Engaging science diplomacy for nanotechnology development in Africa

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Abstract
The concept of science diplomacy is gaining ground as a global strategy in addressing global concerns such as global peace, insecurity, climate change and environmental impact. This study reduces science diplomacy to an effective means for the strategic development of nanotechnology in Africa. African nations are currently not encouragingly close to the leading nations in nanotechnology, yet there seem to be extant diplomatic relationship with many of these forefront nations. African diplomats are state actors in science diplomacy to propose foreign policies that will meet the domestic demand for science and technology development in Africa, especially for emerging technologies like nanotechnology. The necessity of inclusion of competent scientists with diplomatic skills as members of the diplomatic corps is recommended here as one of the ways to develop nanotechnology in Africa. The scientist diplomats will function to foster international scientific collaborations, drive platforms for national research facility development and for non-state actors to thrive in their domestic nano-research. Scientifically informed foreign policies are presented here to have potentials to significantly assist Africa in developing nanotechnology and provide pathways for overcoming the numerous constraints to nanotechnology development in Africa. Critical areas of intervention include human capacity development, national nano-research laboratory facilities, platforms for institutional collaborations, post-graduate student training and robust exchange programs. These machineries also benefit independent individual researchers by leveraging on the international networks created by science attachés through science diplomacy.

Keywords: Nanotechnology, science diplomacy, Africa, human capacity development, Science and Technology, international collaboration
1. Introduction

It is non-controversial that science and technology (S&T) is the economic driver of the 21st century [1-3]. This fact is not likely to change in the future because the innovative ecosystem is constantly improving on the dividends of S&T. Science and technology is dynamic, and innovation (I) is developing very rapidly. The absence of a nation’s consciousness and commitment to ST&I could propel different levels of technological ignorance and inefficiencies that will be enough to cripple such a nation’s economy. The world economic powers pride on their knowledge-based economy that is anchored on ST&I. One of such technologies that are revolutionizing innovations in the world today is nanotechnology. Nanotechnology has miniaturized devices and gadgets, enabled compatibility and flexibility with improved service delivery [3-5].

The proposed single statistical definition of nanotechnology by the Organization for Economic Co-operation and Development (OECD) provides a comprehensive overview. The OECD proposes that, “It is the understanding of processes and phenomena and the application of science and technology to organisms, organic and inorganic materials, as well as parts, products and models thereof, at the nanometre-scale (but not exclusively below 100 nanometres) in one or more dimensions, where the onset of size-dependent phenomena usually enables novel applications” [6]. The unique properties exhibited by nanomaterials which are different from their bulk sizes, have engineered novel researches and applications in diverse areas such as health, agriculture, environmental remediation, food industry, automobile industry, academia, space technology, manufacturing industry, electronics, energy, oil and gas industry [4, 5, 7]. It is a convergence of different fields with a high propensity of transforming nations’ approach to poverty eradication and guaranteeing sustainable economic development [2].

The continent of Africa is in apt need of technologies that can reduce poverty, improve the living standard of the people, ensure a cleaner environment and provide a platform for technological advancement. Unfortunately, the continent has not done much to show priority to the development of nanotechnology, except for South Africa’s contribution which is yet to be identified among the frontline nations [8]. Recent data on the indicators of nanotechnology development under three main categories of Science, Innovations and Industry shows the
leading nations in the development of nanotechnology [9]. It did not reflect significant changes for any of the Africa nations to gain global audience.

However, one encouraging and interesting hope is that the frontline nations in nano-articles publications, patenting and national standards shown in Figures 1, 2 and 3 respectively, have diplomatic relationships with most of the African countries. One pertinent question to ask is how effective are these diplomatic relationships and foreign policies helping to develop required technologies in Africa such as nanotechnology? The answer to this question will be strongly dependent on how African nations especially the two economic giants; Nigeria and South Africa, use the instrumentality of diplomacy to prioritize their technology needs. Important to note is that it takes knowledgeable scientists to be able to engage in scientific diplomatic negotiations that will yield meaningful benefits.

This study therefore, discussed the importance of engaging science diplomacy by African nations to aid foreign policies that will attract the development of nanotechnology to their home countries. It reviewed the offices and the diplomatic corps staffing of Nigeria and South Africa embassies and their high commissions abroad as case studies. It also looked at the role of tertiary institutions and stakeholders research-based public and private establishment in the development of nanotechnology.

