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Rusty gold in Nigeria: Untapped advances in nanotechnology

Significance:

Reasons for the slow pace of nanotechnology research in Nigeria, Africa's most populous country, are explored, given Nigeria's huge human and natural endowments, and solutions are proffered to address the seemingly lagging outlook of the country in nanotechnology. This Commentary is relevant to all critical stakeholders at national, regional and international levels to mobilise efforts to advance the course of nanotechnology in Nigeria and beyond.

This Commentary was born of the author's experience as a leading researcher in nanobiotechnology in Nigeria, having published more than 70 articles on nanotechnology since 2015, a textbook titled *Microbial Nanobiotechnology: Principles and Applications*¹, and as head of a multidisciplinary nanotechnology research group in Nigeria. The Commentary draws on several types of data on nanotechnology R&D in Nigeria including demographic, economic (GDP and budgetary allocation) and scientometric.

Education and its funding in Nigeria

Nigeria is the most populous African nation, with an estimated population of 206 million in 2020² and a growth rate of about 2.6%; its population is expected to surpass that of the USA by 2050. Nigeria also has the largest GDP in Africa, estimated at USD432.294 billion in 2020.³ As a major oil-producing nation, crude oil and gas exports account for about 10% of Nigeria's GDP, 65% of government revenue and about 88% of the earnings from export activities.⁴ These data indicate that Nigeria is not substantially earning from the export of finished goods and is also not a knowledge-based economy. However, the country is endowed with vast natural resources, arable land and a youthful population (more than 62% of Nigerians are under 25 years) that can stimulate industrial growth. Because of the large youthful population, Nigeria is expected to commit huge resources to education, but this is not the case. Nigeria's budget steadily increased from NGN5.07 trillion (USD12.32 billion) in 2015 to NGN13.59 trillion (USD33.02 billion) in 2021, whereas the budgetary allocation to education reduced gradually from 7.38% in 2017 to 5.8% in 2021. Generally, the allocation to education has oscillated between 4.83% and 9.94% since 2010⁵ (Figure 1).

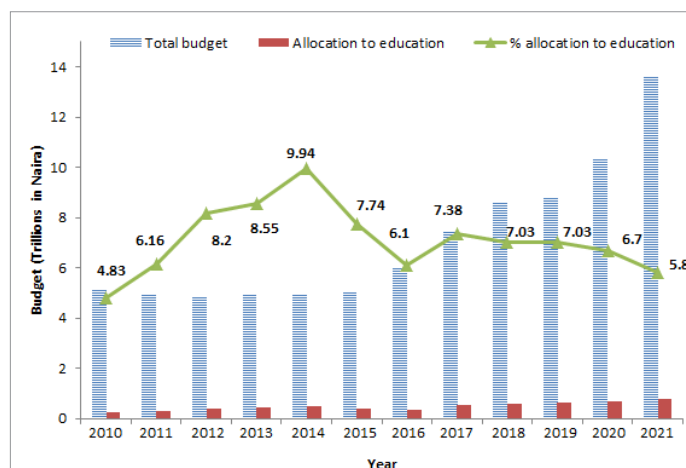


Figure 1: Nigeria's total budget, 2010–2021, and the allocation to education in trillions naira. The line graph and numbers indicate the percentage allocation of the budget to education during the period.

Aside from the federal budgetary allocation, there are state allocations to education, which often follow similar patterns to those of central government. For tertiary education, which covers colleges of education, mono/polytechnics and universities, the Tertiary Education Trust Fund (TETFund), an intervention agency, provides funds for physical infrastructure, acquisition of equipment, and training of personnel at public tertiary institutions in the country. Since 1993, TETFund has independently managed an education tax of 2% of assessable profit imposed on all companies in Nigeria. TETFund has remained the major source of provision of facilities for teaching and research in tertiary institutions in Nigeria in over two decades. However, the impact of its intervention has reduced on a yearly basis as the number of benefitting institutions has grown through their establishment by state and federal governments. For instance, there were only 37 public universities in Nigeria in 1993, but this figure has risen to 101 in 2021.⁶ Between 2009 and 2013, TETFund made interventions totalling about NGN2.065 trillion (USD5.018 billion) to public universities in Nigeria.⁷

