COMMUNICATING SCIENCE, TECHNOLOGY, AND INNOVATION IN THE GLOBAL NORTH AND SOUTH COUNTRIES: FOCUS ON BRICS NATIONS AND RAMIFICATIONS FOR NIGERIA'S DEVELOPMENT TRAJECTORY

Charles Obot, Herbert Batta, Nnamdi Ekeanyanwu & Iniobong Nda

Faculty of Communication and Media Studies, University of Uyo, Nigeria.
Corresponding Author's email: charlesdenis@uniuyo.edu.ng

Abstract

Developments in science, technology, and innovation (STI) are some of the markers in overall economic, social, and cultural progress of nations. Communication is crucial for the dissemination, adoption, and integration of technoscience and innovation culture of nations. This discourse examines the place of science communication and the status of Science Technology and Innovation in Global North nations comparative to selected Global South countries and particularly BRICS nations and zeroes in on the implications on Nigeria's development trajectory. The motivation for this article stems from the fear that if Global South countries, BRICS nations, and particularly Nigeria do not take STI and its communication more seriously as done in the Global North, meaningful and sustained socioeconomic development would continue to elude their people with disastrous consequences. Two theories provide the basis for discourse, namely: Diffusion of innovations and the Information Society Theories. The methodology adopts a literature review approach, using l reports and recently published studies in reputable outlets and statistics from notable global organisations. The findings show that for the Global North, there is serious depth attached to academic, media, public, citizen, industry and government science communication activities. Also, it is marked by institutionalisation, professionalisation, inter, trans, and multidisciplinary, and diversification of rendering as well as dialogic/participatory modes of public engagements. However, the challenges include digital misinformation/disinformation, skepticism/denialism, and contrariness within the scientific/political community. In the Global South, science communication is characterised by poor funding, dismal STI infrastructures, information/communication disparities, and deficits in academic, media, industry, public, and government STI practices. It is concluded that for Nigeria to develop significantly, it must among others: invest meaningfully in STI and science communication, enhance scientific literacy by instigating critical thinking, public engagement in STI, promoting citizen science, entrenching the culture of media science, promoting STEM and STI education, and facilitating partnerships, cooperation, and collaboration involving people, communities, governments, academia, and industry.

Keywords: Developing Nation, Dissemination, Literature Review, Science-Technology-Society

Introduction

One dependable way of measuring development around the world, is to examine nation's investment in Science, Technology and Innovation (STI). That investment is certainly part of the science culture. The top performing countries include the United States, China, Germany, Japan, South Korea, United Kingdom, France, Switzerland, Sweden, Singapore (Michael, 2024; WIPO, 2024). These countries except China are

usually referred to as part of the Global North. In terms of excelling in STI, they are so ranked because they expend a high percentage of their GDP in research and development investments, they boast of remarkable cutting-edge research centres, universities, and innovation hubs, in addition to having commendable and highly skilled workforce that is thoroughly grounded in science, technology, engineering and mathematics (STEM). In addition, these countries enunciate policies and laws that grow innovation, research, and development apart from visibly developing the ecosystem that allows startups and entrepreneurs to thrive (OECD, 2024).

In putting data behind some of these facts, the USA, China, and Germany for example deploy reasonable portions of their GDP to R & D investments. Considering entrepreneurial culture, the numbers of startups are substantial. For government policy on R&D tax incentives, these countries are also leading examples (World Economic Forum, 2023; Sarpong, Boakye, Ofosu, and Botchie, 2023). It follows that Global North countries with consolidated science and technology culture equally have robust science communication culture characterised by trustworthiness, scientific rigour grounded in factual accuracy, transparency, reliability, and balance. In such situations, STI forges a strong connection with the society through public engagement, media literacy and policy relevance.

Global South Countries are found in Africa, Latin America and the Caribbean, Asia, and Oceania and exhibit mutual sociopolitical and economic features such as limited access to education and healthcare, extensive levels of poverty, and lower incomes having been historically impacted by slavery, colonisation and technology deficits. In Africa, the main Global South countries are Ethiopia, Egypt, South Africa, and Nigeria. In Latin America and the Caribbean, the Global South nations are Cuba, Argentina, Mexico, and Brazil. Countries such as Pakistan, Indonesia, India and China constitute the Asian Global South nations whereas those in Oceania are Fiji and Papua New Guinea. It is instructive to note that BRICS countries, a group of five prominent emerging, economic nations of Brazil, Russia, India, China and South Africa some of which are Global South countries are described as large, growing economics with remarkable Gross Domestic Products, a growing middle class with emerging markets and a growing economic influence. The economies of these emerging Global South countries, also called BRICS nations have diversified into manufacturing, services, and natural resources industries and are wielding notable regional and global political, geographical, and economic powers (Tian, Sarkis, Geng, Bleischwitz, Qian, Xu, & Wu, 2020; Vyas-Doorgapersad, 2022; Upadhyay & Saha, 2023; Nach & Ncwadi, 2024; Moch, 2024; Zhou, 2024; Malgalhaes, 2024; & Mahbubami, 2024).

Developments in science, technology, and innovation are some of the markers in overall economic, social, and cultural progress of nations. Communication is crucial for the dissemination, adoption, and integration of technoscience and innovation culture of nations. This discourse examines the place of science communication and the status of STI in selected Global South countries and particularly BRICS nations and zeroes in on the implications on Nigeria's development trajectory.

Following the observed lack of comparative studies of science communication between developed and developing countries, the problem that necessitates this article is the apparent fragile STI communication culture in developing nations which also stems from a poor STI culture. By unveiling the best practices in science and science communication pedagogy and practice in the Global North, it is believed that developing countries or the Global South including BRICS nations (with Nigeria as one of the latest partner countries) can draw pertinent lessons about how to prioritise STI and STI communication to propel their socioeconomic development trajectories.

Arising from this problem, the objectives of this article are to: examine the distinguishing features of STI culture in the Global North and the Global South especially BRICS nations; and to identify the lessons that can be drawn from best practices in STI culture and STI communication as veritable means for solving the development challenges that beset Nigeria.

Theoretical Framework

Two theories provide the basis for this article, namely: Diffusion of innovations and the Information Society Theories. Diffusion of Innovations Theory: a French sociologist and legal scholar – Gabriel Tarde is credited as the originator of the basic idea of the diffusion of innovation. Littlejohn and Foss (2009, p. 307) explain that, "diffusion is the process by which an innovation makes its way over time to members of a social system. An innovation is the introduction of something new – a project, practice or idea." Science, Technology and Innovation are dynamic and bring something new often and regularly hence the relevance to this discourse.

