Communicating Emerging Science, Technology and Innovation for National Development in a Fragile Polity: Views of Four Scientists

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Abstract
Most countries of the world have since moved beyond ordinary science and technologies to emerging science and technologies and innovations, Nigerian is still grappling with the implementation of its Science, Technology and Innovation Policy of 2011. This article explores the various opportunities in science and technology for Nigeria's national development in a volatile political climate. In-depth interviews were conducted on four experts (two each) in Fisheries and Aquaculture and Information Communication Technologies (ICTs) from the Universities of Calabar, Uyo and Akwa Ibom State University, to investigate the potentials of emerging science and technology for national development in Nigeria. The findings reveal that a lot of factors have impeded the successful adoption and application of emerging science, technology and innovation in Nigeria. Such factors include: lack/poor budgetary provisions for research, dearth of infrastructure to support research endeavours, inadequate curriculum that emphasises fields of study out of tandem with the current challenges and needs of the world which have led to knowledge deficit of the Nigerian youths in the various fields of emerging science, technology and innovation. Based on these, it is recommended that government and non-governmental organisations make adequate provisions in funding to encourage research in emerging science and technology; appropriate infrastructure should be provided to aid research endeavours in emerging science and technologies; review of the Nigerian education curriculum as well as media education to meet current realities as well as prepare journalists for emerging science and technology reportage.

Keywords: Development Communication, Science/Technology/Society, In-Depth Interviews, Development Media Theory, Nigeria.

Introduction

Developments in science and technology are fundamentally altering the way people live, connect, communicate and transact, with profound effects on development. The history of the world has been dominated by innovations in science and technology. So much so that science and technology are now two common phenomenon in our daily lives that are almost taken for granted. The everyday routine of humans is science and technology underpinned.

According to the United Nations International Telecommunications Union (UN-ITU), by the end of 2010 there were an estimated 5.3 billion mobile cellular subscriptions worldwide, including 940 million subscriptions to 3g services. About 90 percent of the world's population can access mobile networks, with three-quarters of mobile subscribers living in developing economies. Cellular technology has allowed Africa to leapfrog the age of fixed line telephony, bringing affordable access to millions of people (Chetty, 2012). However, there is a game changer and we cannot deny it, that science and technology have revolutionised the world. What is more on the agenda for discourse now is the subject of emerging science and technologies – science and technologies that are coming from entirely new sectors. This is because the world is gradually moving from basic science and technologies to the emerging sciences and technologies – highly refined, advanced and sophisticated variants
Thus (Chetty, 2012) writes: "the technological revolutions of the 21st Century are emerging from entirely new sectors, based on micro-processors, tele-communications, bio-technology and nano-technology. Products are transforming business practices across the economy, as well as the lives of all who have access to their effects" (p. 1). They are increasingly based on miniaturisation, digitisation, and robotisation (artificial intelligence). Hence, the focus of this article; how to deploy communication on emerging science and technologies in aid of Nigeria's

national development. This is in view of the fact that communication has a critical role to play in facilitating the public understanding of science and technology. Communicators typically assume the position of "intermediaries" between the scientist and members of the public who are interested in a given scientific subject or issue (Lugalambi *et al*, 2011).

Statement of the Problem

The potentials of knowledge for development purposes cannot be over-stressed (Akpan and Nnaane 2011). Communication which in its simplest sense is the sharing of knowledge has played a significant role to aid development. In fact, communication and development are interwoven. Communication process includes all acts of transmitting messages to channels which link people to the language and symbolic codes which are used to transmit messages; it includes the means by which messages are received and stored as the rules, customs, beliefs and conventions, which define and regulate human relationship and events (Asemah 2011). Communication then, is a key component of development.

Development in human society is understood in various perspectives and contexts as Rodney (2009) succinctly puts it: development in human society is a many-sided process. At the level of the individual, it implies increased skill and capacity, greater freedom, creativity, self-discipline, responsibility, and material well-being. In addition, there have been a lot of advancements and innovations in science and technologies in the last decade. There is virtually no area of human endeavour that has not recorded significant improvements and innovations in the sector: medicine and surgery, agriculture, security and defence, astronomy, biotechnology. Emerging science, technologies and innovations are further snacks of human development.

Emerging science, technologies and innovations have reshaped the world around us. It has led to revolutionary breakthroughs in field ranging from manufacturing to healthcare. Emerging science is cross disciplinary, meaning that scientists from a range of fields including chemistry, physics, biology, medicine, computing, material science and engineering are studying and using them to better understand our world. With adequate investments in the various fields of emerging science, technologies and innovation Nigeria can benefit invaluably from these fields. These benefits spread across all of human endeavours: health, education and literacy improvement, food security, environmental safety, etc. According to Ita (2018), emerging science and technologies can provide solutions in areas of pressing concerns in developing countries like Nigeria in the areas of energy, environment, medicine, agriculture.

