Science, Technology and Innovation in African Development: The Role of Universities

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Introduction

It is widely agreed that science, technology, and innovation are indispensable for African development. Universities are generally expected to play a critical in the development of national and regional STI capabilities. The challenge is in the meaning of these axiomatic assumptions and aspirations, the modalities of synergizing them into a virtuous cycle of continuous reinforcement to create knowledges, capacities, opportunities, and mentalities for innovative, integrated, inclusive and sustainable economies, societies, and polities.

STI is integral to Africa's enduring drive for self-determination, development, and democratization, for the continent's transformation, and the restructuring and reimagining of its engagement with the world. Ultimately, it represents a search for African modernities in a world dominated by 'instrumental reason' and characterized by the growing importance of 'knowledge economies' and 'knowledge societies.' It is a project that poses challenges that are simultaneously political and philosophical, concrete and conceptual, about the social and structural conditions and imperatives of Africa's development in a world that rewards scientific and technological progress and punishes those lagging behind.

Knowledge including science and their applied products—technology—are driven and conditioned by powerful epistemic, economic, political and historical forces. Science is as much a scholarly venture spawned by intellectual curiosities and opportunities, as it is a social enterprise sustained by ideological interests, institutional dynamics, and the demands of society for solutions to pressing challenges and the market for profitable products and services. Science and scholarship thrive as much through the motivations, inspirations, and aspirations of the practitioners themselves as it requires structured support provided by universities, governments, businesses and other actors.

STI operates under national and transnational epistemological and regulatory regimes that transcend internal disciplinary proclivities and the agency and ambitions of their experts. The pressures and opportunities for strengthening STI in Africa have risen since 2000 as prospects for economic growth, political liberalization, and struggles for social inclusion have accelerated, and as the imperatives of the Fourth Industrial Revolution have become more evident. COVID-19 has cast its own frightful demands for scientific and innovative mitigations.

Across the continent there has been a proliferation of national, regional, and continental STI policies and plans. African governments and universities are more aware, and even seem more committed, than ever for their countries and institutions to invest and become producers of scientific knowledges, not just consumers of technological products. While science and technology are of course not a panacea for all the challenges of human and social development and by themselves will not solve Africa's stubborn legacies of underdevelopment, without them those legacies cannot be overcome.

My presentation is divided into five parts. First, I will briefly discuss the conundrum of development as part of my argument that universities are essential for STI. Second, I will explore Africa's standing in the global STI landscape. Third, I will examine various efforts undertaken by African states to engineer the development of STI. Fourth, I will suggest the ways in which universities can facilitate Africa's drive for STI. Finally, I will draw some lessons for Malawi.

The Conundrum of Development

Development remains an enigma despite massive intellectual and financial investments by the huge development industry that emerged after World War II. Governments and international and intergovernmental institutions, often supported by research in universities, have sought to decipher and deliver development. Academics in various fields especially in the social sciences and humanities have tried to answer some of these questions: why do some nations develop and others remain underdeveloped; why are some nations wealthy and others poor; why do some nations grow and others stagnate?

In the days of unabashed Eurocentric conceit, race and ethnicity were posited as explanations, that some races and ethnic groups were endowed with the innate attributes for civilization. You still hear these naturalistic fallacies even among Africans, in which some ethnic groups are deemed superior in intellect and entrepreneurship. As Eurocentric and ethnocentric rationales lost currency, the determinisms of geography, culture, and history rose to prominence.

According to the geographical hypothesis, a country's development is determined by its environment, terrain, and natural resources. Its advocates point to the fact that many poor countries are in the tropics and rich ones in the temperate regions. The cultural thesis posits development emanates from a society's cultural norms, social conventions, and even religious beliefs. There is the famous thesis that attributes the development of the Anglo-Saxon countries to the Protestant work ethic, and some attribute the rise of Southeast Asian countries to Confucianism. The historicist perspective comes in many guises: some applaud the genius of European civilization for the West's wealth, while others blame the poverty in the global South on European colonialism and imperialism.