The Information Society: Citing Melody (1990), McQuail (2010, p. 104) describes information societies simply as those that have become "dependent upon complex electronic information networks and which allocate a major portion of their resources to information and communication activities." Communication not only popularises science, technology and innovation, but it also benefits immensely from the latter. This is because the products of STI are used to enhance communication efficiency. Developing countries operate in a world that has since transformed into an information society and to witness overall development driven by advancement in science and technology, they must embrace the tenets of the theory,

Methodology

This article adopted an exploratory literature review approach by utilising over a hundred scholarly materials gleaned purposively (not systematically) from manual google searches (without an intention to quantify) on efforts made by some Global South countries especially BRICS nations (Brazil, Russia, India, China, and South Africa) in their individual capacity comparative to Global North countries to make progress in their science, technology and innovation endeavours. Reports and statistics from notable global organisations such as the Organisation for Economic Cooperation and Development, World Intellectual Property Organisation, and World Economic Forum, are relied upon for facts, insights, conclusions, and recommendations.

Science Communication in the Global North

To appreciate the ideals of science, technology and innovation communication, it is apposite to consider best practices and how STI communication is conducted in the Global North. Science communication takes various forms in the Global North. Academic science communication is seen in schools, institutes, research centres, universities, and research laboratories and is accessible through organs such as science publishing, the public library of science, Open Access Movement (arXIV), Directory of Open Access Journals (DOAJ), science technology and innovation research agencies, institutes, and scientific papers. (Stoklmayer, Netshisaulei, Potgieter, & Walker, 2024).

Media science communication encompasses all the activities conducted by the media of communication – newspapers, radio, television, satellite and cable systems as found in STI journalism in newspapers, podcasts and documentaries used to disseminate STI information to the public. Media science is a bridge between the

scientific world and the public (Zimmerman, Baram-Tsabari & Tal, 2024; Giuffredi, Grasso, & L'Astonna, 2024).

Public science communication involves the various engagements involving the academic science community, industry science world, media science communicators and the public in its variegated forms. The purposes are that of popularising STI, ensuring the public understanding of STI, and encouraging the adoption of STI for development purposes. Public science communication activities include public lectures and events about STI, science and tech festivals, and engagement of citizens in STI programmes (Swords, Porter, Hawkins, Li; Goldswith, Koci, Tansey & Waitowich, 2023; Oliveira, Barata, Gleerackers, Alperin, Falade & Bauer, 2024).

Citizen science is the participation, involvement, and engagement of ordinary citizens in STI activities, programmes, projects, and initiatives to deepen the understanding of STI, broaden the uptake of STI among the citizenry, and involve the ordinary people in the utilisation of STI to initiate, harness, optimise, and maximise developments in health, education, security, environment, democracy, gender equality, etc. (Rufenacht, Woods, Angello, *et al.,* 2021; Hall, Avellaneda-Lopez *et al*., 2024; Columbic, 2024).

Industry science communication occurs within the corporate world where industrial concerns communicate their research and development functions. They do these as a matter of course to facilitate an appreciation of the workings of the STI industry by people, governments, the international community, academia, markets, and entrepreneurs. Science-based firms in green energy, pharmaceuticals, and artificial intelligence, nanotechnology, biotechnology firms all engage in science communication. Similarly, the partnership, cooperation, collaboration involving the science industry, the science academia, government and people for projects, researches, and initiatives are key aspects of industry science communication (Guiffredi, Grasso, & L'Astorina, 2024).

Government science communication denotes the spreading of science, technology, and innovation information and research results emanating from government agencies to the citizens, the media, scientists, policy makers and other relevant stakeholders. This is done to strengthen partnerships and collaborations, facilitate policy making based on empirical evidence, instill probity, accountability and transparency, foster learning and fieldwork, and promote public appreciation and use of STI. The means of information dissemination include science publications and journals, press releases and briefings, official reports and data analyses, public lectures and events, social media and digital outlets, science blogs and podcasts as well as parliamentary visits, briefs, and public hearings (Guiffredi, Grassa & L'Astorina, 2024).

From the foregoing, the nature or distinct characteristics of science communication as practiced in the Global North can be distilled into seven key points.

(i) It can be described as institutionalised, meaning that science communication is an established, statutory, and routine practice in government offices, departments, research institutions and the industries (Qiu, 2020).

(ii) Science communication is highly professionalised. It is conferred with the dignity of a circumscribed field of practices backed by specialised training, education, and expertise (Kirschke, Glahe, Ahrend, Brandt, Hecker, Krohmer, *et al*., 2024).

(iii) It is interdisciplinary, transdisciplinary, and multidisciplinary; meaning that science communication mainstreams knowledge and practice from within and outside of the humanities, social sciences, science, technology, etc. and draws inspiration from society studies, education, philosophy, psychology, etc. to

sharpen its capacity to engage with sundry aspects of the society (Stocklmayer, Netshisaulu, Potgieter, & Walker, 2024).

(iv) Science communication thrives on diversification by incorporating multifarious genres of communication namely: text, print, social media, podcasts, documentaries, gaming, infographics, etc. to attract and sustain divergent interests (Lewinstein, 2024).

(v) It underscores the pivotal essence of public engagement by giving prominence to dialogic, participatory, interactive, transactional models of public engagement based on truth, public trust, integrity, professionalism, fairness, objectivity, the public good, and sharing of understanding (Swenson & Marson, 2024).

In summary, science communication in the Global North include: (a) the resort to robust, high quality science journalism practice with consistent science segments in the media; (b) establishment and maintenance of enduring and funded science media centres, science, technology and innovation hubs, parks, museum, expos, fairs, and festivals; (c) consistent focus on the funding of science, tech, and innovation, regular enunciation/updating of STI policy frameworks; implementation of STI policies, regulation, laws, and dedicated investment in STI education, literacy, popularisation by governments and organisations; (d) placing emphasis on and giving priority to collaborations between STI experts and communicators to emplace workable science communication ecosystem; (e) leveraging technoscientific innovations and digital infrastructure to communicate STI and engender public involvement, participation, and engagement in a digital economy (Gascoigne, Schiele, Leach, Riedinger, *et al*., 2020).

(vii) The challenges facing science communication in the Global North include the urgent need to address the menace of digital misinformation and disinformation, tackling the issue of popularisation within the academic and industry science communities and the confusion it creates for government, citizens, and public science communication in terms of skepticism, contrariness, and denialism; and using science communication to curb the inequalities apparent in accessing STI information due to digital disparities (Mckinnon, 2024).