Regrettably, Nigeria is lagging behind other countries in this area. While other countries are enhancing developments in emerging science and technologies, Nigeria has only demonstrated interest to start the nanotechnology programme without serious practical approach to its implementation (Ita, 2018). In fact, Nigeria is still grappling with the implementation of the Nigerian Science, Technology and Innovation Policy of 2011 while other countries have moved further to harness emerging science and technologies for their national development.

Thus this paper sets out to explore opportunities available in emerging science, technologies and innovations to Nigeria for its national development.

Research Questions

This work poses the following questions:

i. What are emerging science, technologies and innovations?
ii. To what extent are emerging science and technologies being practised and put to use in Nigeria?
iii. What opportunities can Nigeria leverage on regarding emerging science, technologies and innovations To aid its national development?
iv. What are the challenges to the implementation of science, technologies and innovation policy in Nigeria?
v. And how can Nigeria overcome the issues hampering the successful implementation of the emerging science and technologies policy in Nigeria?
vi. What role can communication play in aiding the use of emerging science, technologies and innovations for national development in Nigeria?

Literature Review

The Nigerian Science, Technology and Innovations (STIs) Policy

Nigeria like other countries has developed it science, technology and innovation policy. This framework provides the needed direction to the activities that Nigeria intends to carry out if it is to attain its science, technology and innovation objectives. The current STI policy was birthed in 2011 and expressed that by 2020 its

mission and vision would be realised. The policy mission was aimed at evolving a nation that harnesses, develops, and utilises STI to build a large, strong, diversified, sustainable and competitive economy that guarantees a high standard of living and quality of life to its citizens. It also had the general policy objective of building a strong science, technology and innovation capability and capacity needed to evolve a modern economy (*Science Technology and Innovation Policy,* 2011).

Lofty as the above stated policy objective may sound and keeping in hindsight the fact that this is 2021 (the target year of the policy was 2020) and considering the achievements that have been so far recorded in the sector, it appears that the Nigerian science, technology policy has not met its goals just like other beautifully conceived policies in Nigeria. Whereas in the global North, there has been a lot of advancements and innovations in science and technologies in the last decade; there is virtually no area of human endeavour that has not recorded significant improvements and innovation in the sector: medicine and surgery, agriculture, security and defence, astrology, biotechnology. Sadly, that has not been the case with Nigeria.

Emerging Science, Technologies and Innovations

According to Dvorsky (2013), there are some emerging scientific fields that everyone should know about because these emerging scientific fields are the potential world changers. They include but not limited to the following: Neuroparasitology, Quantum Biology, Exo-meteorology, Nutrigenomics, Cliodynamics, Synthetic Biology, Recombinant Memetics, Cognitive Economics, Organic Electronics, and Quantitative Biology. Others are Nanotechnologies, Robotics and Artificial Intelligence, Drone Technology, Biotechnology, Genomics, Vibration energy harvesting, Community grids, Synthetic jet fuels, Transparent (organic) solar cells on skyscrapers, In-road inductive charging for electric vehicles, 3D printed soil for vertical agriculture, DNA dating agencies, Body hacking for sensory augmentation, Artificial muscles from spun Nano-fibre, Insect-sized surveillance robots, Hacking of implanted neuro-devices, Brain prostheses to enhance or erase memory (Dawson 2017).

In academics for instance, researchers are exploring new sectors in science and technologies leading to innovations to solve life complex issues and make the world a better place. Such research endeavours which have often led to more discoveries and innovations are also termed emerging science and technologies. What are the core focus and most importantly, the significance of these emerging scientific and technological innovations to mankind and by extension its contribution the development of society? A brief look at ten fields of emerging science, technologies and innovations is provided below:

Genomics: Developments over the past decade, arising particularly from the human genome programme, have led to a new phase of plant genetics. Plant genomics applies newly available vast amounts of genomic DNA sequence, using several, new, efficient parallel and other technologies (Gale, 2003). In general, the genome features enormous aspects of noncoding DNA sequence interspersed by small areas of coding DNA, also called genes that contain the instructions required by cells to perform their functions. Its development can help to solve complex medical problems such as cardiovascular and stroke maladies (Musunuru *et al*, 2015).