Undoubtedly, geography, culture, and history affect the processes and patterns of development. But they only offer partial explanations at best. Abundance of natural resources doesn't guarantee sustainable development. In fact, it may be a curse as it fosters the growth of corrupt rentier states and extractive economies that are structurally anti-development. The rapid growth of some tropical countries such as Singapore in Asia and Botswana in Africa undermines geographical determinism. Culture is equally insufficient as an explanation. The same Confucianism held as the secret to Southeast Asia's recent economic miracle, was blamed for the region's grinding poverty decades ago. History is a more compelling explanation. But formerly colonized countries have had different trajectories of development, even those colonized by the same imperial power. Moreover, the historic shift of global power from the West to Asia punctures the narrative of eternal Euroamerican superiority.

Some put analytical faith in vague and ideological notions of market freedom or democracy as the driver of growth and development. But the spectacular rise of a politically authoritarian China rebuts such arguments. Other scholars provide an assortment of explanations focusing on the levels of conflict and stability, patterns of corruption and investment, the presence of capable and committed leadership, and a nation's geopolitical affiliation to hegemonic powers.

More sophisticated and compelling analyses show that historically development prospects (not just rates of economic growth) have depended on the emergence and expansion of inclusive economic, political, and social institutions. Countries with extractive and weak institutions have not fared as well in achieving sustained growth and development. To the quality of institutions, I would add two other powerful factors: the quality of human capital and the quality of the social capital of trust. There is a growing body of research that shows a positive correlation between social trust and economic development including the accumulation of physical capital, total factor productivity, income, and human capital formation and effectiveness.

Since the first Industrial Revolution in the mid-eighteenth century to the unfolding Fourth Industrial Revolution, all the subsequent revolutions have been dependent on the indestructible link between intellectual inquiry, research, and innovation. This is the hallowed province of the university as society's premier knowledge producing institution. The university is also the primary engine for producing high quality and innovative human capital. There are of course strong connections between university education and the production and reproduction of social capital, and intriguing linkages between university learning and the generation of civic attitudes and engagement. At best, university education goes beyond the provision of vocational, technical, and occupational training. It imparts flexible and lifelong values, skills, and competencies. I will come back to the role of the university in promoting STI towards the end of my presentation.

Africa in the Global STI Landscape

The modern world is unimaginable without science, technology and the innumerable innovations that have revolutionized all aspects of socioeconomic life, politics and international relations, transport and communication, and the formation and performance of identities. Ever since the industrial revolution in the 19^{th} century, the links between science and technology have become tighter: there has hardly been any significant technological advancement since the beginning of the 20^{th} century that has not been the byproduct of scientific research. The Fourth Industrial Revolution represents STI on steroids.

The relationship between science and technology is of course not unilinear; there are multiple feedback loops between the two and between them and markets and national economic and social wellbeing. Investment in research and development has become an increasingly critical factor and measure of national competitiveness in a globalized economy compressed and interconnected by informational and communication technologies.

Four key trends are evident in the global knowledge economy. First, a global reshuffling in scientific production is taking place. Asia, led by China, has or is poised to overtake Europe and North America in several key STI indicators, such as research & development expenditures, scholarly publications, number and proportion of researchers, and patents. Second, research has become increasingly internationalized, which is evident in the exponential growth of collaborative research, citations to international work, and international co-authorship. Third, the landscape of research and development (R&D) funding is changing as new players enter the scene. In addition to governments, investments by business firms, philanthropic foundations, and intergovernmental agencies have risen. Finally, the growth of digital technologies have accelerated international collaborations and provided developing countries with almost unprecedented technological leapfrogging opportunities.