Science Technology and Innovation policies are crucial for all as they can help foster economic growth and address numerous societal challenges, thus enabling these countries harness their full potential and drive progress in the 21st Century. According to OECD (2000), science, technology and innovation play a significant role in economic performance, given that Multifactor Productivity (MFP) has increased in countries such as Australia, Denmark, Finland, Ireland, Norway and the United States in recent years. This rapid MFP growth is generally due to improved managerial practices, organisational changes and most importantly, to smarter and more innovative ways of producing goods and services. Therefore, innovation policies can help spur innovations in various sectors, such as healthcare, agriculture, energy and information technology, leading to improvements in the quality of life and sustainable development in Global South Countries. Putera, Widianingsh, Ningrum, Suryanto and Rianto (2022) affirm that developing countries require policy support in the development of appropriate science, technology and innovation, to capture, master, and encourage growth for their countries.

For such countries, there is an obvious need for integrated and coordinated policies which prioritise science, technology and innovation in their development agenda. By adopting a holistic approach which emphasises the transformative potential of science, technology and innovation and acknowledges the interdependence of

various sectors of human endeavor, these countries may effectively harness innovation for sustainable development and inclusive growth (Putera *et al.*, 2022).
Overtime, the governments of the different Global South Countries have made attempts to implement policies with the aim of establishing a science, technology and innovation ecosystem. Some of these policies are highlighted by Chaturvedi, Srinivas, and Rastogi (2015), Silva (2019) and Putera *et al*. (2020).

To sum up, science communication in the Global North in terms of praxis and pedagogy emphasises established science communication institutions and funding bodies, robust science journalism traditions and media organisations and public engagement programmes. It also involves according priority to critical thinking, public participation, and scientific literacy as well as a focus on public understanding of science and the integration of digital media and social networks in the enculturation of STI (Roche, Land-Zandstra, Lewinstein & Massarani, 2023; Fischer, Barata, Scheu and Zieder, 2024).

The extant literature in science communication shows that there are points of convergence and divergence between the Global North and the Global South relating to the pedagogy and praxis of science communication. Under pedagogy and for convergence, science communication is taught in the context of local cultures and the socio-political milieu. The emphasis is on science education, literacy and training seen mainly in schools and research institutions. There is also, ample reliance on indigenous and traditional knowledge and practices. From personal observation, there is a paucity of funds and resources for science communication in the Global South where alternative media channels such as community radio and folk/oramedia are deployed to connect science communication to national development and economic growth. On the other hand, the Global North underscores better funding, greater institutionalisation of science communication, more entrenched public engagement and critical thinking and prioritisation of Western scientific knowledge (Moyo, 2023; de Oliveira & Bomfim, 2023; Chankseliani, (2023); Osborne & Allchin, 2024).

Science Communication in the Global South: Focus on BRICS Countries

Science communication in Brazil

The commitment of the Brazil to engendering a culture of innovation is demonstrated via a set of public policies which are mostly regulatory and aimed at establishing guidelines for technology driven activities in the country. These policies allow for the sharing of resources and infrastructure such as personnel, buildings, laboratories, equipment, instruments, and materials without interfering with the main activities of the agents involved. This practice is believed to have the ability to contribute positively to a systematic culture of innovation focused on sharing between the agents of the country's National Innovation Systems (NIS) (Silva, 2020).

Initiatives such as the Brazilian Innovation Law promulgated in 2004 and the Brazilian Law of Innovation enacted in 2016 are the major innovation policies implemented in Brazil. These policies resulted in what is known as the 'new legal milestone of innovation' and altered nine decisive laws in different sectors involved with innovative activities such as immigration, scientific and technological research, public purchasing and contracts, educational and research institutions, imports of goods intended for scientific and technological development, hiring and professional development of individuals who could be involved with science and technology (Silva, 2020). These policies also provide tax incentives and funding for various innovation projects. As a result, Brazil, recently has witnessed increased investment in research

and development, improved collaboration between academia and industry, and growth of innovative startups in the country.

The highlights of science communication in Brazil according to Massarani, and Moreira (2020)
can be summarised in several points. Science museums and science centres are important aspects of science communication in Brazil beginning from the 1920s. Apart from natural history museums, the interactive museums of science and technology and planetariums were established and instigated by the influence of transformation in science education in the USA and hinged on the criticality of practicum in science pedagogy in physics, genetics, nuclear energy, and tropical morbidities.

Science journalism began in the 19th Century in Brazil leading to the formation of science journalism associations in Latin America in 1960s and 70s and university courses. The return of democracy in the 1980s brought about more freedoms and spurts in the growth of science journalism but the situation in the post-coup eras became tumultuous for the media but science magazines emerged and flourished. Currently, the scientific credibility of some of those outlets is dismal and pseudoscientific. Radio, TV, (i.e. broadcast) science communication developed in Brazil in the 1980s and 1990s, while cable channel programmes have limited reach, the quality of science communication meets with some form of best practices but generally does not peak at adequate levels. Some of the inadequacies include presenting science as a spectacle, episodic, ignoring the production model processes, contexts, limitations, and uncertainties of science as well as deploying a simplified conceptual model to establish the nexus between science and the public (Massarani & Moreira, 2020).

The utilisation of the Internet and new media in Brazil for science communication is mainly through science centres, museums, science institutes, research groups, and some government agencies, the engagement among scientists, bloggers, and the public is still low and then, the science centres and museums are concentrated in the urban and wealthy neighbourhoods. Of the 260 museums as of 2015, most are small-sized, not interactive, and less capable of boosting science communication in a large country like Brazil (Massarani & Moreira, 2020). Organisations, events, and public policy play significant roles in science communication in Brazil. They include science communication bodies, botanical, planetariums. The department of popularisation and diffusion of science and technology gardens, national science Olympiads, international year celebrations, national science and technology week, science and technology universities among others (Massarani & Moreira, 2020).

The major challenges facing science communication are those of getting the large Brazilian population to access STI information, strengthening the existing policy making and implementation capacity of the nation in science communication and improving the quality of science communication through training, more researchers, and recognising the value of culture in science (Massarani (Massarani & Moreira, 2020) & Moreira, 2020).

Science Communication in Russia

Russia is a very large country in terms of landmass (16,376,870 km^2), population (145 million), size of the economy (11th largest: $2.184 trillion in terms of nominal GDP and $6.0909 trillion in purchasing power parity (4th largest), and several other indices (CIA.gov, 2024). These make it an important country to investigate in relation to its focus on science, technology, innovation and how these are communicated.

In an examination of Russian science and technology, Klepach, Vodovatou, and Dmitrieva (2022) interrogated the use or progressive lag in two parts and concluded

that there was a potential in the field of fundamental science and high tech, larger corporations enough to maintain a technological parity with other big five economies, Russia needs to tackle problems of multiple scientific and technological priorities, restricted financing of science, inconsistent policy making in STI, and low support for applied and industry science segment of the economy.