Biotechnology: This is a group of technologies that share two (common) characteristics, working with living cells and their molecules and having a wide range of practice uses that can improve lives. Biotechnology uses organisms or their products for commercial purposes. Recent developments in molecular biology have given biotechnology new meaning, new prominence, and new potential. Modern biotechnology has tremendous impact on the world economy and society (Keener, Hoban, and Balasubramanian, 2015).

Artificial Intelligence and Robotics: Artificial Intelligence (AI) is a widely used phrase for the field of science that endows machines with the ability to perform functions such as logic, reasoning, planning, learning, and perception. It could be applied to any type of living intelligence (Perez, Deligianni, Ravi and Yang, 2018). The development of artificial intelligence makes possible robotics. Robots are artificially created machines that perform human functions. They work more precisely than humans and cost less. Creative solutions such 3D printers and the self-learning ability of these productions means robots can replace human workers in critical areas (Wisskirchen *et al*, 2017).

Synthetic Biology: Synthetic biology is the design and construction of new biological parts, devices, and systems. It also involves the redesign of existing biological systems for any number of useful purposes. Craig Venter in 2008 manufactured the entire genome of a bacterium by piecing together its chemical components. In 2010, his team created, "synthetic life", DNA created digitally, and then printed and inserted into a living bacterium (Dvorsky, 2013). Engineered systems of genes and other molecular components created through synthetic biology make medical treatments more effective and promise cures for a range of health problems. The

clinical uses of synthetic biology already cover diagnostics and therapeutics. Further, these clinical applications will likely expand more rapidly over the next few years because of the easy-to-use gene editing tools now available (May, 2015).

Quantum Biology: Quantum mechanics is the basic theory that explains the properties of subatomic particles, atoms, molecules, molecular assemblies and possibly beyond. Quantum mechanics operates on the nanometre and sub-nanometre scales and is the basis of fundamental life processes such as photosynthesis, respiration, and vision. In quantum mechanics, all objects have wave-like properties, and when they interact, quantum coherence describes the correlations between the physical quantities describing such objects due to this wave-like nature (Marais *et al*, 2018)

Nutrigenomics: Nutrigenomics is the study of gene expression or metabolic pathway depending on the different food material (Banerjee, Pal, and Ray, 2015). It is the area of nutrition that uses molecular tools to search, access, and understand the several responses obtained through a certain diet applied between individuals or population groups. It explores how the components of a particular diet (bioactive compound) may affect the expression of genes, which may have increased its potential or which can be suppressed (Sales, Pelegrini, and Goersch, 2014).

Cliodynamics: Coined by the University of Connecticut's Peter Turchin. It is an interdisciplinary area of research that combines historical macrosociology, economic history (cliometrics), the mathematical modelling of long-term social processes, and the building and analysis of historical databases. The name is a portmanteau of **Clio**, the muse of history, and dynamics, the study of changes over time. Simply put, it is an effort to quantify and describe the broad social forces of history, both to study the past, and as a potential way to predict the future (Dvorsky, 2013).

Neuroparasitology: Neuroparasitology is an emerging branch of science that deals with parasites that can control the nervous system of the host. It offers the possibility of discovering how one species (the parasite) modifies a particular neural network, and thus particular behaviours, of another species (the host). Such parasite–host interactions, developed over millions of years of evolution, provide unique tools by which one can determine how neuromodulation (up-or-down) regulates specific behaviours. In some of the most fascinating manipulations, the parasite taps into the host brain neuronal circuitries to manipulate hosts cognitive functions (Libersat, Kaiser and Emanuel, 2018).

Recombinant Memetics: Memetics is a theory of cultural evolution based on the idea that behaviours, skills, habits, stories, and technologies that are copied from person to person in culture act as a second replicator. That is, they are information that is copied with variation and selection, and they therefore sustain a new evolutionary process, both cooperating and competing with the old. Like genes, memes are selfish replicators that spread for their own benefit, not necessarily for the benefit of the people who copy them, or the culture they form a part of. Unlike genes, they are a new replicator that is copied with varying degrees of success and by various more or less reliable processes, including behavioural imitation, teaching, and many new methods of copying using modern technology (Blackmore, 2010).

Computational Social Science: Similar to cliodynamics, computational social science is the rigorous investigation of social phenomenon and trends over time. The field of computational social science is an emerging field that enhances the ability to collect and analyse data with an phenomenal breadth, depth, and scale. The field is located at the intersection of the social and computational sciences, an intersection that includes analysis of web-scale observational data, virtual lab-style experiments, and computational modelling (Keuschnigg, Lovsjö, and Hedström, 2018).

