</td>
<td>2236</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Information Technology</td>
<td>35770</td>
<td>5</td>
<td>842</td>
<td>4</td>
<td>42</td>
</tr>
<tr>
<td>Engineering studies</td>
<td>61638</td>
<td>9</td>
<td>2046</td>
<td>9</td>
<td>30</td>
</tr>
<tr>
<td>Others</td>
<td>61071</td>
<td>9</td>
<td>476</td>
<td>2</td>
<td>128</td>
</tr>
<tr>
<td>Average</td>
<td>68070</td>
<td>10</td>
<td>2158</td>
<td>10</td>
<td>32</td>
</tr>
<tr>
<td>Total</td>
<td>680696</td>
<td>100</td>
<td>21584</td>
<td>100</td>
<td>32</td>
</tr>
</tbody>
</table>
Higher Education and Scientific Research in Sudan: Current status and future direction

Solving political, social and cultural issues for development and political stability. Universities in Sudan have peace building centres running research and activities that help Sudanese authorities and general people to experience tolerance and reconciliation (Mohamed et al., 2008). However, these centres like the universities themselves are poorly funded by the federal government and hardly get external funding as they are official government bodies and hence deprived of benefits.

Higher Education Institutions cannot be leaders in the drive for sustainable development and still expect to carry on business as usual. Therefore, there is need to create more links between HEIs and industry, with more internships, placements and collaboration. Disruption is coming (as evidenced by the COVID-19 pandemic) and HEIs must face the choice of whether to take the initiative and lead the change in areas such as on-line and distant learning, climate justice, fighting poverty and conflict in marginal areas and ensuring gender equality.

Table 7. Distribution of Higher Education Institutions in Sudan

<table>
<thead>
<tr>
<th>Region</th>
<th>State</th>
<th>Public University</th>
<th>Private University</th>
<th>Private College</th>
<th>Technical University College</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Region</td>
<td>Northern State</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>The Nile State</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Central Region</td>
<td>Khartoum State</td>
<td>12</td>
<td>16</td>
<td>39</td>
<td>1</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>Gezira State</td>
<td>3</td>
<td>1</td>
<td>7</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Total</td>
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<td></td>
<td></td>
<td></td>
<td>83</td>
</tr>
<tr>
<td>Blue Nile and Sinnar Region</td>
<td>Blue Nile State</td>
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<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Sinnar State</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>White Nile Region</td>
<td>White Nile State</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
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<tr>
<td>Eastern Region</td>
<td>Red Sea State</td>
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<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
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<td></td>
<td></td>
<td>10</td>
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<td>Kordofan Region</td>
<td>North Kordofan State</td>
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<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>East Kordofan State</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td></td>
<td>West Darfur State</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>South Darfur State</td>
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<td>0</td>
<td>0</td>
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<td>2</td>
</tr>
<tr>
<td></td>
<td>Total</td>
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<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Darfur Region</td>
<td>North Darfur State</td>
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<td>1</td>
</tr>
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<td>Central Darfur State</td>
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<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>West Kordofan State</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>South Kordofan State</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>36</td>
<td>19</td>
<td>52</td>
<td>18</td>
<td>125</td>
</tr>
</tbody>
</table>

Source: MOHE (2020).
Policy environment for Higher Education in Sudan

Policy for higher education. The policy process in HE operates at four levels and also in different modes (Shattock, 2012). The first is at the international level, although less attention has been focused on this level. International agencies such as the World Bank and the Organisation for Economic Cooperation and Development (OECD), are fertile sources of policy. The second is the national level. The most familiar forms of national policy are: (1) legislation, which determine the legal framework in which HE institutions operate; (2) regulatory regimes, which not only enforce these legal frameworks but play an important role in terms of assessment, evaluation and improvement; and (3) funding agencies and regimes, which determine how resources are allocated. Coordination, and certainly coherence, of policies at national level is usually difficult to achieve. The scope of these policies is very wide – policies that determine access to HE and the institutional taxonomy of national systems; policies that focus on research and innovation; and policies that determine the conditions on which foreign students can be admitted. Typically these policies are the responsibility of different Ministries. Outside
the policy process there are numerous interest groups, including the HEIs themselves, students’ organisations and trade unions.

The third is the intermediate level between States and HEIs. The most obvious forms of this level are public agencies responsible for distributing funding to individual institutions and for ensuring, and improving, the quality of HE. The fourth is the institutional level. The policy process within institutions has traditionally taken two main forms namely; (1) academic policy, focused on teaching programmes, the student experience and research priorities; and (2) administrative policy, focused on supporting resources and infrastructure (financial, human and physical). These two forms of policy have tended to be more strongly coordinated, or combined within overarching policy. Institutions have now been obliged to focus more on policy and to develop more robust management systems.

**Policy environment contribution to the development and promoting investment.**

Education in Sudan is free and compulsory for children aged 6 to 13 years. Primary education up to the 2019/2020 academic year consists of eight years, followed by three years of Secondary education. The primary/secondary educational ladder of 6+3+3 years was switched in 1965 and during the Engaz regime to 8+3 with Arabic as primary language replacing English. Then during the 2019 Sudanese transition to democracy, the educational ladder was returned to 6+3+3 with English as primary language in the 2020/2021 academic year. Schools are concentrated in urban areas; many in the South and West were unfortunately damaged or destroyed by years of civil war. There are several HEIs in Sudan such as the University of Khartoum, where even foreigners attend HEIs because the reputation of the universities are very good and the living expenses are low compared to in other countries.

Noteworthy is that the education system in Sudan went through many changes in 1990s. The educational policies in Sudan changed in 1990, when Engaz regime led the country. The HE policy aimed at creating the largest number of universities and public institutes while cutting down on the government spending on government educational institutions. This led to creation of unfair competition among universities. Under these policies the curriculum and the educational system changed, which led to another big gap between educational achievements and employment. Graduates from schools or universities possess a lot of information about the nature of their field of study, but are hundreds of miles away from labour market skill demands. Currently, the graduate also suffers from not having regularly updated and developed curricula. There is also widespread technical illiteracy among most students in Sudanese universities, in addition to the limitations that were imposed by US sanctions that affected science students and innovators in Sudan. The rapid expansion in student intake without corresponding increase in the quality of academic environment has had negative impacts on research performance at HE institutions. Up to the present there is no direct funding for research at Sudanese universities.

Engaz government only provided 3% of its 2015 budget to education and creating educational environment (Radio Dabanga, 2018). This percentage for a country like Sudan, which suffers from both illiteracy and poverty, was intended to tighten control over the people who had to take their children off school as a result of high government fees or even so that children could work and have an income to help their families. As well, it was justified for teachers to leave public schools and work at private institutions as a result of low salaries, and lack of improvement in the public school environment. Additionally, the lack of improvement in educational infrastructure and development was
made worse with the loss of oil revenues.

Funding of HE in Sudan historically came from the government and this trend continued till the birth of HE revolution in 1990. Since then private bodies became major partners in sponsoring HE. The rapid expansion of the HEIs has resulted in remarkable funding decline. The public universities responded to this financial cut by amending their admission requirements so as to increase student intake, and raise student fees. This rapid expansion in student intake without corresponding increase in the quality of academic environment has had negative impact on research performance at HEIs, with very limited research outputs over the last 20 or so years.

After the Sudanese Revolution in 2019, percentage of the national budget spent on education is planned to increase to 20% (Radio Dabanga, 2019). However, there are a number of local Non Governmental Organizations (NGO) that work in education in Sudan. The most prominent is the Sudanese Organization for Education Development, which focuses on basic education (www.soed-sd.org). Among international NGOs, the most active in Sudan are Save the Children Fund, Refuge Care Netherlands (ZOA), Plan International Sudan, Education Above All, Association of Religious Data Archives (ADRA), the Jesuit Refugee Service, The Sudanese Organization for Combating Violence Against Women and Children (SAO), World Vision, Islamic Relief Worldwide (IRW), amongst others.

The extraction of petroleum in 1999, the signing of the CPA in 2005 and discovery of Gold mining in the North, among others, have led to considerable increases in the volume of foreign investment. Currently, HEIs have sufficient institutional arrangements and practices that can bring HEIs closer and form a common research and innovation agenda. Sudanese HEIs and government public research institutions, as important sources of information for innovation, should raise their profile as sources of innovation and work on linkages with local, regional and international bodies to explore possibilities for the commercialisation of innovations.

The secession of South Sudan has deprived the country of 24% of population, 25% of its total area, 30% of potential arable land, 25% of its water resources and over 80% of its oil income. The economic situation became more precarious with the Darfur and Blue Nile region conflict. Economic crisis no longer looms over the country, but has created pressures from the international society and deprivations of loans and financing. The only viable economic sector is agriculture, with industry demise due to heavy taxations, expensive inputs prices, devaluation of the Sudanese currency and increases in levels of foreign currencies exchange rates. The agricultural sector created 39% of the GDP, employed about 80% of population, and contributed 80% of the country’s exports (FAO, 2018). Additionally, Sudan is endowed with arable land, animal resources, fresh water sources and a variation in climate that makes the country ideal to contribute significantly to the world food security. The Government could expand agricultural educational assistance by building the capacity of the HEIs with the goal of promoting greater food and nutrition security. Assistance should also be given to HEIs, civil societies, and private sector groups and there is need to provide technical assistance to HEIs and other bodies to prepare project proposals for grants.

Higher Education prospects and strategic investments in Sudan

Presence of public and private education. Distribution of public and private universities, private colleges and technical university colleges in Sudanese States in 2019-2020 is presented in Figure 6. Khartoum State had the highest number of public universities (12) followed by Darfur (6), Kordofan (4) and the Northern and the Nile States (4). In 1966 the first private university Ahfad University for
Women was initiated in Omdurman, Khartoum State. It was founded as a familial tradition of educating girls in Sudan. In 1907, Babiker Badri opened up his secular school for girls in a mud hut with nine of his own daughters along with eight neighbourhood girls. Badri family carried on this tradition of private education for three generations in Sudan until Babiker’s son, Yusuf established Ahfad in 1966. The college was then granted full university status in 1995 by the Sudan National Council for Higher Education due to its expansion of curriculum and students’ body. It remains the oldest and largest private university in Sudan to date.

Sudan University of Science and Technology (SUST) began as the Khartoum Technical School and School of Commerce in 1902. The School of Radiology (1932) and School of Arts (1946) were then merged to Khartoum Technical School and School of Commerce to form Khartoum Technical Institute in 1950. The Shambat Institute of Agriculture (1954), Khartoum Senior Trade School (1962), Institute of Music and Drama and the Higher Institute of Physical Education (1969) were merged with Khartoum Technical Institute and renamed as Khartoum Polytechnic Institute (KP) in 1975 and later it was accredited in 1990 as Sudan University of Science and Technology (SUST). Today SUST is one of the biggest public universities and ranked first in Sudan.

In 1977, the International University of Africa was established as a private institute with the major role of educating young African Muslims and training preachers. The institute thrived on financial help and donations from Saudi Arabia and other Arab States in the Persian Gulf. In 1992 the institute was upgraded to a private university which since then has kept active in Islamic HE, training students mostly from sub-Saharan Africa.

![Graph: Types of Higher Education Institutions and their distribution in Sudan](image)

**Figure 6. Types of Higher Education Institutions and their distribution in Sudan**  
*Source: MOHE (2020)*
In Early 2000s there was great need for providing HE for those with social, economic or age conditions and as an extension of the revolution of HE, it was necessary to provide open education in various regions in Sudan. The Open University of Sudan (OUS), established in 2002, is a public university that provides bachelor and postgraduate courses through distance learning with no age limits. The OUS has 12 departments, centres and E-learning projects that provide services to thousands of students in finance, public relations, education, libraries, human resources management and linguistics.

In 1990s after the boom of HE revolution, several private universities and colleges were initiated in Khartoum (16 universities, 39 colleges), Northern and The Nile (1 university), Gezira (1 university, 7 colleges), the White Nile State (1 university, 2 colleges) and The Eastern States (4 colleges). The MOHE is required to open windows and give some incentives for private sectors to establish private colleges and university colleges in marginal areas.

### Strategic investments for the future and centres of excellence in Sudan

Sudan, a country with a rich cultural heritage and enormous potential for development, is the point where Africa meets the Middle East. As a country aspiring toward peace and prosperity, Sudan must invest in its human resources, first of all in its children and youth education. This is one track to see Sudan prosper and move forward. Today, MOHE and HEIs leaders, however, need to re-think again: what would be the right way to ensure sustainability through long-term behavioral change in HE in Sudan? They should put strong emphasis on empowering communities and private sector to take a more active role in the education process. This should include identifying their own needs through inclusive community base associations to taking charge of resource mobilization and HEIs construction with primary government support but also attracting private sector participation.

The private sector may also avail grants and funds that may alleviate some basic needs, such as administrative fees and infrastructure, for the most vulnerable communities of students, often hosted by the communities. This should assist making education affordable for a wider range of students and provide some basic needs for empowered youth thus ensuring their enrollment in HE to develop skills necessary to contribute to the nation’s economic transition.

The MOHE has strong relationship with other institutions from other line ministries and stakeholders in and outside Sudan. Currently, there are private companies that support HE in Sudan by sponsoring students by paying tuition fees, paying for accommodation and availing scholarships for staff to pursue their postgraduate studies in and outside Sudan. However, there is need for more collaboration and partnerships in research and advocacy to ensure that Sudan can tackle the challenges of food and nutrition insecurity, water resource use, climate change, disease outbreaks like transboundary animal diseases, Corona Virus Disease 2019 (COVID-19) and the push for industrialization. The country will also need to invest in data science and digital technology to enable it move towards the Fourth Industrial revolution, an aspiration for countries all over the world. Establishment of training and research centres of excellence in some of these areas will help the country meet the SDGs and contribute more effectively to Africa Union aspirations enshrined in Agenda 2063. This important step requires strategic partnerships with especially African and Arabic governments, private sector as well as global knowledge centres.

### Quality and relevance of HEIs in Sudan

Considerable efforts have been made over the past few years to develop an effective national framework for quality assurance. Part of these efforts resulted in the establishment of the Evaluation and Accreditation Commission in 2003 as a specialized authority to create and encourage a culture of quality assurance.
and accreditation within all HEIs, and to check out that the HEIs are accountable and effective in delivering academic programmes and services. However, the statistics from face to face interviews indicate that there is a quality gap between intended and actual quality assurance practices. Practical implications and recommendations for improved quality assurance practices at Sudanese universities are provided. Therefore, it is the time for current policy makers of HE in Sudan to question what has gone wrong and what has been forgotten in an attempt to put it right in their future policy priorities.

The HE system in Sudan has been affected negatively under the previous governments and many changes with profound cultural and political implications were introduced. The overall impact of these changes is to attempt a social transformation in line with the ideology of the fundamentalist regime. The impact on the economy of the country and the much needed skilled manpower is of grave consequences as changes are motivated by hasty needs for political conformity. At the core of the high and persistent level of poverty in Sudan lie low job creation rates, increasing unemployment and a low level of productivity and know how.

Political instability and the changing state of world economy, coupled with hasty and inadequate and sometimes corrupt economic decisions, caused the failure and abandonment of several projects. The stabilization of oil prices and the development of indigenous work force, reduced employability of Sudanese workers in the Gulf. All this coupled with austerity measures in Sudan have resulted in a serious problem of unemployment among graduates.