The exponential ascent of Asia in STI indicators reflects and reinforces that continent's repositioning as the world's economic powerhouse. In contrast, despite Africa's much-vaunted rise, the continent remains at the bottom of global research indicators. According to data from UNESCO, in 2013, gross domestic expenditure on R&D as a percentage of GDP in Africa was 0.5% compared to a world average of 1.7% and 2.7% for North America, 1.8% for Europe and 1.6 per cent for Asia. Africa accounted for a mere 1.3% of global R&D. In 2018, global R&D expenditure reached US$1.7 trillion, 80% of which was accounted for by only ten countries. In first place, in terms of R&D expenditure as a share of GDP, was South Korea with 4.3%, and in tenth place was the United States with 2.7%. In terms of total expenditure, the United States led with US$476 billion followed by China with US$371 billion. What was remarkable was that, among the top fifteen R&D spenders, expenditure by the business sector was the most important source, ranging from 56% in the Netherlands to 71.5% in the United States.

In contrast, for the fourteen African countries that UNESCO had data, business as a source of R&D was more than 30% in three countries, led by South Africa with 38.90%; and was less than 1% in four countries. In most countries, the biggest contributor of to R&D was either government or the outside world. The former contributed more than 85% in Egypt, Lesotho and Senegal and more than 70% in another two countries, while the latter contributed a third or more in four countries. Higher education and private non-profit hardly featured.

Not surprisingly, other research indicators were no less troubling. In 2013, Africa as a whole accounted for 2.4% of world researchers, compared to 42.8% for Asia, 31.0% for Europe, 22.2% for the Americas and 1.6% for Oceania. Equally low was the continent's share of scientific publications, which stood at 2.6% in 2014, compared to 39.5% for Asia, 39.3% for Europe, 32.9% for the Americas and 4.2% for Oceania. The only area in which Africa led was in the proportion of publications with international authors. While the world average was 24.9%, for Africa it was 64.6%, compared to 26.1% for Asia, 42.1% for Europe, 38.2% for the Americas and 55.7% for Oceania. Thus, African scholarship suffers from epistemic extraversion and limited regional integration, much as is the case with our economies.

In terms of patents, according to data from the World Intellectual Property Organization, in 2018 Africa accounted for 17,000 patent applications, while Asia led globally with 2,221,800 applications, followed by North America with 663,300, Europe with 362,000, Latin America and the Caribbean with 56,000, and Oceania with 36,200. For industrial design applications, Africa claimed 17,400. Again, Asia which led with 914,900, followed by Europe with 301,300, North America with 54,000, Latin America and a Caribbean with 15,300 and Oceania with 9,700. Africa's share of trademarks applications was 245,500, while Asia had 10,000,000, Europe 2,252,200, North America 827,800, Latin America and Caribbean 751,000, and Oceania 199,600. The data for utility model applications (a cheaper and shorter patent-like intellectual property model to protect inventions, which is not available in the US, Canada and Britain) is equally revealing. Africa had 1,050, Asia 2,097,500, Europe 40,773, Latin America and Caribbean 4,391, and Oceania 2,246.[1]

In sum, in 2018, Africa accounted for 0.5%, 1.3%, 1.7%, and 0.04% of global applications for patents, industrial design, trademarks and utility models, respectively.

Engineering Africa's STI Futures

African countries have become increasingly committed to strengthening their STI capacities as a critical driver for sustainable development, democratization, and self-determination. They understand that STI is essential for the public good, private enterprise development, and building productive capacity for sustainable development. However, translating aspirations into reality is often fraught and frustrated by bureaucratic inertia, lack of political will and resources.

By 2010, more than forty countries had established ministries responsible for national S&T policies. In addition, several regional agencies were created to promote the development and coordination of S&T policies, such as the Network of African Science Academies (NASAC) formed in 2001 that by 2020 had 28 members. It 'aspires to make the "voice of science" heard by policy and decision makers within Africa and worldwide.' It seeks to build the capacities of national 'academies in Africa to improve their roles as independent expert advisors to governments and to strengthen their national, regional and international functions.' In recent years, NASAC has focused its attention on research and on providing policy advice to governments on the implementation of the UN's Sustainable Development Goals.