At the level of culture i.e. popular culture, Krynzhria (2023) underscores the influence science communication has on the formation of value orientation of young people. She highlights citing the philosopher scientist Medvedeva, that scientific communication should be holistically conceptualised as a process involving the progression of scientific ideas from the scientific community to mass consciousness including the embedding of scientists and science images into creative/artistic works. Beyond the interpretation of scientific knowledge, science communication ought to involve five stages of: (a) creative processing of scientific ideas by scientists; (b) communication of science within the scientific community; (c) communication of science among the science community, state, science industry, the corporate world, science bodies, associations, academics, foundations; (d) conferment of scientific knowledge through communication with a myth about science. In other words, science communication has a pervasive influence on society, culture, and humanity.

An examination of the state of Russian science in the academic world by Chawla (2020) indicates that Russia has about 6,000 academic journals mostly published in Russian and in 2019 found that Russians publish a lot more in domestic journals than peers in Indonesia, Germany or Poland and that in addition to deficiencies in standards, 4000 cases of plagiarism and doubtful authoring were found involving 150,000 articles in 1500 journals. This investigation shows how prolific the science academy in Russia is but is also indicative of the issues in science communication that need to be addressed.

Furthermore, the Russian State supports science, technology and innovation especially in universities (Vasiljeva, Pankratov, Volkova, Khairova, Nikitina, Dudnik, Alimova, Kuznet-sav, & Elyakova (2020), there is need to democratise science and communication to grow more interest in science information in the population, and fight vestiges of misinformation and pseudoscience brought on by the digital media.

On greater specific details, Borissova and Malkov (2020) have written extensively on Russian science communication from its glorious science propaganda past to its modest public engagement present – a period of 100 years (1917 to 2017). A brief summary of the nature of science communication in Russia through the eras shows several features.

All through the time, the term in widespread use was science popularisation from the space-race-era years of science propaganda to 2010 when science communication as a term came to depict activities connected to the propagation of science. Science and technology propagation activities took the form of public lectures and discussions, science magazines with phenomenally high circulations, science motion movies and television programmes, science and technology museums, including a surge in dissemination of paranormal phenomena, UFOs.

Between 1991 and 2001 and coinciding with the collapse of the Soviet Union, science and its popularisation crashed. Institutional support for science and science communication ran out of funding. Freedom brought with it, inflows of Western literature, culture, philosophy and religion. Private individuals and corporations took over the task of revitalising science and science popularisation from 2001 to 2011 by funding translation of science books, book publishing, science festivals, lectures, science and nano-sciences and fighting the scourge of pseudoscience and paranormal

thought though corporate science communication in universities and research institutes lagged behind (Borissova & Malkov, 2020).

From 2011 to 2016, the Russian State took bolder steps to reinvent the prominence of science and science communication by reorganising the science academies, investing greater funds in research and communication. Digitalisation of the media saw to the establishment of science media in the Web and government practically seized all channels of science communication in a most powerful way. Science communication training was the last to be developed in Russia. First and postgraduate degrees in science communication began to take root from 2013 and many efforts are made to develop programmes in tertiary educational institutions but science communication is yet to be robustly institutionalised or included in policy framework of Russia.

Science Communication in India

Since India's independence in 1947, there have been several science, technology and innovation policies implemented by the government with the aim of engendering a culture of science and technology in the country. These policies demonstrate the country's dedication to promoting an innovative, research-based and entrepreneurial culture in a bid to foster economic growth and societal progress.

One of the earliest STI policies of India was known as the Science Policy Statement (SPS) of 1958. This policy outlined several key objectives and principles for the advancement of science, technology and innovation in the country. Some of the major highlights of the SPS include the promotion of basic research, encouraging scientific education, developing indigenous technology, fostering international collaboration, and ensuring the application of science for societal benefits. As a landmark policy, the SPS laid the groundwork for the establishment of key scientific institutions, research centres and educational programmes, all of which have contributed significantly to India's achievements in the field of science and technology (Chaturvedi, Srinivas & Rastogi, 2015).

The SPS was followed up with another significance policy known as the Technology Policy Statement of 1983 formulated with the aim of leveraging science and technology to drive industrial growth, promote innovation and address particular societal challenges in India. Some of the highlights of the TPS, which were not captured by the SPS of 1958, include the attainment of technological self-reliance in various sectors, industrial competitiveness, technology transfer, human resource development, environmental conservation and international cooperation (Chaturvedi, *et al.,* 2015; Mammen & Nirupana, 2024). Other innovation policies formulated by India include the Science, Technology and Innovation Policy in 2013, the National Innovation Initiative – NinCL in 2006, Startup India in 2016, and Atal Innovation Mission (AIM) in 2016 (Chaturvedi, *et al.,* 2015).

Science communication in India has been extensively traced by Chakraborty, Raman, and Thirumal (2020). In their submissions, they show that for a country with 1.3 billion people, the battle against poverty, a dismal political will, a plummeting budget for scientific/technological programmes and a not so high quality of education have coalesced to stifle development in STI. Other features of the state of science, technology and innovation as well as their communication aspects can be distilled into the following points: (a) STI is seen as an elitist enterprise, the preserve of the male upper caste system antithetical to the translation of citizen priorities into agenda of scientific research; (b) over the years, India's policy on STI has been severally enunciated to increase the salience of the public in formulations with emphasis being

placed on building a scientific temper using education; (c) after the second world war, India invested in science museums and other infrastructures as potent tools for drastic socio-economic transformation through science communication/popularisation in order to reap future demographic dividends; (d) beyond science museums, exploration, science exhibitions, science competitions, and a wide array of public engagement programmes, India has taken conscious steps in strengthening science communication through general education, the media, and other communication avenues to build a scientifically literate citizenry; (e) the focus of science communication and education in India has been on health science/communication, agricultural extension, and development communication in schools, colleges, and universities; (f) studies in India show a lack of scholarly interest in science in the mainstream media and a skewed focus on health, environment, agriculture and information and communication technologies; (g) India recognises the power of effective science communication considering its young post-colonial status but there is an acute need to bridge the gap in uptake of STEM career aspirations of young Indians between the urban and rural dwellers.

Other important observations about science communication in India are that science journalism is need-based and occurs when the country is facing crisis (Naik, 2022), science communication can achieve more if integrated strongly and younger generation brings in greater enthusiasm for the nation's progress to advance (Garima, 2023); India needs to boost its sciences and technology funding gap by encouraging businesses to contribute more as leading economies do to become a science power house (*Nature*, 2024); though there is exponential diversification of science promotion in India, the same is not true for popular science communication for there exists a lacuna in people's understanding of science, passion for science and diffusion of novel science and technologies such as GMOs (Kaur, 2023).

