Using Science, Technology, and Innovation to Develop Africa: Progress, Challenges, and Opportunities

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Abstract

The United Nations (UN) Sustainable Development Goals (SDGs) recognize the role of science, technology and innovation (STI) in eradicating poverty, pursuing equity, protecting the planet, ensuring prosperity, and fostering global peace. In particular, SDGs recognize the importance of national, regional, and international cooperation in advancing the frontiers of science, technology, and innovation for societal benefits. At the same time, the world is witnessing the advent of the fourth industrial revolution, which is shaping economic and social activities on the globe. To benefit from global progress in STI, African countries have instituted various mechanisms to foster the development, access, and use of science, technology and innovation for economic development and to improve the lives of people on the continent. Among other things, STI policy, legal, and institutional frameworks have been developed or improved; efforts have been undertaken to strengthen universities and research and development (R&D) institutions; bilateral, multilateral, and regional agreements on STI have been established; mechanisms to finance STI activities have been put in place at national and regional level; and there have been efforts to create links between universities, R&D institutions, and the industry.

However, these efforts are not without a number of challenges, which are mainly related to weak national and regional systems of innovation and philosophical aspects of science, technology, and innovation in Africa. With respect to weak innovation systems, literature shows that most African countries lack appropriate scientific and technological capacity required to successfully engage in the use of STI for development. Some challenges regarding this include poor coordination and duplication of efforts among regional and international organizations providing financial and technical support for improving STI in Africa, a relatively strong emphasis on research and development at the expense of technological innovation, negligible national budgets for spending on STI, and the apparently insensitive nature of STI to the cohesion of African societies. As regards the philosophical aspects of STI in Africa, there are concerns about the nature of what is regarded as science, technology, and innovation in Africa, given the history, culture, and geopolitical position of Africa. The scholarly community, in particular, has expressed worries that STI, in its present form, could be used as a tool to advance neocolonial interests.

Based on the STI achievements and challenges in Africa, this paper recommends the need for improved coordination and commitment among STI stakeholders on the continent; the need for deliberate efforts to strengthen technological innovation on the continent by converting scientific and technological knowledge into products and services, which are a catalyst of economic development; and the need for more research and dialogue on better ways to

implement the STI agenda on the continent of Africa. In particular, there is need for context-sensitivity when pursuing the STI agenda in Africa.

1. Introduction

The United Nations (UN) Sustainable Development Goals (SDGs) recognize the role of science, technology and innovation (STI) in eradicating poverty, pursuing equity, protecting the planet, ensuring prosperity, and fostering global peace (United Nations, 2015). In particular, SDGs recognize the importance of national, regional, and international cooperation in advancing the frontiers of science, technology, and innovation for societal benefits. To align with this, in Africa, efforts have been made to create and/or strengthen national, regional, and international cooperation in advancing the frontiers of science, technology, and innovation for societal benefits (Mugabe, 2011). STI strengthening efforts have focused on different technologies, including biotechnology, nanotechnology, agriculture, and Information and Communication Technologies (ICT) (Gastrow, 2011; Mugabe, 2011). Admittedly, efforts to strengthen STI in Africa were in place even before the advent of the Millennium Development Goals in 2000. After independence, most African countries had put in place policy, legal, and institutional frameworks to support the STI agenda. For example, in Tanzania, the government of Mwalimu JK Nyerere formed the Tanzania Scientific Research Council in 1968 (Bourne, 1975), which was succeeded by the creation of the Commission for Science and Technology (COSTECH) through Act of Parliament 7 of 1986 (COSTECH, 2022).

