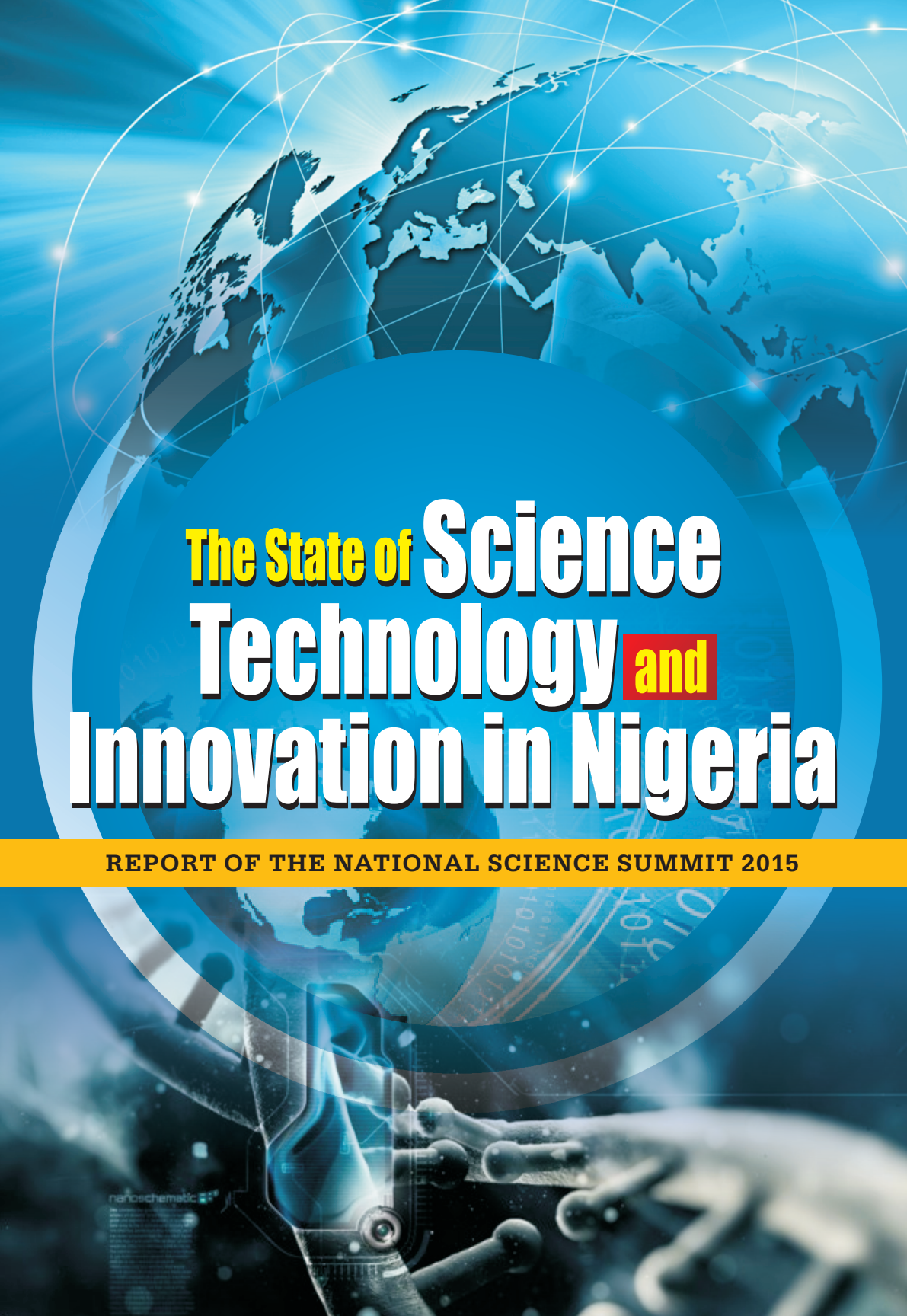

The State of Science Technology and Innovation in Nigeria

REPORT OF THE NATIONAL SCIENCE SUMMIT 2015

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REPORT OF THE NATIONAL SCIENCE SUMMIT 2015