For students and for society, a core aspect of HE is to prepare for future employment. Research on employability has to be taken as the starting point for targeted training investment, to align with the labour market. However, what has been done does not take into consideration changes in the labour marked that might make it easier or more difficult to obtain a job independently of the qualifications of the candidates. Knight and Yorke (2004) suggested four main areas of competence that constitute employability: Understanding: mastery of the subject matter of a field; Skillful practices: called “generic skill” in addition to subject specific skills; Efficacy beliefs: trust that one can make some impact on situations and events; and Metacognition: awareness of one’s own competence as well as limitations combined with an insight in how to learn more and called the USEM model.

Currently, effective quality management systems within HEIs are becoming priority in national HE strategies for almost all countries throughout the world. Since the 1990s Sudan has experienced mass HE, associated with growing number and size of institutions and the diversity of programmes delivered. Hence, concerted efforts should be undertaken to assess and improve HEIs quality. One of these efforts has to lead to work actively with private sector and civil society institutions through Boards and by establishing joint research and outreach platforms.

**CONCLUSIONS**

There are 36 public universities distributed in 26 cities and 20 private universities distributed in six cities out of the total 26 cities in 26 States in Sudan. The HEIs offer various disciplines that include education, humanitarian, social, administration and law, agriculture, health, science, information technology, engineering and others as services studies. Number of students in HEIs has multiplied nine times since the early eighties (26,000) compared to 2018 (300,000). Percentage of female students has increased from 37% in 1980 to 54% in 2018 while percentage male students have reduced from 63% in 1980 to 46% in 2018. Most students register in social followed by education and health studies. Surprisingly, few numbers
of students register in agricultural studies, science and information technology. Further, highest numbers of staff were employed in health followed by social and education studies. The lowest numbers of employed staff were in information technology followed by administration and law and other disciplines like service studies.

Data showed that lecturers and the teaching assistants are significantly more than professors, and assistant professors; 64% of total number of employed staff are males and 36% are females. This study found out that the averaged ratio of affiliated staff to enrolled students is 1:32 (thirty two students for every staff member) which is considered higher than the averaged world ratio of 1:16.5 (World University Rankings, 2020). Amongst the 600 best universities in the World University Rankings in 2019, none has more than nine students for every staff member. A joint pilot study conducted by the Association of African Universities, Ghana’s National Council for Tertiary Education and the Population Reference Bureau shows that Ghana alone needs an additional 3,410 faculty who are PhD holders to achieve the government’s desired teacher-student ratio, and as many as five times that number if the country is to achieve its policy goals by 2025. Certainly, the situation is much worse in Sudan than Ghana, calling for more than tripling investments in HE in the country.

It is apparent from the data that the staff number has not kept pace with students numbers, requiring more trained staff. The rapid expansion of HE was not accompanied by the increase in staff quantity and quality, not to mention the small number of professors nor in infrastructure development. The impact of this shortfall is that students do not fully understand what is being taught because there are not enough faculty members to tailor learning, track students’ grades, track absentees or provide any additional support.

The revolution of 1990 made HE accessible for all students regardless of socio-economic status and constraints. The Central region (Khartoum and Gezira states) had the highest percentage of public universities (66.4%). The Eastern region had 8% of them as universities and private colleges, Darfur (6.4%) and White Nile (6.4%) regions had low percentages of HEIs. There is a need to establish HEIs in the Blue Nile and Sinnar region because they had the lowest percentage (2.4%) followed by Kordofan (4.8%) and the Northern (5.6%) regions. The Central region had 89% of the private HEIs which is the highest percentage. This could be attributed to the presence of private sector interests and high population size. There is need to establish private HEIs in Darfur, Kordofan and Blue Nile and Sinnar regions too. However, the Northern, White Nile and Eastern regions accounted for 11% of the private HEIs. Outside the Central region (42%), Darfur (17%), Kordofan (11%) and Northern (11%) regions had modest public university percentages. The Eastern (8%), White Nile (6%) and Blue Nile and Sinnar regions had low percentages of public universities. Generally, there is need for government and private sectors to establish institutes in those regions with low HEIs so as to give opportunity to more students in those regions.

The private universities and private colleges are not only concentrated in one location, Central region, but also not well-prepared to address issues related to diversification besides having low enrolment. There are no major differences between disciplines offered by public and new private institutions. It may be said that private institutions are based on profit rather than addressing the needs of the country. Accessibility of HEIs has been made possible by the opening of non-conventional education such as distance education which also serves as a response to the growing social demand for more diverse academic programmes. But lack of qualified teaching staff and education infrastructure coupled with the mass waves of students has led
to low quality and quantity output of training and research. Currently, university environment is not conducive to conduct quality research. Moreover, there is need for the Government to expand agricultural educational assistance by building capacity of the HEIs to enhance food and nutrition security.

Higher Education in Sudan has proven to be long-lasting despite eras of change and social upheaval. Today, 125 Sudanese HEIs face the most challenging time with issues thrust upon them by elected officials, economic changes, shifting values, political polarization and diverse demographics. However, these HEIs should use this time to focus their efforts and search for opportunities rather than hope for the past, continue to attract students, local, regional and international collaborators and employers for better cooperation to meet the needs of their communities. Innovation and improved services will contribute to production of high human capitals that will have an effective role on economic and social growth. Continuous reform and adoption of modernized curricula and improved teaching methods and practical solving research problems will gain the confidence of the labour market and increase opportunities for more jobs and unemployment reduction.

In Sub Saharan Africa, the value added from a college degree boosts earnings by over 20% (Chamorro-Premuzic and Frankiewicz, 2019). While university qualifications become more commonplace, employers will increasingly demand them, regardless of whether they are actually required for a specific job. Therefore, universities could substantially increase the value of the college degree if they spent more time teaching their students critical soft skills. Chamorro-Premuzic and Frankiewicz (2019) reported that half of organizations listed problem solving, collaboration, customer service, communication, adaptability, culture fit, and growth potential for in-demand technical skills as the most valued skills requested by employers. Additionally, employers like Google, Amazon and Microsoft have highlighted the importance of learnability, which is being curious and having a hungry mind, as a key indicator of career potential.

Nevertheless, the HE revolution reform of 1990 in Sudan led to the degrading culture of research that accommodates society needs and concentrates on teaching as the main institutional function. Like other HE systems in developing countries, the HE sector in Sudan is currently experiencing substantial challenges. Some of these challenges include, among others, unplanned enrolment expansion according to community needs, brain drain among the academic affiliated staff and immigration to seek for high payment, and shortage of regional and international funds and scholarship opportunities due to sanction from USA which steered staff training to be local and only very few lucky staff find personal chances for regional or international training. Besides, deterioration of research due to lack of research funding, there is no research policy to direct research to address community needs and this is made worse by lack of partnership with leading organizations in Africa and across the globe. Also poor English language that is reflected in failure to write manuscripts and fundable research proposals adds to the challenge of dwindling resource base and regional and global isolation.

RECOMMENDATIONS
September 2020 marks five years since UN Member States unanimously adopted the SDGs, laying out 17 goals for the world to be achieved by 2030 with a view to ending poverty, protecting the planet and ensuring that all people enjoy peace and prosperity. Sudan is not excluded from this action. In order to make change and be able to achieve the mentioned SDGs, Sudan Government should support the MOHE to be able to focus on several issues. For example, MOHE with support from the Government should consider developing a policy to train,
promote and support HEIs affiliated staff and graduates to participate in curriculum and innovative research development and fund raising. The ministry should also seek more collaboration with private sector towards finding solutions and technologies that fit their interests and secure funding for their students. On the other hand, academic writing skills mostly involve the linguistic competence development of the students which many English Second Language learners, like the Sudanese, may identify as a challenging task. Some editors might describe the writing proficiency of the Sudanese university students to be poor as many students lack the basic skills required for communication writing. The Government through the MOHE should step in and help affiliated staff and students enrolled in HEIs to enhance their academic writing and grammar skills. The graduates need to be familiar with authentic written materials so that they can observe how writing is used by native speakers. Writing instructors and syllabus designers should consider this issue when devising writing materials and activities.

Nevertheless, curriculum and teaching methods reforms in universities are needed to ensure a focus on SDGs. A big challenge to meeting the SDG time frames is brain drain. Youth are leaving Sudan as soon as they graduate, which is depleting the country of the skilled human resource that it seriously needs. Sudan needs this manpower back and needs to come up with programmes that can successfully answers the needs of the society that support it, provide employment to youths, and give incentives to the highly qualified so that the country can retain them. It is also important for MOHE and HEIs leaders to revisit educational programmes and focus especially on education in the fields of science, technology, engineering and mathematics, while paying attention to girls because the science and mathematics gap by gender is very wide (Figures 3 and 5). In the same vein, MOHE and HEIs leaders should rethink their higher educational systems and use them to prepare young people for specific types of work. Young people can then take advantage of the Sudanese or African or Arabic evolving megatrends. There is a need to start building capabilities of the future generations of Sudan by nurturing them to become better at seeking and creating opportunities for employment.

Besides, resilience enhancement has potentially many ingredients. For example, it challenges HEIs leaders to improve everybody’s awareness of challenging situations, create partnership networks to address short-term students’ needs and run stress testing drills to clarify crisis management roles and provide an additional protective layer. Further action points can be identified through focusing on the enhancement of organizational resilience by strengthening the institution’s anti-fragility mechanisms. There is a need to use financial flexibility and/or enhancing this further or obtaining contingent funding to cover short term liquidity gaps and to find approaches to address the long-term gaps and move away from a reliance on private students to finance poor students’ fee subsidies and staff salaries. Also anti-fragility mechanisms build on institutional resilience and also aim to generate strategic benefits as a result of the disruption. The 2020 Covid-19 pandemic highlights this issue. Thus, the HEIs should be more responsive to change and be more willing to make adjustments to find the best way forward, which can potentially improve HEIs market positions relative to others and reap the rewards accordingly. The need to find new ways of widening and ensuring access to HE is evident. Quality assurance and continuous improvement of services will also attract foreign students who will create international experience to the staff and students, bring new mindsets and a global outlook that enriches academic and social environment.

There is also urgent need for accreditation of HEIs to be carried out to raise the quality of HE
services. Accordingly, there is need to activate the role of universities boards of directors and inclusion of private sector representatives in these boards will assist in assuring that graduates have the right skills for the labour market. Importantly, there is urgent need for strategic investment in infrastructure and human resource capacity to support Higher Education and research in Sudan; and indeed the wider education and S&T value chains. This would require among others:

a. Investment in infrastructure development for training and research in Sudan universities and research institutions, paying attention to regional balance.

b. Investment in human capital development in terms of increasing intake for postgraduate training and for staff development for universities and research institutions. This needs attention in light of the urgent need to strengthen staffing and research capacity in Sudan. In these efforts attention needs to be paid to inclusivity issues.

c. Strengthening integration of Sudan Higher Education and Research into especially Africa Higher Education space, utilizing platforms such as the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM). In this regard Sudan Government needs to put in place mechanisms for training its Postgraduate students in different African universities, and also bringing in students from other African countries to train in Sudan.

d. There is need to reposition Sudan as a Higher Education and research hub in Africa, in strategic areas to Sudan development and in areas where Sudan has comparative advantage. As such it is recommended that Sudan Government through well-structured and independent review processes establishes HE Centres of Excellence in targeted fields. Possible areas could include Centres of Excellence in Agro-Food Systems, Management of Water resources and Irrigation, Management of Transboundary Animal Diseases (Centre for Animal Diseases Control), Climate Change Studies and Agrometeorology, Centre for Human Health Disease Control, Digital Innovations including Data Science and Foresight studies, amongst others.

e. The MOHE and Government of Sudan need to promote Technical and Vocational Education and Training (TVET). The TVET addresses the need for skilled manpower in both existing and emerging economic sectors to be able to compete in and outside Sudan. There is thus need to offer various technical programmes to provide human resource training to meet the needs of the world of work at the middle professional level.

f. There is need to set up programmes to build entrepreneurial skills of Sudan youth and enhance their employability.

g. Finally, there is need to establish a Research and Innovation Fund for generating research outputs and innovations, and for supporting linkage with Industry.

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

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ABSTRACT
Ghana has shown keen interest in promoting Science, Technology and Innovation (STI), and Higher Education (HE). However, the STI and HE systems do not seem to be adequately focused on Ghana’s socio-economic needs. Furthermore, existing STI and HE policies and programmes 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. The study was undertaken to examine the role of STI and HE policies in capacity development in Ghana. The desk study showed that there has been a lot of investment in setting up STI and HE institutions which have yielded some positive outcomes especially in the country’s recent research output. Progress on Ghana’s capacity for STI looks encouraging, given that Ghana’s overall Africa Capacity Index is Medium primarily because of a narrow financing base. The country also currently has a comprehensive STI policy draft to work with up to 2024. However, there is the need for Ghana to put in place workable monitoring and evaluation strategies on STI and HE policies and programmes. This will enhance the impact of STI and HE on the economy of the country.

Keywords: Education, Ghana, innovation, science, technology

RÉSUMÉ
Le Ghana a montré un vif intérêt pour la promotion de la science, de la technologie et de l’innovation (STI) et de l’enseignement supérieur (ES). Cependant, les systèmes STI et ES ne semblent pas suffisamment focalisés sur les besoins socio-économiques du Ghana. En outre, les politiques et programmes existants en matière de STI et d’ES ne semblent pas suffisamment motivants pour stimuler les investissements et la modernisation technologique. C’est pourquoi de nombreuses institutions importantes du pays dans le domaine des STI ne sont pas en mesure de s’acquitter efficacement de leur mandat. L’étude a été entreprise pour examiner le rôle des politiques de STI et d’enseignement supérieur dans le développement des capacités au Ghana. L’étude théorique a montré que de nombreux investissements dans la création d’institutions de STI et d’ES ont donné des résultats positifs, en particulier dans les résultats de recherche récents dans le pays. Les progrès concernant la capacité du Ghana en matière de STI sont encourageants, étant donné que l’indice de capacité de développement du Ghana par rapport aux autres pays africain est moyen, principalement en raison de la base de financement étroite. Le pays dispose actuellement d’un projet de politique

Mots clés: Education, Ghana, Innovation science, technologie

INTRODUCTION
Role of Higher education (HE) and Science, Technology and Innovation (STI) in capacity development. In many African countries, basic education is seen as a right and most children have access to it. However, Higher Education (HE) especially in Science, Technology and Innovation (STI) is more crucial for the development of African nations (Addo, 2010; Brito, 2014). Similarly, higher education in Africa has been identified and recognised as a significant tool in facilitating Africa’s development process (NEPAD, 2005). Higher education is any form of formal training given by Universities, Colleges and other institutions established and approved by competent authorities and for which the basic entry requirement is the completion of secondary education (UNESCO, 1998). On completion of HE, students acquire honour certificates, diplomas or degrees. The role of higher education towards sustainability of Africa’s social, political and economic development is not contestable (Jowi et al., 2016). Countries which have expanded higher education systems with higher levels of investment in research and development (R & D) activities have higher potential to grow faster in the globalised knowledge economy (Varghese, 2013).

