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Increasing Massive Enrolment at African Universities Weakened by a Dismal STEM Content and Miniscule Funding for Research

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Abstract

Massification of, especially higher education, characterised by rapid growth in number of students enrolled, is traced to the USA in the 1970s. It is now a global phenomenon, with Africa embracing it. This study was aimed at establishing the depth and breadth of massification in university education in Africa explore the STEM content in their programs and find out the related progress in research. By interrogating statistics relating to various aspects of universities on the continent, several conclusions have been made. This study established that the continent's Gross Tertiary Enrollment Ratio (GTER), that is, total enrolment in tertiary education, regardless of age, expressed as a percentage of the population in Africa is low. Its Gender Parity Index (GPI), the ratio of female to male enrolment in tertiary education, is also low. The continent has a staff to student ratio in many cases rising up to 1:100 in some departments. Laboratories are poorly equipped and Africa has a lukewarm attitude towards science, technology, engineering and mathematics (STEM) courses. Female students are worst affected. For the latter, it goes as low as 8% in Togo and Burkina Faso. In West Africa the percentage of women in these courses is below 25% of the total enrolment. The most successful enrolment of females is in North Africa, where for example, Tunisia has a score of 47%. As statistics indicate, emphasis on research and STEM is spurring social, economic and technological development is exemplified by High Performing Asian Economies (HPAEs)

Keywords: Africa, Knowledge Society, Massification, Research, STEM, Universities

1.0 Introduction

The concept of mass higher education originated from the USA, in particular, the State of California. It referred to the exponential growth in student enrolment in the 1970's (Scott, et al., 2016). Education, the conscious and organized learning process, should be geared towards the accumulation, verification and use of knowledge. Access to it should be controlled, but in a liberal environment. Regarding STEM it has been referred to as the purposeful integration of the Science, Technology, Engineering, and Mathematics disciplines, with the objective of solving real life world situations (Xie et al., 2015).

2.0 Methodology

The study has been conducted by extensively reviewing literature on the topic, synthesising data with precision, summarising the findings and meaningfully drawing conclusions. By use of global research to benchmark the current state against international standards, conclusion has been drawn and point to the urgency for continuous improvement. The approach ensures the recommendations are grounded in a well-established knowledge base, reinforcing the need for transformative changes in mathematics and science education in underserved regions. The approach has provided an excellent way of corroborating data on a meta-level in areas where research is

interdisciplinary but disparate. Quantitative data from credible sources has been elucidated by qualitative narration with deserving fluency. To contextualise the research the literature has been drawn mostly over the period from when massification commenced in Africa, generally coinciding with the attainment of independence from the colonial masters and the time of the research. Comparative reference has been made to regions that were relatively underdeveloped a few decades ago but that have made phenomenal achievement in an impressively short period in science and technology with resultant related innovation. They are now greatly transformed and developed.

2.1 Justification.

It is necessary to establish what has occurred as the phenomenon of massification takes root in the content because, among others, it affects not only the quality and quantity of knowledge generation and dissemination but also the direction and dimensions of sociological, economic, technological and scientific development. This study traces the trend in the massification of higher education and metrics associated thereto and makes comparative developments elsewhere for the purposes of learning therefrom. A particular aspect, STEM, has been especially interrogated, as has been the impact it has had on those domiciles that have emphasised it. Finally research as an overarching and a key factor at universities as generators and disseminators of knowledge has featured as a metric in light of massification.

3.0 Literature review

It has been observed that literature reviews are critical in evaluating existing knowledge, theories, methodologies, and research findings, enabling researchers to build innovative ideas (Boumezrag, M. B., 2022). This is no less true for an area such as massification of higher education, a global phenomenon. It largely resulted from the democratisation of education and the advent of the knowledge economy. It allows solving the problems encountered in the areas of knowledge generation and dissemination and enables members of society to individually, and as a community, achieve their subjective well-being (Kalashnikova, 2017). Massification of higher learning affects quality assurance and assessment of learning and teaching in concerned institutions (Tight, 2019). In Sub-Saharan Africa, universities are continuously experiencing large and accelerated increases in student enrollments, although the Gross Tertiary Enrollment Ratio (GTER) in the region is still lower compared to other regions. The phenomena is alarming for Africa because it is occurring in a context of a crisis of resources (Mve, 2021).