At the continental level several ambitious initiatives were advanced by the major intergovernmental agencies from the African Union Commission (AUC) to the United Nations Economic Commission for Africa (UNECA). In 2005, Africa's Science and Technology Consolidate Plan of Action (CPA) was created. The CPA merged the science and technology programs of the AUC and the New Partnership for Africa's Development. It sought to promote the integration of Africa into the global economy and the eradication of poverty through five priority clusters: biodiversity, biotechnology and indigenous knowledge; energy, water and desertification; materials sciences, manufacturing, laser and post-harvest technologies; information and communication technologies; and mathematical sciences.

The plan outlined strategies for improving policy conditions and building innovation mechanisms through the creation of the African Science, Technology and Innovation Initiative to establish common STI indicators and an STI observatory. It also sought to strengthen regional cooperation in science and technology, build public understanding of science and technology, a common strategy for biotechnology, and science and technology policy capacity as well as promote the creation of technology parks. The plan concluded with a list of institutional and funding arrangements as well as overall governance structures needed to ensure its effective and efficient implementation.

The CPA received vigorous support from UNESCO, which selected areas for assistance and proceeded to help a number of countries to review and reformulate their science policies. Notwithstanding all the fanfare that greeted the adoption of CPA, progress in implementing its programs proved slow hobbled by insufficient funding, weak organizational capacity, and inadequate infrastructure and expertise on STI policy development. Nevertheless, the CPA helped raise awareness about the importance of STI and foster bilateral and multilateral cooperation.

In 2014, the AUC adopted the Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024), which sought to place 'science, technology and innovation at the epicenter of Africa's socio-economic development and growth.' Six priority areas and four mutually reinforcing pillars were identified. The priorities were: eradication of hunger and achieving food security; prevention and control of diseases;

communication (physical and intellectual mobility); protection of our space; live together—build the society; and wealth creation. The pillars were: building and/or upgrading research infrastructures; enhancing professional and technical competencies; promoting entrepreneurship and innovation; and providing an enabling environment for STI development in the African continent.

It was envisaged STISA-24 would be implemented by incorporating the strategy in national development plans at the national level, through the regional economic communities and research institutions and networks at the regional level, and the AUC at the continental level. Targets would be established at each level, monitoring and evaluation undertaken, and domestic and external resources mobilized. Flagship and research programs would be established. Investment in universities as centers of excellence in research and training was emphasized, as was the engagement of the private sector, civil society, and the diaspora. STISA-24 was touted as a powerful tool to achieve the AU's Agenda 2063 by accelerating 'Africa's transition to an innovation-led, Knowledge-based Economy.'[2]

In 2018, UNECA produced a lengthy report on the STI profiles of African countries. It noted that Africa's economic growth since 2000 did not result in significant socioeconomic transformation because it was not knowledge-based and technology-driven. Africa needed to establish 'economies with sustained investments in science, technology and innovation (STI), and that have the capacity to transform inventions into innovations in order to drive national competitiveness and improve social welfare. Such countries have economic and STI policies integrated as coherent national policies and strategies; their decisions on STI are guided by carefully drafted country STI readiness and assessment reports.'

The report key indicators for measuring STI. It identified four pillars of country STI readiness and their input and output indicators. First, STI actors' competences and capacity to innovate. Under this pillar input indicators include R&D intensity, R&D intensity of industry, number of researchers in R&D, public sector investment in R&D, private sector investment in R&D, education expenditure as percent of GDP, and science and engineering enrollment ratio. Among the output indicators is the proportion of the population with secondary and tertiary level education, share of low, medium and high tech products in total manufacturing output, share of low, medium and high tech exports in total exports, and patents, trademarks and designs registered.

Second, STI actors' interactions. Inputs for this pillar comprise electric fixed power consumption per capita, telephone main lines in operation per 100 inhabitants, fixed broadband Internet subscribers per 100 people, and mobile cellular subscriptions per 100 people. Outputs encompass number of new products and services introduced, number of firms introducing new production processes, and level of FDI inflows.