African countries are probably taking inspiration from China and Brazil which have given priority to and have established a strong link between HE and STI. They are typical models for consideration by policy makers. Current trends show rapid establishment of Universities and colleges in Africa with several of them offering programmes in engineering, technologies and the sciences. This trend is indicative of enhanced wealth creation and improvement in the competitiveness of such nations and stimulates their attainment of the sustainable development goals of the United Nations (UNESCO, 2018).

Historical background of Higher Education and STI in Ghana. In 1995, a coordinated programme of economic and social development policies, dubbed Ghana - Vision 2020 was designed, which emphasized the need to promote a Science and Technology (S&T) culture at all levels of society and in all types of production to accelerate economic growth and improve the quality of life of the population. The potential for Science and Technology (S&T) to promote economic growth and poverty reduction was given prominence again in Ghana’s Growth and Poverty Reduction Strategy (GPRS II - 2006-2009) (GoG, 2005). The policy document identified S&T as a key strategic support sector that needed to be developed to catalyse productivity in agriculture and agro-industry. Information and Communication Technology (ICT) was prioritized as an important sector to be developed to support economic growth.

In 2007, the National Development Planning Commission (NDPC) included STI development agenda in the long-term policy development framework for the country. Subsequently, in 2009, the Ministry of Environment, Science and Technology (MEST) initiated a process to prepare a Science, Technology and Innovation (STI) policy for Ghana. This process led to the development of an STI Policy in February 2010. A review by UNCTAD and other organisations in 2011 showed that most of the expected results from planned initiatives of the 2010 National STI Strategy were not achieved. To leverage on
the foundation laid by previous government policies and to accelerate the mainstreaming of STI in all sectors and interventions across the country, the Government of Ghana has developed a new STI Strategy (currently in draft). In addition, the Government is in the process of developing a new National Development Policy (NDP) that takes into consideration the social and economic context and the imperatives of Ghana’s development over the period from 2017 to 2020. The new policy aims to enable the country to harness the development potential that STI offers in a constructive and structured manner. This NDP adequately highlights the role of STI and HE in national development and also points out that improvements in STI and HE 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.

HE and STI Policy landscape in Ghana. Science, Technology and Innovation (STE) and Higher Education (HE) are critical drivers of rapid economic growth and development in every country. Since Ghana attained independence in 1957, conscientious effort and investments have been made to place STI and HE at the centre of the country’s development agenda. All past governments of Ghana attempted to mainstream STI into their national development policies to drive socio-economic development of the country. However, the effort to use STI as a catalyst for the country’s growth and development has not yielded the expected benefits regardless of the huge investment made in STIs over the years. Consequently, the desired economic transformation and growth has not been realised. Inadequate political commitment and financial support for effective planning and implementation of strategies have been identified as the main causal factors of the unsuccessful attempts to use STI and HE as drivers of Ghana’s socio-economic development agenda.

Capacity development priorities for HE and STI. The major capacity imperatives for effective STI and HE in Ghana’s context include the need for the Ghanaian Government to create institutional arrangements that promote STI and HE in accordance with the Sustainable Development Goals to solve capacity-related problems. Another major priority for STI and HE capacity development is the urgent need to build capacity among researchers, industry, communities, and individuals to tap into new and emerging opportunities in STI and HE. The 2017 ACR report indicates that Africa’s quality of tertiary education is a major concern with only five of the world’s top 500 universities in the continent, against six in Brazil and 32 in China. The report further stressed that the ranking of universities is of utmost importance as an indicator of university outputs, including numbers of papers published in top journals, of awards and recognitions received by universities, staff, and alumni, and of citations of published papers.

Furthermore, there must be strategic investments and capacity development in Science, Technology, Engineering and Mathematics (STEM), and in innovation systems to catalyze innovation, promote competitiveness, and nurture the next generation of innovators, entrepreneurs, and scientists. The 2017 ACR report noted that investment in science capabilities of countries, and development of STI institutional capacity are crucial to the application of STI in Africa, and are central to the provision and management of HE. Investments in STI and HE are fundamental to sound policy making, good governance, and economic transformation. STI policies and their implementation must be inclusive and gender-sensitive to
Role of higher education and science, technology and innovation in capacity development in Ghana

deal with the low participation of women in STI and HE. In order to attract women and girls to STI and HE gender should be mainstreamed in STI policy and programs; fellowships, scholarships, and award systems; career guidance and mentoring in institutions of higher learning; adaptation of curricula; and continuous sensitization and lobbying of policymakers and legislators (ECA, 2011). Reducing the gender gap through the promotion of women’s participation in STI development, and encouraging girls to pursue science and engineering programmes, have the potential to make African societies more vibrant and its institutions more resilient and responsive. Finally, it is imperative that the Government provides a conducive environment that propels creativity, innovation, and inventiveness and guides the acquisition and commercialization of R&D for sustainable growth and development. That way most of the nation’s youth will be attracted to embrace STI and HE. Finally, Ghana should promote international collaborative bilateral and multilateral partnerships based on STI and HE best practices.

Vision, Goal and Objectives of the STI and HE capacity policy

Vision. The STI Policy should envision a Ghanaian economy transformed to world class standard with STI and HE as the key drivers. The policy should aim at building a strong STI capacity to drive the social and economic development for the sustainable transformation of the economy. The policy must target a country transformation from the current low science-and technology-poor practices in line with the global consensus on STI to knowledge-based society functioning within an economy based on high levels of productivity in all the sectors of the economy including agriculture, industry and services.

Goal. Given the historical background of Ghana’s efforts in STI application and HE development, the STI and HE policy must be properly contextualized, aligned with national development goals and fully integrated into a national development strategy to fully harness the nation’s total science and technology capacity. That way, the national objectives for wealth creation, poverty reduction, enterprise competitiveness, sustainable environmental management and industrial growth will be achieved.

Objectives

The STI and HE Policy should aim to:

- Facilitate mastering of scientific and technological capabilities by a critical mass of the products of all institutions;
- Provide the framework for inter-institutional efforts in developing STI and programmes in all sectors of the economy to provide the basic needs of the society; create the conditions for the improvement of scientific and technological infrastructure for research and development and innovation;
- Ensure that STI supports Ghana’s trade and export drive for greater competitiveness; and promote a science and technology culture in the society.

Rationale and objectives of the study

Science, Technology and Innovation (STI) and Higher Education (HE) have long been considered critical for the growth and development of Ghana. There is substantial evidence that STI and HE are instrumental to creating sustained economic growth and improving standards of living in Ghana. STI and HE are central to economic development, trade competitiveness, and social progress. Improvements in STI and HE 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 HE and STI 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 order to harness the potential that STI and HE offer for economic growth, Ghana Government needs to design comprehensive STI and HE policies, and support their deployment with adequate budgetary allocation, practical implementation strategies and monitoring and evaluation mechanisms.

In Ghana, many of the building blocks required to support STI and HE policy development including reputable universities, research institutes, and a growing private sector are already in place. However, the STI and HE systems do not seem to be effectively coordinated and adequately focused on Ghana’s socio-economic needs. Furthermore, existing STI and HE policy and 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. It was in recognition of the critical roles that HE and STI play in Ghana’s economic development that the study was done to examine the role of STI and HE policies in capacity development in Ghana. Specifically, the objectives of the study were as follows:

- Conduct an overall assessment of Ghana’s HE and STI policies and their integration into National Development Plans (NDP)
- Discuss the capacity development priorities for HE and STI
- Assess the role, status and key challenges of HE and STI environment in capacity development
- Identify and discuss related and complementary policies to HE and STI policies in Ghana
- Discuss policy monitoring aspects of STI and HE policies
- Present case studies of HE and STI contribution to capacity development in Ghana

**RESEARCH METHODOLOGY**

The study focused on the role of Higher Education and Science, Technology and Innovation in capacity development in Ghana. The study was done mainly as a desk study involving literature review and document analysis. The desk research helped in the retrieval of information on STI and HE policies of previous and present governments as well as other international documentation regarding Ghana’s STI and HE policies among others. The Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) provided copies of some documents and others available online were retrieved. The documents provided by RUFORUM included ACBF 2017 Report and UNESCO Science Report 2018. Furthermore, RUFORUM provided a template of specific issues to be addressed to serve as the main guiding tool for literature search for information that addressed questions posed therein. Data obtained during the study was analysed by descriptive statistics using Microsoft Excel.

**RESULTS AND DISCUSSION**

**Assessment of Ghana’s STI policies and their integration into national development plans.** The assessment of Ghana’s STI capacity is summarized in Table 1. Overall, Ghana’s HE and STI-driven capacity development profile is not very good (Table 1). The ACBF 2017 report indicated that Ghana ranked 94 out of 100, and 108 out of 141 countries in the 2013 and 2015 global innovation index rankings, respectively.

Establishing and maintaining a vibrant national research system can be a complex and costly undertaking for any country, but developing countries can encounter even more complex financial and structural constraints. The Gross
Expenditure on Research and Development (GERD) is one of the key indicators of how much money a country dedicates to research and development activity as a percentage of its GDP. The Frascati Manual (OECD, 2002) suggests that the appropriate expenditure data for computing GERD can be collected for four sectors: the business sector, government sector, higher education sector, and private non-profit organizations. African Union adopted a resolution that commits each African country to spend a targeted 1 per cent of its GDP on Research and Development. The 2015 UNESCO Science Report shows that Ghana spent 0.38% of its GDP on Research and Development in 2010. To put this into perspective, this gross expenditure on R&D is less than half of the overall African target of 1 per cent of the GDP. In comparison, Malawi spent 1.06% of its GDP while Nigeria spent 0.22% of its GDP (2007).

**Does Ghana have an STI Policy?** Ghana currently has an STI strategy document which was developed out of the result and lessons from previous STI initiatives as well as a review by a cross section of the science and technology community including scientists and policy makers. Unlike previous documents, the concept of innovation is an integral part of the new framework of actions, policies and programmes to apply science and technology towards social and economic objectives. The policy which covers the period 2017 to 2020 seeks to harness Science, Technology and Innovation (STI) to address the country’s development challenges. The National Science, Technology and Innovation policy has also been formulated to enable a constructive and structured implementation taking into account the social and economic context and the imperatives of Ghana’s development.

**Justification for the STI Policy.** The priority themes underpinning Ghana’s National Science, Technology and Innovation Policy drive the justification for the STI Policy. These are:
- Promoting competitiveness in the productive sectors of the economy

### Table 1. Ghana’s Science, Technology and Innovation and Higher Education capacity profile

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Year</th>
<th>data</th>
<th>Source of Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Innovation Index (GII)</td>
<td>2013 ranking (out of 100)</td>
<td>94</td>
<td>ACBF report 2017, Annex 1</td>
</tr>
<tr>
<td></td>
<td>2015 ranking (out of 141)</td>
<td>108</td>
<td>ACBF report 2017, Annex 1</td>
</tr>
<tr>
<td></td>
<td>2017 ranking (out of 127)</td>
<td>Not ranked</td>
<td>GII Rankings 2017</td>
</tr>
<tr>
<td>Network Readiness Index Ranking</td>
<td>2014 ranking (out of 143)</td>
<td>96</td>
<td>ACBF report 2017, Annex 2</td>
</tr>
<tr>
<td></td>
<td>2016 ranking (out of 139)</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>Gross expenditure on research and development in Africa as a percentage of GDP and per capita</td>
<td>% of GDP</td>
<td>0.38</td>
<td>UNESCO Science Report 2015</td>
</tr>
<tr>
<td></td>
<td>Per capita</td>
<td>11.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year</td>
<td>2010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Business</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Government</td>
<td>68.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Higher Education</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Private non-profit</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abroad</td>
<td>31.2</td>
<td></td>
</tr>
</tbody>
</table>

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Does Ghana have a Higher Education Policy?

Although Ghana currently does not have a comprehensive higher education policy document that guides, coordinates and harmonizes higher education, there are numerous Science and Technology-oriented education policies including the National Science and Technology policy which seeks to revitalize laboratories and workshops and increase investment in science and technology. Furthermore, the Education Strategic Plan I 2010-2020 targeted the mainstreaming of mathematics, science and technical education at all levels, as well as the extension and the diversification of post-graduate programmes, especially in the applied sciences. The Education Strategic Plan I 2010-2020 policy further outlined strategies regarding the promotion of ICT in education, by providing relevant opportunities for ICT skills development, and ensuring that science and computing students have access to relevant up-to-date teaching/learning materials.

In a bid to achieving the goals of ICT in education policy objectives, a 3-phase strategy is to be used. Phase I aims to enhance a system-wide and institutional readiness to use ICT for teaching, learning and administration (teachers’ capacity building in ICT). Phase II is targeted to ensure a system-wide effective integration of ICT into teaching and learning. Phase III intends to integrate ICT at all levels of the education system, namely, management, teaching, learning and administration. The Government has also underlined the need to promote “collaboration between local and international educational institutions to facilitate educational exchange and the promotion of ICT education and training” (ICT4AD, 2003, p.39). The Education Strategic Plan II 2010-2020 has the objective of strengthening linkages between tertiary education and industry. Different strategies are identified, namely: the integration of “entrepreneurial training and career counselling.”

Ghana’s STI and HE policies are expected to drive the development of the country, given the pivotal role both STI and HE can and must play in: Promoting increased productivity; stimulating economic growth and reducing poverty in Ghana; leveraging opportunities associated with STI and HE to transform the economy; avoiding marginalization from the global economy, and ensuring global competitiveness of Ghana. The Government of Ghana launched the National Science and Innovation Policy (2010) as a key policy document to drive research and innovation programmes in the country. The relevance of STI is amply highlighted in previous policy documents including Ghana Poverty Reduction Strategy (GPRS II, 2006-2009).

Ghana’s STI policy is intended to use HE institutions to build a strong STI capacity to support the social and economic development needs as the country has attained a middle-income status. According to the national STI Policy, “Ghana intends to migrate from the low science and technology-poor practices and worldview associated with tradition-bound society to an STI and knowledge-based society with an economy based on high levels of production, processing, industrialization and manufacturing”. Ghana’s STI policy seeks for the country a future whose STI capability would enable it to produce and process maximally the natural resources that she is blessed with and also has the knowledge base to participate actively in the production of higher technology goods and services for local consumption and for export”.

The draft STI policy is intended to be contextualized and fully integrated into a national development strategy which promotes the development of HE to fully harness the nation’s total science, technology and innovation capacity. This will enable the country to achieve her objectives of wealth creation, poverty reduction, and competitiveness of enterprises, sustainable environmental management and industrial growth. In the short term (considered as the first five years in the national STI Policy), the STI policy objective is to restructure the entire science and technology machinery, infrastructure and programmes so as to make them more responsive to national needs and priorities in all sectors of the economy including the HE system. To that end, emphasis is to be placed on:

- restructuring the National Science and Technology Advisory system;
- improving basic and applied research infrastructure;
- revitalizing the teaching of science and mathematics at the basic, secondary and tertiary levels of the education system;
- promoting the training of a critical mass of middle-level technical personnel;
- acquisition of skills in high technology areas such as ICT, biotechnology and nanotechnology and their integration into known technologies; and
- promoting mastery of known technologies and their application in industry.

