Science, Technology and Innovation as Drivers of Environmental Sustainability in Africa

Kayode Olaitan KALEJAIYE
Kayodekalejaiye1@gmail.com
+2348028663333
+22999541943 (WhatsApp only)

Faculty of Arts and Social Sciences
Department of Educational Management
Lead City University Ibadan, Oyo State, Nigeria

This paper examines Science, Technology and Innovation (STI) as Drivers of Environmental Sustainability in Africa. The relationship between science, technology and innovation (STI) was examined from scholars' perspectives. The paper highlighted the inability of African countries to meet up with Gross Expenditure on Research and Development (GERD) commitments by setting aside 1% of their Gross Domestic Product (GDP) towards building and accelerating scientific and technological capabilities. This inability militated against the attainment of the objective designed to improve innovation, productivity, economic growth and human development as well as produce the requisite number of scientists and researchers. The unattained objective by African countries when compared with economically advanced countries in practical terms of scarcity of resources, slow economic recovery and growth through STI, and an inappropriate enabling environment was identified as the gap that needs to be bridged. The theoretical framework rests on United Nations Economic and Social Commission for Asia and the Pacific's "Strengthening of National Innovation Systems" model. The literature review focused on the twin scientometric indicators of research publications and patents as indicators of development. The extent to which African countries have developed when compared with the rest of Europe was backed up with data. The paper proffered solutions as the way forward. Some of these include: Developing talents, scaling up investments in science and technology, establishing scientific organization bodies, and improving STEM education in schools, among others.

Keywords: Science Technology and Innovation (STI), Patent, Scientometric, Environment, sustainability.

Word Count: 240

Introduction

An environment refers to all factors and conditions of the physical and biological world and the complex interactions of forces between them. While it is true that the environment, being the sum of elements that surround us, plays a role in the life cycle of human beings and that human life is

also highly dependent on its environment, it is also worth saying that the onus is on humans to engineer as well as re-engineer their environment to absorb the most benefits accruable from it. Thus, science, technology and innovation can be seen not only as the panacea to the challenges and inadequacies within the total environment (be it economic, political/governance, legal, social, or cultural) of the African continent but also as drivers for the environmental sustainability of each country.

Lyndsay (2009) asserted that science is "the observation, identification, description, experimental investigation, and theoretical explanation of natural phenomena" and is essential to the economic development of nations. Technology is the practical application of scientific knowledge as humans attempt to resolve the challenges of changing and manipulating the human environment. Technology also refers to the "totality of the ways to do things, which include inventions, techniques, and the vast store of organized knowledge about everything ranging from aerodynamics to printing" (Ejiogu, 2011, p.76). Ejiogu's definition of technology is very insightful and will serve as the pedestal of the initial part of this discourse. Improved technology, of course, brings about increased productivity, better working conditions, varieties of quality products needed to satisfy actual needs of modern life, improved standard of living, enhanced quality of life and improved general level of human happiness. These derived benefits of technology set the economically advanced countries apart from the African continent. Brocks (2014), however, asserted that "scientific thinking is the backbone of modern science and technology". The economically advanced countries of the world developed by studying science through systematic data gathering and processing by embracing science, technology and innovation as one of the cornerstones of economic development. Furthermore, through the engineering-related field of material science, more science and new knowledge about the applicability of materials are discovered as scientists work with materials. Hence, technology is the practical application of science as it is difficult to delineate between both concepts since they are highly interdependent activities.

Changing the present perspective of the African continent through science, technology and innovation geared towards sustaining the African Continent has remained the focus of Africa's socioeconomic development and growth since 1980. It is instructive to restate that the former Organization of African Unity (OAU) encouraged member nations to set aside 1% of their Gross Domestic Product (GDP) for Gross Expenditure on Research and Development (GERD) towards building and accelerating their scientific and technological capabilities. When the African Union (AU) convened in September 2002, member nations were again encouraged to set aside 1% towards GERD. Other fora during which the AU reiterated the same goal were during the African Union Ministers Conference in 2003, the African Science and Technology Consolidated Plan of Action (CPA) in 2005, and the Science, Technology and Innovation Strategy for Africa (STISA) in 2014 (Kahn, 2022).