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The Nigerian Academy of Science

The Nigerian Academy of Science (NAS) is the foremost independent scientific body in Nigeria which was established in 1977 but incorporated in 1986. NAS is uniquely positioned to bring scientific knowledge to bear on the policies and strategic direction of the country and is also dedicated to the development and advancement of Science, Technology, and Innovation (STI) in Nigeria. The aims and objectives of the Academy are to promote the growth, acquisition, and dissemination of scientific knowledge and to facilitate its use in solving major problems of national interest. The Academy strives to do this by:

- providing advice on specific problems of scientific or technological nature presented to it by the government and its agencies, as well as private organizations
- bringing to the attention of the government and its agencies problems of national interest that science and technology can help solve
- establishing and maintaining the highest standards of scientific endeavour and achievement in Nigeria, through the publication of journals, organization of conferences, seminars, workshops and symposia, recognition of outstanding contributions to science in Nigeria, and the development of a working relationship with other national and international scientific bodies and academies

As with national academies in other countries, NAS is a national not-for-profit organization with current membership comprising 169 Fellows, who have distinguished themselves in their fields both locally and internationally, elected through a highly competitive process. Some of its members have served as Vice-Chancellors of universities, Directors-General of government parastatals, and Ministers in Federal Ministries. The Academy, given its clout, also has the ability to attract other experts from around the country and internationally when needed. NAS is

Nigeria's national representative on such bodies as the International Council for Science (ICSU) - the umbrella body for all science associations and unions, and the Inter-Academy Panel (IAP) - the umbrella body for all national science academies globally. The Academy is also a member of the Executive Committees of the Inter-Academy Medical Panel (IAMP) and the Network of African Science Academies (NASAC).

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The Academy acknowledges the contributions and efforts of the numerous individuals whose support made the 2015 National Science Summit possible, enlivened the Summit's deliberations and enhanced the quality of this report.

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Executive Summary

Scientists, representatives of national science-based associations, and relevant stakeholders in Nigerian science and technology, under the aegis of the Nigerian Academy of Science (NAS) and the Science Association of Nigeria (SAN), held a two-day National Science Summit on the 12th and 13th of May 2015 in Abuja. The objectives of the Summit were to formulate strategies for improving scientific research and innovation in Nigeria, strengthen and build the capacity of science associations in Nigeria, as well as foster collaboration among national science associations and other key stakeholders for national development.

Day one of the Summit focused on the relationship between STI and the society. The central presentation was a keynote address by Dr. Umar Bindir on the place of collaborative STI in national development. This address spotlighted the need for the establishment of linkages between the integral elements of STI; science, technology, and innovation in Nigeria's quest for meaningful national development. This is especially pertinent in Nigeria where large quantities of scientific data are generated but unfortunately lie dormant, not being transformed into the solutions and products that would yield development. Some prescribed action points to successfully network the STI elements include the promotion of indigenous technology through regular institutional exhibitions and techmarts (at the zonal, national, and international levels), the deliberate creation of a critical mass of entrepreneurial manpower, establishment of effective linkages between research and socio-economic development, as well as the effective utilization of the National Research and Innovation Fund (NRIF).
Subsequent presentations highlighted the interplay between science and other aspects of society in achieving developmental goals. These presentations covered education, media, social sciences, policy making, and industry. Speakers and participants agreed that policy implementation is a key step to ensuring national development through STI as there are well-intentioned science policies both at the national and regional levels. It was also

agreed that Nigerian scientists should re-double efforts in forming working relationships with other stakeholders. Furthermore, it was put forward that steps should be taken to expand the quality and quantity of the science content and teaching at the earlier stages of education as this would have a ripple effect on the quality and quantity of Nigerian scientists produced in the future.