Organic Electronics (Proteotronics): Normally, electronics are associated with inert and inorganic conductors and semiconductors, like copper and silicon. However, a new branch of electronics is emerging that uses conductive polymers and conductive small molecules, both of which are carbon-based. Organic electronics introduces the potential for organic solar cells, self-assembling monolayers in functional electronic devices (Dvorsky, 2013).

Quantitative Biology: This examines biological processes through the language of mathematics. To represent a living system using mathematical principles, practical quantities with units are required. Quantities are not only the bridge between mathematical descriptions and biological observations; they often stand as essential elements similar to genome information in genetics. Biology has reached a state of maturity where theoretical models of biological mechanisms can be tested experimentally. This important realisation has greatly rejuvenated research in the area of quantitative biology (Hiroi, Draviam, and Funahashi, 2016).

Communication of Emerging Science, Technology and Innovation

Emerging science and technologies coverage and reportage as an area of mass media research is still at its infancy when compared with other areas. However, scholars both locally and internationally have begun delving into the aspect and this has brought about some scholarly articles and researches in the field in the last decade. Fisk, Fitzgerald & Cokley (2014) in a longitudinal international sample of news and feature articles about nanotechnology, examined "Controversial New Sciences in the Media: Content Analysis of Global Reporting of Nanotechnology During the Last Decade". The study showed that journalists in Australia and New Zealand deployed direct sources from the laboratories to highlight scientific advancements while journalists in the US provided positive coverage across all areas. However, media practitioners in the United Kingdom offered the most critical analysis and risk reporting as far as controversial new sciences were concerned.

The study noted that these messages have also evolved overtime in each region. In addition, the paper identified positive reportage or acceptance as a common theme but without disregard for health risk across the regions under review. Furthermore, the researchers stated that nanotechnology was only now beginning to infiltrate the mainstream public consciousness through media channels. Thus, the article suggested the infiltration was taking different forms, depending on the nationality of the journalist reporting on the emerging science.

Similarly, in the United States of America, a group of researchers: Cacciatatore, Anderson, Choi, Brossard, Scheufele, Liang, Ladwing, Xenos & Dudo (2012), studied the, "Coverage of Emerging Technologies: A Comparism Between Print and the Online Media" with specific focus on the volume of coverage and thematic content between US print and Online media for emerging technologies.

The study found out that while American print news media and Google news coverage of emerging technologies has peaked and started to decline, Google Blog Search coverage of nanotechnology was still growing. Also, the study highlighted discrepancies in thematic content of online and print news coverage. Specifically, online were more likely to encounter environmentally themed content relating to emerging technologies then users of American print newspapers.

In Nigeria, Batta, Ashong and Obot (2014) using the content analysis research method explored, "Science, Nano-Science and Nano-Technology Content in Nigeria's Elite and Popular Press: Focus on Framing and Socio-Political Involvement". The study which set out to investigate the extent to which science and nano-science are framed and reported in the Nigerian press reported that there was a near absence content on emerging science issues in Nigerian newspapers while the coverage of other science issues was high.

Science Communication in an Atmosphere of Political Fragility

There is now a blurring of boundaries between science and politics in contemporary society. This is due to the interdisciplinary nature of modern science. Thus, there is an increasing orientation among some scientists toward media and public audiences to shape public attitudes or even attract funding to their research endeavours. This has resulted in hugely politicised science communication (Scheufele, 2014). Since science does not exist in a vacuum, thus, science, technology and innovations programmes are significantly impacted by the political atmosphere and happenings in any society. These conditions: political instability, economic turbulence, social tensions, cultural distortions amongst many others arguably, also significantly influence science communication in positive and negative ways. It suffices to say that the current climate for communicating science globally, is complex and replete with challenges that impede clear communication and understanding of the subject matter (Scrimshaw, 2019; Smith and Merkle, 2020).

In addition, cultural orientations play a big part in science communication as well (Medina and Bang, 2014). Members of society exhibit sensitivity and reservations fuelled by the cultural dispositions inherent in a community. This sensitivity and growing public concern over the impacts of science on society has meant that the advice of scientists is increasingly seen as only one among a number of inputs into the policy making process of any government or society. The voices of other stakeholders, which can range from environmental groups to religious organisations expressed either directly or through the mass media, have come to play an equally important role in shaping the judgment of politicians and government decision makers (Dickson, 2004). This arguably might explain the laissez-faire attitude of governments globally and the lack of political will by those in positions of authority to support, initiate and execute science, technology and innovation policies, much more in the areas of new sciences.