At the moment, the world is talking about creating digital economies, in which ICT is used to support all economic sectors, and knowledge-based economies, in which scientific knowledge is used to derive innovation, producing goods and services that accelerate economic development (Bukht and Heeks, 2017; Makhoba, 2018). A digital economy is characterized by the prevalence of digital goods and services (Bukht and Heeks, 2017). Africa has also joined the global conversation on building digital economies. Tanzania, for example, through the National Five Year Development Plan 2021/2022-2025/2026 endeavours to build a digital economy, one that is heavily supported by digital computing technologies. The notion of digital economies is also inline with the dictates of the fourth industrial revolution (4IR), in which machines are made to be intelligent, and there are interactions between humans and machines to increase productivity (Jegede and Ncube, 2021; Lamola, 2021). According to the World Economic Forum, the fourth industrial revolution enables technologies to be combined in such a way that it is almost impossible to differentiate between the physical, biological, and digital realms. Also referred to as the second internet wave, 4IR is characterized by overwhelming numbers of digital connections between people, between people and things, and between things, forming the internet of everything. It is accompanied by technologies like Artificial Intelligence (AI), Internet of Things (IoT), blockchain, robotics, augmented reality, virtual reality, drones, and 3D printing. The way we live and work is already changing as a result of the 4IR. Numbers of people at workplaces are being reduced by automating jobs previously done by humans. The 4IR is

disruptive and could nullify some famous economic theories, because digitization and automation will dramatically minimize information asymmetry in markets and hence increase market efficiency by lowering the impact of human behaviour on corporate operations (Jegede and Ncube, 2021).

Being part of the world, African countries are automatically compelled to align with the dictates of the 4IR. Despite its potential benefits, the 4IR could negatively affect the lives and livelihoods of people on the continent of Africa. Thus, African countries must be well-prepared to face these grand developments in Science, Technology, and Innovation. In the next section, I discuss the progress that Africa has made regarding science, technology, and innovation.

2. Progress

To be able to cope with global developments in STI, African countries have put different mechanisms in place. Only some of the STI efforts in Africa are discussed here. First, African countries have developed policy, legal, and institutional frameworks on STI. Individual countries have developed national policies on STI. For example, Tanzania has the national science and technology policy of 1996 (MSTHE, 1996), the national research and development policy of 2010 (MCSTa, 2010), the national biotechnology policy of 2010 (MCSTb, 2010), and the national information and communication technology (ICT) policy of 2016 (MWTC, 2016); Kenya has the science, technology and innovation policy and strategy of 2008 (MST, 2008); and South Africa has adopted the science, technology, and innovation policy of 2019 (DST, 2019). African countries have also developed laws to guide science, technology and innovation. In Tanzania, for example, the Act of Parliament No 7 of 1986 established the Tanzania Commission for Science and Technology. The Uganda National Council for Science and Technology was established by the Act of Parliament in 1990. Kenya has enacted the Science, Technology, and Innovation Act of 2013. South Africa has the Science and Technology Laws Amendment Act 9 of 2020. In addition to policies and laws on STI, African countries have also created and strengthened universities and research and development (R&D) institutions, and the private sector has been engaged in pursuing the STI agenda. Efforts of different African countries in strengthening policy, legal and institutional frameworks on STI are well summarized by Mugabe (2011) and Gaillard and Mouton (2022).

Second, Africa in general and individual countries in particular have created bilateral, multilateral, and regional cooperation on STI. The AU Constitutive Act (Union, 2000) recognizes the importance of cooperation in advancing the STI agenda on the continent of Africa (see Article 13(i) and Article 14(d)). The need for collaboration in STI is also emphasized in various regional cooperation treaties, including the Southern African Development Community (SADC), the East African Community (EAC), the Economic Community of West African States (ECOWAS), and the Common Market for Eastern and Southern Africa (COMESA) (Mugabe, 2011). Cooperation in STI compensate for poor

availability of human, physical and financial resources in individual African countries. Cooperating countries can pool and share limited resources like R&D infrastructure and skilled human resources, leverage economies of scale in undertaking R&D and technological innovation, and learn from each other and improve accordingly.

Third, mechanisms to finance STI activities at national and regional level have been established. National budgets of individual African countries have been used to finance STI activities, albeit on a small scale (Mugwagwa et al., 2019). Figure 1 shows that, in 2011, 2013, 2015 and 2017, the average GDP spending on R&D was below 0.4% in Sub-Saharan Africa, way lower compared to other regions of the world. At the level of a continent, the African Development Bank has been funding various STI initiatives. And various international organizations such as the European Union, the United Nations Educational, Scientific and Cultural Organization (UNESCO), and the United Nations Conference on Trade and Development (UNCTAD) have been supporting various STI endeavours on the continent of Africa.