Deliberations on the second day of the summit sought to examine the current state of various broad fields of science in Nigeria including the health sciences, biological sciences, agricultural sciences, engineering sciences, physical sciences, mathematical sciences, chemical sciences, and the earth sciences. There were presentations on each of these fields covering history, the current challenges and recommendations for advancement. Most presenters spoke of a grander past in the various fields of science in Nigeria and a gradual decline due to a seeming shift in national priorities, culminating in the disquieting present.

In the health, biological, and agricultural sciences, speakers and participants called for improved allocation and utilization of resources, public-private sector partnerships, restructuring of the educational system with an emphasis on practical exposure, institution of research priorities and goals by researchers, as well as a reorientation to an interdisciplinary approach to research. With regards to the physical, engineering, and mathematical sciences, there was a call for adequate funding, science-industry linkages, improved teaching curriculum, teaching methods, and infrastructure, and better remuneration for science teachers and lecturers. Similarly, in the chemical and earth sciences deficiencies in funding, policy, curricula, manpower, and infrastructure were identified as a few of the prevailing challenges requiring urgent attention.

Following the presentations and deliberations during the course of the Summit, the following consensus points were agreed on:

- Science, Technology, and Innovation are fundamental to development, peace, and progress in Nigeria. They

constitute the engine for economic growth and prosperity. Nigeria's myriad of social, economic, political, infrastructural and cultural challenges can be ameliorated through the use of advancements in science and technology

- The government should adopt a fresh and positive attitude to STI, realizing that the categorization of nations as developed, developing, or under-developed is largely based on the level of scientific and technological development
- In this regard, the Ministry of Science and Technology (and indeed the Minister to direct the Ministry) should be a prominent member of the government's cabinet. The Minister of Science and Technology should also be a member of the Economic Management Team
- The Presidential Council on Science, Technology, and Innovation (PCSTI) should be backed by law and chaired by the President and Commander-in-Chief of the Armed Forces of Nigeria, with service-wide representation in its composition. Its report should be part of the President's annual address to the National Assembly
- A National Science Foundation should be urgently established, backed by law, and managed by the PCSTI

Preface

This document is a summary of the National Science Summit which took place on the 12th and 13th of May 2015 in Abuja, Nigeria. The Summit was organized by NAS in collaboration with the Science Association of Nigeria (SAN). The Summit was convened to arrive at a collective voice of Nigerian scientists to ensure the highest standards of scientific endeavours for systematic national, scientific, and technological development of Nigeria.

The Academy has as part of its core mission, the promotion of science, technology, and innovation as tools for attaining national development. National development can only be achieved through the advancement and application of science and research findings as well as the strategic organization of the Nigerian scientific community. In 2011, NAS organized a meeting with national science associations in Nigeria to initiate a process of re-organising the Nigerian scientific community. At this forum, it was agreed that NAS was best positioned to take the lead in this regard and that the scientific community needs to meet regularly to assess progress and articulate ways to improve science research output in the country. The National Science Summit was structured as a follow up to the 2011 meeting and an opportunity to re-engage with stakeholders in scientific and national development. This two-day stakeholders' meeting featured presentations focused on the relationships between science and various aspects of society (including media, industry, economy, education, and the social sciences), stakeholders' roles in ensuring the advancement of science in Nigeria, as well as the current state of various disciplines of science in Nigeria, focusing on challenges and strategic steps for the future.

This report, which presents highlights of the presentations, discussions, and recommendations made during the Summit, is intended for all stakeholders involved in scientific and national development in Nigeria.

Foreword

Welcome address by Professor Oyewale Tomori, President, NAS

I am delighted that we have this opportunity to meet and come up with a common voice and map out a direction and a role for science and technology in the development of our country.