Science Communication in China

The communication or popularisation of science in China is described as being on the road for ever beginning in the 19th Century but changing radically in 1949 with the establishment of the new China. Since then, it has been a long, tortuous journey of institutionalisation, government-led programmatic roles, top-down model of mass science communication, development of multiple science communication forms, provision of science popularisation infrastructures, public engagement activities, social mobilisation/participation, networking and cooperation for national scientific literacy and science communicator training (Ren & Zhai, 2014; Lin & Honglin, 2020; Ren, Yin & Raza, 2021).

Citing Cui (2010), Lin and Honglin (2020) provide the challenges that informed China's modern science communication trajectory as follows: (a) insufficient recognition of the strategic importance of science popularisation; (b) inefficient administrative mechanism of science popularisation in terms of synergying scientists' work with government initiatives; (c) dismal funding of science popularisation that was supportive of meaningful achievement; (d) paucity of avenues and infrastructures for science popualrisation, exhibitions, and education; (e) poor science literacy among science popularisation bodies.

To address these challenges, China resorted to targeted legislation, policy making, stimulation of consciousness and capacities of social organisation for science popularisation, increment in science popularisation infrastructures, funding of science, technology and innovation as well as the science media and scaling up of public involvement, engagement, and participation in science (Li, Wang, Yasin, Hashim, Ang & Kang, 2022; Lin, 2023).

China's recent achievements in science and technology, as well as its rapid economic growth, have garnered more and more attention globally. The country's successes in these areas are largely due to its strong innovation culture, which has encouraged the adoption of new technology and research in virtually all aspects of the society. Indices of China's culture of innovation, according to Hui (2018) are several: government support, entrepreneurship**,** investment in research**,** collaboration and open innovation, talent and skill development.

Today, it is easy to examine and recognise key features of China's science communication landscape to include critical thinking and scientific literacy of the Chinese public especially in assessing traditional Chinese medicine. Science popularisation emphasises the need to make science accessible to the larger Chinese public through thousands of STI museums, science centres, science week, national days, exhibitions, fairs, etc. The new media platforms have also drastically expanded the depth of science communication in China, with scientists and science communicators harnessing social media platforms for public engagements. Dissemination of STI knowledge in China however, is more of a one-way, instead of being dialogic; and bureaucratic constraints slow down science popularisation efforts. Dealing with ownership and restriction on scientific information, misinformation and pseudoscience in the social media and expanding the space for public participation and engagement will improve science communication in China (Jia, 2022; Li & Zhang, 2023; Wen, Zhao, Zang, & Li, 2024).

Science Communication in South Africa

South Africa is an important sub-Saharan country, a middle-income economy and a significant member of the African Union, Southern African Development Community, one of the BRICS nations, and a major Global South country in Africa. With a turbulent colonial and post-colonial past mired by a long history of political, economic and cultural segregation – Apartheid; South Africa cannot escape attention as pertains to science, technology, innovation and the development of science communication.

South Africa has a population of 64,302,739 as of November 24, 2024 and ranks 24th in the world (Worldometer, 2024). It has a Gross Domestic Product of $373 billion in 2024 to rank first in Africa followed by Egypt, Algeria, Nigeria and Ethiopia (Statista, 2024). Its total landmass is 1,219,090 square kilometres to rank 26th in the world (CIA.gov, 2024). In the 2024/25 fiscal year, South Africa budgeted R10,874 billion for its Department of Science and Innovation (Department of Science and Innovation, 2024).

A number of scholarly studies can be used to gauge the character of science communication in South Africa. Riley, Joubert, and Guenther (2022) for instance probed the motivations and barriers for young scientists to engage with society. Also, Joubert and Costas (2019) investigated what tweeting South Africans indicated about their interests in research and found that astronomy, astrophysics, ecology and the environment were the most popular research topics among Twitter users in South Africa affirming the notion that the social media platform was a veritable tool to dialogue on scientific production. Similarly, Joubert (2018) studied country-specific factors that compel South African scientists to engage with public audiences. The factors bordered on history, politics, culture, and socio-economic conditions – factors often ignored in probes of public communication behaviour of scientists.

These and more researches bring home the imperatives of science communication in the world for in the words of Weingart, Joubert, and Falade (2019), in countries around the world, scientists, policy makers, and the public have high hopes

for science communication: elevating its populations educationally, raising the level of sound decision-making for people in their daily lives, and contributing to innovation and economic wellbeing.

A clear picture of science communication in South Africa is painted in by Rasekoala (2023) and particularly in by Gahvi-Molefe and Nemutudi (2023). They underline that science communication plays a crucial role in the context of structural and infrastructural deficits that stifle science and development. For that reason, science communication has to have the agenda of curbing serious development challenges and building a scientifically literate Africa. This necessity is significantly strong in South Africa where there is the dire need to bridge the gap between science and society for a transformation impact on national innovation, sustainable development and progressive democracy. The deleterious legacy of Apartheid which institutionalised social, gender, and socio-cultural inequities makes the call more urgent. To rectify this problem Gahvi-Molefe and Nemutudi (2023) suggested as follows: (a) ensure the effective implementation of South African government well-articulated policy on science, technology and innovation; (b) develop the closure of the gaps in the practical implementation of its scientist's compulsion to deliver, using correctly resourced mechanisms, a healthy enduring and utilitarian science communication agenda; (c) build capacities and documented resources to provide science communication activities in South Africa through equipping and growing the critical segment of science communication in the country using holistic, socio-cultural and empowering ethical frameworks; (d) consciously steer science communication away from a predominantly Eurocentric posture to an Afrocentric one through partnerships, collaboration, and multisectoral/multidisciplinary approaches.

In a much more comprehensive chronicling of science communication in South Africa, Joubert and Mkansi (2020) have taken note of the following:

(i) although Apartheid in post-colonial South Africa brought with it social disruption; scientific exploration, amateur and professional intellectual curiosity in mammals, birds, fishes, plants and fossils occurred unhindered;

(ii) the Apartheid Era (1948 – 1993) was characterised by political (State) control, censorship and strategic investment in science and esoteric research;

(iii) pioneering science communication activities in South Africa involved the establishments of libraries, observatories, museums, science academies. There were also notable pioneers of science in paleoanthropology, cardio transplantation, ichthyology, etc.;

(iv) the transformation of South Africa into a democracy since 1994 fundamentally altered the science-society interface with government taking public science engagement as an avenue to right past injustices and grow the society and economy using public awareness campaigns, researcher articulations, and declaration of science and technology year with the greater challenge being access to rural areas;

(v) a democratic South Africa has demonstrated commitment to the promotion, protection, and preservation of indigenous knowledge systems with policies, acts of parliament, foundations, funding and with respect for traditional medicine. These efforts aim at fighting pseudoscience and decolonising science in South Africa;

(vi) using policies, funding, legislation and strategies, there is an increasing resort to public engagement as a means to democratise science, increase its impact on society and sustain public trust in science. The establishment of an agency for science and technology advancement in 2002, science centres, NGOs are clearly

ways of institutionalising science communication in South Africa. Science journalism especially on radio, as well as science communication research and university training are added avenues.