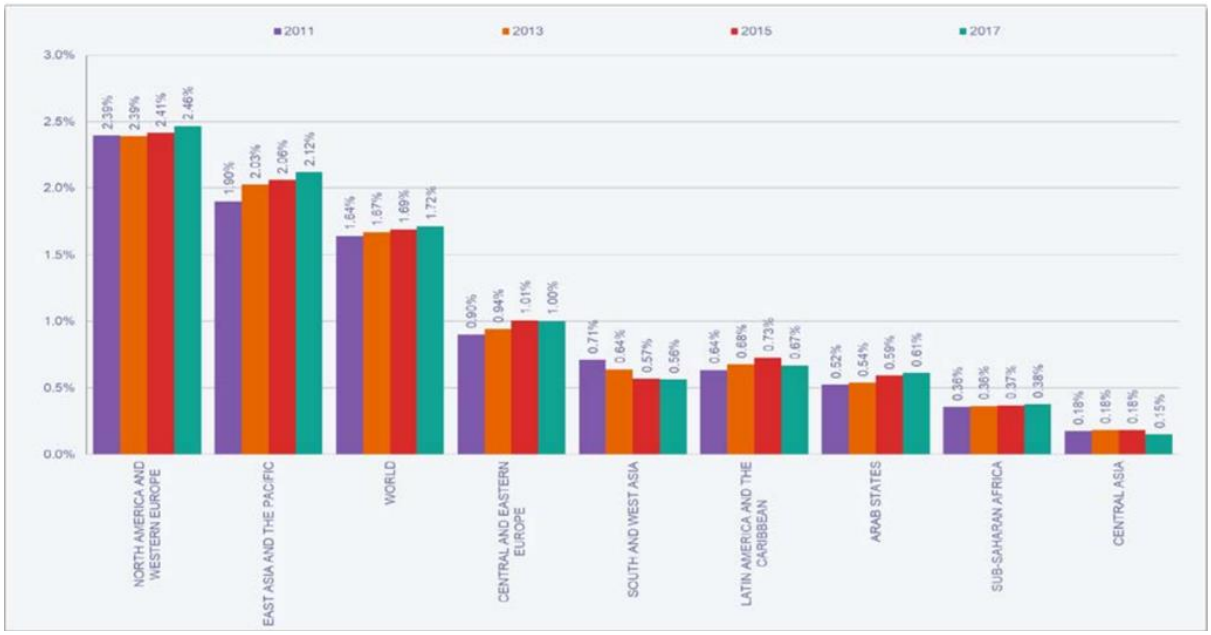

Figure 1: Gross domestic expenditure on R&D as a percentage of GDP by region, 2011, 2013, 2015 and 2017 (Source: UNESCO Institute for Statistics estimates, February 2020)

Fourth, there have been efforts to create links between universities, R&D institutions, and the industry in various African countries (Zavale and Langa, 2018). This is important to facilitate systematic conversion of scientific and technological knowledge produced by universities and R&D institutions into products and services, which are important in accelerating economic development. It is common knowledge that it is easy to reap the benefits of STI if these key players work together. Research in universities and R&D institutions can inform product and services in industry, and challenges faced in industry can inform research in universities and R&D institutions. The opposite is also true: if universities, R&D institutions, and the industry work in isolation, it will be difficult to exchange value among them.

3. Challenges

Despite the progress made regarding STI on the continent of African, a number of challenges still persist. Some of these challenges include the following. There are weak national and regional innovation systems (Watkins et al., 2015; Mugabe, 2011). This is mainly caused by the fact that, in Africa, activities by various STI players such as Universities, R&D institutions, government, financial institutions, the private sector are not well coordinated to maximize impact. As a result, most African countries lack appropriate scientific and technological capacity required to use STI for social and economic development. Specifically, there is poor coordination and duplication of efforts among organizations providing financial and technical support, there is a relatively strong emphasis on research and development at the expense of technological innovation, and most African countries spend negligible budgets on STI (Gaillard and Mouton, 2022).