Table 1 Gross Tertiary Enrolment Ratio (GTER) and Gender Parity Index (GPI)

| REGION | 2000 GTER % | 2004 GTER % | 2008 GTER % | 2011 GTER % | 2010 GPI |
|--------------------------------|-------------|-------------|-------------|-------------|----------|
| Arab states | 18 | 20 | 22 | 23 | 1.02 |
| Central & East Europe | 43 | 55 | 04 | 08 | 1.26 |
| Central Asia | 21 | 20 | 20 | 24 | 1.09 |
| East Asia & the Pacific | 16 | 22 | 20 | 30 | 1.05 |
| Latin America & the Caribbean | 23 | 20 | 30 | 42 | 1.28 |
| North America & Western Europe | 60 | 68 | 71 | 77 | 1.32 |
| South & West Asia | 9 | 10 | 14 | 18 | 0.70 |
| Sub-Saharan Africa | 4 | 5 | 6 | 8 | 0.62 |
| World | 19 | 23 | 27 | 30 | 1.08 |

Source: UNESCO Institute for Statistics (2013).

Table 1 above reveals single digit growth rates for Africa for GTER, compared to those of some countries with scores ranging from fourty to seventy percent. The continent also has the lowest GPI amongst the regions. This implies greater efforts are needed if the status quo of the continent is to change in the global society of knowledge and enjoy related benefits.

3.1 Characteristics of massification in Africa

In Africa, characteristics of massification of university education include a staff to student ratio in many cases rising up to 1:100 in some departments, implying increased teaching load and administrative duties of the staff, at the expense of faculty contribution to research and quality of teaching. Lecture rooms and theatres are overcrowded. Libraries capacities are stretched. There are insufficient facilities and equipment for practicals in science, technology, engineering and mathematics (STEM) courses (Damte, 2021). African universities thus run the risk of getting lost in a race to “world-class” status principally driven by international ranking agencies (Mohamedbhai, 2014).

3.2 The role of big voices

Despite the challenges, massification of higher education in Africa has further been accelerated by the messages from highly respected personalities, like Makhtar Diop and Ban Ki-Moon and the late Kofi Annan. They emphasised the role of higher education in achieving social, economic, scientific and technological transformation and development. This, it is believed, builds human capital in science and technology, which is critical for empowering Africa to take advantage of its strengths (Bloom & Chan, 2006).

4.0. Findings and interpretation

Even before the big voices, and from the time colonies in Africa began attaining political independence in the 1960s, student population rose from 120,000 to 782, 500 in 1975. A Quarter a century later on, the student population was 6,000,000. By 2015 it had more than doubled to slightly more than 13 million. In Ethiopia, growth was phenomenal, with the number of public universities growing from a mere two in 2000 to thirty-six in 2015 (Nega & Kassaye, 2017). In Kenya, liberalisation of the education sector led to a vibrant and growing private education sector. Over time, the country’s student enrolment increased from 112,229 in 2006 to 539,749 in 2016 (World Bank, 2002). Africa’s average annual growth rate between 1985 and 2002 was 13%. However, some countries exceeded the average by multiples of the average. For example, Rwanda (55 percent), Namibia (46 percent), Uganda (37 percent), Tanzania (32 percent), Cote d’Ivoire (28 percent), Kenya (27 percent), Chad (27 percent), Botswana (22 percent), and Cameroon (22 percent) (Materu, 2006). Nevertheless, African countries growth rates are unacceptably low by global standards (Blom et al., 2016).

4.1 Lukewarm emphasis on STEM in Africa

Proponents of the need for embracing STEM courses argue that it expands the transformative abilities of students, by equipping them with technical and scientific education in a way that strongly emphasises critical, practical and creative thinking skills (Siekmann & Korbel, 2016). The courses are expected to go a long way in addressing the rampant unemployment challenges the continent is faced with (Burnett & Jayaram, 2012). Low levels of enrolment for STEM courses are attributed to many factors. In most countries in Africa, students are introduced to STEM late in the educational system, with the majority of teachers characteristically biased against the subjects and incompetent in instruction. The case is worse for female students. In West Africa for example, the percentage of women in these courses is below 25% of the enrolment. It goes as low as 8% in Togo and Burkina Faso. The most successful enrolment is North Africa, where for example, Tunisia has a score of 47% (Okeke et al., 2016; Khumbah, 2018). STEM courses require big amounts of sunk capital, compared to arts, social sciences and humanities. It is therefore not surprising that these courses lag behind in Africa. A

typical pattern exists in Africa, exemplified by Uganda, for the proliferating private universities, where for the period between 1970 and 2020 out of the 1025 doctorate degrees awarded in public universities, 699 (68.1%) were in STEM. Only 326 (31.9%) were in non-STEM disciplines. Over the same period, for private universities, out of the 172 PhDs awarded, only 19 (11%) were in STEM, and 153 (89%) were in non-STEM disciplines. Indications are that the increasing enrolment will continue to be skewed that way (Kumba, 2018).