An appraisal of the above-stated objective revealed that South Africa and Egypt allocated 1% of their GDP to Gross Expenditure on Research and Development (GERD), while many countries are yet to allocate up to 0.5% to improve innovation, productivity, economic growth and human development, and production of the requisite number of scientists and researchers. The above narratives explain the existing gap between Africa and the economically advanced countries in practical terms of scarcity of resources, slow economic recovery and growth through STI, inappropriate scientific environment, stagnation in the capability to produce scientific knowledge efficiently and effectively, inadequate international collaboration mechanisms, decreasing job opportunities, lack of support for youth entrepreneurship through STI, among others. Therefore, this paper attempts to discuss the panacea to the above narrative with the ultimate intent to provide a sustainable environment and broaden the perspective of Africa in science, technology and innovation (STI) by discussing Science, Technology and Innovation as Drivers of Environmental Sustainability in Africa in the following order: Introduction with an embedded statement of the problem and an identified gap, theoretical framework-which is an adaptation of the conceptual framework developed by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), the literature review and the way forward.

Theoretical Framework

Strengthening of National Innovation Systems

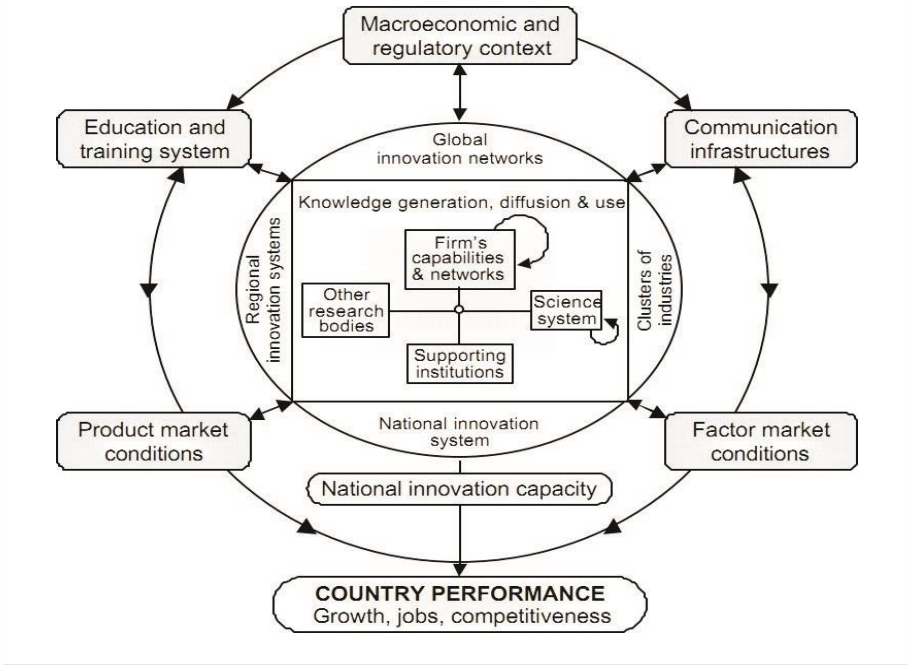

Figure 1. Elements of a national innovation systems Source: OECD (1999), UN ESCAP.

The theoretical framework adopted was a conceptual model developed by the United Nations Economic and Social Commission for Asia and the Pacific's (ESCAP) "Strengthening of National Innovation Systems".

The 'National Innovation System (NIS) refers to the complex and interactive web of knowledge flows and relationships between industry, government and academia in making them work systematically to sustain innovation, science and technology development efforts. The performance of a country on innovations depends to a large extent on how these NIS actors relate to each other as elements of the collective system of knowledge creation and use, as well as the technologies they use. NIS can consist of Sectoral Innovation Systems (SIS), which are closely associated with a specific sector or industry. Often, NIS is linked with regional and global innovation systems that may be influenced by them. Sometimes within a country, there can be a Regional Innovation System (RIS) that caters for global markets and linkage to the global innovation system. In the case of Asia-Pacific, there were suggestions that a comprehensive and inclusive Asia-Pacific Innovation System may contribute to inclusive growth and economic integration. A regional innovation system consisting of innovation clusters and Exclusive Export Zones can be a strategy to attract foreign direct investments, enhance competitiveness and absorb the technology acquired through transfer.

Figure 1 shows the NIS concept with the inner ring constituting the institutions and policies directly involved in scientific and technological innovation. The outer circle represents a “broad” NIS perspective, which accounts for the economic, social and political environments. As STI cuts across the work of various ministries, effective coordination among government ministries and agencies in advancing and mainstreaming STI for development is called for to ensure policy consistency and coherence.

It is vital to understand how strong or weak the inter-linkages are between the various NIS actors and the effectiveness of the flow of knowledge and resources across the sectors. A clear understanding of the linkages between the actors involved in innovation would improve technological performance. Creating and implementing a responsive NIS requires a holistic policy design and formulation that fosters and encourages collaboration and partnerships among firms and between public and private institutions. These collaborations and partnerships are increasingly becoming international, regional and global in the current globalized technology and economy. Therefore, it is essential to diagnose or evaluate the quality and efficiency of NIS by conducting evidence-based studies to understand the strengths and weaknesses of various components of NIS and evolve an informed policy decision and implementation mechanisms. Good analysis of an existing system can provide excellent information for policymakers in planning changes and strengthening science, technology and innovation (STI) systems and strategies relevant to the evolving national context and development objectives.