Science and technology has been used by all advanced countries to nurture and lift their countries from the bondage of poverty, through the appropriate application of relevant science into productive technology for national development. Jawaharlal Nehru, a former Indian Prime Minster once said "It is science alone that can solve the problem of illiteracy, of superstition, and deadening custom and tradition, of vast resources running over waste, of a rich country inhabited by starving people. I do not see any way out of our vicious circle of poverty except by utilizing the new sources of power which science has put at our disposal". Stephen Hawking, the British Physicist, appreciating the use of science and technology for accelerating development, said - "The world has changed far more in the past 100 years than in any century in history. The reason is not political or economic but technological - technologies that flowed directly from advances in basic science."

It is for this purpose that NAS and SAN have jointly worked together to organize this Summit of scientists and science societies. Somewhere in the history of science and scientists in Nigeria, we became each other's enemies. NAS is the brainchild of SAN, but somewhere along the line the brain left the body and we are where we are today. However, with this Summit, brain and body have reunited and are better able to function for the good of our society. This is not the first of such meetings. I was made to understand that in 1988 such a meeting was held, but nothing came out of it. On 10th May 2011, the Academy had a meeting with representatives of science societies in Nigeria. The meeting was attended by three NAS Fellows and participants representing the

Botanical Society of Nigeria, the Pharmaceutical Society of Nigeria, Association of Public Health Physicians of Nigeria, Nigerian Mining and Geosciences Society, Nigerian Veterinary Medical Association, Nutrition Society of Nigeria, Nigerian Society of Chemical Engineers, Nigerian Society of Biochemistry and Molecular Biology, Nigerian Mathematical Society of Nigeria, and the Nigerian Society for Microbiology.

The goal of the current summit of scientists is for the re-organisation/re-orientation of the science community in Nigeria towards improved research, competitive scientific output, and innovation for national development. Specific objectives of the summit include:

1. To bring together key members of the science community to discuss the state of science in Nigeria.
2. To formulate strategies for improving scientific research and innovation among the national science associations in Nigeria.
3. To foster collaboration among key stakeholders in national development.

The country has consistently expressed the vision of becoming one of the top 20 economies in the world by 2020. We only have 5 more years to 2020, and it is obvious that we are not even close to achieving the vision as we continue to vehemently refuse to use science and apply technology for social and economic development. No nation has made significant improvement in her standard of living without tapping available resources of science and making use of technological know-how. We have attempted to side-track developing science and technology and tailoring it to our needs. Instead, Nigeria has taken a shortcut by importing other peoples finished technology, and calling it transfer of technology. Nigeria disdains and neglects science and technology; for years we had no Ministry of Science and Technology, while the budget for science and technology drops every year. One year we had no Minister for nine months after the incumbent was sacked, and the national science and technology policy has been amended by every government and no one has implemented it

Nigeria has only been blessed with one or two Ministers of Science and Technology, who know their science from their superstitions, or their technology from their tale telling. The Ministry was the perpetually neglected and disdained child of the Nigerian government. The lack of commitment of the government on developing and implementing a sound national science and technology policy led to the frequent dissolution and re-emergence of the Ministry. It was as if the government never really made up its mind about using science for technological development. We must all come out with one clear and loud voice from this Summit telling the incoming government to differ from previous governments by making science and technology the cornerstone of our transformation to a developed country. A rising Gross Domestic Profit (GDP) will result in another form of escalating "GDP", where development is not based on science and technology. The other "GDP" is Gross Domestic Poverty.

This government and future Nigerian governments must:

i. Consider the Ministry of Science and Technology as important as that of Finance, Petroleum, Defence etc. and get a credible reliable, patriotic, decent, diligent, and incorruptible Nigerian to head it.
ii. Implement, as appropriate, the existing national science and technology policy.
iii. Review and implement as appropriate, the submission of the last national conference on science and technology.
iv. Evaluate current practices for funding research in Nigeria.
v. Think seriously about establishing a National Council on Science and Technology, preferably headed by the President, with relevant ministries, private sectors, civil societies, educational institutions etc. represented as members of the Council.
vi. Nigeria is ripe enough for a Science Adviser to the government/president.