The challenges facing science communication in South Africa include the need to communicate the improvement in the living standards of people especially those with poor access to water, food, sanitation, education, and health in the rural areas while government is spending huge sums of money on space exploration. Another challenge is that of granting access to science, health, environmental and risk information to young people without access to science centres or schools and in the language, they understand; South Africa being a multilingual society and science engagement lacking in those capacities.

Africa in the Global STI Research Ranking and Implications for Development: Lessons for Nigeria

A fairly good idea of the status of STI in Africa has been provided here from copious data from sundry sources particularly the STI Strategy for Africa 2024 (STISA) by Kahn (2022), OECD (2024), World Economic Forum (2023), the World Intellectual Property Organisation (2024), to stitch together useful indices on talent development, scientific production, innovation activities and linkages.

Firstly, the improvement of STEM education in Africa has been seen as a recurring challenge. Over a period of a decade, enrollment in higher education in sub-Saharan Africa increased by 42% and 25% in North Africa, the explanation for North Africa being political instability and lower oil and gas revenue (Kahn, 2022). STEM education is critical because STI is at the nucleus of Africa's socio-economic development and progress. The leading universities are in South Africa and Egypt. Nigeria ranks low.

Secondly, the share of Africa's scientific production (659,910) between 2010 and 2019 rose from 1.7% to 3% with dominance in the top 10 science categories being engineering, public environmental/occupational health and health sciences. The scientifically prolific countries in Africa are South Africa, Egypt, Tunisia, Kenya. Nigeria ranks fifth (Kahn, 2022).

Thirdly, in terms of innovation activities, using the Global Competitiveness Index (GCI), the median rank for African participating countries stands at 117, i.e. 40 positions below the global average (Kahn, 2022). with Mauritius, Rwanda, then South Africa ranking at the top in that order. Regarding Global Innovation Index, on innovation inputs and outputs, South Africa ranks top in Africa followed by Mauritius, Morocco, Tanzania, and Kenya. Other innovation achievers in Africa are Kenya, Rwanda, Senegal, Uganda, Mozambique, and Malawi. In terms of patent registration Morocco and South Africa lead in Africa. Nigeria ranks very low in indices of technological readiness, innovation, and patents application

Fourthly, linkages, partnership, collaboration, and international cooperation are fundamental to development in science, technology, and innovation in Africa. This means that funding, access to grants, and ease of doing business are important. Africa's top seven countries in term of working together and linkages are Mauritius, Rwanda, Morocco, Kenya, Tunisia, South Africa, and Zambia. Again, Nigeria does not feature at the top!

Now let's juxtapose these African realities with other countries and regions of the world. Utilising data from the World Intellectual Property Organisation (WIPO) (2024), it is possible to see who the world leaders are using several parameters such as regulatory quality, policy stability, ease of doing business, ICT access, logistics

performance, venture capital received and invested, high tech manufacturing and Git Hub commits. Countries that rank top in 2024 as innovation leaders are Switzerland, Sweden, United States, Singapore, and Republic of Korea. The qualification for these top ranks includes leading in knowledge, technology and creative outputs, infrastructural innovations, business sophistication, human capital research, knowledge intensive employment, low carbon-energy use, quality of universities, production and export complexity, etc. However, countries such as China, India, Indonesia, and Turkiye known as Asian middle-income economies have made significant progress including Thailand and Vietnam in the top 40 while Morocco has joined the top 70 in the world. A few sub-Saharan countries have made inroads: Mauritius (55th), Cape Verde (90th), Kenya (96th), Burundi (127th), Madagascar (110th (WIPO, 2024). Nigeria received no mention, sadly.

The WIPO data also indicate that innovation overperformers include India, Moldovia, Vietnam, while Indonesia, Pakistan, and Uzbekistan retained their positions as overperformers for three years running. African countries in this group include Rwanda, Madagascar, Senegal, South Africa, Morocco, Burundi, while the BRICS countries in this category are India, South Africa, and Brazil. Also, some countries referred to as efficiency champions are adept at tuning innovation investments into tangible innovation outputs. The middle-income economies in this category include China, Turkiye and Bulgaria surpassing the outputs of some high-income countries.

Considering innovation performances by world regions, in North America, the USA is the world leader. Europe hosts 15 out of the top 25 innovation leaders while seven are among the top 10. In South East Asia, East Asia, and Oceania, seven countries: Singapore, South Korea, China, Japan, Hong Kong, Australia, and now Zealand are world innovation leaders. In Central and Southern Asia, India, Kazakhstan, Sri Lanka, Kyrgyzstan, and Tajkistan, rank between 78th and 107th except India at 39th position as world innovation leaders. In Northern Africa and Western Asia, the leaders are Israel (15th), Turkiye (37th), Saudi Arabia (47th), Qatar (49th) and Morocco (66th). The innovation leaders in Latin America and the Caribbean are Brazil (50th), Chile (51st), Mexico (56th), Columbia (61st) Uruguay (62nd), Costa Rica (70th) etc. In Sub-Saharan Africa, Mauritius (55th), South Africa (69th), Botswana (87th), Calso Verde (90th), Senegal (92nd), and Kenya (96th) are innovation leaders (WIPO) (2024)

Unfortunately, Nigeria ranks 113th in the world of innovation. This points to a number of things: the quality of STEM/STI education, the funding of STI, the quantity and quality of scientific production, the development of talent, investment in research and development, ease of doing business as well as policy enunciation, implementation and translating knowledge into tangible outputs. This being the case, it calls for introspection about the state of science communication and the task before science communication to raise both awareness about the problem and take strategic steps to solutions.

Without doubt, science, technology and innovation are drivers of transformational change and one of the challenges include communicating the benefits and risks of STI to achieve extensive understanding and informed choice (Parker, *et al.*, 2014). In Global North countries such as the United Kingdom, the communication of the UK Science and Technology framework 2024 is taken seriously. It uses a systems approach involves the public sector, civil society, academia, industry and private sector, and international partners working with the general public to make science and technology the centre of citizens' lives. The framework involves identifying critical technologies, investment in research and development, developing talents and skills, financing innovative science and technology companies, creating access to physical and

digital infrastructures, paying attention to regulations and standards, building innovative public sector among others. At the centre of every successful STI framework is clear, credible, consistent communication; building a sense of shared goals, promotion of strengths, increasing the reach to different audiences and partners and improving the uptake of STEM subjects, technical education and advanced digital skills campaign. (Gov.uk, 2024).