Third, human resources for innovation. Its inputs consist of education expenditures as percentage of GDP, sciences and engineering enrollment ratio, number of universities and other institutions of higher education, number of specialized universities in science and technology fields, and number of institutes providing technical vocational education. Its outputs are evident in the number of researchers in R&D, number of graduates in STI fields (sciences, engineering and maths), proportion of population with secondary and tertiary level education, and share of employment in manufacturing and services sectors.

Fourth, STI policy governance whose inputs are the existence of an STI policy derived from a participatory approach that ensures widespread stakeholders' ownership and commitment, existence of an STI policy implementation framework that enjoys support of the political leadership at the highest level, while its outputs are the number of STI initiatives completed and scaled up per year, proportion of planned STI investments achieved, FDI inflows, and number of STI initiatives by nationals from the diaspora.[3]

Each of the regional economic communities also promulgated their own STI initiatives and programs. In 2008, the Southern African Development Community issued its Protocol on Science, Technology and Innovation 'to foster cooperation and promote, the development, transfer, and mastery of science, technology and innovation in Member States.'[4] In its Vision 2050, the East African Community noted 'STI, whether embodied in human skills, capital goods, practices and organizations, is one of the key drivers of economic growth and sustainable development.' It bemoaned

‘The weak development of science, technology and innovation has delayed the emergence of African countries as knowledge economies,’ and outlined a series of STI initiatives including the formation of the East African Technology and Science Commission.[5]

Similarly, in the treaty of the Economic Community of West African States member states agreed to ‘strengthen their national scientific and technological capabilities in order to bring about the socio economic transformation,’ by ensuring ‘the proper application of science and technology to the development of agriculture, transport and communications, industry, health and hygiene, energy, education and manpower and the conservation of the environment,’ and reducing ‘their dependence on foreign technology and promote their individual and collective technological self-reliance.’ They undertook to harmonize their science and technology policies, plans, and programs.[6]

Despite these commitments, African countries faced capacity challenges and constraints in building robust STI systems. In the literature four key issues have been identified. First, at the policy level, STI is often poorly grounded in the prevailing needs of society, national development plans, and lacks coordination. Second, there is lack of adequate and stable funding for STI infrastructures and poor implementation. Third, the private sector invests too little in research and development both for itself and in collaboration with higher education institutions. Fourth, scientific literacy as a critical means of popularizing science, technology and innovation in society, and among students at all levels of the educational system, tends to be weak.

It stands to reasons that developing and executing effective S&T policies entails the mobilization of key stakeholders including public institutions, the private sector, universities and research networks, international agencies, non-governmental and civil society organizations, and the media. The latter is indispensable for translating science to the public and building popular support for it. In short, if the goal is to promote STI for sustainable development, the processes of policy formation and implementation require democratic engagement. This calls for political will and bold and visionary leadership, strong institutions, and strategic planning and coordination of programs and activities into a single, strong and sustainable national

STI system. Without providing adequate resources to build research infrastructures and capacities national plans become nothing more than ritualistic and rhetorical gestures to fantasy.

Universities as Incubators of STI

Clearly, building collective, creative and transformative STI systems is exceedingly demanding. As noted in a report by UNESCO on co-designing sustainability science, it entails, first, building robust capacities that promote strong training and research infrastructures, intersectoral linkages, and multisectoral plans, and ensuring implementation and impact; second, strengthening the interdisciplinary and transdisciplinary generation of basic and applied knowledge and integrating different knowledge systems including indigenous and local knowledges; third, fortifying the science-policy-society interface through the incorporation of various stakeholders and mainstreaming the participation of women, the private sector, and civil society.[7]

Universities are crucial for Africa's drive to build effective transdisciplinary, collaborative and participatory STI capacities and systems that address the pressing needs and the development challenges and opportunities facing the continent. The package of prescriptions for this agenda is predictable. It is imperative to raise the number of tertiary institutions and enrollment ratios, levels of research productivity, and institutional commitments to public service and engagement and innovation and entrepreneurship.