**Actualizing Ghana’s STI and HE capacity policy.** The key strategies to actualize Ghana’s STI and HE Capacity development policies are summarized below:

- Improving science education at all levels and in all aspects of the educational system, especially at the basic and secondary levels with emphasis on creativity and innovation;
- Promoting technical and vocational education and training to enhance middle level management in science and technology delivery to all sectors;
- Promoting science and technology innovativeness within the educational system;
- Increasing the country’s capacity in the training of personnel in emerging technologies such as biotechnology, nanotechnology and material science and engineering;
- Using the mass media to popularize STI;
- Enhancing collaboration between research institutions and universities to train high-level scientific manpower;
- Ensuring that adult literacy classes include studies into cause and effect relations and how things work;
- Facilitating regular review to identify skill
gaps in STI (new emerging technologies);
• Revamping the practice of industrial attachments for technical, vocational education as well as science, technology and engineering students;
• Devising ICT-driven education and training programmes in science and mathematics in basic and second cycle education;
• Reviving the National Science and Technology Museum project which began as far back as 1965 to use it as a major instrument to promote science acculturation nationally. Regional Science and Technology Museums should be built nationally as a major project to promote science and technology education.

Policies related and complementary to Ghana’s STI and HE capacity policy. In Ghana, the National Science, Technology and Innovation (STI) Policies such as the STI (2010) and now the STI (2017) are the main policy documents that drive research and innovation in Ghana. In addition, several major institutions have policies in place assist in the coordination of policy towards enhancing production and utilization of research and innovative outcomes to drive socio-economic development. These institutions include the National Development Planning Commission, The Ministry of Environment, Science and Technology, the Ministry of Education, the National Council for Tertiary Education (NCTE), the Research Institutions coordinated by the Council for Scientific and Industrial Research (CSIR), the Universities and other tertiary institutions. Additionally, Ghana has a stable macroeconomic and political conditions necessary for innovation and development technology support and regulatory agencies, and standardized intellectual property (IP) legislation (UNCTAD, 2011).

Indeed, STI has been highlighted in almost every recent Government vision and planning document, including Vision 2020, the subsequent Vision 2015, the National Science and Technology Policy of 2000, the GPRS II and the current STI policy (2017). For instance, the Ghana Poverty Reduction Strategy Paper I (1996 – 2005) (GoG, 2003) has a section on science and technology. Besides, Ghana’s Growth and Poverty Reduction Strategy (GPRS II, 2006-2009) (GoG, 2005) also makes reference to the importance of Ghana’s national development. The GRPS II makes it clear that science, technology, and innovation are to be key elements of Ghana’s development strategy (National Science, Technology and Innovation Policy, 2010). Evidently, Ghana has over the years demonstrated an impressive sophistication in terms of STI policy frameworks and governance arrangements for the management of the national research and innovation systems. Again, all the policies emphasise on developing more effective national institutional arrangements to promote STI governance and nurture knowledge economies. The major and most persistent downside to these policies is the lack of national and institutionalized programmes that stimulate collaboration and knowledge exchange between research subsystems and the industrial and business subsystems.

HE and STI institutions in Ghana. Ghana has one of West Africa’s most developed national innovation systems. There is a Council for Scientific and Industrial Research, established in 1958, with 13 specialized institutes for research on crops, animals, food, water and industry. Other scientific institutions include the Ghana Atomic Energy Commission, the Centre for Scientific Research into Plant Medicine and the Noguchi Memorial Institute for Medical Research at the University of Ghana.
Table 2. Higher Education and STI institutions in Ghana

<table>
<thead>
<tr>
<th>Universities (degree-granting)</th>
<th>Total number in country (public)</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total number of Technical Universities/Polytechnics</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Total number of private Universities</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Number of Agricultural Universities</td>
<td>1</td>
</tr>
<tr>
<td>Other post-secondary institutions</td>
<td>Total number of Colleges (public)</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Total number of Colleges (private)</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Total number of Agricultural Colleges</td>
<td>6</td>
</tr>
</tbody>
</table>

1. **Ghana Academy of Arts and Sciences**
   It is a learned society that aims to promote the pursuit, advancement and dissemination of knowledge in all branches of the sciences and the humanities.

2. **Council for Scientific and Industrial Research (CSIR)**
   The CSIR is mandated to perform the following functions among others:
   - To pursue the implementation of government policies on scientific research and development;
   - To advise the sector Minister on scientific and technological advance likely to be of importance to national development;
   - To encourage a coordinated employment of scientific research for management, utilization and conservation of the natural resources of Ghana in the interest of development.

1. **Animal Research Institute**
   The Institute was established as Biological Research Institute in January 1957 as an agency of Tsetse Control Department of the Gold Coast Administration. In 1964 the name of the Unit was changed to ANIMAL RESEARCH INSTITUTE, when the research programme was widened from strictly animal health to include other areas of animal agriculture.

2. **Building and Road Research Institute**
   Mandate is to conduct research into building and road
constructions.

3. **Crops Research Institute**
Mandate is to develop and disseminate demand-driven technologies and build capacity for sustainable food and industrial crops productivity to enhance livelihoods. CRI has a broad research mandate covering all food and industrial crops.

4. **Food Research Institute**
Food Research Institute (FRI) is tasked to provide technical, analytical services, contract research and consultancy services to governmental agencies, micro-medium and multinational agro-food processing industries and international development agencies.

5. **Forestry Research Institute of Ghana**
The mandate is to assist in poverty reduction through the creation of opportunities for generating and increasing incomes within the SMEs; contribute towards food security, generate foreign exchange earnings and apply cost-effective industrial technologies that are both environmentally friendly and commercially viable.

6. **Institute for Scientific and Technological Information**
The Institute serves as the main STI resources clearinghouse for CSIR.INSTI's mandate is to develop national capacity and capability for the efficient and effective delivery of real-time scientific and technological information (STI) and customized knowledge on demand for the benefit of policy makers, research scientists, industrialists, and others in appropriately packaged form for national development.

7. **Oil Palm Research Institute**
The OPRI carries out research on Oil Palm and Coconut and offers technical backstopping to the oil palm and coconut industries.

8. **Plant Genetic Resources Research Institute**
PGRRI is mandated to collect and conserve PGR of Ghana and those from abroad to prevent their extinction.

9. **Soil Research Institute**
The Soil Research Institute has the mandate to undertake inventory of the soil resources of Ghana and carry out
scientific research to generate information and technologies for effective planning, utilization and management of the soil resources of Ghana for increased and sustainable agriculture, industry as well as ensuring safe and sound environment.

10. **Science and Technology Policy Research Institute**
The Science and Technology Policy Research Institute (STEPRI) was established in 1987 under the (CSIR) to act as a focal point to articulate policy on national Science and Technology (S&T) development.

11. **Water Research Institute**
WRI has a mandate to conduct research into water and related resources.

12. **Institute of Industrial Research**
The mandate of the Institute is to assist in poverty reduction through the creation of opportunities for generating and increasing incomes within the SMEs; contribute towards food security, generate foreign exchange earnings and apply cost-effective industrial technologies that are both environmentally friendly and commercially viable.

13. **Savannah Agricultural Research Institute**
SARI's mandate is to provide small scale farmers in the three regions of the northern Ghana (Northern, Upper East and Upper West regions) with appropriate innovation/option/technology to increase their food production base on a sustainable production system, which maintains and/or increasing soil fertility.

<table>
<thead>
<tr>
<th>Large Research infrastructure</th>
<th>Number of facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cocoa Research Institute</td>
<td></td>
</tr>
<tr>
<td>2. Ghana Atomic Energy Commission</td>
<td></td>
</tr>
<tr>
<td>3. Centre for Scientific Research into Plant Medicine</td>
<td></td>
</tr>
<tr>
<td>4. Noguchi Memorial Institute for Medical Research</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Science Granting Council</th>
<th>Ministry of Environment, Science, Technology and Innovation</th>
</tr>
</thead>
</table>
Number of researchers and publications

- Total number in the country and number per million of population
  941 (2011)
- Percentage of female researchers in country
  18.3%
- Profile of number of researchers by sector (Business, Higher Education and Government)
  Business: 1%; Higher Education: 59.9%; Government: 38.3%
- Profile by field of science
  Natural Sciences: 164; Engineering: 120; Med. & Health Sciences: 135; Agricultural Sciences: 183; Social Sciences: 197; Humanities: 118.

Table 3. Tertiary enrolment by level of programme

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Post-Secondary Non-Degree</th>
<th>Bachelor’s and Master’s</th>
<th>PhD</th>
<th>Total Tertiary</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>27,707</td>
<td>82,354</td>
<td>123</td>
<td>110,184</td>
</tr>
<tr>
<td>2012</td>
<td>89,734</td>
<td>204,743</td>
<td>867</td>
<td>295,344</td>
</tr>
</tbody>
</table>

Table 4. Total enrolment in Science, Engineering, Agriculture and Health

| Year  | Post-Secondary 1st & 2nd Degrees | PhD Post-Secondary 1st & 2nd Degrees | 1st & 2nd Degrees | Post-Secondary 1st & 2nd Degrees | PhD Post-Secondary 1st & 2nd Degrees | 1st & 2nd Degrees | Post-!-
---------------------------------|-------------------------------------|-------------------------------------|------------------|-------------------------------------|-------------------------------------|------------------|-----------------------------------|
| 2008  | 64,993                              | 124,999                         | 52               | 7,290                                | 9,091                                | 29               | 6,534妨24,072                      |
| 2012  | 89,734                              | 204,743                         | 17               | 8,306                                | 14,183                                | 57               | 8,281妨24,072                      |

The number and percentage of publications that focus on agriculture, and number and percentage that focus on other life sciences are 255 (10.6%) and 85 (3.5%) respectively. Ghana has a total number of 941 researchers (105 per million population in 2011), and they are increasingly publishing in international journals. Ghana’s scientific publication record almost tripled between 2005 and 2014 (208 to 579). This performance is all the more noteworthy in that Ghana devoted just 0.38% of GDP to GERD in 2010. Between 2008 and 2014, the total number of research collaborations with other countries was 2273. The countries involved were: USA (830); UK (636); Germany (291); South Africa (260); and Netherland (256).

Between 2004 and 2011, Ghana invested 6.3% of GDP in education, on average, and between one-fifth and one-quarter of this in higher education. The number of students enrolled in degree courses shot up from 82,000 to 205,000 (12% of the age cohort) between 2006 and 2012 and the number of PhD candidates from 123 to 867 (Table 3).
Table 5. Participation in Centres of Excellence (CoE)

<table>
<thead>
<tr>
<th>Centre of Excellence</th>
<th>Host university</th>
<th>Funder/Sponsor</th>
<th>Other Collaborators</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Africa Centre for Crop Improvement (WACCI)</td>
<td>University of Ghana</td>
<td>World Bank</td>
<td></td>
</tr>
<tr>
<td>Training Plant Breeders, Seed Scientists and Technologists</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Africa Centre on the Cell Biology of Infectious Pathogens</td>
<td>University of Ghana</td>
<td>World Bank</td>
<td></td>
</tr>
<tr>
<td>Regional Water and Environmental Sanitation Centre</td>
<td>Kwame Nkrumah University</td>
<td>World Bank</td>
<td></td>
</tr>
<tr>
<td>of Science and Technology (KNUST)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African Institute of Mathematical Sciences (AIMS)</td>
<td>Affiliated to KNUST</td>
<td></td>
<td></td>
</tr>
<tr>
<td>It is a pan-African network of centres of excellence for postgraduate education, research and outreach in mathematical sciences.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Petroleum Engineering</td>
<td>KNUST</td>
<td>Ghana Government</td>
<td>and the World Bank</td>
</tr>
<tr>
<td>A hub for developing Africa’s capacity in the Oil and Gas value chain.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noguchi Memorial Institute for Medical Research</td>
<td>University of Ghana</td>
<td>Ghana Government</td>
<td>and Japan</td>
</tr>
</tbody>
</table>

Key challenges in the STI and Higher Education environment in Ghana. Since independence, Ghana has made significant investment towards harnessing the potential of STI and optimizing the benefit of HE. However, according to the 2011 STI Policy Review by United Nations Conference on Trade and Development (UNCTAD) and the Draft National Science, Technology and Innovation Policy (2017-2020), Ghana has not been able to fully exploit the enormous potential of STI and the benefits of Higher Education (UNCTAD, 2011). The review delineates the following eleven challenges as key constraints in the STI
and Higher Education environment in Ghana:

i. Inadequate funding and resourcing of the sector;

ii. Weak linkage between policy formulation and national development planning;

iii. Weak linkage between universities, industry and the R&D system;

iv. Inadequate scientific capacity in the country;

v. Lack of effective advocacy for STI at the highest political and policy levels;

vi. Low science and technology culture among the populace;

vii. Weak structures for the management of STI;

viii. Ineffective coordination of the STI system

ix. Weak implementation and lack of robust monitoring and evaluation mechanism;

x. Weak linkages and coordination of activities and programs of various agencies and organizations in STI;

xi. Over reliance on the use of foreign expertise to the neglect of the use and development of local expertise;

As posited by Sawyerr (2004), the challenge has been exacerbated by deteriorating working conditions of practitioners in the field; worsening academic quality standards in the light of rapid increase in enrolment against inadequate teaching and learning infrastructure.

Case studies. Despite these shortcomings, however, the following two case studies showcase some successes that Ghana has achieved regarding STI and HE capacity development.

1. Building leadership skill for Africa’s Transformation: The GIMPA / PSMTP model.

The Ghana Institute of Management and Public Administration (GIMPA) is the leading management development institution in Ghana with a vision of becoming a world class Centre of Excellence for training in Leadership, Management and Administration, Policy Analysis, Consultancy and Research, Distance Learning, Gender and Development programmes and to create a forum for discussions and resolutions of important contemporary national and international issues. Over the years, GIMPA has demonstrated remarkable consistency of purpose through the provision of high quality programmes and services, skilled faculty, customized educational approaches and the cultivation of a client-centred learning environment.

In September 2005, GIMPA and the Africa Capacity Building Foundation (ACBF) signed an agreement by which the ACBF supported GIMPA to host the Public Sector Management Training programme (PSMTP) for Anglophone West Africa. Under this agreement GIMPA set up a Master’s Degree programme in Public Sector Management in partnership with the five Anglophone West African countries - Nigeria, Ghana, Liberia, Sierra Leone and The Gambia.

The main goal of the PSMTP was to enhance the performance of the public sector through the provision of a balanced, academic and professional training in Public Sector Management to promote a more effective and efficient leadership for socio-economic development in the Anglophone West African countries. Participants were drawn from the middle to senior level managers that have practical experience in public sector management.

Every year, a selected number of participants from the five (5) Anglophone West African countries are offered scholarships to participate in the programme. The governance structure of the PSMTP is composed of a Project Steering Committee (PSC) that provided oversight and
policy direction and a management team that is responsible for the day to day management of the program. The governance structure is designed to ensure effective delivery and ownership of the program by the targeted countries.

To ensure effectiveness and impact of the programme GIMPA with support from ACBF provided all the necessary physical facilities and teaching resources: both material and human, including appropriate instructional equipment and tools as well as regular collection and integration of stakeholder feedback to ensure continuous improvement of the program.

The PSMTP curriculum includes: Background and Perspective on Africa’s Public Sector; Strategic Planning and Management in the Public Sector; Public Sector Resource Management and Global and Regional Perspectives and Experiences in Public Sector Management, which relates to areas of critical manpower needs of the participating countries. To ensure effective assimilation and value addition to client’s skills and competencies, the programme used a combination of training methods which included regular lectures, participatory class discussions and hands-on exercises, seminars and individual case studies.