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Development of science and technology policy in Nigeria

Science and technology policy in Nigeria has been re-engineered with the enactment of a science, technology and innovation (ST&I) policy in 2012 geared towards realisation of the full potentials of ST&I for the nation's development.⁸ This policy is in addition to the earlier establishment of the National Agency for Science and Engineering Infrastructure (NASENI) in 1992 among several agencies to promote ST&I in Nigeria and to move the nation towards a knowledge-based economy. Nigeria is a major contributor of knowledge in science in Africa as documented in various studies⁹⁻¹¹, but this is yet to materialise in translational output as seen, for example, in South Africa. Both national policy on ST&I and NASENI have identified nanotechnology¹² as a critical input towards realisation of the goals of ST&I. The country set forth to engage in nanotechnology research since 2006 through the National Nanotechnology Initiative programme that was spearheaded by NASENI through organisation of a workshop on the production of nanoparticles, involvement in the activities of the African Materials Research Society and designation of one of its constituent laboratories (the Engineering Materials Development Institute, Akure), as the coordinating centre on nanotechnology research. But how successful has this journey of 15 years of nanotechnology pursuit been? The answer is mixed.

Outlook of nanotechnology research in Nigeria in comparison with South Africa

Some authors have described Nigeria's participation in nanotechnology as dormant – characterised by a non-existent budgetary allocation for nanotechnology and lack of a national policy on nanotechnology.¹³ With the lack of advanced equipment to study nanomaterials, the nation's engagement can only be seen in limited research activities by scholars in some universities and occasional organisation of conferences on nanotechnology. Research groups at the University of Nigeria, Nsukka (<http://nanotechunn.com/new/>) and Ladoko Akintola University of Technology, Ogbomoso (<https://lautechnanotech.com/>) take the lead, having organised four and five conferences, respectively. Coincidentally, these two universities are the major contributors to knowledge in nanotechnology research among public-funded universities in Nigeria.¹⁴

Recent data obtained from Scopus shows that Nigeria contributed only 508 articles on nanotechnology in a decade (2010–2019), whereas South Africa and Egypt published 2282 and 4604 articles, respectively, in the same period. Abodunde and Jegede⁹ reported a poor outlook for Nigeria in nanotechnology publishing in their report. It is noteworthy that the South African Nanotechnology Strategy commenced in 2006 and the country has made giant strides since then. The Strategy provided a framework for the funding of nanotechnology research and establishment of centres for characterisation of nanomaterials as well as human capital development, and it was followed with the 10-year plan on nanoscience and nanotechnology that was released in 2010. These efforts, among others, have propelled South Africa to 23 patents on nanotechnology issued by the US Patent and Trademark Office (2016–2020), development of nanotechnology standards and production of nano-based products.¹⁵ Mintek is a successful nano-based company in South Africa that has produced and marketed gold, nanospheres, and nanorods, including polyethylene glycol coated gold nanoparticles and polyethylene glycol–biotin gold nanoparticles, to the research community and industry.¹⁶

To date, Nigeria is yet to develop a nanotechnology standard or have a patent on nanotechnology issued by the US Patent and Trademark Office. There is also no national strategy on the exploitation of nanotechnology within the research and development landscape of Nigeria. Thus, Nigerian researchers are limited to synthesis of nanomaterials and composites, along with the evaluation of their basic activities, which have not been transformed into products in the market. In contrast, South African researchers have used nanotechnology to reach milestones in nanomedicine, sensors, magnetism, catalysis, phosphors and optics, electronics, energy, nanobiotechnology, water research and communicable diseases.^{16,17} Unlike Nigeria which lacks specific

budget for nanotechnology, South Africa invested about USD77.5 million on nanotechnology R&D between 2005 and 2012¹⁸ and additionally committed USD28.6 million to her national nanotechnology equipment programme to support nanotechnology infrastructure as of 2015¹⁹, thereby laying a very solid foundation for the country in the pursuit of nanotechnology enterprise by universities, research councils and even private entities.

Is nanotechnology a worthwhile venture to be pursued by a developing nation?