In 2018, Africa had 1,682 universities, 8.9% of the world's total (18,772) compared to 37% for Asia, 21.9% for Europe, 20.4% for North America, and 12% for Latin America and the Caribbean. The tertiary enrollment ratio for sub-Saharan Africa was 9.08% and for the Arab states, some of which are in Africa 33.36%. In comparison the world average was 38.04%, for North America 86.26%, for Europe 71.56%, for Latin America and the a Caribbean 51.76%, East Asia and the Pacific 45.77%, Central Asia 27.64%, and South and West Asia 25.76%.[8]

Comparative global data on enrollment ratio by program is hard to come by. For the few African countries that UNESCO had data covering 2013-2018 (Malawi is not one of them and Kenya's data is often confined to one year), enrollments were highest in business, administration and law programs, social sciences, journalism and information programs, and arts and humanities programs, in that order. In many countries these three program clusters often registered more than two-thirds of students. Enrollments in the STEM and heath programs tended to be much lower.

Enrollment in the natural sciences, mathematics and statistics programs actually fell in Algeria, Benin, Burundi, Cape Verde, Lesotho, Madagascar, Morocco, Mozambique, Namibia, and South Africa. It only rose in Côte d'Ivoire and Seychelles. During the same period enrollment in engineering, manufacturing and construction programs fell in Benin, Cape Verde, Côte d'Ivoire, Lesotho, Mauritius, Namibia, Niger, Nigeria and South Africa, while they rose in Algeria, Burkina Faso, Burundi, Egypt, Madagascar, Mali, Morocco, and Tunisia.

Enrollment in agriculture, forestry, fisheries and veterinary programs fell in ten countries (Algeria, Burundi, Cape Verde, Egypt, Mali, Morocco, Namibia, Rwanda, Seychelles and South Africa), and increased in eleven (Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Eritrea, Ghana, Lesotho, Madagascar, Mauritius, Mozambique, and Niger). Enrollment in health and welfare programs rose in more countries—fourteen (Algeria, Burundi, Eritrea, Ghana, Lesotho, Madagascar, Mali, Morocco, Mozambique, Namibia, Niger, Seychelles, South Africa, and Tunisia)—and fell in seven (Benin, Burkina Faso, Cameroon, Cape Verde, Côte d'Ivoire, Egypt, and Mauritius).

STEM disciplines increasingly benefited from the establishment of universities of science and technology, the growth of these programs in other universities, and expansion of national and international research institutions. Africa's leading economies, Nigeria, South Africa and Egypt launched ambitious programs and initiatives to promote science and technology, which benefitted universities. Nigeria's Vision 2020 embraced science and technology as 'key to global competitiveness' and turning the country into one of the top 20 economies in the world. It identified twelve priority areas for systematic intervention and development including biotechnology, nanotechnology, renewable energy, space research, knowledge intensive new and advanced materials, ICT, and traditional medicine and indigenous knowledge.[9]

In South Africa, the government adopted the National Research and Development Strategy in 2002, which rested on three pillars: innovation, human capital and transformation, and alignment and delivery. It sought to promote a coordinated science system, increase investment in R&D to 1% of GDP, and enhance the country's innovation and competitiveness in the global knowledge economy.[10] Universities benefitted through the establishment of a Research Chairs initiative, Centers of Excellence Program and a Postdoctoral Fellows Program. In 2010, the Department of Science and Technology adopted a ten-year innovation plan building on the 2002 plan that placed emphasis on South Africa becoming a world leader in biotechnology and pharmaceuticals, space science and technology, energy security, global climate change science, and human and social dynamics. To promote these activities an innovation fund was established.[11]

In Egypt, the STI system was shaped by the Academy of Scientific Research and Technology, founded in 1972. Until 2007 the Academy controlled the budget for R&D in universities and research centers. After that it ceased to be a financing body but continued to play a central role in coordinating the country's research programs. New organs were created to strengthen STI capacities and collaboration. Universities stood to benefit from investments to increase the number and remuneration of researchers, large government research institutes from 18 to 28 and smaller ones from 180 to 230, and make governmental sources of research funding available to private universities for the first time. [12]