A strong STI capability is necessary for national economic growth. This has found affirmation in Long (2019) who sees innovation as the fundamental driving force for long-term sustainable development of an economy. Therefore, there is a potent argument to use STI as a strategic support to boost social productivity and comprehensive national power by positioning it as the pivot of holistic development. Beyond the economy, STI ensures national security and social stability, promotes the smooth transition to an information society, improves the quality of life, and creates a new culture appropriate for a new society. Moreover, STI promotes energy conservation, sustainable waste management, ensures food security, efficient urbanisation, and responsible industrialisation (CGPSC Prelims, 2024).

Seeing how important STI is the course of development in the world and the centrality of research and development for growth – boosting sustainable innovation system especially for Global South Countries and BRICS nations, relevant lessons are apparent for Nigeria. Pertinent suggestions by Sarpong, Boakye, Ofosu, and Botchie (2023) include:

(a) nurturing entrepreneurial scientists by providing entrepreneurial training, training environmentally concerned scientific cadres, commercialising innovation ideas, incorporating economic value into basic research, and promoting university-industry collaboration;
(b) integrating scientific knowledge with innovation targets by matching research output with industry needs; initiating demonstration projects for innovation concepts, developing eco-innovations with ubiquitous use and measuring research impact on growth and sustainability;
(c) catalysing experimental research through a focus on sustainability-oriented research providing research laboratories, materials, and resources investing in rare talents; and adoption of modern technology for research.

Science Communication and Nigeria's Development Trajectory

Nigeria is the second largest economy in Africa in terms of Gross Domestic Product. With a 46% poverty rate in 2023, Nigeria's 104 million people out of 226 million are the second largest poverty-stricken country in the world after India. (US Department of State, 2024) The major obstacles to Nigeria's development include corruption being ranked by Transparency International as 150th out of 175 countries in 2022; a protectionist trade regime, an abysmally poor power sector, insecurity caused mainly by political volatility, armed banditry, terrorism, insurgency, separatist agitations, other crimes, and skyrocketing inflation (US Department of State, 2024).

The above reflects how Nigeria is seen externally. Also, to the Food and Agricultural Organisation, Nigeria's cumulative agricultural imports stood at ₦3.135 trillion, quadrupling its ₦803 billion exports for 2016 to 2019. It cultivates 70.8 million hectares, animal production is underexploited and is the largest fish consumer in Africa and among the largest in the world (FAO, 2024). Nigeria's population as at November 5, 2024 stood at 234,612,072 about 2.85% of the world's population. This places the country at the 6th position and has a land mass of 910,770 $km^{2.}$ The life expectancy at birth in Nigeria is 55 years. The infant mortality rate is 69 per 1,000 live births while

103 deaths are likely to occur per 1,000 live births at under age five (Worldometer, 2024). As at the second quarter of 2024, Nigeria's size of the economy, measured by Gross Domestic Product stood at ₦20.12 trillion with crop production contributing 27%, trade 15%, telecommunications 14%, crude petroleum 6%, and real estate 5% (BBC.com., 2024).

Indeed, battling the odds succinctly describes science communication in Nigeria. In its contribution to the first attempt to document the emergence of science communication in the world, the book *Communicating science: A global perspective* recorded developments in 39 countries and the Nigerian chapter by Falade, Batta and Onifade (2020) noted that agricultural extension which began as early as 1910 was the precursor to science communication. The book chapter documented developments in health campaigns, drug trials, vaccination, emerging diseases such Ebola, and the national health campaigns overpopulation, against malaria, HIV/AIDS and environmental degradation through oil spills and other pollutants as significant aspects of early science communication in Nigeria. Other important issues include public engagement with science through print and broadcast media as well as policy framework for STI in Nigeria noting deficits in implementation, the dismal state of science popularisation through museums, parks and science centres and the nascent nature of science communication as a distinct disciplinary concern in the universities and the nation (Falade, Batta, & Onifade, 2020).

Other science communication researches in Nigeria reveal that there is a near zero coverage of emerging science, technology and innovation in four national dailies in Nigeria (Batta, Ekeanyanwu, Obot & Nda, (2022); there is a paucity of qualified science correspondents and special science desks in major broadcast networks in Nigeria (Obot, Batta, Nda, & Ekeanyanwu (2022), there is an appreciable interest and awareness of science communication among academics in Nigeria but participation and involvement were low (Batta, Ali, Ekeanyanwu, & Obot (2021); and there was a positive perception of science communication among communication educators in Nigeria but commitment to the discipline at personal level was dismal.

Further research findings on science communication in Nigeria also show a perceived poor (fragile) science communication culture among Nigerian communication scholars (Batta & Iwok, 2019), the social media seemed in Nigeria to escalate misinformation, fake news, and conspiracy theories about health, yet they also possessed the capacity to curb these dysfunctions because of their inherent characteristics and informational support mechanisms (Ali, Batta & Ogaraku (2021). Similarly, studies on Nigerian science communication indicate that as widespread as African traditional medicine use was in Nigeria, its coverage in four major Nigerian newspapers was negligible (Batta, 2013); nano-science and nanotechnology content in the Nigerian press was equally, nearly non-existent (Batta, Ashong & Obot, 2014) although African traditional medicine practice was making in-roads with the Internet/digital media in Nigeria (Bashir & Batta, 2022).

Also, earlier researches in Nigeria indicated that science coverage in three Nigerian newspapers showed a preference for biomedicine, routine reportage and foreign sourced reports (Batta, Ekanem & Udousoro, 2024), that climate change coverage in select Nigerian newspapers reflected framing bias (Batta, Ashong & Bashir, 2013), that environmental discourses on energy utilisation in some Nigerian newspapers depicted a lopsided coverage (Batta, Ashong & Udousoro, 2015) and that the mass media in conjunction with other critical stakeholders needed to play concerted roles in promoting biodiversity, biotechnology, biosafety, and food security for the sustainable development of Nigeria (Batta & Wilson, 2008). These research outcomes

present sufficient rationale for making suggestions about science communication in Nigeria related to the discipline and practice of science communication and implications for development.

What has been reviewed so far on the status of science, technology, and innovation as well as science communication in Global North countries, Global South States especially the five BRICS nations portend a few significant lessons for Nigeria. It is apparent that science communication can be utilised in Nigeria to attract foreign investment, boost innovation and drive economic growth if used effectively and if key stakeholders are committed to investing in science communication infrastructures at national, regional and local levels (Davies, 2020).