4.2 Why STEM courses for Africa

The impact of technological advances on society and the importance of STEM proficiency in a knowledge-based economy has been emphasised by many researchers. In a contemporary context, investigation has been done on the integration of 3D printing in technology and engineering education, showcasing the ongoing advancements in educational approaches. Thus, STEM is promoted as a dynamic force in the broader education and career development (Yamada, 2023, Lin *et al.* 2023).

The contours that divide countries between developed and underdeveloped are mostly defined by the level of scientific and technological achievement and sophistication. This implies that science and technology play pivotal roles in the development of nations. Given that global power play is focused on the levels of science and technology of nations, African countries are precariously positioned (Ekanem, 2010). In 2015, the African Union Commission published a report titled “*The Africa We Want*” which articulated the continent’s leadership aspirations by 2063. These included, among others, being topmost performers in global quality of life measures. To achieve this status, leaders hoped to have in place strategies of inclusive growth, job creation, increasing agricultural production; investments in science, technology, research and innovation. Ten years earlier in 2005, the continent had coined “**Africa’s Science and Technology Consolidated Plan of Action**”. This consolidated the science and technology programmes of the African Union (AU) Commission with those of the New Partnership for Africa’s Development (NEPAD).

The continent should take cognizance of the reality around the world. It is estimated that over the next decade, 75 million jobs requiring traditional skills will be lost, only to be replaced with 133 million new jobs, requiring technologically inclined competences, which have become key drivers of the knowledge economy (Kariwo *et al.*, 2014). The world will inevitably be greatly impacted upon by five trends in science and technology, namely, advances in mobile Internet, sophisticated cloud technology, increase in the availability of big data, massive adoption of new technology, and advances in artificial intelligence (WEF, 2018).

4.3 A competitive world and the need for STEM

If Africa is to share in the opportunities of the many jobs created as above, and in order for its population not to be relegated to destitution as a result of lack of competitiveness in the global job market, policy makers and educational services providers, mainly the universities must pay great attention to STEM courses. Analysis of facts and figures in table 2 below attest to the precarious position of the continent.

Table 2 Distribution of African University graduates by field of study 2005

| <i>Field of study</i> | <i>Distribution of graduates (%)</i> |
|--------------------------------|--------------------------------------|
| Agriculture | 3 |
| Education | 22 |
| Health science | 7 |
| Engineering | 9 |
| Sciences | 9 |
| Social sciences and humanities | 47 |
| Other | 3 |

Source: World Bank EdStats.

Table 2 above confirms the preponderance of social sciences and humanities in Africa. It indicates that in 2005, almost half (47%) of the students who graduated from African University were from these fields. This is not to argue that humanities and social sciences are any less valuable. Indeed many of the challenges that face the globe and Africa in particular require solutions that require social, psychological, cultural and economic component, to augment the achievements arising out of scientific and technological progress. For example these lead to urbanization, environmental degradation as well as growth and displacement of populations, and vices such as prostitution and drug abuse, which require counselling and preparing the populations on many aspects. Technologically and scientifically advanced countries consistently score highly on human development indices. Furthermore, given that Africa is a continent mainly dependent on agriculture, it is surprising that graduates in this sector constituted only 3% of the total number. Continued rudimentary practices in agriculture, due to limited scientific development is partly to blame for low levels of production and productivity and high exposure to the vagaries of nature, leading to food insecurity. Meanwhile, advance in technology and science has led to dramatic increase in agricultural production and productivity, amazing ways of communication, and improvements in health and quality of life, elsewhere (Kehdinga, 2020). Finally, the figures reflect the precarious Africa's position regarding employability, and ability for graduates to create jobs for themselves (Penprase, 2018). Unfortunately, despite its big population, Africa's expenditure on research disproportionately accounts for only 1.3 % of that of the whole world. It is therefore not surprising that of the patents registered globally, Africa's share is a mere 0.1%. Additionally, in comparison to the UK, USA and the other developed western economies who boast of 4,000 researchers per one million of their population, Africa has 198 researchers for a similar number of people. Africa needs to evaluate many aspects which have generally retarded its growth and development in the generation, dissemination and accumulation of knowledge. Research is a critical feature of knowledge society. Universities or institutions of higher learning are the bastions of research (Sazir and Hakim, 2022). The low number of PhD holding faculties at universities is a key factor. The data in table 2 below indicates the low number of PhD holders viz-a-viz other academic staff at Makerere University, over the period 2004-2006 and 210-2011.