Literature Review

Brocks (2020) posited that the "first 20 years of the 21st Century presented a real start of serious qualitative changes as a process of implementation of up-to-date achievements of modern science and technologies" cannot be dismissed with a wave of the hand when the same assertion is considered quantitatively and qualitatively to the African continent. Thus an overview of the African continent as a prelude to appraising the status of Science, Technology and Innovation (STI) in Africa becomes inevitable.

There are fifty-five (55) member states with a virile and young population (poised to emerge as the largest youthful workforce on earth) whose leaders in 2016 agreed on urgent and necessary institutional reforms under the Agenda 2063 vision of inclusive economic growth and development by setting Seven Aspiration goals. The set goal was that through the formulation and implementation of effective pro-science, pro-technology, and pro-innovation policies on STI, a well-educated and skilled Africa, underpinned by science, technology and innovation for a knowledge-driven society will be the norm; no child misses school due to poverty, or any form of discrimination.

These fifty-five African Union states would work towards the goal of boosting the state of science and technology in Africa to meet international standards by improving two scientometric indicators employed internationally - research publications and awarded patents. But the Second Continental Report on the Implementation of Agenda 2063 only highlighted the progress made within the first ten-year implementation plan using school enrolment. However, the report was silent on the extent to which African Union institutions and other research centres have aligned as one of the key priorities with continental scope. Pouris and Yu-Shan stated that the world share of publications by different regions shows that Africa produced only 68,945 publications over the 2000-2004 period representing 1.8% of World publications, compared to Latin America with 3.5% of the world's research. More detailed analysis reveals that research in Africa is mainly in just two countries – South Africa and Egypt. These two countries produce just above 50% of Africa's publications. The top eight countries published above 80% of the continent's research. Between 2012 to 2018, South Africa released 114,795 research publications, followed by Egypt (92,103), Tunisia (35,687), Algeria (25,886) and Nigeria (25,362). Next is Morocco (18,348), followed by Kenya (15,940). Thus, only two countries, South Africa in Sub-Saharan Africa and Egypt in North Africa, have jointly and consistently led the continent in scientific production in different fields of science by producing about half of the total publications in Africa (Cerdeira et al 2023; Pouris and Pouris, 2009; Sawahel, 2022).

Concerning global contribution, Africa contributed 659,910 research output in 2019, representing 3% of world publications. The percentage of the GDP allocated to Gross Expenditure on Research and Development (GERD) and science, technology and innovation policies of member countries were the major causes of this unequal contribution (Sawahel, 2022). The situation is almost the same in June 2023. The statistics obtained from Scopus indicated that Egypt published a total of 34,575 while South Africa, Nigeria and Morocco are next with 28,365, 13,282, and 9,463,

respectively. Analysis showed that without South African and Nigerian total publications, the North Africans have more than twice the publications of the rest of Africa.

On the other hand, as it concerns inventive profiles as manifested in patents, available data indicate that Africa produces less than one-thousandth of the world's inventions (Pouris and Pouris). Furthermore, 88% of the continent's inventive activity is in South Africa.

Innovation, a response to a demand or anticipation of a new market, manifests when a new or improved product is made available to potential users or manufactured by the innovating party. In this regard, an example of a market innovator is Dangote, with 18 subsidiaries in some African countries. Further reports indicate that as China surged forward in inventions, Africa's world share of patent registrations fell from 0.6% to 0.5%. South Africa, however, has the highest number of patent applications.

The Way Forward

The onus is thus on Africans to chart a development course for the Africans on the way forward. To achieve this objective, the paper suggests the following:

1. Developing Talent

Gurib-Fakim and Signé (2022) argued that as human talent develops across the continent, investment in research, science, and innovation will increase dramatically across various sectors, including manufacturing, which will be a significant factor in helping Africa realize its development potential and narrow its income and welfare gaps. They further opined that success requires effective tripartite (public-private-academia) collaborations and partnerships to be sustained over time.

Reducing the skills-related deficiency gap in science, technology, and innovation (STI) is vital to unlocking Africa's potential and accelerating economic growth and prosperity. The availability of modern equipment is a leverage that can attract the best-trained and most talented researchers to an environment where modern equipment, reliable utilities, sufficient funding for supplies and perhaps most critically, where they can benefit from the presence of other researchers.