The decision to communicate science always involves an ethical component: choices about what scientific evidence to communicate and when, how, and to whom are a reflection of values. This fact becomes especially salient when the science pertains to an individual decision or policy choice that is contentious (NCBI, 2017). This is because the lack of scientific literacy among nonexpert publics and their limited frameworks for processing

new scientific information are of particular concern, given the scientific and policy uncertainties surrounding many areas of science, technology, innovations and even emerging science (Scheufele, 2013). This greatly affects the practice of science communication as it leaves most science, technology and innovative topics in obscurity.

Nigeria provides the irrefutable evidence of a country plagued by political misdirection, economic turbulence, social tensions, and cultural drawbacks among others. These road bumps on the science, technology and innovation highways of Nigeria have in no little way contributed to the disjointed approach of Nigeria to the subject matter. Successive governments in Nigeria have failed in the area of fashioning and implementing a workable science, technology and innovation policy in Nigeria. Governments in power prefer to pursue and execute science and technology projects that will only provide short term benefits for their selfish political aggrandisement at the detriment of the future generations and long-term economic prosperity of the country. As a result, Nigeria is lagging behind other countries as far as developments in science, emerging science and technologies are concerned (Ita, 2018).

Again, Nigeria's economic woes are well documented. As recent as 2020, Nigeria experienced its deepest recession in two decades. Recall that that Nigeria was highly vulnerable to the global economic disruption caused by COVID-19, particularly due to the decline in oil prices. Nigeria's economic outlook remains highly uncertain (World Bank, 2021). These unfavourable economic conditions have always been cited as one of the reasons for the gross underfunding that science, technology and innovation initiatives in Nigeria. Underfunding of the sector equally mean under communication to the public members of society are left bereft of the necessary knowledge of science, technology and innovations. Communication is an essential ingredient of science communication because communicators typically assume the position of intermediaries between the scientist and members of the public who are interested in a given scientific subject or issue (Lugalambi *et al*, 2011).

Theoretical Framework

This study draws its strength from the development media theory. The theory formulated by McQuail in 1987 and often seen as a combination of the libertarian and social responsibility theories is anchored on communication for development which is the focus of this study – how to communicate emerging science, technology and technology for national development despite Nigeria's fragile polity. The fundamental tenets of the theory include that the: media should accept and carry out positive development task in line with nationally established policy; freedom of the press should be opened to restriction according to economic priorities and development needs of society.

In summary, the theory assumes that the media should be used in the interest of the overall development of the society. It should focus on the collective interest of the society and not the selfish interest of few individuals. It proposes that government can intervene and foster development through the use of communication programmes and policies (Johnson and Johnson, 2013). The theory envisages the positive utilisation of the media in national development for the autonomy and cultural identity of a particular nation (Asemah, 2011). This means, the Nigerian media are expected to obtain knowledge of emerging science, technology and innovation and communicate the same to Nigerians to aid national development.

Research Methodology

This study adopted the qualitative research method with the in-depth interview used as the instrument for data gathering. The aim of qualitative research is to understand, explain, explore, discover and clarify situations, feelings, perceptions, attitudes, values, beliefs and experiences of respondents. It entails the selection of people from whom the information, through an open frame of enquiry, is explored and gathered. The parameters of the scope of a study, and information gathering methods and processes, are often flexible and evolving (Kumar, 2011). The semi-structured, interview questions were five and bordered on the Nigerian Science, Technology Policy of 2011, level of implementation of the policy, challenges and drawbacks of the policy, areas of emerging science, technologies and innovations as they relate to and affect food sufficiency and Information Communication Technologies and the opportunities Nigeria can leverage to push its long sought after national development.

Accordingly, four experts whose fields of studies and occupations centre on some areas of emerging science and technologies were interviewed. Using the purposive research technique, these experts selected, spread across the federal universities of Calabar and Uyo as well as Akwa Ibom State University. In the area of food sufficiency, two aquaculture and fisheries scientists were interviewed. The other two were ICTs experts, one currently the director of ICTs in the university. Part of what qualified them for selection and interview was the number of years

they have spent on their jobs and the relevance of their fields of studies to Nigeria's national development. This is very much in tune with purposive sampling techniques which the researcher uses their own judgement to choose respondents and select those who best meet the purpose of the study (Asemah *et al*, 2012).
The interviews lasted over 30 minutes in their conducive offices. It was recorded, transcribed and used this study. Thus, to ease identification of the respondents in the next section, the respondents are identified with letters A, B, C, and D in the following order:
Respondent A – Associate Professor of Fish Biology and Ecology, Department of Fisheries and Aquaculture, Faculty of Agriculture, University of Uyo.
Respondent B – Lecturer I, Department of Fisheries and Aquaculture, Faculty of Agriculture, Akwa Ibom State.
Respondent C – ICTs practitioner and software developer. Director of ICTs Akwa Ibom State University.
Respondent D – ICTs practitioner and member of Staff of the University of Calabar (ICTs Unit) with postgraduate qualification.