Table 3: PhD holders viz-a-viz other academic staff at Makerere University, over the period 2004-2006 and 210-2011.

| Year | PhD | Masters | Bachelors | PGD | Diploma | Certificate | Total |
|------|-----|---------|-----------|-----|---------|-------------|--------------|
| 2004 | 549 | 2,221 | 1,715 | 684 | Nil | 80 | 5,249 |
| 2005 | 558 | 2,167 | 1,694 | 153 | 611 | 75 | 5,258 |
| 2006 | 746 | 2,651 | 1,949 | 224 | 772 | 123 | 6,465 |

| | | | | | | | |
|------|-----|-------|-------|-----|-----|-----|--------------|
| 2010 | 858 | 2,967 | 2,621 | 209 | 734 | 480 | 7,869 |
| 2011 | 914 | 3,657 | 2,923 | 269 | 748 | 191 | 8,702 |

Source: National Council for Higher Education, 2011

Regarding the situation, a study by a former Executive Director of the country’s National Council for Higher Education observed that the number of PhD holders in the country is so low that it is wishful thinking that Uganda can be transformed into a modern society by 2040 as the official plan would make us believe. This according to him, at the time of the study, in a population of 35 million people, the ratio is about one PhD holder per 35,000 people, which is 0.1 percent (Kasozi, A, B 2019). This is too far below the 1.2 percent in USA and even most emergent countries. Holders of PhD qualifications are essential for nurturing a research community. The very low ratio above, combined with the very low number of researchers inevitably results in the very low share of global patents attributed to Africa of a mere 0.1%.

These in turn greatly explain the position Africa holds in terms of global human indices.

4.4. Lessons from the East Asian development miracle.

Between 1965 and 1990, particular countries registered rapid economic growth rate, most especially in what were dubbed High Performing Asian Economies (HPAEs)-Japan, the “four tigers”, namely, Hong Kong, the Republic of Korea, Singapore, and Taiwan; and the three newly industrializing economies (NIEs) of Southeast Asia, Indonesia, Malaysia, and Thailand (John, 1994). It is mainly prioritizing technological innovation that did the miracle (Wade, 1990)

By 2009, the East Asia and Pacific region had more scientific publications and patents filed by residents than the total for Sub-Saharan Africa, South Asia and the Middle East and North Africa combined. No doubt, universities had a great role to play in knowledge generation and dissemination for this to happen. Table 4 below gives the statistics.

Table 4 Scientific publications and patent application by region

| <i>Region</i> | <i>Scientific publications</i> | <i>Patent applications filed by residents</i> |
|---------------------------------|--------------------------------|---|
| East Asia and Pacific | 25,391 | 65,506 |
| Europe and Central Asia | 40,043 | 32,728 |
| Latin America and the Caribbean | 16,789 | 40,003 |
| Middle East and North Africa | 4,468 | 926 |
| South Asia | 12,127 | 2,143 |
| Sub-Saharan Africa | 3,696 | 101 |

Source: World Bank 2009.

Table 4 compares Africa with selected regions in 2009. The continent scored comparably badly in terms of scientific publications, which is a mirror reflection of how much is being contributed to the stock of knowledge. In turn this shows how active the academia in an institution, country or region are. East Asia’s 25,391 scientific are greater than the total of Middle and North Africa, South Asia and Sub-Saharan of 20,291 by a big percentage (21%). It is worse for patent applications. At 65,506 East Asia more than dwarfs the other regions’ total of 3,170 patent applications. For all the countries that have made great strides in areas as wide ranging as infrastructure, energy, industrial, health, education, communication, financial, entertainment, transport, agricultural, economic and environmental protection, to name but a few, scientific and technological evolution and many times revolution have been key. Evidently, the rate of growth of science and technology in Africa is slow. This can only change if the continent changes the attitude towards STEM and lay emphasis on those key

elements and measures that are of priority to development. Universities are crucial in bringing about the transformation (Engwa, 2014; Adedokun et al., 2019; Ahrens, 2002; Ajoku, 2004).

4.5 Africa and the comparative research output by subject grouping.

Universities principally exist to add to stock of knowledge. Naturally their addition is made by enabling the findings known through publication by their faculties and students. Generally, the higher the number and the better the quality of publication in peer-reviewed journals, the greater their impact in knowledge society.

Table 5 Percentage of Total Article Output by Subject Groupings 2012

| | Southern Africa % | East Africa % | West and Central Africa % | South Africa % | Malaysia % | Vietnam % |
|-----------------------------|-------------------|---------------|---------------------------|----------------|-------------|-----------|
| Physical science and STEM | 28 | 25.3 | 32.3 | 44.7 | 69.2 | 67.9 |
| Agriculture | 33.4 | 34.4 | 28.2 | 22.9 | 15.3 | 22 |
| Health Science | 44.8 | 47.8 | 43.1 | 26.5 | 13.1 | 16.5 |
| Social Science and Humanity | 17.5 | 15.4 | 14 | 21.8 | 19.4 | 8.4 |
| Life Sciences | 15.7 | 15.0 | 15.2 | 8.7 | 5.1 | 8.6 |

Source: Scopus, 2012.