Overall, the PSMTP made sufficient progress towards its three key objectives, namely, (i) strengthen the Masters’ Degree programme in public sector management to meet the current and emerging issues in the public sector; (ii) enhance the institutional and human capacity of GIMPA to meet the current and emerging public sector issues; and (iii) strengthen the institutional and human capacities of IPAs to deliver in country PSMTPs.

The impact of the PSMTP programme on leadership capabilities on the continent is demonstrated by the skills and competencies acquired by graduates and their ability to initiate and mobilise stakeholders towards the achievements of national development priorities. A significant number of the PSMTP graduates are occupying leadership roles in their respective countries and are leading and managing a number of strategic national policy processes and programmes (ACBF, 2010)

2. Teaching and Learning Innovation Fund (TALIF)

The Teaching and Learning Innovation Fund (TALIF) was the third component of Ghana’s Education Sector Project (EdSeP) launched in March, 2004. TALIF Operational Manual (Version 2.B, August 2005) described the Fund as “a development tool designed to enhance the ability of the country’s tertiary institutions to fulfil their primary responsibilities” of teaching, learning and extension of knowledge to the wider community. TALIF was planned to last five years, 2004-2009 and was the second major joint initiative of the Government of Ghana and the World Bank in the tertiary education sector within the past 20 years. At the request of the Government of Ghana, the International Development Association (IDA) of the World Bank, once more, agreed to provide assistance to the Education sector and preparatory work began on the Education Sector Project (EdSeP) of which the Teaching and Learning Innovation Fund (TALIF) was a component.

TALIF was designed as a medium term instrument of tertiary education policy to:
• raise the quality of tertiary level teaching and learning;
• sharpen the relevance and skills content of technical education;
• improve the efficiency by which polytechnics, universities and system supervisory institutions manage their academic programmes;
• open greater access to tertiary level academic education through the combined effect of the above; and
• tackle the problems of HIV/AIDS by assisting institutions to develop institutional policy and framework for managing HIV/AIDS on the campuses.

TALIF was funded with $33.4 million credit from the International Development Association of the World Bank group. The Government of Ghana contributed the equivalent of 10%. In addition, the institutions were requested to contribute the equivalent of 10% in kind, time and effort.

The organisation and management of TALIF

TALIF was managed by the National Council for Tertiary Education (NCTE), the body responsible for the coordination of tertiary education in the country on behalf of the Ministry of Education and Sports. The Fund was designed as a collaborative venture involving the NCTE and seventeen (17) tertiary level institutions in the public sector in the country at the time - made up of ten (10) polytechnics and seven (7) university institutions. TALIF was organized and managed at the two levels - the NCTE and institutional levels. By 2011, TALIF had supported 412 sub-projects and over 80% of the sub-projects had been completed.

The three biggest problems the Fund encountered in its first year were:

(i). Inadequate staff and lack of dedicated offices for the Fund. The absence of dedicated offices for the Fund and the inadequate staff limited the ability of the TALIF Unit to meet deadlines.

(ii). Slow pace of accessing approved project funds because of the inability of the institutions to follow procurement procedures introduced by the Public Procurement Act, Act 663. It took not less than five weeks for institutions to return Performance Agreements and additional three weeks to submit approved Procurement Plans. The implementation of TALIF Projects coincided with the coming into effect of the Public Procurement Act 2003, Act 663. The Act seeks to streamline procurement procedures in public institutions and many of the tertiary institutions found it difficult to comply with the requirements of the Act. In addition, it took between three and four months to go through the National Competitive Bidding process and for items to be received by institutions when some projects were expected to be completed within 12 months. The Proposal Originators had little time to implement projects.

(iii) There was also the need to improve proposal writing skills particularly for Polytechnic staff on continuous basis.

Lessons learnt from the two case studies

A number of lessons were learnt from the initiatives implemented, foremost being the need for reliable financing, commitment and government support. The GIMPA programme was hugely successful as it was very well thought through before implementation. Besides, the necessary physical facilities and teaching resources, both material and human including appropriate instructional equipment and tools were provided in adequate and timely manner. Furthermore, during the implementation phase, there was regular collection and integration of stakeholder feedback to ensure continuous improvement of the programme. The GIMPA / PSMTP case showed that the programme depended significantly on funding from ACBF. However, only a few private sector or non-governmental organisations are available and willing to provide funding for STI and HE interventions in Africa. It is therefore imperative for African governments to increase their commitment and financial support to sustain STI and HE development initiatives.

Another important lesson is that the success of any policy including STI and HE policies is incumbent on regular consultation among key stakeholders. For instance, the design of TALIF allowed the TALIF Unit to consult the stakeholders on regular basis, and the constant interaction and pooling of ideas together
enabled the Unit to deal very quickly with the emerging issues. Thus, although there were initial problems, eventually, processes and procedures were clearly appreciated by key actors and end-users of the Fund as adequate education and information were provided to the institutions. Moreover, the procedures and processes and, in particular, the TALIF Operational Manual and Proposal Submission Form were regularly reviewed to ensure that they were well understood by all stakeholders. The two documents were revised three times. Furthermore, the design of the project as a collaborative venture involving the NCTE, the tertiary institutions and the World Bank was helpful in managing the novel concept in Ghana.

Comparison with the key lessons learnt and capacity imperatives in the 2017 ACR report
In accordance with the 2017 ACR report which states that ‘African countries should develop and implement policies inspired by STISA-2014, as well as create institutional arrangements that promote STI in solving problems aligned to the Sustainable Development Goals’, the success of STI and HE interventions in Ghana is hinged on the coherence among the local policies and regional, and international policies. Similar to the Ghana STI policy, in the 2017 ACR report, gender issues have been strongly emphasized in the same way as they have been highlighted in the Action Plan for the implementation of the Second Decade of Education for Africa (2006–2015), Africa’s Science and Technology Consolidated Plan of Action, and the AU’s progressive gender policies. The 2017 ACR report revealed that Africa’s share of the world’s research output does not reflect its population size largely due to a lack of state-of-the-art R&D laboratories and facilities, poor transport systems, and inadequate energy and communications infrastructure.

Key messages from the study
The key messages from the study are:

1. Ghana has generally shown renewed commitment and enthusiasms toward STI and HE development. This has culminated in very comprehensive STI polices such as the Ghana draft STI policy for 2017 to 2024.
2. Building STI capacity is a key driver and enabler in achieving economic transformation and development goals, such as food security, poverty eradication, job creation and access to energy and health.
3. Progress on Ghana’s capacity for STI looks encouraging, given that Ghana’s overall Africa Capacity Index is Medium. Ghana has a strategy for promoting STI, including capacity development, although capacity to implement it remains a challenge, given a narrow financing base.
4. Ghana has one of West Africa’s most developed national innovation systems. There is a Council for Scientific and Industrial Research, established in 1958, with 13 specialized institutes for research on crops, animals, food, water and industry.
5. Ghana has only a small pool of researchers (39 per million population in 2010) but they are increasingly publishing in international journals. Ghana’s scientific publication record almost tripled between 2005 and 2014. This performance is all the more noteworthy in that Ghana devoted just 0.38% of GDP to GERD in 2010.
6. Investment in education has not lived up to expectations, as it has not acted as a stimulus for R&D. This is because science and engineering are accorded insufficient status in Ghana. Government scientists and academics (who perform 96% of GERD) receive an inadequate budget and private sector opportunities are rare.
7. Ghana needs to strive to achieve critical mass in human resource development in STI through substantial investment in research institutions, universities, laboratories, ICT infrastructure, and research-funding.
8. There is a persistent and systemic weakness in monitoring and evaluation on STI and HE projects and programmes.

**Recommendations for policy action**
The following are the policy recommendations:

1. Ghana needs to increase capacity support for the development of STI and HE through international partnerships and linkages among researchers, academia, government, industry, and civil society actors.

2. Closing the socio-economic development gap between Ghana and the developed world will depend on Ghana’s commitment to closing the STI investment gap. Countries with strong and effective STI systems invest up to 3.5 percent of their GDP in R&D, a rate far higher than Ghana’s. To break the poverty cycle and rise above the low rankings on technological and innovation capabilities, Ghana must strive to meet its 1 percent of GDP STI target and even set a more ambitious target of up to 3 percent of GDP in STI.

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 the country’s economic growth – and the current gaps – depending on their resource endowments and national development plans. This exercise should involve government, the private sector and academia.

4. Ghana 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).

5. Ghana should develop and implement sensitization and capacity building programmes that promote and facilitate gender mainstreaming in STI for decision makers.

6. STI and HE policies should also be aligned with long term International policies to enable the nation to attract the required support for implementation.

7. Finally, the nation should strengthen its monitoring and evaluation components of their STI and HE interventions.

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

**REFERENCES**


Assessment of current status of technical and higher education sector in Liberia

M. M. ZINNAH and M. S. JACKOLLIE
University of Liberia, Capitol Hill, P.O. Box 9020, Monrovia, Liberia

Corresponding Author: zinnahmm@ul.edu.lr

ABSTRACT
Liberia is among the countries with the lowest human development index, ranked at 181 out of 189 countries in the world. Its education sector is a reflection of the political and economic fragility of the country. The sector is generally weak and fragmented. The current status of the education sector reflects years of public neglect and inadequate investment. The delivery of quality higher and technical and vocational education and training (TVET) in Liberia has numerous constraints ranging from over-crowdedness of classrooms to poorly equipped libraries, laboratories and inadequate qualified faculty especially in specialized courses. Available facilities are mismatched with the constant growth in student population. These constraints are a reflection of underfunding of the sector by the Government. Politics shapes society and influences the course of destiny from time to time. It is playing a critical role in influencing the delivering of quality higher education by exerting pressure on the National Commission on Higher education (NCHE) that has an oversight responsibility in higher education sector. Accordingly, the observed proliferation of higher institutions across the country without thorough assessment of required standards such as the academic qualification and experience of the faculty, adequate infrastructure facilities and alignment of proposed programs with Liberia’s workforce development priorities is a direct reflection of the failed oversight role of the Commission. In the crafting of the Government’s Pro-Poor Agenda for Prosperity and Development (PAPD) development agenda, the Government admits the concern of a “miss match” between disciplines pursued by students and the current and future demands for skills in the economy. Government of Liberia has traditionally focused on providing recurrent expenditure funding such as wages and salaries with limited investment into much needed areas such as infrastructure. These effects are not only felt in the university education sector but also in the TVET sector as well. The country still remains far behind other countries in West Africa in Science, Technology, Engineering and Mathematic (STEM) education. Science education in particular is substandard owing to lack of equipped laboratories, obsolete equipment in most instances, inadequacy of qualified instructors and laboratory technicians in specialized STEM disciplines. Other factors for the weakness in the education system include the lack of interest of qualified Liberians with graduate and post graduate degrees to enter the teaching profession. Their demonstrated preference is for high paid and more prestigious jobs. This is why universities and colleges requiring graduate or post graduate level faculties have the greatest challenge attracting and retaining highly trained faculty. For example, only 13% of the teaching staff the College of Agriculture and Forestry at the University of Liberia (UL) hold PhD degrees, while 82% hold master degrees. The remaining 5% are bachelor degree holders that serve as Teaching Assistants for undergraduate courses. Even then Higher education institutions are experiencing challenges in retaining instructors because of the severe shortage of qualified Liberians willing to take teaching positions. As a result, a significant percentage of instructors work on part time basis in two or more institutions. Part-time instructors of University of Liberia College of Agriculture and Forestry ideally requiring graduate and post graduate degrees in specialized disciplines make up over a third of the

teaching staff (36%) while the University of Liberia College of Engineering is over a quarter (28%). Aging of instructors further exacerbates the weakness of TVET and higher education institutions. On average, 11 percent of teaching staff in higher education and TVET institutions have either reached or surpassed the official 60-year retirement age. Moreover, an additional 3-4 percent will reach retirement age in the next 5 – 10 years. Data from the institutions surveyed show a disproportionate gender representation in both Higher Education and TVET faculty and staff. The consolidated female share of faculty and staff in three major TVET and Higher Education institutions is 9 percent while male share is 91 percent. These data indicate a need to pay special attention to attract and retain females teaching staff in the TVET and higher education institutions. The scale and scope of research and scholarly activities in Liberia’s higher education is negligible compared to other universities in the region. Although University of Liberia and Cuttington University have demonstrated some level of research activities, neither of these two institutions has published significant research results in recent years. Key recommendations for improving Liberia’s education sector are, but not limited to; investment of significant public resources (financing) in faculty and staff development, improvement of demonstration laboratories, libraries and infrastructural facilities, and payments of commensurate salaries and benefits to enhance the recruitment and retention of quality teaching staff, and putting emphasis in STEM education and increasing the pool of women students and academics. In addition, regulatory bodies, especially the National Commission on Higher Education should be adequately funded and depoliticized to enable them carry out their mandates of quality assurance and relevance of higher education. If investments are not increased in higher and TVET education, it is unlikely that the broader development goals enshrined in the Government’s Pro-poor Agenda for Prosperity and Development (PAPD) will be achieved.