2. Scale-Up Investment in Science and Technology

High cost and economic regression have ensured that adopting a new, productive technology becomes costly in Africa. Consequently, many technologies that seem to meet the Global Competitive Index (GCI) do not sufficiently tackle the challenge of increasing productivity and profitability that militate against African producers. Gurib-Fakim and Signé (2022) further posit that investment in science and technology is vital to an economic boom. Africa accounts for 1.3% of research spending while producing 0.1% of all patents. Simultaneously, African governments must also invest in creating an ecosystem that facilitates investment in science and technology in a way that will not just accelerate discovery but also allow innovations to enter the marketplace more quickly.

3. Increase Research and Development

Another innovation-related activity is research and development conducted in universities, public research organizations and the business sector. The 1980 target that countries should allocate 1% of their GDP for research and development remains a mirage which should not be. A report on GERD stated that no African country can claim that 1% of its Gross Domestic Product is allocated to research and development (Sooryamoothy, 2022).

4. Science, Technology and Innovation for Sustainable Development in Least Developed Economies

To assist least-developed countries (LDCs) in Asia in combating sustainable development challenges and improve science, technology and innovation capacity-building techniques, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) strongly encouraged the promotion of innovations manufactured from locally available resources.

Replicating this in the least developing countries (LDCs) in Sub-Saharan Africa may not immediately lead to the emergence of patents for recognition. However, it will go a long way in alleviating challenges peculiar to a particular country, thereby necessitating governmental support, skills development and training in technological areas relevant to sustainable development. Hence, developing STI-related mechanisms towards the alleviation of developmental challenges becomes vital.

5. Adoption of 4th Industrial Revolution Technologies

Recent research has heralded emerging technologies in the Fourth Industrial Revolution (4IR) as a game changer that can accelerate the economic transformation of developing countries. Adopting the 4th Industrial Revolution technologies in sub-Saharan Africa could bring substantial economic growth and welfare benefits and create asymmetric opportunities, earnings, and incomes between lower and middle-class educated workers.

6. Need for Scientific Organizations Bodies

Presently, Africa is the only continent without an organization/agency responsible for promoting and assisting in the development of STI indicators, as well as providing services and conducting studies. Lack of scientometric expertise, disinterested science authorities, weak and fragmented national STI policies, lack of STI statistical data and knowledge base for evidence-based policy-making and inadequate financial resources are responsible for this phenomenon.

7. Improve STEM Education in Schools

Improving and expanding science, technology, engineering and Mathematics (STEM) education and strengthening this in schools remains an ongoing challenge. Information and communications technology (ICT) based (STEM) instruction holds promise. However, training teachers to be competent to ensure smooth implementation is vital.

8. Proper Funding of Education

Funding education adequately across levels of education in all schools across Africa should be sacrosanct. There should be total commitment to African countries vigorously and realistically pursuing the agenda of investing 1% of the Gross Domestic Product into the education system. Furthermore, devoting 26% of a budget to education (UNESCO) should be attained.

9. Collaboration with Other Researchers

Governments may encourage indigenous researchers to collaborate with foreign researchers in the area of research underpinning modern technology in material science to gain critical knowledge from researchers from other countries and strengthen technology transfer capacity so that the interests of science and technology can be further promoted (Pouris and Yu-Shan). Hence, this will also offer an opportunity to engage in learning processes that will lead to the discovery of new knowledge and emergent technologies and increased access to intellectual property in core areas of sustainable development.

10. Subsidize Research Activities

The funding of research-related activities of research institutions may be subsidized by individual African countries when they engage in meaningful discoveries by encouraging these research institutions to venture more into patents, thereby developing solutions to technological challenges.

11. Replace Political Instability with Good Governance

The tide of political instability in Africa has become an obstacle to scientific development, technology and innovation as it concerns environmental sustainability. It is instructive to note that the negative consequences of instability are rife in many African countries. Democratic governments are being replaced by the military, as witnessed in recent times in Burkina Faso and Niger Republic; this is not to forget the booming guns in Ethiopia, Mali, Libya, South Sudan, Somalia, and other African countries. It, therefore, becomes imperative to silence the guns in African nations. African nations can achieve this if good governance is considered a sine qua non to creating a sustainable environment for science, technology and innovation (STI) to thrive. The development of science, technology and innovation will also serve as a cornerstone for the African economy. It is a win-win situation for African nations because strengthening these areas can further improve the gross domestic product of a country as well as foster an open, transparent, meritocratic system of governance.