Table 5 above disaggregates endeavours in scientific and social sciences achievements in Africa compared to two East Asian countries, Vietnam and Malaysia, by way of percentage of total article output by subject groupings. For STEM in particular Malaysia leads (69.2 %) followed by Vietnam (62%). From Africa, South Africa leads (44.7%). In descending order it is followed by West and Central Africa (32%), Southern Africa (28%) and East Africa (25.3%). The continent’s average of about 30% is less than half of the second placed country from East Asia, Vietnam.

The perception of Mathematics and Science as complex subjects, coupled with societal pressures to prioritise less ‘challenging’ subjects, has resulted in a quantity-over-quality approach to education in Africa. There is great need for establishing dedicated Mathematics, Science, Engineering, and technology centres in these underserved regions, drawing upon global research findings that underscore the importance of continuous improvement in STEM subjects for individual and national advancement. Successful case studies and global research demonstrate the positive impact of such centres on student engagement, teacher development, and community involvement. By addressing challenges in the existing classroom dynamics, these centres offer a promising avenue for hands-on, inquiry-based learning, alleviating resource constraints and overcrowded classrooms. (Ntsanwisi, S., 2024).

Gender, age, and cultural beliefs require immediate attention to tackle the entrenched and persistent perception of mathematics and Science as complex subjects. Unfortunately this is compounded by teachers, either because they believe so or by themselves being poor facilitators in these areas. Thus efforts should focus on effective professional development to improve teaching methods and motivation.

The significance of mathematics and Science in societal progress, personal growth, and career opportunities cannot be overstated. The global consensus on the importance of STEM proficiency reflects the

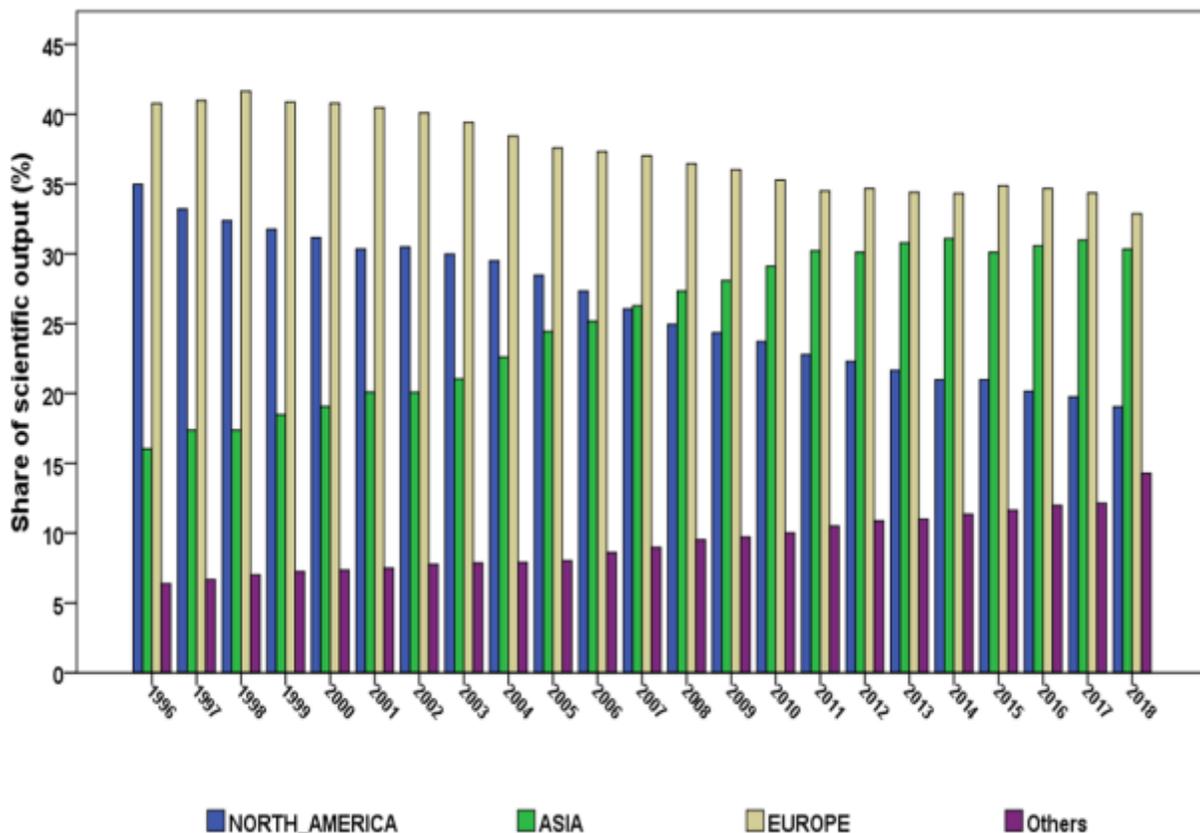
interconnectedness of education with economic development and innovation. African countries face a skills crisis and challenges in STEM. They need to navigate the paradox of quantity versus quality in education.