Our value and relevance are tied to the way we use science and technology to positively change the life of our people. We must seek relevance in using science and technology to serve and meet the

identified needs of the society. Our priority must be to use science as a channel for all-round development and a better life for the neglected majority of the society. Science rightly pursued and technology wisely applied, be it in medicine or engineering, should impact positively on our daily life. This is the expectation of the society from science and scientists. Just as health is not only the absence of disease, but also a state of mental, physical, and emotional wellbeing, so also we should see the evidence of the impact of science on our day to day activity, whether we are at work, at home, on the road, or even sleeping. Science and the technologies derived from it should, according to Sydney Brenner, "form the basis of all human activity, from the houses that we live in, the food that we eat, the cars that we drive, to the electronic gadgetry in almost every home that we use to remain informed and entertained". The Nigerian society should not expect less from her scientists.

We must use science and technology to change the face and nature of Nigeria.

Thank you.

List of abbreviations

African Institute of Mathematical Sciences (AIMS)
African Union (AU)
African Union Scientific Technical and Research Commission (AUSTRC)
Agricultural Research Council of Nigeria (ARCIN)
African Union Trade Office (AUTO)
Basic Education Curriculum (BEC)
Benchmark Minimum Academic Standards (BMAS)
Centre for Basic Space Science (CBSS)
Centre for Development and Promotion of Entrepreneurship and Enterprise (CDPEE)
Chemical Environmental and Earth Sciences (CEES)
Cocoa Research Institute of Nigeria (CRIN)
Committee of Deans of Engineering and Technology in Nigerian Universities (CODET)
Consolidated Plan of Action (CPA)
Council for the Registration of Engineering in Nigeria (COREN)
Directorate of Food Roads and Rural Infrastructure (DFRRI)
Ebola Virus Disease (EVD)
Education Trust Fund (ETF)
Engineering Materials Development Institute (EMDI)
Forestry Research Institute of Nigeria (FRIN)
Getting Research into Policy and Practice (GRIPP)
Gross Domestic Profit (GDP)
Human Development Index (HDI)
Informatics Development for Health in Africa (INDEHLA)
Information and Communication Technology (ICT)
Institute for Agricultural Research (IAR)
International Astronomical Union (IAU)
Luonnontieteet Matematiikka (LUMA)
Manufacturers Association of Nigeria (MAN)
Mathematical Association of Nigeria (MAN)
Memorandum of Understanding (MoU)
Millennium Development Goals (MDGs)

Ministries Departments and Agencies (MDAs)
National Agency for Science and Engineering Infrastructure (NASENI)
National Board for Technical Education (NBTE)
National Cereals Research Institute (NCRI)
National Commission for Colleges of Education (NCCE)
National Economic Empowerment and Development Strategy (NEEDS)
National Education Research and Development Council (NERDC)
National Fadama Development Project (NFDP)
National Horticultural Research Institute (NIHORT)
National Office for Technology Acquisition and Promotion (NOTAP)
National Research and Innovation Council (NRIC)
National Research and Innovation Fund (NRIF)
National Research Foundation (NRF)
National Space Research and Development Agency (NASRDA)
National Special Programme for Food Security (NSPFS)
National Strategic Industrial Development Master Plan (NSIDMP)
National Universities Commission (NUC)
National Veterinary Research Institute (NVRI)
Nigerian Institute for Oil Palm Research (NIOPR)
Nigerian Institute of Journalism (NIJ)
Nigerian Meteorological Agency (NIMET)
Nigerian Stored Products Research Institute (NSPRI)
Obafemi Awolowo University (OAU)
Organization of African Unity (OAU)
Parliament of the Union of Science and Technology (PUST)
Partial Deschooling and Apprenticeship (PaDA)
Projects Development Institute (PRODA)
Regional Economic Communities (RECs)
Resource Conservation Recovery Act (RCRA)
Rubber Research Institute of Nigeria (RRIN)
Science and Technology Education Post Basic (STEP- B)
Science Teachers Association of Nigeria (STAN)