![Graph showing number of ISI nano-articles published in 2019 by 10 leading countries in nanotechnology/nanoscience development. Data from Web of Science (ISI Web of Knowledge) [9]](image)

**Figure 1.** Number of ISI nano-articles published in 2019 by 10 leading countries in nanotechnology/nanoscience development. Data from Web of Science (ISI Web of Knowledge) [9]
2. Science Diplomacy and National ST&I Development

Although, science diplomacy is a relatively new area of diplomacy study, the concept is however not entirely new. Science diplomacy is the deployment of scientific knowledge to aid...
diplomacy for sound foreign policies that also contribute to improve global issues such as peace, political stability, economic ties, climate change, health and environmental management [11-13]. There are three dimensions of science diplomacy: diplomacy for science, science in diplomacy and science for diplomacy [14]. Diplomacy for science takes place when state actors such as government units facilitate international cooperation to advance scientific goals. Science in diplomacy plays out when science is the bedrock upon which the frameworks for foreign policies or international agreements are formulated.

Science for diplomacy is an attribute of using scientific assets to help improve diplomatic relationship between a strong and a weak nation. These three dimensions often overlap in operation especially for the technologically advanced nations. In any case, scientific and diplomatic skills are highly required. This implies training a scientist in diplomacy, referred to as “diplomat scientist” or training a diplomat in deep scientific knowledge, referred to as “scientist diplomat” [13]. The flexibility in bridging this gap by the choice of training will be dependent on which of the trainings is easier to achieve. Arguably, it might be easier for a scientist to develop diplomatic skills than for a diplomat to engage in deep scientific knowledge because the rout to becoming a renowned scientist entails fundamental understanding of scientific principles and applications, rigorous laboratory experiments or in-depth theoretical analysis, hands-on experiences and publication records of repute.

One of the most referenced examples of the origin of the practice of science diplomacy concept dated back to 1300 BC regarding a formal peace treaty agreement between Ramesses II of Egypt and Hattusili III of Hittite [12, 15]. This relationship gave Hattusili an opportunity to request for the scientific assistance of a medical doctor from Ramesses Kingdom to help his sister get pregnant. Towards the end of the 18th century, the American Colonies sent Benjamin Franklin as a Minister to France to seek for technical support for their decolonization from the British. His achievement as an accomplished scientist and an innovator gave him the capacity to reach a common ground with the French for a successful mission [12]. The work of Turekian [12] shows further examples of the relationship between science and diplomacy in strengthening diplomatic ties and advancing science from the 18th to 19th century.

Since the 19th century, the United States of America developed a strategic model for the dispatch of scientific envoys to nations with ST&I capacity to keep abreast with global
development of ST&I and remain a leading nation in technology matters [16]. However, this suffered some setbacks at some stage due to difficulties in recruiting suitable personnel and funding challenges [16, 17]. The ST&I interest in the regime of USA former President Barrack Obama, reintroduced the practice of scientific envoys [16]. The numerous efforts before, during and after his regime have contributed to strengthening the capacity of the American Association for the Advancement of Science (AAAS) in advancing the course of science diplomacy. The AAAS currently has the only open access journal on science diplomacy launched in 2012. Some other notable developed countries that have shown similar interest in using science diplomacy for ST&I development include France, Germany, Switzerland, United Kingdom and Japan [18]. They show different areas of interest where they require the application of science diplomacy in improving national ST&I and addressing common global challenges.

3. The instrumentality of science diplomacy in developing nanotechnology in Africa

African nations, especially Nigeria and South Africa must prioritize the development of nanotechnology because of its multidisciplinary nature and the potential to transform ST&I landscape, enhance socio-economic thrive, public health and sustainable development. Such priority will guide science and technology foreign policy formulation. Science diplomacy is central to the achievement of this fate and it is reduced here to an instrument that African countries can deploy for nanotechnology development. Of the three dimensions of science diplomacy, diplomacy for science and science in diplomacy will be most instrumental for Africa. This is because science for diplomacy requires that a nation’s science and technology assets be deployed as soft powers in persuading the weaker nations into bilateral agreements, especially in the recent numerous economic sanctions around the world. Africa does not currently have the sufficient capacity to engage science for diplomacy effectively. Some of the vital envisaged areas of engagement for nanotechnology development in Africa include human capacity development, national nano-research laboratory facilities, platforms for institutional collaborations, post-graduate student training and robust exchange programs that have direct bearing on nanotechnology training.
3.1 The need for Science Attachés from Africa

Science attachés are critical human assets in achieving effective science diplomacy in the 21st century for nanotechnology development in Africa. They are members of a nation’s diplomatic corps whose main functions are to give advice to the ambassadors of their home country on science and technical matters, report on scientific development in their host countries, and represent the home country in scientific and technical meetings. Every country can redefine these roles to suit their national ST&I priorities. For example, when USA introduced the idea of science attachés in 1950, their functions among the main functions stated above were such as, facilitating exchanging of scientists, providing assistance in the procurement of scientific apparatus, chemical and biological, arrange for collaborative research projects and cooperate with all USA scientific groups abroad. Africa can leverage on the soft powers of their natural and young human resources, using diplomacy for science and science in diplomacy to influence foreign policies that will consciously develop nanotechnology. It is not out of place for a country to formulate foreign policies that will directly aid the development of a particular technological need [19].