More detailed statistics in this area indicate the share of STEM research in Sub-Saharan Africa has, since 2002, marginally declined by 0.2 percent annually. Ten years later, in 2012, the quality of STEM research in Sub-Saharan Africa, as measured by relative citation impact, was 0.68 (32 percent below the global average), which is below that of all disciplines in Sub-Saharan Africa (0.92) and the global average (1.00). This trend that has virtually stayed the same since 2003. Correspondingly, Sub-Saharan Africa achieved a Field Weighted Citation Impact (FWCI) of 0.92 in 2012, meaning it was cited 8 percent less than the world average. The regions' average FWCI in the Physical Sciences and STEM was only 0.68 in 2012, that is, it was cited 32% percent less than the global average. It has virtually stayed so since 2003. The World Bank has more or less the same findings in its research of the continent. Although Sub-Saharan Africa more than doubled their yearly research output from 2003 to 2012 and its share of global research increased from 0.44 percent to 0.72 percent during the decade examined, citations of Sub-Saharan Africa articles comprised a small but growing share of global citations, when it increased from 0.06 percent to 0.12 over the period (Blom Andreas et al.; 2016).

4.6. The changing global positioning in research by regions and impact on development

There has always been a coincidence between technological advancement on the one hand and development in other sectors. Figure 1 below shows the trend in scientific publications, which in turn translate into patents and products and services of certified quality, for various regions.

Figure 1: Trend in scientific publication for the period 1996 to 2018



Source (Oliveira EA et al 2022)

It is undisputed fact that Asia has made significant growth in economic and scientific terms. The trend has been for the combined west to recede in absolute terms of scientific publications, while Asia has been on the rise.