Results/Findings
In line with the objectives and research questions of the study, the results and findings of the study are discussed below:

i. **What are emerging science, technologies and innovations?**

According to Dvorsky (2013), there are some emerging scientific fields that everyone should know about because these emerging scientific fields are the potential world changers. They include but not limited to the following: Neuroparasitology, Quantum Biology, Exo-meteorology, Nutrigenomics, Cliodynamics, Synthetic Biology, Recombinant Memetics, Computational Social Science, Cognitive Economics, Organic Electronics and Quantitative Biology. Others are Nanotechnologies, Robotics and Artificial Intelligence, Drone Technology, Biotechnology, Genomics. Emerging science and technologies are innovations and new discoveries in all scientific fields that aim at improving the way things were originally done. These scientific innovations have been made possible due to the availability, application, and advancement in all scientific and technological fields such as the ones mentioned above. They have sprung out of already existing science and technologies in the recent years due to research, and they at improving and adding quality to life as well as offering solutions to once intractable problems of society and mankind.

All these fields of emerging and technologies can in one way or the other contribute significantly to human and societal development. According to Joshi (2019), over the past few years, drones technologies for instance, have become central to the functions of various businesses and governmental organisations and have managed to pierce through areas where certain industries were either stagnant or lagging behind. From quick deliveries at rush hour to scanning an unreachable military base, drones are proving to be extremely beneficial in places where man cannot reach or is unable to perform in a timely and efficient manner. Increasing work efficiency and productivity, decreasing workload and production costs, improving accuracy, refining service and customer relations, and resolving security issues on a vast scale are a few of the top uses drones offer globally.
All of the above and many more constitute what is known as emerging science, technologies and innovations and their uses, impact and significance are crucial to national development in any society.

ii. **To what extent are emerging science and technologies being practised and put to use in Nigeria?**

To all the respondents, this was problematic. Nonetheless, in their opinion, they expressed that Nigeria currently cannot boast of significant, documented evidence of visible development in emerging science, technologies and innovations. Siyanbola *et al* (2016) affirms this, "in many developing countries, there is a gap between policy and development priorities. Most policies are not based on scientific facts either because they are unavailable or where they exist, unreliable". Furthermore, Nigeria as a developing mentioned above has only demonstrated interest to start the emerging science and technology programmes without serious practical approach to its implementation (Ita, 2018).

Respondent C was more specific where he stated that Nigeria was still grappling with implementing its *Science, Technology and Innovations Policy of 2011*. He believes unfortunately that even if Nigeria successfully implements it, it might be putting itself in an unenviable position of achieving what other countries are phasing out. Ita (2018) states that Nigeria is lagging behind other countries in this area while other countries are enhancing developments in emerging science and technologies. In terms of digital competitiveness Nigeria is seriously lagging behind (Ovakporie, 2020). Similarly, *The Vanguard* (2021) reported that tech stakeholders have decried the pace of growth in Nigeria's tech ecosystem saying the country is still lagging behind technologically.

This was during a one-day programme on technology development organised by the federal government of Nigeria in collaboration with some non-governmental organisations.

iii. **What are the opportunities that Nigeria can leverage on with regard to emerging science, technologies and innovations to aid its national development?**

Respondents A and B as agricultural experts (Fisheries) were food security/sufficiency biased. They were of the views that in order for Nigeria to successfully leverage on the vast opportunities as abound in emerging science and technologies it needs to have a planned programme. Nigeria can exploit the window of opportunities offered by emerging science and technologies with a brood stock management programme.

This is different from capture fishes where the fishermen go the seas to capture fishes. This will help Nigeria achieve food sufficiency in the area of aquatic resources. In simple terms, this means the continuous availability of protein content in Nigerian meals which will lead to a healthy population which will translate to a quality workforce and manpower for Nigeria's national development.