Very shocking to reveal is that most of the leading nations in nanotechnology like China and USA have a department for science and technology in their foreign embassies in many of the developed nations, while developing countries in Africa like Nigeria and South Africa do not have S&T departments in their embassies. These leading nations carefully select the countries with ST&I capabilities for diplomatic scientific representation. USA is one of the developed leading countries in nanotechnology. A case study of China [20], India [21] and France [22, 23] shows that they have S&T departments at their embassies in USA, while South Africa [24] and Nigeria [25], as the two leading economies in Africa do not have S&T department. There is the need for African countries to consider the establishment of S&T department in their embassies, especially in the countries that are leading in nanotechnology. This will facilitate opportunities for stronger and sustainable scientific collaborations. The S&T department usually have science envoys, science attachés, or well-informed technical personnel as members of staff.

Countries like Brazil and Egypt are not among the top twenty countries in basic research on nano-science and nanotechnology, however, Figure 4 shows that they stand out among the developing nations compared to South Africa and Nigeria in ISI nano-articles publication.
These results might not be strange because Brazil has a unit for Education, Science, Technology and Innovation [26], while Egypt has an academic and cultural collaboration unit in their foreign embassies [27]. Such international representation could facilitate research opportunities and collaborations in nano-science between the scientists from the host and home countries. Therefore, a significant impact on research outputs is expected. The benefits derived from individual scientist efforts and collaborations might not have national and global impacts compared to research collaborations that are established based on national platforms resulting from science diplomacy. Certainly, developing nations of African can benefit from developed countries in the training of personnel, curriculum development and acquisition of equipment to drive nanotechnology agenda of the continent [28].

Funding is necessary to sustain research until results are evident. Individual researchers might lack the capacity for sustenance when there are no guaranteed immediate results unless government or well-established private organizations commit their funds. Science diplomacy can provide the opportunity for joint research and funding that will have a global impact.

![Figure 4](image.jpg)

**Figure 4.** Number of ISI nano-articles published in 2019 by some developing countries. Data from Web of Science (ISI Web of Knowledge) [9]
3.2 Recommendations and defining functions for Science attachés from Africa

There is the need for the government of African countries to understand the impact that nanotechnology can have in all the sectors of the economy for improved standard of living of the populace. This invites a fundamental role for the tertiary research institutions and national research centres. They should act as consistent sensitization agents to the government through seminars, workshops, short courses and conferences that involves active participation of stakeholders from government. This will raise government confidence and support commitment in prioritizing nanotechnology. Such priority will naturally give credence to tailored foreign policy drive, human capacity development such as training of concerned personnel, post-graduate student scholarships, exchange programmes and facility development. Adequate and appropriate research facilities are vital to sustaining trained personnel and graduates, absence of which could lead to brain drain or diversion of research interest.

African nations should consider introducing the department of science, technology and innovation in their foreign embassies and high commissions in developed nations with excellent nanotechnology development and applications such as the first ten leading countries. The staff composition should consist of an informed science and policy envoy supported by science attaché(s). In addition to the roles defined for USA science attachés when the concept started in 1950, we recommend that African science attachés engage in an annual stakeholder’s forum in their home countries for interface with domestic scientists to discuss latest development in nanotechnology with a view to strategise on how Africa can feature for global competitiveness. An annual review of the effectiveness of the collaboration platforms initiated by science attachés will ensure that challenges to efficiency are managed both for the home and host scientists.

4. Conclusion

The potential in using nanotechnology to develop African ST&I is enormous. Nanotechnology has the capacity to cause an economic revolution and improve the living standard of the people. This study has shown the importance of engaging science diplomacy in developing nanotechnology in Africa. Sensitizing the government and policy makers on the need for nanotechnology development is crucial through the instrumentality of workshops, seminars, conferences and short courses. Tertiary research institutions are fundamental to
guiding African governments in prioritizing nanotechnology development. Government commitment will reflect in their budgeting, inclusion of the department of science, technology and innovation at various embassies and high commissions in the leading countries. Since science diplomacy involves the combination of scientific and diplomatic skills, science envoy and science attachés with both skills are strong considerations to form the core staff composition in the ST&I department.

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