4.7. Asia’s General Rise on the Global Scene

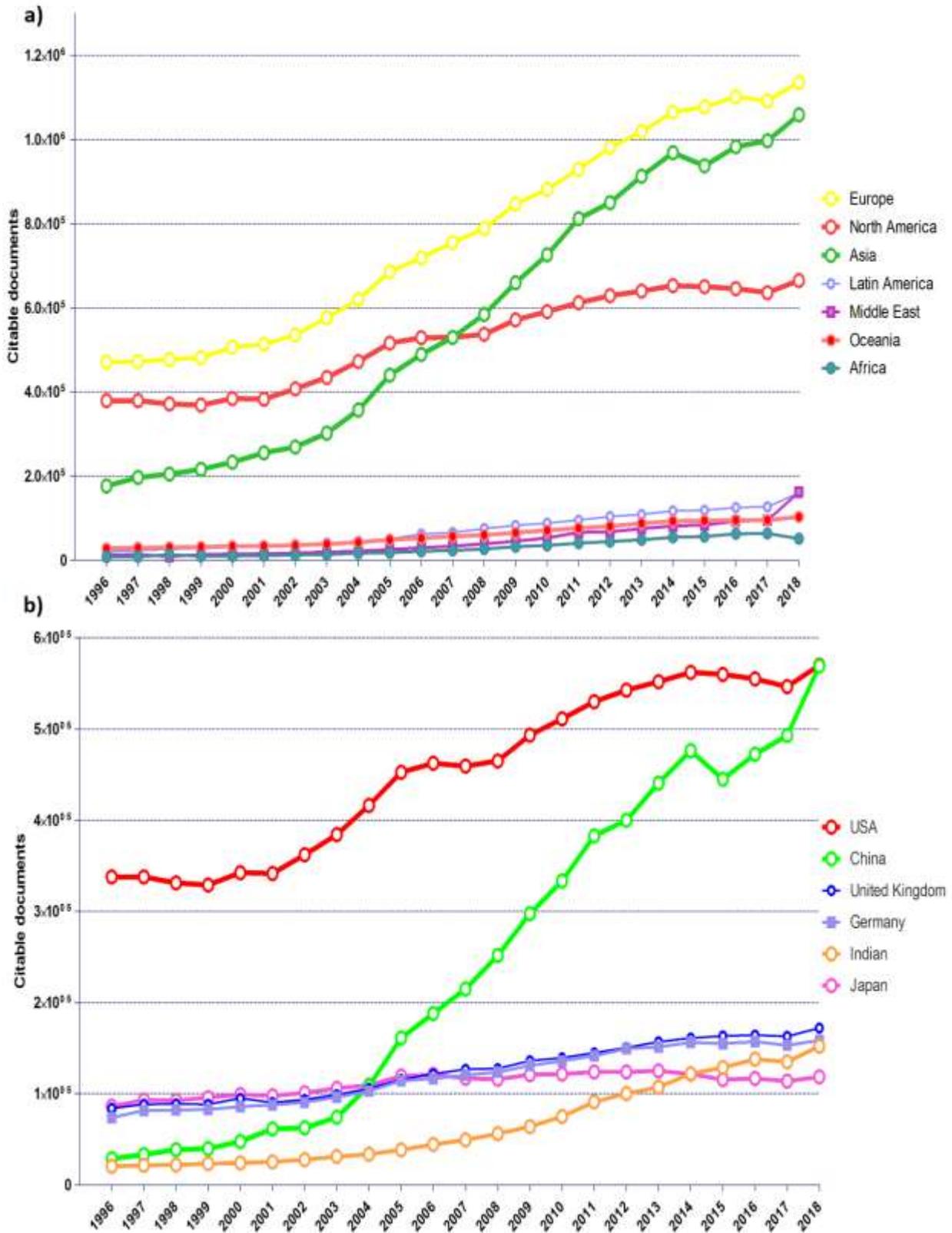
In 1966, when the Asian Development Bank (ADB) was established, the Asia and Pacific region was very poor. In 1967, The Association of Southeast Asian Nations (ASEAN) was launched by its original five members as a grouping for promoting regional peace. Yet, ASEAN economies had not initiated the strong growth based on reforms and the “flying geese” model. Central Asian countries were under the Soviet system. Many countries in the region suffered from conflicts and political instability (ADB, 2020). In 1968 Swedish economist Gunnar Myrdal, published *Asian Drama: An Inquiry into the Poverty of Nations*, which portrayed the region as one stuck in “doldrums” constrained by rapid population growth and government inability to implement effective development policies (Myrdal, G. 1968). The success story of the countries in the region is quite revealing. In 1960, developing Asia’s per capita gross domestic product (GDP) was \$330 (in constant 2010 United States dollars). By 2018, it had risen to \$4,903, a nearly 15-fold increase, while global per capita GDP only tripled over the same period. As a result, the region’s share of global GDP jumped from 4% to 24%; it increased from 13% to 34% when Japan, Australia, and New Zealand are included (ADB, 2020).

7.2 The dis-aggregated profile of research by regions

Innovation and investment in R&D were key factors in the extra ordinary progress of the Asian tigers. Other countries need to do so in order to improve productivity and increase the share of high tech exports in the global market (Gulshan F B and Sandeep K 2019).

Although Europe tops research and publications, it is doing so at a decelerating rate. The gradient for Asia is meanwhile steeper in rise. North America is performing quite below these other top regions. The scenario is depicted in figure 2 below.

Figure 2 disaggregated publication statistics by region.



Source (Oliveira EA et al 2022)

Annual production of scientific articles indexed in the SCImago database by seven continents; **b)** Annual production of scientific articles indexed in the SCImago database by the six most productive countries.

5.0. Recommendations.

Individually universities in Africa are for the most part too underfunded to enable carrying out meaningful and developmental research. Rising massification compounds the challenges.

5.1 Collaboration between universities at domestic, regional and global level is recommended. Unity is strength. Universities in Africa have, as anticipated, learnt lessons as they massify, and recognise the role of research in elevating an institution’s global rankings. Collaboration, it has been noted, creates immense synergies and is beneficial. The integration of collaborative learning and technological advancements in STEM education offers a promising pathway to addressing the unique challenges faced by African educational systems. By fostering an environment that encourages active participation and practical application, students can develop essential problem-solving and critical thinking skills (Baingana, J, 2024). This is especially given the limited resources available to the education sector in general and research in particular. International collaboration played a vital role increasing the badly needed research. In 2012, it accounted for 79 percent, 70 percent, and 45 percent of all research by Southern Africa, East Africa, and West and Central Africa, respectively. Decades of intense massification of higher education coupled with advance of globalisation and marketisation, have seen leading university positioning by the highly respected Times Higher Education (THE) ranking and Shanghai Ranking (alternatively called Academic Ranking of World Universities (ARWU). These highly rank those universities that score highly in the capability to conduct globally impactful and excellent scientific research with ‘world-class’ status (Blom Andreas et al.; 2016). Table 6 below rates universities from Africa over the period 1996-2015.