Key words: Gender representation, higher education, Liberia, staffing, technical education

RÉSUMÉ
Le Libéria est l'un des pays ayant l'indice de développement humain le plus bas, classé 181ème sur 189 pays dans le monde. Son secteur éducatif est le reflet de la fragilité politique et économique du pays. Le secteur est généralement faible et fragmenté. La situation actuelle du secteur de l'éducation reflète des années de négligence du public et d'investissement inadéquat. La provision d'un enseignement et d'une formation techniques et professionnels (EFTP) de qualité au Libéria est soumise à de nombreuses contraintes allant de la surpopulation des salles de classe aux bibliothèques, aux laboratoires mal équipés et aux professeurs qualifiés insuffisants, en particulier dans les cours spécialisés. Les installations disponibles ne correspondent pas à la croissance constante de la population étudiante. Ces contraintes traduisent le sous-financement du secteur par le gouvernement. La politique façonne la société et influence de temps en temps le cours du destin. Il joue un rôle essentiel en influençant la prestation d'un enseignement supérieur de qualité en exerçant une pression sur la Commission nationale de l'enseignement supérieur (CNES), qui a une responsabilité de surveillance dans le secteur de l'enseignement supérieur. En conséquence, la prolifération observée d'établissements supérieurs à travers le pays sans une évaluation approfondie des normes requises telles que la qualification académique et l'expérience du corps professoral, des infrastructures adéquates et l'alignement des programmes proposés sur les priorités de développement de la main-d'œuvre du Libéria est un reflet direct de l'échec du rôle de la supervision de la Commission. Dans l'élaboration du programme de développement du gouvernement en faveur des pauvres, pour la
prospérité et le développement (PAPD), le gouvernement reconnaît la préoccupation d'une "correspondance manquée" entre les compétences acquises par les étudiants et les demandes actuelles et futures de compétences exigées par l'économie. Le gouvernement du Libéria s'est traditionnellement concentré sur le financement de dépenses récurrentes telles que les salaires et traitements avec un investissement limité dans des domaines très nécessaires tels que les infrastructures. Ces effets se font sentir non seulement dans le secteur de l'enseignement universitaire mais aussi dans le secteur de l'EFTP. Le pays reste loin derrière les autres pays d'Afrique de l'Ouest en matière de science, technologie, ingénierie et enseignement mathématique (STIM). L'enseignement des sciences en particulier est inférieur aux normes en raison du manque de laboratoires équipés, d'équipements obsolètes dans la plupart des cas, de l'insuffisance d'instructeurs qualifiés et de techniciens de laboratoire dans les disciplines STIM spécialisées. D'autres facteurs expliquent la faiblesse du système éducatif, notamment le manque d'intérêt des Libériens qualifiés titulaires d'un diplôme d'études supérieures et postuniversitaires pour accéder à la profession d'enseignant. Leur préférence démontrée est pour les emplois bien rémunérés et plus prestigieux. C'est pourquoi les universités et les collèges qui ont besoin de facultés de niveau supérieur ou postuniversitaire ont le plus grand défi à attirer et à retenir des professeurs hautement qualifiés. Par exemple, seulement 13% du personnel enseignant du Collège d'agriculture et de foresterie de l'Université du Libéria (UL) sont titulaires d'un doctorat, tandis que 82% sont titulaires d'un master. Les 5% restants sont des titulaires d'un baccalauréat qui servent d'assistants d'enseignement pour les cours de premier cycle. Même alors, les établissements d'enseignement supérieur rencontrent des difficultés pour retenir les instructeurs en raison de la grave pénurie de Libériens qualifiés désireux d'occuper des postes d'enseignant. Par conséquent, un pourcentage important d'instructeurs travaillent à temps partiel dans deux établissements ou plus. Les instructeurs à temps partiel du Collège d'agriculture et de foresterie de l'Université du Libéria, qui exigent idéalement des diplômes d'études supérieures et postuniversitaires dans des disciplines spécialisées, représentent plus du tiers du personnel enseignant (36%), tandis que le Collège d'ingénierie de l'Université du Libéria compte plus d'un quart (28 %). Le vieillissement des instructeurs aggrave encore la faiblesse de l'EFTP et des établissements d'enseignement supérieur. En moyenne, 11% du personnel enseignant des établissements d'enseignement supérieur et d'EFTP ont atteint ou dépassé l'âge officiel de 60 ans de la retraite. De plus, 3 à 4% supplémentaires atteindront l'âge de la retraite dans les 5 à 10 prochaines années. Les données des établissements interrogés montrent une représentation disproportionnée des sexes dans les facultés et le personnel de l'enseignement supérieur et de l'EFTP. La part féminine consolidée des professeurs et du personnel dans les trois principaux établissements d'EFTP et d'enseignement supérieur est de 9%, tandis que la part des hommes est de 91%. Ces données indiquent la nécessité d'accorder une attention particulière pour attirer et retenir le personnel enseignant féminin dans l'EFTP et les établissements d'enseignement supérieur. L'ampleur et la portée de la recherche et des activités savantes dans l'enseignement supérieur au Libéria sont négligeables par rapport aux autres universités de la région. Bien que l'Université du Libéria et l'Université de Cuttington aient démontré un certain niveau d'activités de recherche, aucune de ces deux institutions n'a publié de résultats de recherche importants ces dernières années. Les principales recommandations pour améliorer le secteur de l'éducation au Libéria sont, mais sans s'y limiter; investissement de ressources publiques importantes (financement) dans le développement du corps professoral et du personnel, amélioration des laboratoires de démonstration, des bibliothèques et des infrastructures, et paiement de salaires et d'avantages proportionnels pour améliorer le recrutement et la rétention d'un personnel enseignant de qualité, et mettre l'accent sur l'enseignement des STIM et accroître le bassin de...
Assessment of current status of technical and higher education sector in Liberia

femmes étudiantes et universitaires. En outre, les organismes de réglementation, en particulier la Commission nationale de l'enseignement supérieur, devraient être financés et dépolitisés de manière adéquate pour leur permettre de s'acquitter de leurs mandats d'assurance qualité et de pertinence de l'enseignement supérieur. Si les investissements ne sont pas augmentés dans l'enseignement supérieur et l'EFTP, il est peu probable que les objectifs de développement plus larges inscrits dans le programme gouvernemental en faveur des pauvres pour la prospérité et le développement (PAPD) soient atteints.

Mots-clés: représentation des sexes, enseignement supérieur, Libéria, dotation en personnel, enseignement technique

BACKGROUND

The Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) was established in 2004, and currently has 126 member universities in 38 countries across the African continent. RUFORUM has a mandate to strengthen the quality and relevance of postgraduate training and research in African universities, especially in agriculture, science, technology, and innovation. As such, RUFORUM commissioned the assessment of technical and higher education institutions in Liberia. The overall objective of the assessment was to identify challenges and gaps and develop specific recommendations towards improving the performances and contributions of technical and higher education institutions to agriculture, science, technology and innovation in Liberia. This assessment built on discussions during the Liberian Higher Education Day held on 26th April 2019 in Monrovia, Liberia, consultations with key stakeholders and review of documents.

Tertiary education in Liberia began in 1862 with the establishment of the public-funded Liberia College, which later became a full University in 1951 (University of Liberia). The first private (faith-based) higher education institution, Cuttington College (now Cuttington University), was established in 1889 by the Episcopal Church of the United States. According to the National Commission on Higher Education (NCHE), currently there are 20 universities offering bachelor degrees and above, and 18 higher education institutions offering associate degrees in various disciplines (NCHE 2019). No higher education institution offers Ph.D. degree in Liberia. The list of accredited institutions of higher education in Liberia is shown in Table 1.

The National Commission on Higher Education (NCHE) is the regulatory body for all degree-granting higher education institutions in Liberia. It was established by an Act of Liberia National Legislature in 1989. It oversees implementation of the Revised Policy on Higher Education in Liberia Act of 2015. The NCHE has drafted policies that set minimum standards for the accreditation of Higher Education institutions. The draft standards have not yet been validated by stakeholders for use as a tool for evaluating higher education institutions. Additionally, the NCHE has not been able to facilitate establishment of the proposed autonomous National Accreditation Center (NAC) enshrined in its mandate to take responsibility for evaluating and accrediting higher institutions of learning in Liberia.

The NCHE has two major challenges: (1) underfunding, and (2) politicization. Funding has been especially limited in the last few years. Funding to NCHE has largely covered payrolls with limited funds for operations. Moreover, until recently investments from development partners (especially the World Bank) for the African education sector were focused more on basic and childhood education
### Table 1. Recognized and accredited higher education institutions in Liberia, 2018/2019 - National Commission on Higher Education

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of institution</th>
<th>Year established</th>
<th>Type of institution</th>
<th>Location</th>
<th>Degrees offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>University of Liberia</td>
<td>1862</td>
<td>Public</td>
<td>Monrovia</td>
<td>B &amp; M</td>
</tr>
<tr>
<td>2</td>
<td>Cuttington University</td>
<td>1889</td>
<td>Faith-Based</td>
<td>Suakoko, Bong County</td>
<td>B &amp; M</td>
</tr>
<tr>
<td>3</td>
<td>African Methodist Episcopal University</td>
<td>1996</td>
<td>Faith-Based</td>
<td>Monrovia</td>
<td>B &amp; M</td>
</tr>
<tr>
<td>4</td>
<td>United Methodist University</td>
<td>1998</td>
<td>Faith-Based</td>
<td>Monrovia</td>
<td>B &amp; M</td>
</tr>
<tr>
<td>5</td>
<td>Stella Maris University</td>
<td>2005</td>
<td>Faith-Based</td>
<td>Monrovia</td>
<td>B &amp; M</td>
</tr>
<tr>
<td>6</td>
<td>Starz College of Technology</td>
<td>2012</td>
<td>Private</td>
<td>Monrovia</td>
<td>B &amp; M</td>
</tr>
<tr>
<td>7</td>
<td>William V. S. Tubman University</td>
<td>1978</td>
<td>Public</td>
<td>Harper, Maryland County</td>
<td>B</td>
</tr>
<tr>
<td>8</td>
<td>African Methodist Episcopal Zion</td>
<td>1995</td>
<td>Faith-Based</td>
<td>Monrovia</td>
<td>B</td>
</tr>
<tr>
<td>9</td>
<td>Liberia Baptist Theological Seminary</td>
<td>1975</td>
<td>Faith-Based</td>
<td>Roberts International Highway</td>
<td>B</td>
</tr>
<tr>
<td>10</td>
<td>African Bible College University</td>
<td>1977</td>
<td>Faith-Based</td>
<td>Yekepa, Nimba County</td>
<td>B</td>
</tr>
<tr>
<td>11</td>
<td>Liberia Assemblies Of God Bible College</td>
<td>1980</td>
<td>Faith-Based</td>
<td>Brewerville, Montserrat County</td>
<td>B</td>
</tr>
<tr>
<td>12</td>
<td>African Methodist Episcopal Zion University</td>
<td>1995</td>
<td>Faith-Based</td>
<td>Monrovia</td>
<td>B</td>
</tr>
<tr>
<td>13</td>
<td>Adventist University Of West Africa</td>
<td>2010</td>
<td>Faith-Based</td>
<td>Monrovia</td>
<td>B</td>
</tr>
<tr>
<td>14</td>
<td>Harbel College</td>
<td>2014</td>
<td>Public</td>
<td>Harbel, Margibi County</td>
<td>B</td>
</tr>
<tr>
<td>15</td>
<td>Bong County Technical College</td>
<td>2013</td>
<td>Public</td>
<td>Gbarnga, Bong County</td>
<td>B</td>
</tr>
<tr>
<td>16</td>
<td>Blue Crest University College</td>
<td>2014</td>
<td>Private</td>
<td>Monrovia</td>
<td>B</td>
</tr>
<tr>
<td>17</td>
<td>St. Clements University College</td>
<td>2010</td>
<td>Private</td>
<td>Monrovia</td>
<td>B</td>
</tr>
<tr>
<td>18</td>
<td>Bushrod Institute Of Technology</td>
<td>2016</td>
<td>Private</td>
<td>New Kru Town Monrovia</td>
<td>B</td>
</tr>
<tr>
<td>19</td>
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AA = Associate degree; B = Bachelor degree; M = Master degree

Assessment of current status of technical and higher education sector in Liberia

(World Bank, 2009). Fortunately, the World Bank made a complete turnabout at the turn of the century when it declared that the rate of return on African higher education was as high as 21%, among the highest in the world (Bloom et al., 2014). The World Bank is now actively engaged in supporting a new initiative to revitalize the African higher education sector through its innovative “African Higher Education Centers of Excellence” aimed at strengthening universities’ capacity to deliver high quality training and applied research, and promoting regional specialization in areas that address specific common regional development challenges.

In terms of politicization of professional bodies, the appointments of Commissioners at the NCHE is no exception. Leadership turnovers have led to the lack of continuity in the national vision about higher education. As such, the NCHE has not been able to effectively deliver on its mandates which are crucial for delivery of quality higher education in Liberia. The Commission acknowledges the proliferation of higher education institutions across the county as a challenge, but lacks the requisite resources to assess their integrities for accreditation.

The objective of this study was to assess the current landscape of Higher and Technical education in Liberia, in terms of historical set up, current status, and institutional and policy frameworks guiding the sector so as to establish underlying issues and opportunities for making the sector more competitive and responsive to the development needs of Liberia. Special attention was given to analyse gender parity in the higher and technical education institutions. In addition, effort was made to establish the current trends in other West African countries so as to inform intervention strategies in Liberia.

METHODOLOGY AND LIMITATIONS
Qualitative and quantitative data were collected and analyzed to inform this report. Secondary data were collected through desk review of existing national policy documents and reports. In addition to Liberia higher and TVET education regulatory and policy frameworks, a desk study was conducted to appreciate the experiences of Ghana, Nigeria and Sierra Leone that have more advanced TVET and higher education programs and more robust regulatory frameworks than Liberia. A desk review of two World Bank Policy Review documents was also conducted to appreciate its experience in financing TVET programs in less developed countries. Primary data were collected from key informants’ interviews with leaders of TVET and higher institutions and regulatory agencies in the education sector. The draft report was shared and validated by key stakeholders in the education sector in Liberia. The assessment had several limitations: (i) four of the seven institutions (both public and private) purposively selected for the assessment did not respond to the questionnaires; and (ii) there were also varied levels of restrictions on information that institutions could release for public consumption, especially related to finances. These limitations are responsible for the limited data presented in this report regarding institutions’ funding trends, faculty qualities in terms of academic levels and ranks, and concentrations of students’ enrolment in colleges and courses. Yet these trends are necessary to inform the design and relevance of future capacity development programmes for TVET and higher education in the country. However, the findings in this report adequately represent the true status of TVET and higher education in Liberia. The recommendations are tailored to remove the major challenges and constraints hindering the delivery of quality TVET and higher education in Liberia.

KEY FINDINGS
Liberia’s TVET Sector: Genesis and current status. Technical and vocational education and training (TVET) is the most practical means for acquiring readily employable skills for the world of work (African Union, 2007). TVET started...
in Liberia with the establishment of the Booker Washington Institute (BWI) in Kakata in 1929. Booker Washington Institute was established to produce middle level technicians in agriculture, business education, mechanical trades, building construction and electrical trades mainly to benefit the Firestone Natural Rubber Plantation as well as the middle level technician needs of other businesses. The turning point of TVET in Liberia was the emergence of large companies/concessions and businesses during the 1960s and 1970s (e.g. Liberian-American-Swedish Mining Company (LAMCO), Bong Mining Company (BMC), Liberian Mining Company (LMC), and National Iron Ore Company (NIOC). These companies set up TVET centers to train technical and administrative staff that required specific skills sets for efficient operation of their companies.

Many Liberians perceive TVETs as institutions for school dropouts who lack academic potential for formal education. Studies by Oketch (2014) and Rima (2014) support this perception that general education has the promise of better career mobility and higher wages than TVET. Experience from Ethiopia by Tamrat (2019) also indicates that in spite of potential of TVET to address the challenges of skill gaps and reduce unemployment in Ethiopia, students, parents and the larger community appear to show little interest towards TVET as compared to university degrees. It is widely considered as inferior to the academically-oriented degrees offered by higher education institutions and is seen as a training route suitable for those with poor academic abilities.

In spite of these negative perceptions, the Government of Liberia acknowledges that TVET holds the key to technological progress, rapid industrialization, wealth creation and poverty reduction in the country. Section 2.2 (Building Human Capacity for Knowledge Economy) of Pillar II (Power to the People) of the Government’s Pro-Poor Agenda for Prosperity and Development (PADP), places emphases on TVET. TVET programs will provide training opportunities for the youth (both men and women) to acquire the needed skills for the emerging job opportunities in agriculture value chains from production to marketing encompassing processing, manufacturing and other light industries. The Ministry of Education forecasts a potential demand for 620,000 skilled workers to fulfill demands of industry by 2030. Training in Science, Technology, Engineering and Mathematics (STEM) will be critical for preparing youth to meet the demands for these huge job opportunities. However, the PAPD classifies STEM education and TVET programs in Liberia as underdeveloped and that no national qualification framework or competence-driven curriculum exist. The PAPD further states that there is a severe mismatch between disciplines pursued by students and the current and future demands for skills in the economy (Government of Liberia, 2018).