Science Technology and Innovation (STI)
Science Technology Engineering and Mathematics (STEM)
Science Technology and Innovation Strategy for Africa (STISA)
Scientific Equipment Development institute (SEDI)
South African Centre for Epidemiological Modelling and Analysis (SACEMA)
South African Mathematical Society (SAMS)
Student Industrial Work Experience Scheme (SIWES)
Teachers Salary Scale (TSS)
Tertiary Education Trust Fund (TETfund)
United Nations Development Programme (UNDP)
United Nations Environment Programme (UNEP)
Universal Basic Education System (UBE)
Universal Primary Education (UPE)
World Health Organization (WHO)

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CHAPTER ONE
SCIENCE AND NATIONAL DEVELOPMENT

COLLABORATIVE SCIENCE AND TECHNOLOGY INITIATIVES FOR NATIONAL DEVELOPMENT

Dr. Umar Bindir

Director General/Chief Executive Officer, National Office for Technology Acquisition and Promotion (NOTAP)

History has shown through the experiences of Europe, North America, and Asia, that the use of science-based technology is fundamental to national development. These continents have used science and technology to alleviate poverty and promote development. Unfortunately, Africa has largely been unable to apply this principle. The successful development of any country through the application of STI initiatives can be said to progress in three stages. The first stage is the total eradication of absolute poverty- this involves the provision of minimum needs for the citizenry such as basic education, basic healthcare, potable water, adequate shelter, good sanitation etc. Beyond access to these minimum needs, all individuals should also have access to opportunities to lead a happy, safe, and fulfilled life; this is the second stage. These include the ability to acquire and build skills and competencies, the existence of employment opportunities, adequate security, as well as avenues for recreation. The third stage is the emergence of the country as a knowledge and learning society built on values of hard work, honesty, discipline, productivity, sincerity, and a collective sense of purpose. Progressing through these stages will ensure a modern knowledge-based economy, a dynamic population, well-focused productivity, global competitiveness, and credible global visibility all of which are essentially indicators of development. Conversely, the absence of these, as is the case with Nigeria, indicates the failure to effectively translate STI to societal dividends.

Nigeria is a country of nearly 200 million people with a large and diverse resource base. Despite this, there is a high poverty rate, weak physical and social infrastructure, weak local industries, as well as emerging environmental challenges. The solutions to Nigeria's problems lie in STI. The attainment of Nigeria's national

goals depends firmly on the vibrancy, productivity, and efficiency of its STI system. Unfortunately, Nigeria has not yet understood the importance of the STI value chain. Science, the first step in the STI value chain, involves the generation of facts, figures, and documents by highly trained, qualified, and motivated specialists (scientists). Nigeria has failed to recognize the wealth of knowledge it has in Nigerian scientists, and Nigerian scientists are largely disregarded and undervalued. Though adequate investment in science and scientists is important, the value that will be realized from doing this alone is not sufficient to bring about any kind of national development. The next step in the value chain is engineering and technology which is the transformation of the facts, figures, and documents produced by scientists into solutions and assets that address societal needs. The process through which this is achieved is technology transfer and if this is successful, it leads to the final step in the value chain; innovation and entrepreneurship- using the solutions to competitively sustain socio-economic relevance.

Theoretically, Nigeria has a well-established STI system. The STI infrastructure in the country includes: 140 universities, 125 mono/polytechnics, 98 Colleges of Education, over 300 research institutes and centres, world class industries, qualified experts, and a number of existing partnerships. Furthermore, some of the country's past scientific achievements and outputs are impressive. Since 2003, Nigeria has been operating satellites in space; strides have been made in biotechnology and renewable energy research; and on the African publishing landscape, Nigeria is second only to South Africa. The question then is how much of Nigeria's research has been successfully transformed to technology? The answer is despite the potentials for development through science and technology, there is little to no innovation in the country. It is not that Nigeria doesn't understand what can be gained from STI, the problem lies in the fact that in the Nigerian STI system, these three interrelated components; science, technology, and innovation, work independent of each other. The solution lies in networking the STI elements to ensure that the generated facts

and figures illuminate possibilities and applications which can be transformed into solutions and products. The following steps/action points are pertinent to reaching this goal:

1. The promotion of indigenous technology through regular institutional exhibitions and techmarts at the zonal, national, and international levels.
2. The implementation of a deliberate mass employment generation and wealth creation posture.
3. The strategic building of a critical mass of entrepreneurial manpower. Technology contracts can be used to create academia-industry linkages.
4. The creation of effective linkages between research and socio-economic development. This can be done through the establishment and management of science and technology parks.
5. The adoption of a strategic national posture; Agenda 1777, a generic post 2015 drive. This development model will involve **one** united Nigeria in **seven** years establishing **seven** multinational companies that will produce **seven** international products.
6. The gradual development of visible and viable partnerships between stakeholders including scientists, government, industry, and local communities.
7. The effective usage of the approved NRIF provided for by the new STI policy. Funds for this need not come solely from government budget but can be supported by centralized research and development funds. Furthermore, the approved and inaugurated National Research and Innovation Council (NRIC) chaired by the President should be fully functionalized.

It is time for Nigeria to look inwards for solutions to its problems. The responsibility to develop the country lies with all Nigerians. The way forward for Nigeria is a collective attitude of responsibility, compassion, vision, and practical priority. Nigerian scientists must remain undeterred in continuously working together to achieve a better Nigeria for all Nigerians. This collaborative science and technology will ensure sustainable national development for the country.

APPLYING SCIENCE AND TECHNOLOGY TO POSITIVELY CHANGE NIGERIA AND NIGERIANS

Professor Oyewale Tomori
President, NAS

The words 'science and technology' appear once in the 1999 Nigerian constitution where it states that "Government shall promote science and technology". However, rather than promote science and technology, Nigeria has neglected science by expelling it from its education and misapplied technology by banning it from its shores resulting in the truncation of national development. Science and technology can be used as tools to lift Nigeria from its current state to one comparable with developed and advanced nations.

The Federal Ministry of Science and Technology under whose purview scientific and technological development falls has had a checkered past. The Ministry was instituted in 1980 after past metamorphosis as the National Council of Science and Technology and the National Science and Technology Development Agency in 1969 and 1977 respectively. In 1992, the Ministry was dissolved and then re-established in 1993 and by 1999 it had been under the leadership of 10 different ministers. The first national science and technology policy was developed in 1986 and then consecutively revised in 1997, 2003, and 2005. In 2012, there was a policy overhaul giving rise to the current science policy. The main objective of this policy is to build a large, strong, diversified, sustainable, and competitive economy that guarantees a high standard of living and a good quality of life for the people. Achieving this objective will require:

- Strong political will, commitment, and leadership with private sector participation in research and development
- Linkages, partnership, and competitiveness among all STI stakeholders
- Investments by government, private sector, and development partners
- Popularization of science and inculcation of a science and technology culture

- Improved curricula for relevant scientific knowledge and vocational skills acquisition
- Improved human capacity for assured self-sufficiency and global competitiveness
- Multi-disciplinary, mission-oriented research and development activities in science and technology for national development

Another factor to be considered is the funding of research in Nigeria. Locally, funding for science and science research has been haphazard with only a few bright spots through the introduction of programmes and initiatives such as the Education Trust Fund (ETF), Science and Technology Education Post Basic (STEP-B) Project, and the Tertiary Education Trust Fund (TETfund). However the success of these initiatives has been hampered by poor basic infrastructure, inadequate electricity, unavailable reagents, equipment and supplies, poor supervision, inadequate monitoring and evaluation, poor mentorship, irrelevant research, insufficient adherence to merit in assessment of research proposals, poor management and misuse of research funds, as well as apathy and failure to make returns on received grants.