Moreover, STI infrastructure in most African countries are generally of poor quality. Laboratories used for scientific research in most African universities lack appropriate state-of-the-art equipment, computers, and software applications (Mugabe, 2011). Unstable supply of electricity also affect research and innovation activities on the continent, and exacerbates the digital divide between the global north and the global south and between rural and urban areas in different parts of Africa. For these and other reasons, globally, R&D institutions in Sub-Saharan Africa are still performing poorly on a number of STI indicators. For example, by 2020, countries in Sub-Saharan Africa had smaller numbers of researchers per million inhabitants who are fully committed to R&D activities (see Figure 2).

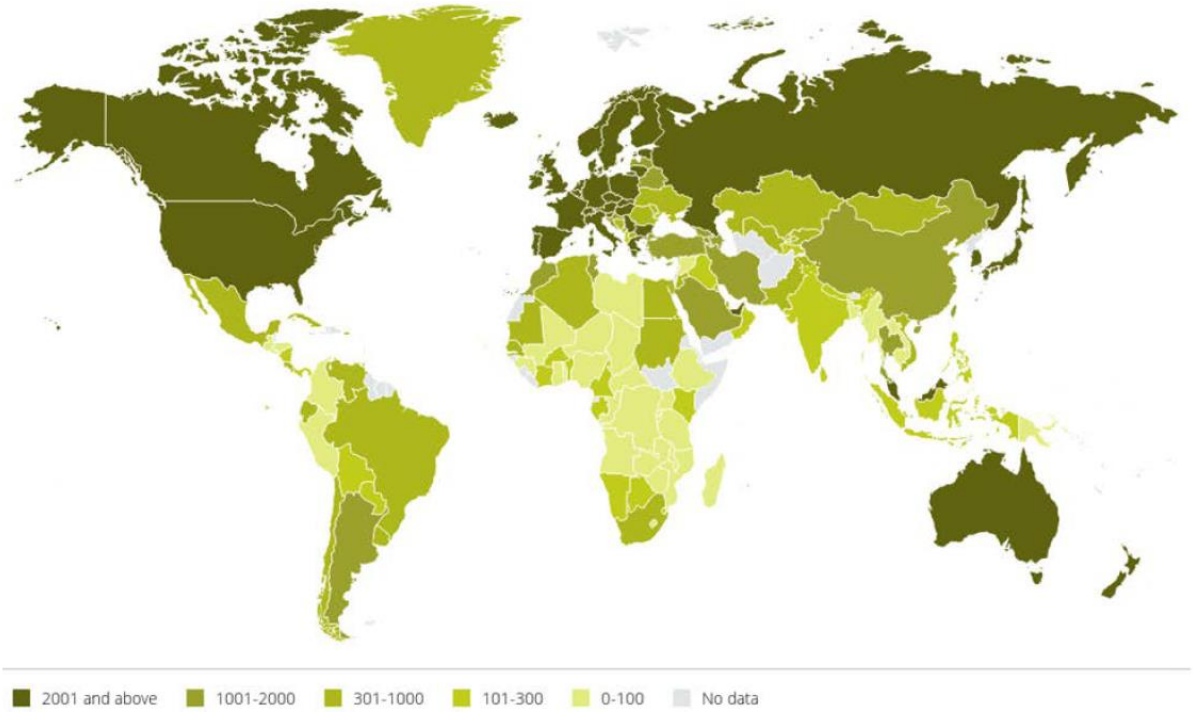

Figure 2: Researchers per million inhabitants, 2018 or latest year available (Source: UNESCO Institute for Statistics estimates, June 2020)

In addition, STI is, apparently, insensitive to the cohesion of African societies (Mhlanga et al., 2021). Computer algorithms could exacerbate unemployment rates, because of automation of works that could otherwise be done by humans. Moreover, algorithms could increase levels of unfairness, widening social and economic gaps between people of different genders, ethnicities, social classes, etc. For example, if not carefully developed and implemented, the increased use of AI in different social and economic activities could see the rise of machine learning (ML) algorithms that favour men over women, people of a certain tribe over another, or people of a certain political persuasion over another. Similar examples are already in place: in other parts of the world, machine learning algorithms have categorized black people as criminals and people of other ethnicities as innocent citizens (Fuchs, 2018; Temming, 2017).