For Respondents C and D, emerging science and technologies like robotics and artificial intelligence if probably invested in, harnessed, and exploited greatly help Nigeria address some of the fundamental issues such as insecurity and unemployment that have bedevilled Nigeria for a long time. The evolving digital economy is closely associated with several technologies frontiers and fuelled by data such as Blockchain, data analytics, Artificial intelligence, 3D printing, Internet of Things, Automation and Robotics, and cloud computing. There is an emerging new renaissance in the world of information technology, Nigeria stands to benefit greatly, but only if adequate steps are taken early enough (Ovakporie, 2020). This is unparalleled because science and technology capabilities are fundamental for social and economic progress in developing countries much more so emerging science, technology and innovation (National Research Council, 2006). Ita (2018) adds that emerging science and technologies can provide solutions in areas of pressing concerns in developing countries like Nigeria in the areas of energy, environment, medicine, agriculture.

iv. **What are the challenges and stumbling blocks to the emerging science, technologies and innovation policy/implementation in Nigeria?**

For Respondents A and B, maybe due to their professional and occupational experience, they were unanimous and equivocal that the paramount challenge is lack of adequate funds to support and encourage research endeavours in the various fields of emerging sciences, technologies and innovations. According to them, the great concern in Nigeria's quest for national development vis-à-vis leveraging on the vast opportunities in emerging science and technologies is always the problem of allocation of adequate budget for science. This posses a foundational problem thus making scientists (emerging scientists too) battling hard because facilities are depreciating or in some cases not existent. "We want to collaborate (with other scientist all over the world) but we are hampered. Again we need sponsorship. We need funding foundations. Scientists cannot do it without adequate financial support" (Respondent B).

For Respondents C and D the challenges are varied and should be discussed specifically to each field of emerging science and technologies. However, the common denominator in their experience in the field of ICTs is the obvious lack of knowledge of the citizenry about the emerging fields of science and technologies. This obvious lack of sufficient knowledge on emerging technologies accounts for the lack of interest on the part of the population resulting in poor attitudes of Nigerians towards these emerging sciences and technologies. There are many explanations to this lack of interest of Nigerians. The common one according to them is the Nigerian education system which they decried is training students on irrelevant fields that are not in tandem with current societal trends and needs. Thus, the Nigerian education system must improve its role in the quality of graduates its churns out to the labour market.

The technological advancement of the country has been hindered by lack of an effective system of gathering scientific evidence that can be integrated into science, technology and innovation policy process (Siyanbola *et al*, 2016). According to Oyewale, Adebowale, and Siyanbola, (2017) implementation of the policy is commonly plagued with the absence of emerging science, technology and innovation physical infrastructures, capital goods producers, and policy-implementing institutions or agencies, the non-integration of science and technology policy with other cognate policies, and fairly frequent policy somersaults.

Furthermore, the standard of Nigeria's educational system is a very big challenge. The Nigerian educational system has worsened to a point where students cannot learn the requisite skills needed by them to become employable or innovative in an ever-changing world, upon graduation. Higher institutions in Nigeria are troubled with not enough science and technology facilities and materials for practical skills growth. Most laboratories lack the basic equipment for meticulous scientific research. Nigeria is producing thousands of science and technology

graduates each year, but majority of them are underemployed (Igbinovia and Krupka, 2019).

v. **How can Nigeria overcome such issues bedevilling the successful implementation of the emerging science and technologies policy in Nigeria?**

Respondents A and B believe that government has the greatest part to play. In addition, non-governmental organisations, multinational corporations and all stakeholders must play a significant role in providing funding to encourage emerging science, technology and innovation education and research.

For Respondent C, government will have to reorder its priorities and investments in education. A situation where you look at the budgetary allocation for education and you see something very dismal allotted to education leaves much to be desired. The world is in the era where knowledge is key. The era of countries depending on their natural resources is gone. Countries of the world are now exporting knowledge. And Nigeria should not be left out.

Respondent D believes that the development gap is so wide for us to catch up with the rest of the world. So, if anything positive is to happen in terms of Nigeria benefiting from these emerging science and technologies, it is for the government to invest adequately in education. Also, there has got to be a revision of the school curriculum to synchronise and align with current realities. This is because there are academic courses that are described as courses of the future. Other countries are churning out graduates in fields that will position them to take charge of the world in the fields of emerging science and technologies in the near future. Nigeria should follow suit.

In this regard, Ovakporie (2020) states that the widening digital divides threaten to leave developing countries, and especially least developed countries, even further behind. However, a smart embrace of new technologies, enhanced partnerships and greater intellectual leadership are needed to redefine digital development strategies and the future contours of globalisation. This is necessary because in formulating science, technology and innovation policies, scientific indicators play a fundamental role of providing evidences for formulating national innovation strategies. The absence of relevant indicators is often a major obstacle for the design and implementation of science, technology and innovation policies in developing countries (NPCA, 2014). In the same vein, policies for science and technology in human resources development should aim at providing science education at the basic secondary and tertiary level, so as to prepare young people enter a diverse labour force that requires various levels of science and technology sophistication and encourage the conduct of research and advanced training (Anaeto et al 2016).

vi. What role can the mass media play to ensure that the challenges and solution prescribed above are achieved to facilitate Nigeria's national development?