Secondly, considering the precarious state of healthcare in Nigeria and the pivotality of health to national development, science communication can be deployed to improve healthcare through the enhancement of public understanding of health issues. These include maternal and child health, public health, mental health, reproductive health, environmental health, and occupational/recreational health promotion, etc. This can make significant impact on the promotion of health, treatment of diseases, and prevention of epidemics, pandemics, emerging diseases, etc. (Riera, Latorroca, Padovez, 2023; Naughton, Kuswara, Burgess, *et al*., 2024).

Thirdly, science communication if developed to an appreciable level can foster the right atmosphere for technological advancement especially in areas such as biotechnology, artificial intelligence, synthetic biology, information technology, nanoscience and nanotechnology, etc. This can be done through the facilitation of technology transfer, adoption and innovation (Davis, 2022).

Fourthly, science communication can, since we live in culturally diverse world, deepen our cultural foundations. It can enrich the Nigerian culture by promoting indigenous foods, dress, agriculture, science, environmental and technological culture, preserve them and institutionalise the Nigerian national identity (Medin & Bang, 2014; Scrimshaw, 2019).

According to Ullah (2020), Science and Technology culture is important for socioeconomic growth of the country and needs to be supported by stakeholders. The media influence people's opinion significantly regarding the promotion of science and technology. They create an intellectual environment in the society; foster academic and logical temperament in the public and in their absence, unseriousness, confusion, uncertainty, frustration and disappointment resulting in sensationalism, propaganda, and political sloganeering; evaluate viewpoints, detect deficits and point to progress and prosperity by utilising science and technology; and promote national identity and cohesion to integrate the citizenry to engender progress and development.

The media help to harness factors relevant for national development in terms of cultural, social, technological, geopolitical and economic spheres. The impact areas of media advocacy include governance, economic impact, social impact, and innovation. To promote environment conducive to STI development, TV, radio, print, online, and social media, documentaries, advocacies using conferences, seminars, summits should be used in collaboration with the industry. Public-funded STI projects must have communication funds for promotion on social, digital, and print media spaces and primetime. Government agencies dealing with STI function, projects, and programmes should have communication units to help popularise STI. Regular training of communication personnel is important for success. Science communication programmes and degrees are necessary for communicators and the training of scientists in science communication critical for impact. Communication for the advancement of STI in nation states act as: (a) articulators of national identity, promoting campaign for

the various disciplines of STI in the form of scholarly debates, discussions, and analyses as re-enforcers of recognised national priorities; (b) instigators of national pride and cohesion in STI by representing divergent stakeholders and promoting motivation and zeal for the propagation and stimulation of STI; (c) storehouses for useful content on STI development by giving recommendations to sectoral areas such as agriculture, climate change, ICT, health, sustainable energy, industrialisation, natural resource management, etc.; (d) unwavering tools for national development using policies, and propaganda for STI; (e) avenues for little known and minority experts, scholars, researchers, scientists to make notable contributions to STI development.

To be able to perform the roles delineated above, science communication in Nigeria must position itself to do three relevant things namely; enhance scientific literacy by instigating critical thinking, public engagement in STI, promoting citizen science, entrenching the culture of media science, promoting STEM and STI education in and out of school, facilitating partnerships, cooperation, and collaboration involving people, communities, governments, academic, industry, etc. The next step is that of bridging the knowledge gap in the Nigerian society, by lessening the disparity in access to STI information and knowledge at home, in the workplace, in schools, in government, and in society. The third step is to ensure that policies, decisions, laws, and regulations are informed by scientific research, technological impact assessment and similar considerations.

Concluding Remarks and Recommendations

The conclusion that is drawn from this discourse is that science communication has made remarkable progress in the Global North and less so in the Global South although BRICS nations perform averagely as this review has indicated. With Nigeria's recent admission as a BRICS partner country, it needs to draw useful lessons from both blocs in the nurturing and deployment of science, technology, and innovation for socioeconomic development. Nigeria faces a lot of challenges and has quite a lot to do if it must retrace its steps and work towards placing itself where it ought to belong in the comity of States. Regarding how science communication can help Nigeria resolve its development deficits, the country can commit to a number of solutions:

(a) there is an urgent need to invest properly in science communication infrastructures by developing institutions, establishing programmes, constituting funding mechanisms for science communication;

(b) investment in capacity building of science communicators is critical to success. Nigeria needs to take the training and education of scientists, communicators, journalists, science scholars in science communication seriously in schools, at workplaces, in the community to promote public understanding of science;

(c) to account for the multilingual, multicultural diversity of Nigeria, there is the dire need to contextualise science communication by fashioning it to local cultures, languages, and socio-political circumstances. This can be done through language translation and interpretation, use of multilingual websites/social media accessibility, utilising culturally relevant examples, inclusive imagery, respect for traditional knowledge, visual and audio content, and community outreach. Others are, public events and exhibitions, collaboration with stakeholders, capacity building for communicators, leaders, development of materials, and monitoring/evaluation;

(d) no nation works in isolation, Nigeria needs to foster national, regional, and global partnerships, cooperation, and collaboration through soft power/cultural diplomacy with institutions, organisations, industries, academia, governments

to enhance expertise, harness resources, and mine the best practices in science communication;

(e) lessons and inspirations should be drawn from Global North countries, Global South countries, and BRICS nations such as Brazil, Russia, India, China, and South Africa to develop veritable science communication strategies for effectiveness;

(f) Nigeria has a fertile ground in digital penetration. Though digital inequality is not bridged, accessibility can be expanded and digital platforms such as social media and other online fora leveraged to promote STI, deepen public engagement, and generally improve science communication in the country;

(g) by nature, science communication is interdisciplinary, transdisciplinary, and multidisciplinary. This provides ample opportunity to liaise with academics, communicators, scientists, humanists, social workers, the industry, communities, governments and policy makers to engender development based on STI;

(h) particularly in the area of traditional medicine, agricultural, and environmental/ecosystems management, Nigeria should blend useful areas of indigenous knowledge and Western ideas for beneficial effects using science communication;

(i) it is necessary to develop broad-based science communication curricula for educational institutions from primary to tertiary levels considering the cruciality of STI for development. Communicators must be taught to communicate science; scientists must be taught to do the same. Lay people must have access to STI knowledge in order to democratise and decolonise STI;

(j) media science i.e. science journalism on radio, television, new media, newspapers, and magazines as well as video, film, and cinema should be taken seriously to widen the spread of STI through extensive coverage, training, funding, transaction, interpretation, and contextualisation;

(k) science centres, science cafes, museums, festivals, weeks, carnivals, lectures, workshops, and other public events should become more widespread in Nigeria to make STI more common and available to everyone. Policymaking, legislation, funding, implementation and evaluation should support these.

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