Also, there are concerns regarding the philosophical aspects of STI in Africa. These worries are premised on the nature of what is regarded as STI in Africa, given the history, culture, and geopolitical position of Africa. Some Afrocentrists argue that, since what is today regarded as science, technology, and innovation mainly originate from the Conceptual West, it contains inscriptions of the Western world, and therefore cannot be fully compatible with African culture and values (Lamola, 2021; Mavhunga, 2017). Thus, STI could be used to advance neocolonial interests. STI in its current form, presents a number of design-reality gaps (Heeks, 2002), especially when viewed from the African context.

Other challenges include limited availability of reliable R&D data and scientometric indicators; diverse and heterogeneous science systems across the African continent, shaped by factors such as country history, funding, national policies, and commitment of African governments to the STI agenda; and pursuing STI based on foreign interests that dictate funding for research and innovation (Gaillard Mouton, 2022).

4. Opportunities

STI challenges existing in Africa present a number of opportunities for STI stakeholders in Africa. The following are some opportunities. There is a need to improve coordination and commitment among STI stakeholders on the continent. STI stakeholders should stop from working in silo, and this will strengthen national and regional systems of innovation, enabling African countries to reap the benefits envisioned by the STI agenda. Universities and R&D institutions should endeavour to generate scientific knowledge that is required for the development of Africa; African industry should prioritize the consumption of scientific knowledge generated by African universities and R&D institutions; financial institutions should give high priority to innovation, by providing, among other things, venture capital and finance for technology prospecting; and African governments should increase the amount of GDP spent on STI activities, and should be committed to sustaining STI financing.

Moreover, there should be deliberate efforts to strengthen technological innovation on the continent, by converting scientific and technological knowledge into products and services, which are important in stimulating social and economic development. There is a relationship between the scientific productivity of a country (as measured through publications in globally reputable sources), technological production (as measured through registered patents), and the wealth of a country (as measured through GDP per capita) (Ribeiro et al, 2009; Zavale and Langa, 2018)

Additionally, there is a need for more research and dialogue on better ways to implement the STI agenda on the continent of Africa. For example, African universities and R&D institutions should conduct research to assess the preparedness of African countries to effectively participate in the fourth industrial revolution (e.g., Olaitan, 2021), and on better ways to participate in 4IR without compromising the cohesion of African societies, their cultures and values. Without paying attention to the context of Africa, the costs of STI in Africa could outweigh the benefits. Issues of fairness of machine learning algorithms for use in Africa have to be prioritized, if Africa has to feature well in the fourth industrial revolution. Importantly, it is imperative for the scholarly community to revisit the broader theorization of STI in Africa. Such efforts have started (see for example Lamola, 2021; and Mavhunga, 2017) and should continue.

As well, African countries need to revisit policies that guide the collection and sharing of data on various STI indicators. This will simplify the process of measuring STI progress and identifying areas for improvement. At the moment, STI data in most African countries are difficult to obtain and are sensitive to methodological choices (Gaillard and Mouton, 2022). Importantly, the success of AI in Africa will very much depend on the availability of data required to train the algorithms. Huge volumes of data are required to be able to train machine learning algorithms that truly represent the African context. The success of Africa in the 4IR will depend on the data that is collected and used to build ML models that will act as a backbone of social and economic activities. At the time of the Mwalimu Julius Nyerere centenary intellectual festival, Tanzania, the county that Mwalimu so ardently found, is seeking to build a digital economy. As good as this aspiration may sound, without instituting and operationalizing clear data sharing policies, it will hardly come to fruition.

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