For the all the respondents, the answer was in unison that the mass media can deploy all their agenda-setting functions to ensuring that citizens are informed, educated and to draw attention of the government and the those concerned to the challenges mentioned above.

The mass media can play the role of linking the science, technology and innovation community with the policy makers by giving sufficient airtime and space to emerging science issues; reporting such issues objectively and working in collaboration with those in the field so that they can always cross-check their facts before reporting the same in the mass media for the public consumption.

Several studies have backed up the claim above that there is paucity of science issues in mainstream journalism all over the world. The Nigerian mass media are not exempted. Mochahari (2013) notes that lack of interest among the mainstream media on issues related to science and technology stems from the fact that science including emerging science and technologies writing requires proper training and skills in science and other related scientific matters. It is a lengthy, of course a laborious process that the communicator has to first understand the subject, simplify the scientific terms in non-scientific language and then communicate it in everyday language. There is a necessity for appropriate training of science writers. The mainstream media coverage on issues related to science and technology is alarmingly poor and limited.

Despite witnessing a phenomenal growth in mass communication and journalism in the past three decades, the growth trajectory of science communication is very much limited and does not look promising for emerging science, technologies and innovations. Science writing is mostly concentrated among the scientific community and academic institutions, and shackled by complacency and over dependence on foreign sources (Patairiya, 2002). Sadly, this might continue for a few more years to come unless something drastically happens in the Nigerian education system and the mass media curriculum in relation to journalism training and orientation about emerging science communication.

Conclusion

Emerging science, technologies and innovations have come to stay. These new scientific and technological fields have come with and are posing a lot of challenges to society. However, their potentials for solving human problems cannot be denied. Regrettably, emerging science and technologies benefits are still far-fetched in Nigerian society. Nigeria as country is still grappling with the implementation of the 2011 policy on Science, Technology and Innovation. This means that Nigeria has a lot of catching up to do if it intends to leverage on the vast potentials of emerging science, technology and innovations and add value to its citizens. As far back as 2003, the United Kingdom government had commissioned the Royal Society and the Academy of Engineering to carry out independent study in current and future developments in emerging science, technologies and their impact on society (*The Royal Society and the Royal Academy of Engineering, 2004*). However, Nigeria is yet to have a distinct policy on emerging science, technologies and innovations.

The experts interviewed from a few fields of science, technologies and innovations in Nigeria identified the major factors militating against the successful development of emerging science, technologies and innovations in Nigeria. The problems they highlighted included: lack of budgetary provisions from the government to support and encourage research endeavours in the sciences before mention is then made of the emerging sciences, technologies and innovations. This they identified as the major roadblock on Nigeria's pathway to success in emerging science, technologies and innovations.

Second, the experts decried the poor Nigerian educational structure evident in its educational curriculum from the primary, to the secondary, tertiary and post-graduate levels that has resulted in producing graduates who are not adequately prepared to embrace the evolving and dynamic future in emerging science, technologies and innovations.

Recommendations

The following recommendations are made:

i The Nigerian mass media should have explicit policies and guidelines informing the coverage of emerging science, technologies and innovation. This would ensure a proactive approach in looking for and publishing stories relating to the three areas. This will also ensure that science and technology issues are given space /airtime for routine and incidental coverage. This may also mean numerous dedicated journalists are encouraged to develop interest. This will no doubt raise the profile of science and technology issues and undoubtedly encourage journalists to take it up as specialty.

ii Given the deficit in specialised knowledge of emerging science and technology issues, it is important for media organisations to invest in people with science and technology backgrounds rather than those with only journalistic knowledge and skills. This would ensure meaningful coverage of emerging science and technology issues. If this is not possible, the media should seek expert knowledge and cultivate relationships with scientists, to increase the chances for better coverage of science and technology.

iii The government should ensure that infrastructure to support scientific research in Nigeria, poor or near absence of budgetary provisions, are addressed. Going forward, adequate funding/foundation should be provided to support and encourage research endeavours in emerging science, technologies and innovations. However, the government cannot achieve this alone. Non-governmental organisations, multinational corporations within and outside the country should collaborate by providing research grants and funds to aid research endeavours. By so doing, they would have also fulfilled their corporate social responsibility to the Nigerian society and humanity at large.

iv A review of the Nigerian education curriculum to meet with the current trends and needs of the Nigerian society is more than necessary. This follows the experts' observations that Nigeria is lagging behind in channelling its education focus to solving the problems of its society. In the same vein, the Nigerian mass media industry should work closely with training institutions to introduce science communication curricula as a way of improving the understanding of emerging science and technology issues.

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