Egypt's new constitution adopted in 2014 'sets a goal of allocating 1 percent of the country's gross domestic product to scientific research, up from 0.4 percent in 2010-11.'[13] In 2019, the country issued its *National Strategy for Science, Technology and Innovation 2030*. The plan envisaged enhancing the system of STI management, human resources and infrastructure, quality of scientific research, investment in scientific research and linking it to industry and development plans, international collaboration, and developing a scientific mindset in society. Thirteen priority areas were identified: energy, water, health and population, agriculture and food, environment and natural resources protection, technological application and future sciences, strategic industries, information, communication and space technology, education, mass media and social values, investment, trade and transportation, tourism, and social sciences and humanities.[14]

The inclusion of the social sciences and humanities in the Egyptian STI 2030 strategy goes against the grain. All too often, African policy makers and educators create a Chinese wall between STEM and the humanities and social sciences, celebrating the former and disparaging the latter. In reality, what is needed is what some call STEAM—science, technology, engineering, arts, and mathematics. As I have argued extensively elsewhere, the Fourth Industrial Revolution—a term that refers to the emergence of quantum computing, artificial intelligence, Internet of Things, machine learning, data analytics, Big Data, robotics, biotechnology, nanotechnology and the convergence of the digital, biological and physical domains of life—makes it more imperative than ever to provide students with an integrated and holistic education that equips them with both essential employability skills and life-long learning skills.

The extraordinary changes in the nature and future of work, as well as living in a world that is increasingly digitalized and interconnected, processes that are being accelerated by COVID-19, require the merging of hard skills and soft skills; training students in both the liberal arts and STEM; linking content knowledges and mindsets acquired in the classroom, campus (co-curricula actives), community (experiential learning), and in terms of career preparedness (work based learning); offering an education that promotes interdisciplinary literacy, information literacy, intercultural literacy, international literacy, and inter-professional literacy; and providing teaching and learning using multiple platforms—face-to-face, online and blended.

We need to prepare our students for the next forty years of their lives, not the last forty of some of us. Their world will be characterized by extraordinarily complex and rapid changes, and by challenges and opportunities that are hard to predict. The best we can give these students, then, are the skills, competencies, literacies, and mindsets for flexibility, adaptability, versatility, and resilience. In short, the economies, societies, polities, and worlds of the twenty-first century will require lifelong and life wide learning skills, which entails continuous reskilling and upskilling.

Education for lifelong learning has to transcend the narrow disciplinary silos many of us were trained in and to which we are so often passionately attached. Such an education must be inclusive, innovative, intersectional and interdisciplinary. That, I submit, is at the heart of science, technology, and innovation as a project and process for sustainable development.

Enhancing Malawi's STI Landscape

Malawi's STI indicators offer a mixed picture. The key indicators should be familiar to many of us. According to a World Bank overview released on July 31, 2020, 'Malawi has made progress in building its human capital—the knowledge, skills and health that people accumulate over their lives—in recent years,' but poverty and inequality remain stubborn realities. In fact, 'the national poverty rate increased slightly from 50.7% in 2010 to 51.5% in 2016, but extreme national poverty decreased from 24.5% in 2010/11 to 20.1 in 2016/17. Poverty is driven by low productivity in the agriculture sector, limited opportunities in non-farm activities, volatile economic growth, rapid population growth, and limited coverage of safety net programs and targeting challenges.'[15]

The challenges of growth and development reflect, in part, the country's low levels of STI. According to the UNDP, Malawi's expected levels of schooling stands at 11 years; government expenditure on education is 4% of GDP; gross enrollment ratio at secondary school is 38%; population with at least some secondary education aged 25 and above is 21.8%.[16] Available data shows that in 2017 Malawi had 17,337 fixed telephone lines, putting it number 178 out of 214 countries, which translated into a subscription rate of less than 1 per 100 inhabitants. Subscriptions for fixed broadband were even lower. There were 40 subscriptions per 100 inhabitants for cellular phones, and 1.8 million internet users, which ranked the country at 106 and 115, respectively. The proportion of internet users represented 9.6% of the population, which placed the country at 191.[17]

This is an important backdrop for the development of STI. The country's first science and technology was established in 1990, followed by a revised policy in 2002, and the passing of the National Science Act of 2003. The new law led to the creation of the Commission for Science and Technology from a merger of the merger of the National Research Council of Malawi with the Department of Science and Technology of the Ministry of Science and Technology. In the university sector, there was the establishment of the Malawi University of Science and Technology and the Lilongwe University of Agriculture and Natural Sciences from the Bunda College of Agriculture a constituent college of the a University of Malawi.