Summary

This paper examines science, technology and innovation (STI) as drivers of environmental sustainability. The central argument of this paper lies in the fact that African countries neglected the growth of science, technology and innovation (STI) in this sector since the 1980s when the

Organization of African Unity mandated African countries to commit 1% of the revenue to Gross Expenditure on Research and Development (GERD) to improve productivity. Furthermore, the leaders of African nation-states refrained from committing 26% of the GDP to education. This reluctance has contributed to economic stagnation manifesting now. The paper noted that African countries allocate less than 0.5% of their GDP to Science, Technology and Innovation (STI) related causes to improve innovation, productivity, economic growth and human development, and production of the requisite number of scientists and researchers.

The gap between African and European countries was in terms of scarcity of resources, slow economic recovery and growth through STI, inappropriate scientific environment, stagnation in the capability to produce scientific knowledge efficiently and effectively, inadequate international collaboration mechanisms, decreasing job opportunities, lack of support for youth entrepreneurship through STI, among others.

The literature review focused on the extent to which African scientists have published research works and patents as the twin scientometric indicators. Analysis showed that Africa produced less than 0.1% of the world's patents and 3% of research publications.

The way forward is a veritable attempt to proffer solutions to the existing challenges based on the panacea embedded in the theoretical framework. These solutions ranged from developing talents, up-scaling investments in science and technology, allocating more grants to science and technology, creating and supporting research institutions, collaborating with other researchers from other countries to facilitate knowledge transfer, subsidizing research activities, and replacing political instability with good governance.

The paper finally argues that the panacea to the conundrum in Africa lies in member nations embracing science, technology and innovation as the cornerstone of environmental sustainability in Africa.

Conclusion

This paper discussed science, technology and innovation as drivers of environmental sustainability in Africa. The study highlighted obstacles and challenges that militated against the African continent concerning scientific development, technology and innovation. These challenges ranged from the unwillingness of the various governments in Africa to financially commit to the requirements of GERD, to the inability to create a stimulating environment within universities and institutionalize scientific structures. The paper appraised the extent to which Africa contributed to world development in terms of patents and new inventions. The way forward, was examined, and viable solutions were discussed. Hopefully, the paper will help broaden the African perspective on how science, technology and innovation (STI) can be seen as drivers of environmental sustainability.

References

Brocks, Andris, (2014). Scientific Thinking: The Backbone of Modern science and Technology Education. Journal of Baltic Science Education. Vol. 13, issue 6, p764-766. ISSN-1648-3898. http://www.scientiasocialis.lt

Brocks, Andris, (2020). General Remarks on Basic Actualities Within Our Life and Education During First 20 Years of 21st Century. Journal of Baltic Science Education. Vol. 13, issue 5, p692-695. ISSN-1648-3898. https://www.ceeol.com/search/article

Cerdeira, J., Mesquita, J., Viera, E. S., (2023). International Research Collaboration: Is Africa Different? A Cross-Country Panel Data Analysis. Scientomeric (2023) 128:21452174.link.springer.com>article.7

Ejiogu, A. (2011): Introduction to Strategic Management: Succeeding Without Violence. School of Research and Graduate Studies, Institute of Professional Studies. ISBN 978-9988-1-4840-9.

Gurib-Fakim, A. and Signé, L. (2022): Investment in Science and Technology is Key to an African Boom. brookings.edu/articles

Intercessional Panel of the United Nations Commission on Science and Technology for Development (CSTD). Contributions by Egypt to the CSTD 2022-2023 Theme on "Technology and Innovation for Cleaner and More Productive and Competitive production". idsc.gov.eg

Kahn, M. J. (2022). The Status of Science, Technology and Innovation in Africa. Sage Publications. https://journals.sagepub.com.pdf

Lyndsay T. W. (2009). Definition of Science. https://explorable.com/definition-of-scienceMember States. African Union. Au.int/en/member_state/countryprofiles

Pouris, A., and Pouris, A. (2009). The State of Science and Technology in Africa (2000-2004). A scientometric Assessment. Scientometrics, 98(2), 297-309. https://doi.org/10.1007/

Pouris A. and Yu-Shan Ho. Research Emphasis and Collaboration in Africa. University of Pretoria. https://www.up.ac.za.articles pdf

South Africa Department of Science and Innovation (2023). South Africa: Next Year's Science Budget to Focus on Exploiting STI to create Job Opportunities. https://sciencebusiness.net/network-updates/south-africa-next-years-science-budget-tofocus-on-exploiting-sti-to-create-job

United Nations ESCAP: A Conceptual Framework for Science, Technology and Innovation Driven Sustainable Development and the Role of ESCAP: Thoughts for Regional Dialogue. https://www.unescap.org.files