Table 6 Top 1 per cent most highly cited publications per African university (1996-2015)

| | Number publication | of Global cooperation | Intra-Africa cooperation | Domestic cooperation | No cooperation |
|------------------------|--------------------|-----------------------|--------------------------|----------------------|----------------|
| Eduardo Mondlane Univ. | 109 | 83% | 7% | 1% | 9% |
| Univ. Cape Town | 402 | 82% | 0% | 7% | 11% |
| Stellenbosch Univ. | 192 | 82% | 0% | 6% | 11% |
| Makerere Univ. | 235 | 78% | 5% | 5% | 12% |
| Univ. Nairobi | 110 | 78% | 1% | 9% | 12% |
| Univ. Witwatersrand | 248 | 77% | 0% | 10% | 13% |
| Univ. KwaZulu-Natal | 180 | 75% | 1% | 8% | 17% |
| Univ. Ghana | 161 | 71% | 1% | 8% | 20% |
| Univ. Dar es Salaam | 123 | 70% | 6% | 4% | 20% |
| Univ. Pretoria | 125 | 67% | 3% | 10% | 21% |
| Univ. Mauritius | 174 | 54% | 5% | 10% | 31% |
| Univ. Botswana | 301 | 45% | 11% | 3% | 42% |

Data source: Thomson Reuters *Web of Science Core Collection* database (SCI Expanded, SSCI, and AHCI).

The trend is for overwhelming reliance on collaboration with universities and organisation from outside the continent to produce quality research work. Also noteworthy is the low level of cooperation in research between African universities.

5.2 As a participant in the global knowledge society, Africa needs not to only increase the quantity but also quality of its research. A multidimensional subject, research excellence, is largely viewed transparently with lenses of bodies like African Science Granting Councils (SCGs). However, whatever view one may have about research excellence, key is the issue of quality and utility of output. Of course the more amount of utilizable quality output the better for the beneficiaries, implying, the quantity dimension must linearly move with value. The diverse views about research excellence, as well as ideas about how it could or should be applied within the African context, has led to demand for African-context derivations (Ndofirepi & Cross, 2016). Improving the quality of research is a central objective of science, technology, and innovation (STI) policies in many African countries. Low levels of progress in science over the continent implies the need to develop individual skills of its scientists, scholars and researchers, as well as upgrading general infrastructure and ensuring adequate funding. This will enable them to produce quality, thus globally acceptable work (Robert Tijssen et al.; 2018).

5.3 A relatively commendable number of continental and multilateral bodies have made efforts to assist Africa achieve greater results in STEM. The major ones include the African Union (AU), the New Partnership for Africa's Development (NEPAD), the African Development Bank (AfDB), the World Bank and the United Nations Educational, Scientific and Cultural Organization (UNESCO). However there is more need to coordinate their activities for efficient and effective building of national and regional systems of innovation to take place (Mugabe, 2011).

5.4. Gender and research Networking

Gender equalisation efforts must be promoted. As noted earlier in the study, there was disparity between genders. A study carried out in Uganda concluded that female scientists in research networks have positive experiences such as higher chances of getting research grants, projects, better research skills, career growth, participating in conferences, mentoring, and post-doctoral fellowships. Of course not to forget negative experiences like hectic schedules. Those female scientists believed that their inter-institutional, national, regional, and international interactions and engagements spurred excellent opportunities for them in their universities and for the universities themselves. This was because they were exposed to top-notch scientists in their disciplines. This study, therefore, recommends to the management of public universities in Uganda to establish formal research networks and strengthen the existing informal research networks. It has been confirmed that women scientists in networks improve their communication skills and expand their networks internationally because of accumulated knowledge (Barabino et al.2020).

6.0 Conclusion

Enrollment at private and public universities in Africa has been phenomenally growing, but still at a rate lower than the rest of the world. Africa's contribution to global research remains at a miniscule 2%. Accordingly publications from the continent have a Field Weighted Citation Impact (FWCI) of less than 1%. However the continent must take cue by preparing the learning populace for a future driven by technology, if they are to competitively survive in knowledge society. The encouraging news is that there are formidable voices in support of fundamental reforms to enable Africa promote the quality of education in general and STEM studies in particular, with corresponding concern for quality as the quantity grows. At the global level the UN Sustainable Development Goals and related multilateral programs and frameworks take cognizance of the dire need to promote education with a view to transforming the status quo. They are especially concerned with and aim at promoting STEM and girl inclusion. At the continental level, the Science, Technology and Innovation Strategy for Africa 2024, Aspiration 1 of Agenda 2063, intend to unlock the potential in Africa so that the continent occupies a respected position in knowledge society, with globally competitive human resources.

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