These developments were encouraging, but the country's STI system remained weak. In 2014, UNESCO produced a detailed report on Malawi's STI system. It noted that out of a score of 1-7 and 148 countries, Malawi scored as follows:

- quality of education 3.4 and ranked 92
- quality of math and science education 3.2 and ranked 113
- quality of management schools 3.3 and ranked 124
- availability of research and training services 3.7 and ranked 104
- internet access in schools 2.3 and ranked 123
- extent of staff training 3.9 and ranked 84
- availability of latest technology 3.9 and ranked 127
- firm level technology absorption 3.8 and ranked 133
- FDI and technology transfer 3.6 and ranked 130
- capacity for innovation 3.0 and ranked 116
- tertiary education enrollment ratio 0.8% and 146
- scientific articles listed at SCOPU 382 and ranked 103
- citable scientific articles-H index 80 and ranked 83
- quality of scientific research institutions 3.2 and 104
- company spending on R&D 2.3 and ranked ranked 113
- university-industry collaboration in R&D 3.1 and ranked 111
- government procurement of advanced tech products 3.4 and ranked 83
- availability of scientists and engineers 3.6 and ranked 101
- Number of applications filed under the Patent Co-operation Treaty per million population 0.1 and ranked 98.

The data speaks for itself in so far as the areas for investment to enhance the country's STI system are clear. As noted in the country's Vision 2020 and numerous policy documents, it entails on the educational front: improving access, quality and equity in education, enhancing technical and vocational education and training, improving tertiary education, supporting institutions, and strengthening the management of education. Malawi's rate of tertiary enrollment at 0.8 is scandalous—it is the lowest in the world.

The UNESCO report notes, Malawi's R&D expenditure in 2010 as a share of GDP was higher than the african average at 1.06%, although it had dropped from 1.4% in 2007. But the report cautions: 'Taken at face value, this may give the impression that Malawi is one of Africa's biggest investors in R&D, as it is one of the few countries on the continent to devote more than 1% of GDP to GERD. However, Malawi's GDP is the smallest of any country with a comparable population (15–17 million). For example, the GDP of Niger is 1.5 times higher, that of Burkina Faso 2.3 times higher, Guatemala 10 times higher, Ecuador 16 times higher, Kazakhstan 25 times higher, Chile 47 times higher and the Netherlands 195 times higher. On average, a country with a population the size of Malawi will have 37 times its GDP.'

Clearly, Malawi needs to increase its R&D expenditures. It is also imperative for Malawi to strengthen its STI policies and monitoring mechanisms. Moreover, the fields of research need to be broadened. According to the UNESCO report, in 2012-2013, agriculture and agronomy accounted for 35.5% of research publications, and medicine and health 36.7%, that is almost three quarters. Also in need of broadening are the institutions producing scientific knowledge. The University of Malawi accounted for 57.6%, followed by the Tea Research Foundation with 10.7%, the Ministry of Agriculture, Food Security and Natural Resources with 5.7%, the Agricultural Research Council with 1.6%, Fisheries Research Center 1.1%, and Bvumbwe Agricultural Research Station 1.1%.

The range of countries that Malawian scientists and scholars collaborate in terms of co-authorship is also too narrow. In 2012-2013, Britain accounted for 44.3% of co-authored publications for Malawian scholars and scientists and the US 37.8%, or more than four-fifths. There is need to enhance the country's participation in regional and continental collaborations and STI initiatives and programs.

THANK YOU!

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