Nanotechnology is the gold mine of the future as nanotechnology products and services could contribute USD3 trillion by 2030, produce 6 million jobs and a share of more than 10% of the global GDP.¹⁹ Yet Nigeria with her vast human and natural resources is not tapping into this burgeoning nano-inspired economy – nanotechnology remains a dusty gold in Nigeria at present. Although effort is being made by the Federal Ministry of Science, Technology and Innovation to put in place a national policy on nanotechnology R&D in the country, this policy also is yet to be realised. Therefore, there is no national stimulus for nanotechnology growth and development – be it policy or funding. By comparison, in 2020, TETFund committed about USD29.161 million to establish 12 centres of excellence in fields such as agriculture, food science, ecology, renewable energy, public governance, arid research, medical science and computational intelligence; such commitment has not been extended to nanotechnology, which is a key thematic area in Nigeria's ST&I. Meanwhile, the quartet of nanotechnology, biotechnology, informatics and cognitive science has been recognised as a convergent discipline that will address global challenges and opportunities²⁰ and drive the Fourth Industrial Revolution and beyond. Thus, it is imperative that Nigeria, as a developing nation, responds to the new ST&I landscape in the world by investing in nanotechnology along with biotechnology and informatics to stimulate convergence science and technology.

Lessons for Nigeria from South Africa and international collaboration to fast-track nanotechnology R&D

The success story of South Africa so far in nanotechnology R&D provides lessons for Nigeria to move up the ladder in nanotechnology. Nigeria was the most collaborating nation in Africa with South Africa on nanotechnology, with these collaborations accounting for 5.2% (585) of the publications of South Africa in the Web of Science during 2000–2019.¹⁷ Several notable researchers in nanotechnology in Nigeria have footprints in South Africa, either through training or collaboration¹⁴; these experiences can benefit Nigeria in developing its roadmap for nanotechnology. The national policy on nanotechnology that is long overdue must be enacted without further delay, and should address the aggressive and sustainable funding of nanotechnology initiatives in the country through improved budgetary allocation to education, science, technology and innovation. This policy should not be limited to support for nanotechnology research, a nanotechnology equipment programme, human resource development, and establishment of centres of excellence in nanotechnology research and innovation, but also should establish the framework for public engagement and a tripartite partnership of academia with government and the private sector.

The establishment of a centre of excellence in nanotechnology should be based on empirical data on the productivity of scholars and institutions in the field, so that there will be a return on investments made in nanotechnology. This principle was effectively explored by South Africa. Nigeria could also benefit from the advances made by trading partners such as Brazil, China, India, Japan, USA and the European Union through science diplomacy within the channels of bilateral and multilateral cooperation via training of experts and donations of nanotechnology infrastructure. As a leading nation in the South, developed nations, active players in nanotechnology, and development partners should assist Nigeria to bridge another widening gap in nanotechnology pursuits between the North and the South to arrest the widening nanotechnology divide.



At the regional level, the African Union, Economic Community of West African States, and African Development Bank should also set agendas for nanotechnology research among member states for the development of Africa. Similarly, the African Academy of Sciences and other national African academies should set agendas for African nations on nanotechnology by 2025–2030. For instance, the African Materials Research Society in conjunction with the UN Economic Commission for Africa offered a platform on 3–4 May 2021 to discuss ‘Nanotechnology for Transformation of African Development: Looking Towards a Sustainable African Future’ and seeks to mentor young African scientists in nanotechnology through its nanotechnology research and innovation bootcamp.²¹

Through these interventions, Nigeria can tap into the rapidly developing nano-economy and improve its economic indices through mobility towards a knowledge-based economy. In addition, nanotechnology can be deployed to address a myriad of problems that confront the nation, such as physical and food insecurity, water and sanitation, environmental degradation, inadequate healthcare facilities and an energy crisis. The aforementioned can serve as the focal points of national initiatives in nanotechnology. Thus, nanotechnology becomes a complementary tool to achieving some Sustainable Development Goals (SDGs) in the country; particularly SDG 1 (No poverty), SDG 2 (Zero hunger), SDG 3 (Good health and wellbeing), SDG 6 (Clean water and sanitation), SDG 7 (Affordable and clean energy), and SDG 9 (Industry and innovation). Nigeria cannot afford to further watch the rusty gold of nanotechnology; it must advance in the field of nanotechnology for the good of the country, and the time to act is now.

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Competing interests

I have no competing interests to declare.

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