The Ministry of Education (MOE) has a TVET Bureau which provides oversight for non-degree granting TVET institutions which are not governed by the NCHE. It is responsible for monitoring, management and coordination of TVET programs in Liberia. TVET provision is divided between public, private, faith-based and community providers. The Education Management Information System (EMIS) data reported that 148 TVET institutions were formally registered in the country with the Ministry of Education and Ministry of Youth and Sports (MYS) in 2015/2016. However, only 65 institutions were active where the majority were private (63%) followed by public (20%), faith-based (11%) and community-owned (6%) (Ministry of Education, 2017).

Key challenges to TVET delivery include, among others, (i) fragmented data on TVET supply and ad-hoc labor market information collection; (ii) weak linkages between TVET curricula and the productive sectors of the economy limit relevance; (iii) poorly equipped demonstration facilities; (iv) inadequate trained technical
Assessment of current status of technical and higher education sector in Liberia

...faculty; (v) absence of state-of-the-art in-country training opportunity for training TVET teachers; (vi) lack of adequate gender-sensitive activities to address the obstacles girls and young women face in TVET; (vii) damaged infrastructure as a result of 14 years of civil conflict; (viii) training tools and equipment are inadequate and in most instances obsolete; and (ix) inadequate funding to efficiently run the institutions. In addition to these challenges, the diminishing level of large businesses and industrial activities has limited opportunities for internships or experiential learning opportunities that previously enforced TVET delivery. The employment windows have also shrunk significantly due to closure of many large businesses, concessions and industries and the thriving ones are said to not be making enough profits to accommodate TVET students and graduates.

The Government is planning to pass into law the establishment of the Liberia TVET Commission (LiTCom) that will govern, regulate, harmonize skills development, and guide all aspects of TVET delivery across Liberia. The responsibility of LiTCOM will also include ensuring quality and accreditation, and setting up occupational standards and system for monitoring and evaluation. LiTCOM is expected to also establish a national database for TVET graduates across the country. Other African countries have established similar commissions that have helped to improve the quality of their TVET programs. Examples include the Council for TVET (COTVET) in Ghana, and the Workforce Development Authority in Rwanda (Afeti and Adubra 2012, Afeti n.d). However, unless there is dramatic improvement in the economy and increased government investments in TVET programs, setting up LiTCOM will not solve the huge challenges of TVET in Liberia.

In 2018, the European Union (EU) committed €20 million grant to support TVET programs in Liberia for a period of six years. These grants are intended to improve the quality and relevance of TVET institutions to equip youth with skills, especially in ICT, agriculture, technology and electrification that actually match emerging labor market demands and respond to new economic growth opportunities. The United Nations Industrial Development Organization (UNIDO) as the implementing agency will collaborate with the Ministry of Education (MOE) and institutions to assess and improve their infrastructures, demonstration laboratories including modern training equipment, and to improve the quality of the faculty. The grant will also send a number of vocational instructors abroad for training and practice to enable them to serve upon their return as instructors in TVET institutions and as master trainers in the Centre of Excellence for Training of Vocational Instructor that will be established with support from the program. The institutions that will initially be supported by the grant are Booker Washington Institute, Monrovia Vocational Training Center (MVTC), Greenville Multilateral High School; Cape Palmas High School and Zwedru Multilateral High School.

Liberia needs to learn from ongoing efforts in other countries especially in West Africa. For example, According to Ansah and Ernest (2013), the Government of Ghana has, in recent times, given renewed recognition to TVET. The recognition highlights TVET in the Ghana Poverty Reduction Strategy (GPRS) document as means of developing the technical and skilled human resource base and a stimulant for rapid economic growth for Ghana to realize its Vision 2020 Plan. Similarly, the Federal Government of Nigeria acknowledges the critical role of TVET in national development and the mixed outcomes of previous TVET policies. As a result, its recent policy recognizes TVET as an integral part of technological development and provides for the apportioning of a greater proportion of education expenditure to TVET at both Federal and State levels. The recent policy

"Associate Degree" in the Liberian context is a two-year post-secondary course (equivalent to the first two years of university undergraduate degree). It can also be equated to the Higher National Diploma (HND) in the British education system.
also recognizes the fundamental importance and cost intensive nature of TVET; hence, the Government of Nigeria made a commitment to provide adequate funds for TVET (Okorafor and Nnajiofor 2017).

Sierra Leone has several institutions of higher learning offering Bachelor, Master and Doctorate degrees while the polytechnics offer two-year programs leading to the Higher National Diploma (HND). The HND which is equivalent to an Associate Degree has been introduced in the agriculture programs of community colleges in Liberia. In 2018, GIZ conducted a diagnostic study of the quality of TVET in Sierra Leone that found out that existing TVET curricula were primarily assessed by the training providers themselves (GIZ, 2018). Similarly, in Liberia, TVET institutions make changes that are needed to improve their curricula from suggestions by employers on the basis of appraisals of interns. Unlike Liberia, however, Sierra Leone has a TVET Coalition composed of members from a variety of stakeholders both in private and public sectors who collaborate to foster the development of TVET. Similar coalition could help improve TVET programs in Liberia.

The 1992 review of the World Bank TVET Policy (Adams et al., 1992) found that TVET funding has produced mixed result in such a way that, where successful in achieving set goals, a large proportion of graduates find jobs that use their skills. There is also evidence that TVET efforts have proved mainly unsuccessful because they are based on mistaken assumptions about the nature of employment and skills demand. Moreover, TVET has been found least effective where its objective is to solve broad social problems unrelated to prevailing or anticipated demand for skills. These assertions should be a wakeup call for Liberia to chart a new course of policy and action that will make TVET demand driven rather than supply driven for addressing social issues.

Higher education in Liberia: Current status Programs and level of academic achievement. Liberia has two public higher education institutions - the University of Liberia (UL) and Tubman University (TU). These two universities and a host of private universities and colleges provide a wide array of academic and technical training programs at various degree levels, including Associate, Bachelor and Master. The major higher education programs include, but not limited to, agriculture and forestry, applied sciences, environmental science, mathematics, engineering and technology, social studies, and business studies. The majority of these programs are at the Bachelor degree level. Few higher education institutions, including University of Liberia and Cuttington University, do offer Master’s Degrees in selected fields such as Business Management, Accounting, Urban and Regional Planning, Public Health, and Environmental Science. No PhD degrees are currently being offered in Liberia.

Clearly Liberia lags behind other regional countries in Science, Technology, Engineering and Mathematics (STEM) programs, for example with Uganda (see Tizikira et al., 2019). The impact of the weakness of STEM education in Liberia is largely felt in its share of the high profile and well-paid jobs which are dominated by other nationals. Enrolment data show higher number of higher education students in the business and social studies courses compared to STEM courses. This is an indication that the contribution of STEM education to production of a competitive workforce for high tech industries will remain a challenge in the foreseeable future. Be it as it may, STEM programs have three key constraints in Liberia which are: (i) lack of equipped laboratories, (ii) inadequate qualified faculty and laboratory technicians in specialized science courses and, (iii) inadequate infrastructure in terms of
classroom space to conveniently accommodate high student enrolments so that each student has a work station for science demonstration. In addition, local source for science materials is unavailable and if found, the cost of materials can be quite exorbitant. Assumption is that perhaps enrolment in STEM programs will increase if these key constraints are removed or significantly minimized to improve quality of the programs.

Emerging demands for new skills sets in the current Liberia workforce has led to inclusion of Information and Communication Technology (ICT) primarily by private institutions. As such, the ICT is gradually taking root as a major technology program in the education system though there are institutional accreditation problems. The introduction of environmental science by several higher education institutions adds another course of relevance to workforce development in Liberia. These disciplines and others in the broad area of Digital Technology and Information Science are shaping the future of higher education and global development. As such Liberia needs to make more substantial investments in these areas. Similar recommendations have been made for Africa generally (World Bank and Elsevier, 2014).

Enrolments and faculty-student ratios in Higher Education Institutions. Higher education enrolment has increased rapidly over the last decade while the number of qualified faculty has increased slowly. This has led to high students’ to faculty ratios, especially in public universities and colleges. For example, the student-faculty ratio in the College of Agriculture and Forestry at University of Liberia with about 2,900 students and 76 faculty members was 38:1 in the 2018/2019 academic year. The overall enrolment pressure on the University of Liberia in particular is due to its more ideal location and accessibility by students from 10 of Liberia’s 15 counties and very low tuition fees as compared to in the private universities in the same locality. Tubman University, the second public higher education institution is located remotely in the southeast of Liberia (about 403 km from Monrovia).

Southeast Liberia is hardly accessible during the rainy season from the greater part of Liberia. The region hosts five of the fifteen counties of Liberia.

The disciplines most affected by high student population are business studies and social science and humanities. Stella Maris University, one of the private higher education institutions surveyed has made some strategic gains in attracting students in science, engineering and agriculture courses. It has fairly equipped science laboratories and demonstration farms for agriculture students. Moreover, female enrolment is peculiarly higher in agriculture compared to at University of Liberia (Figure 1). Stella Maris University’s medium term goal is to train entrepreneurs who will do farming as a business and create jobs. However, its service learning/internship programs are facing some challenges due to limited opportunities in businesses.

Higher education faculty by academic level and gender inclusiveness. The total number of faculties with PhD and master degree in Liberia’s Higher Education institutions is not representative of an ideal faculty for institutions granting undergraduate and graduate degrees. Considering the case of University of Liberia College of Agriculture and Forestry with the largest students enrolment (2,900) only 13% of the total teaching staff hold PhD, 82% hold Master Degree while the balance 5% are Bachelor Degree holders. The shortage of qualified faculty underpins why some institutions are allowing faculty members with bachelor degrees to teach undergraduate courses and master degree holders teaching graduate courses. This requires urgent intervention by the Government of Liberia and other partners
to invest substantial resources in higher education faculty development programs. This is to ensure that Liberia’s future workforce is competitive enough to meet the contemporary needs of employers especially the private sector.

In addition, gender inclusiveness in higher education faculties is quite disproportionate and more pronounced in the University of Liberia College of Engineering (Figure 2). Female share of the Engineering College faculty is as low as 3% compared to 97% for males. Also, female share in the Agriculture College is low, being only 9% compared to 91% male share (Figure 3). This disproportionate representation of male and female is not intentional but attributed to the biased assumption that women generally do not like to enroll in technical and related courses coupled with their lack of appetite for teaching profession. There is therefore a national need to address this balance and to put in policies that entice female students to enroll for higher degree training including in science disciplines.

![Figure 1. Student Enrollment in the Colleges of Agriculture at University Liberia (UL) and Stella Mari](https://example.com/figure1)

(Source: Based on data from the survey)

![Figure 2. Academic qualification of Faculty in the College of Engineering at University of Liberia](https://example.com/figure2)

(Source: Based on data from the survey)
Funding of higher education institutions in Liberia. Funding is unique challenge across all development sectors in Liberia and the education sector is no exception. The Education Reform Act of 2015 makes higher education a national priority and provides for the allocation of at least 20 percent of national budget to education. This policy statement has never materialized as actual Government of Liberia budgetary allocations to education has ranged from 10 - 13 percent in 2014 - 2017 to 6 - 7 percent as its lowest in 2018 and 2019. In the last two years, over 50 percent of national budget have been allocated for personnel services alone. Public Higher Education institutions are experiencing their share of this economic problem which has been further exacerbated by the recent tuition free pronouncement for all public Higher Education by the Government under its PAPD policy. Moreover, Higher Education has not also been a high priority for donors’ funding in the past decade; their focus is on the lower echelon of the education system – from early childhood to second high school (Bloom and Canning, 2006; World Bank, 2009; Montenegro et al., 2013; Montenegro and Patrines, 2013).

The private sector is contributing immensely to the education sector from the foundation level to higher education. Public schools would have been overwhelmed with student enrolment if the private sector had not intervened by building many educational institutions ranging from nursery schools to colleges and universities across the country. Private schools however rely primarily on tuitions and fees and occasional external grants. The Government of Liberia previously provided varied amounts of subsidies on annual basis to selected private institutions to keep tuitions and fees in some reasonable range for students. In 2017, these subsidies were abolished owing to economic constraints. This underpins the higher cost of education in private higher
education institutions. Nevertheless, there is still proliferation of private institutions to cater for the growing number of secondary school graduates requiring higher education although there are certification challenges.

**Higher education faculty retention challenges and matriculation.** The retention of quality faculty or to circumvent their full time instructional commitment to single institutions has been a challenge to universities and colleges. Remunerations and benefits are not commensurate with faculty qualifications. As a result, faculties matriculate from one institution to another to improve their monthly incomes. Faculty matriculation is noticeable to the extent that some instructors are commuting from institution in Monrovia to institutions outside of Montserrado County on the same day to provide instructions. Faculty matriculation is exacerbated by the huge shortage of graduate and post graduate degree holders in Liberia with appetite for instructional jobs. In addition, higher education institutions are desperate to have instructors in their classrooms but have limited options in identifying qualified instructors. Administrators blame the brain drain that emerged as a result of the 14-year civil conflicts (1989 – 2003) for Liberia lingering behind other regional countries in terms of the quality of faculty and staff at higher and TVET institutions. Figure 4 illustrates the proportion of full time and part time instructors in the higher education institutions surveyed.

**Aging of faculty and retirement scenarios.** Aging faculty is a major challenge to the implementation of retirement plans by both private and public universities and colleges. For example, 25 percent and 4 percent of the instructors at the University of Liberia College of Agriculture and Stella Maris, respectively, have either reached or surpassed retirement age, and an average of 4 percent will reach retirement ages in 5 -10 years (Figures 5 and 6).

By comparison, the aging problem is also more severe in the University of Liberia College of Agriculture with 25% of faculty being 60 years old or above, but the figure for the College of Engineering is lower (6%). Identifying qualified replacements for faculties that are at or have even surpassed the lawful retirement age of 60 is preventing institutions from rigorously implementing their retirement plans. This situation, coupled with existing faculty gaps, poses serious challenge to the improvement of higher education and should be a concern to the Government of Liberia as well as university administrators.

**TVET Institutions**

**TVET programs and level of achievement.**

There are two categories of TVET education in Liberia: (i) Associate degree granting programs at Community Colleges (see Table 1), and (ii) non-degree granting programs. The Non-degree granting TVET institutions offer diploma and certificate of proficiency in agriculture technology, electrical technology, mechanical technology, building construction technology and business education courses (Table 3). Non-degree granting TVET courses are designed for the production of proficient middle level technicians for Liberia’s workforce (Table 4).

The associate degree granting TVET programs are based mainly at the community colleges spread in several counties in Liberia. The community colleges were established to address the workforce needs of the various counties. However, this arrangement is no longer the case and alludes to the socioeconomic theory of TVET delivery (African Union, 2007; Afetí and Aduba, 2012; Afetí n.d). Most of the community colleges award associate degrees in agriculture equivalent to High National Diploma (HND) in other countries in West Africa as well as associate degree programmes in other TVET courses - businesses courses, social studies,
geology, among others. TVET post associate courses in higher education institutions award bachelor degrees in engineering and are largely theory-based with limited hands-on activities due to lack of properly equipped demonstration facilities.

Opportunities for internships or service learning for both TVET and higher education are not readily available due to the closure of many large businesses and concessions and industries that provided such opportunities in the past. To support market assessment to propel TVET curricula review, students returning from internships bring back appraisals from collaborating industries and businesses. Such feedbacks form the basis for TVET institutions to update their curriculum and this is often done without the approval of the Ministry of Education or school board.

TVET enrolment and faculty-students ratio. The emergence of large industries and concessions in the 1970s changed perceptions that TVET was for academically disadvantaged youth. This has not only led to steady increase in TVET enrolment but also to a proliferation of private TVET institutions. TVET is intended to produce proficient middle level technicians and requires reasonable number of students to a faculty to be able to properly evaluate learners’ skills development outcomes. The establishment of community colleges in Liberia was based on this assumption and the aim was to reduce enrolment burden on the University of Liberia and private universities. Data show an average of 25 – 38 students per faculty in the TVET institutions surveyed.

TVET funding trends. TVET has consistently featured prominently in discussions by politicians, policy makers, stakeholders as well as technocrats at educational forums and events. TVET is viewed in nearly all educational policy documents as the way forward for socioeconomic development and for constructive engagement of youth for national security. However, the consolidated funding trends from the 2015 - 2017 academic years for two leading TVET institutions (Booker Washington Institute and Nimba County Community College) do not indicate that TVET is considered as a vital tool for developing a competitive and robust workforce in Liberia. Gaps between these two major TVET institutions’ funding request to Government of Liberia and actual disbursements

![Figure 4. Full and part time instructors at Colleges of Agriculture of University of Liberia, Stella Maris and Cuttington University](Source: Based on data from the survey)
M. M. ZINNAH and M. S. JACKOLLIE

Figure 5. Ages of staff in Faculties of College of Agriculture and College of Engineering at University of Liberia (Source: Based on data from the survey)

Figure 6. Ages of staff in the Faculties of the Colleges of Agriculture at University of Liberia and Stella Maris (Source: Based on data from the survey)

ranged from 15 - 20% from 2015 - 2017 to 38% in 2018/2019. In 2018, the European Union brought some relief to Government by allocating €20 million grant to help improve the delivery of TVET education including the community colleges. The grant is intended to train TVET instructors’ trainers, improve infrastructures and upgrade TVET demonstration laboratories.

Age implications for the TVET sector. TVET institutions, like the Higher Education institutions in Liberia, are also challenged by inadequate qualified faculty (Figure 7). These institutions cannot proceed with timely implementation of retirement plans because replacement faculties are not readily available. As such, faculties that have reached or even surpassed official retirement ages are retained on faculties even if ineffective. This alludes to an urgent need for TVET teacher training facilities in Liberia to train new instructors as well as provide refresher training for existing staff to cope with contemporary technological advancements. From 1978 to 1999, Tubman College (now Tubman University) trained TVET instructors in the STEM disciplines. Tubman University was transformed into a university in early 2000. Its transformation has
created a vacuum in the supply of trainers for community colleges and non-degree granting TVET institutions in the STEM disciplines. Consequently, many graduates from Higher Education institutions with degrees in civil, electrical and mechanical engineering are those currently providing instructions in technical areas such as building construction, electronics, electricity and mechanical technologies.

**Gender inclusiveness in tvet faculty and staff.** Though gender equality is relatively a new development phenomenon in Liberia, the disproportionate representation of women and men in both Higher Education and TVET faculty is wide (Figure 8). It is a common perception in Liberia that that most Liberian women do not have appetite for teaching profession especially with the low wages and incentives paid to instructors. The ascendency of Madam Ellen Johnson-Sirleaf as the first female Liberian and African President provided impetus for the Government of Liberia and development partners to give increased attention to inclusion of an agenda for gender equality in development programs in Liberia. However, a lot still needs to be done to significantly increase women participation in both the TVET and Higher education sectors.

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<td>William V.S. Tubman High School Accelerated Vocational Training Program (AVTP)</td>
<td>Formal/Post-Secondary</td>
<td>Monrovia</td>
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Status of educational infrastructure in Liberia. The relocation of many of the colleges from the University of Liberia main campus on Capitol Hill in Monrovia to Fendell brought some relief to the over crowdedness problem. However, being the only low cost public Higher Education institution accessible to majority of the student population in two thirds of the nation, University of Liberia is already experiencing serious over-crowdedness. This is due to the steady increase in student population which underpins the inadequacy of infrastructure especially classrooms and demonstration facilities. The need for expansion of infrastructural capacity to accommodate the steadily growing student population is therefore urgent. Unlike University of Liberia, Tubman University, the second public university, is located remotely in the southeast of Liberia. Southeast Liberia, comprising five of the fifteen counties, is not accessible during the rainy season from the greater part of Liberia. It is foreseeable that enrolment will increase sharply in subsequent academic years at these two public institutions of higher learning if the Government of Liberia maintains its tuition free
Assessment of current status of technical and higher education sector in Liberia

Policy for Higher Education. This will further deteriorate the quality of higher education in Liberia.

Most of the private universities and colleges are located in the center of Monrovia and surroundings where there are very limited opportunities for expansion of infrastructure in the future. These private institutions are also experiencing increases in students who cannot be accommodated by the University of Liberia. According to some of the administrators interviewed, this challenge was anticipated years back and they have already acquired land outside of Monrovia for relocation and expansion of their institutions.

Agriculture education. Agriculture provides livelihood for approximately 70 percent of the population of Liberia. The country is rich in soil and agro climatic conditions including fallow land, rain and sunshine. However, Liberia has yet to be food secure despite huge investments in the agriculture sector by government and donor agencies. Agriculture education is integral to the achievement of food security; thus integral to both Higher Education and TVET programmes. All of the institutions surveyed have multi-faceted agriculture activities for demonstration and income generation purpose. These institutions produce crops such as vegetables and rubber and raise poultry, cattle, goat, pigs and pond fish. Unfortunately, graduates from TVET programs and agriculture colleges seek employment opportunities with government and large concessions and businesses rather than engaging in farm enterprises to be self-employed and to create jobs. Hence, one could assume that something is fundamentally wrong with the design and delivery of agriculture education in Liberia.

Higher education and TVET agriculture curricula are currently focused primarily on the production phase of agriculture value chain development. Though value addition (processing, packaging and marketing) is relatively a new phenomenon in Liberia's agriculture, its inclusion in the curricula of Higher Education and TVET programs has several economic and social advantages. It a) offers opportunities for food processing and preservation and improved food security; b) creates marketing and manufacturing jobs for youth and women; and, c) provides supplementary income for institutions to reduce their dependence on external resources. This will require a paradigm shift in agriculture education delivery from training agriculturist to training farmers and agripreneurs who will engage in farming as a business to create jobs. Recruitment processes, which are currently academic and primarily based on results of entrances and placement exams, will have to include other requirements like applicants' previous farming backgrounds, land holdings and personal vision and interest about the application of acquired knowledge and skills in agriculture from training.

Status of research activities in higher education institutions. The scale and scope of research and scholarly activities in higher education in Liberia is almost a euphoria compared to other universities in the region and other parts of the continent (see Bloom and Canning, 2006; Cloete and Bailey, 2011). In 2015, the Ministry of Education reported that 16 institutions of higher learning in Liberia comprised of vocational schools, community colleges and universities and eight were degree granting institutions. The University of Liberia which is the nation's largest Higher Education institution and Cuttington University, a private university, are the only two with some aspiration for research. However, none has produced any significant stand-alone research data or publication in recent years. The underlying factors for Higher Education institutions renegeing on scholarly activities need to be assessed and research and scholarly activities
should be supported in higher education, as ably argued by Cloete and Maassen (2015).

**Research at the central agricultural research institute.** The Central Agricultural Research Institute (CARI) is the only research institution in Liberia. The 2016 Revised Research Strategy of CARI underscores adaptive research and promotion of knowledge, information and technologies that respond to clients’ demands and opportunities towards the attainment of food security. The strategy also aims to promote poverty alleviation, income generation and job creation. However, the achievement of this new vision is constrained by inadequate budgetary support to attract experienced scientists, fund research proposals and to equip research laboratories. The only functional laboratory at CARI currently is the Seed Testing Lab which is even minimally equipped. Unfortunately, CARI has had very limited budgetary support and funding especially over the last two years. CARI is somehow hopeful of prospects for securing funding from external partners to elevate its research activities.

**RECOMMENDATIONS AND CONCLUSIONS**

The aim of this study was to conduct an assessment of the status of higher and technical education in Liberia so as to identify priorities for strengthening competitiveness of the sector. Although tertiary education in Liberia began in 1862 with the establishment of Liberia College (now University of Liberia), which was followed by establishment of the first higher education institution, Cuttington College (now Cuttington University), Liberia remains among the countries with the lowest human development index, ranked at 181 out of 189 countries in the world. This has been a result of a myriad of problems including civil strife, limited investment in higher and technical education, and indeed the broader education sector, and inconsistent government policies including political interference. The findings of this study revealed that TVET’s effectiveness on employability and national development has been hindered by a number of constraining factors especially limited funding, poor policy direction, limited expertise and synergy with industry, and poor public perception of TVET in the country. Likewise, the higher education sector is extremely weak, with the country having only two public universities, both of which are poorly staffed, but a number of private universities have emerged. The proportion of PhD qualified staff is very low (13%) with 28% above the retirement age. Worse still, the proportion of female staff in public universities is decimal, 13%, being even lower in the TVET institutions (6%). In some of the institutions, part time staffing is more than full time staff, due to the poor remuneration of the staff in academic institutions. Currently there is no PhD training offered in Liberian Universities.

The above challenges are recognized by policy makers in Liberia. As part of the effort to strengthen the sector, the Government approved the Education Reform Act of 2015 but its implementation is still at infancy. The Government has also created the National Council for Higher Education, a regulatory body to provide quality assurance and accreditation of institutions and their programmes in the country. However, until the Government of Liberia depoliticizes regulatory agencies including the NCHE to function as a professional entity and increase public resource investment in the education sector, Liberia’s chance of being on par with other countries in developing a competitive workforce is highly unlikely in the foreseeable future from TVET and Higher Education perspectives. Moreover, developing a competitive workforce for Liberia’s economic growth and overall development will remain in jeopardy if the weak state of STEM education is not improved. This requires priority attention by the Government of Liberia and her development partners.

Improving training in STEM disciplines will
increase Liberia’s share of its own professional workforce to take charge of the economy which is currently in the hands of foreigners. Achieving this objective requires a strong political will to put Liberia on track for effective policy implementation and prioritization of its meager resources for the general good of building the human resource capacity of the country.

Constructive engagements between the Government of Liberia and its development partners on aligning assistance packages with the priorities of national development agenda including education which is in poor state cannot be over emphasized. Any further deterioration of the education sector beyond its current state will be tantamount to virtual non-existence of a serious competitive workforce development programmes in Liberia from TVET and Higher Education perspectives. Moreover, improving transparency and accountability for meager public resources to address development priorities will create opportunities for increased funding for much needed social services including education.

The proposal advanced in Pillar One of the PADP for improving the quality of TVET delivery is a step in the right direction for developing a competitive workforce for Liberia. As overly ambitious as it may sound with respect to the current state of the economy, the compelling reasons for supporting Pillar One has to do with regulating and standardizing TVET. These are among the major problems currently associated with the poor quality of TVET delivery in Liberia. Importantly Liberia needs to build its research capacity and learn from other countries experiences in linking research institutions and academia. This would enhance the role of education in development as elucidated by Reimers and Klasen (2013). Research development in Liberia will be enhanced if CARI and Higher Education institutions make concerted efforts to link with similar institutions in the continent, and intensify effort in developing joint proposals for funding consideration. This includes capacity building encompassing research proposal and report writing, equipping research laboratories as well as strengthening the human resource base for research.

Finally, the study findings indicate six key gap areas which need to be urgently addressed; a) the disproportionally very low women participation in higher education at all levels but especially in STEM areas; b) significantly high level of aging staff (close to retirement age) or staff who have reached retirement age; c) low staffing at both higher and TVET institutions; d) poor remuneration which makes it difficult to retain staff; e) little or no research activities in Liberian universities; and f) absence of PhD programme in Liberian Universities. These gaps will continue to hamper the quality of education and human resource in the country, with negative consequences on the country’s development.

RECOMMENDATIONS AND WAY FORWARD
There is an urgent need for the Government to implement the various policy frameworks developed for strengthening the Higher and Technical Education Sector. Firstly, appointments of Executive Directors and deputies of the National Commission on Higher Education (NCHE) should be guided by the Act that created the Commission to ensure competencies. Second, NCHE should institutionalize credible accreditation system in order to standardize all current and future higher education institutions in Liberia to ensure the quality of the training programs. Third, the Government should provide resources for implementation of the draft TVET policy to ensure the certification and standardization of TVET education which are critical to developing a competitive workforce for Liberia. Other recommendations are detailed below:

1. Based on the findings, the study recommends that for TVET to stimulate employability and promote national development there is
need for the policymakers to improve the level of funding, entice positive perception to TVET education, strengthen expertise of TVET instructors, and ensure curriculum harmonization. First, there is a need to create a national TVET enabling environment, including conductive policy framework and quality assurance mechanisms for TVET to effectively contribute to economic and industrial transformation in Liberia. Second, TVET institutions, particularly the flagship institutions, need to institutionalize their linkages with industries, to be forward-looking and adjust their programs to respond to the changing skill needs, use technology in the delivery of training, and efforts be made to upgrade the technical knowledge and practical skills of the TVET instructors to enable them promote student-centered teaching approach.

2. Government of Liberia needs to review its funding mechanisms to the Higher Education sector, especially to the two public universities. There is thus a need to a) significantly increase funding for operations, teaching, staffing and infrastructure development, and b) ensure Government pays unit costs for the students’ education in the two public universities. Overall, Government of Liberia should increase funding for the education sector to the minimum 20% of National Budget proposed in the Revised Education Act of 2011 and 2016.

3. There is a staffing crisis in both Higher and Technical education institutions, with often less than 30% qualified staff. Accordingly, the Government needs to made significant and long term investment to increase the pool of high level trained staff and arrange for upgrading of existing staff. In this regard Liberia should seek support from other African Governments and agencies to help it build up its staff capacities including in emerging areas to support its national development. In these endeavors deliberate effort should be made to increase the pool of women scientists.

4. Liberia needs to prioritise STEM education. While initial efforts have been made at especially University of Liberia, the scale is too low to support the development needs of the country. Liberia needs to make deliberate effort to build its STEM capacity to help the country leap-frog also towards the Fourth Industrial revolution

5. Currently Liberia Universities are not offering PhD level training. This will negatively affect the country’s ability to strengthen its higher education sector. As such, effort should be made to launch initially 2-3 PhD programmes at the University of Liberia in areas of strategic importance where there is basic capacity (PhD level trained staff). Partnership with other Universities especially in Africa, such as through the RUFORUM Network Universities, should be utilized to backstop this effort.

6. The inclusion of value addition and marketing in agriculture education will increase technical skills and knowledge base for achieving food and nutrition security and provide opportunities for increasing the inclusion of women and youth in the agriculture sector. Curricula revision in the future should therefore include value addition and marketing courses. In this regard, effort should be made to identify agro-food producing and processing zones and universities and CARI be tasked to develop programmes to build capacity and programmes responding to this strategic need.

7. The Government of Liberia should undertake a skills audit so as to guide human skill development at various levels in the country.

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

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