Interestingly, despite the aforementioned challenges, Nigeria, when compared with other African countries, produces one of the highest numbers of research publications (Figure 1). However, the quality and benefits of these research outputs remains questionable. South Africa which also produces a large number of research publications has done a lot better than Nigeria technologically. In terms of its Human Development Index (HDI); a common indicator for the impact of scientific and technological advancement, Nigeria with a HDI of 0.504 is globally ranked 152nd[1]. Furthermore, there has been little change in this figure over the last 10 years and Nigeria has been consistently classified as a Low Human Development (LHD) country.

The implications of this categorization is evident in our poor transportation system, defunct educational system, inequality

[1] Human Development Report 2014

and disparities in the standard of living, poverty, fractured healthcare delivery system with consequent increasing disease burdens, inadequate power supply, as well as growing insecurity. These problems are what science and scientists should be striving to remedy. Science, rightly pursued and wisely applied, should impact positively on all aspects of the life of the everyday Nigerian. Nigerians expect Nigerian scientists to transform their elegant theories of development into practical solutions for daily needs. Nigerian scientists, the government, industries, as well as the society all have roles to play in lifting Nigeria out of its current state of under-development. The Nigerian government should fully commit to investing in science and technology. Nigerian scientists must identify with the society, ask the right questions relating to the problems of the society, focus research activities on finding answers to questions asked, and collaborate with other stakeholders in serving and meeting the identified needs of the society.

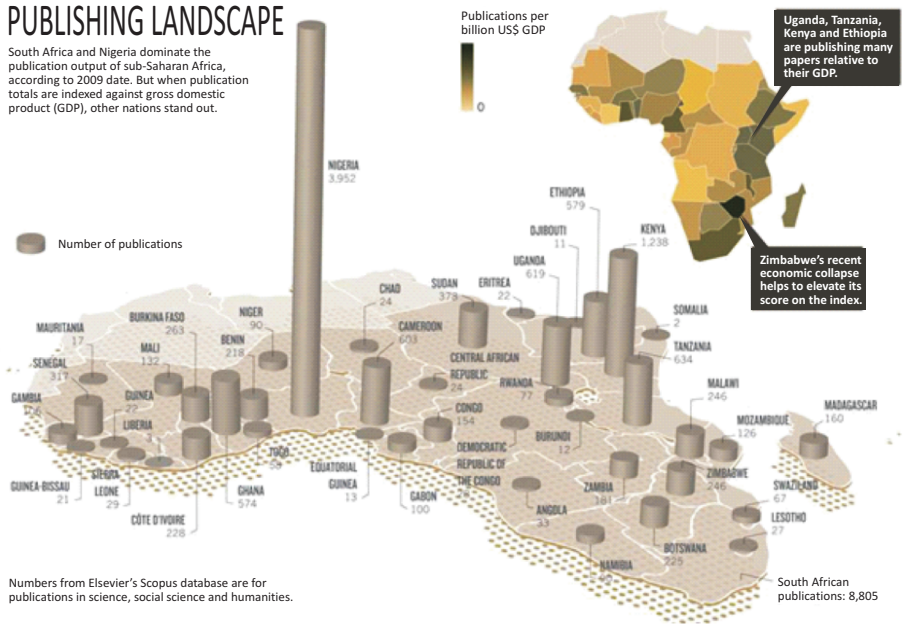

Figure 1: Publishing Landscape in sub-Saharan Africa (Global Research Report, 2010)

RESEARCH AND INNOVATION FOR SUSTAINABLE DEVELOPMENT: AFRICA ON THE WINGS OF INNOVATION

Dr. Mohammed Kyari

Senior Scientific Officer Coordination African Union, Scientific, Technical and Research Commission (AUSTRC)

Science and technology have been at the top of Africa's political agenda since the establishment of the Organization of African Unity (OAU) in 1963. During a speech at the Foundation Summit on the 24th of May 1963, President Kwame Nkrumah expressed the continent's dreams "to make the Sahara bloom into a vast field with verdant vegetation for agricultural and industrial development". Since then, there have been several plans to achieve this dream. In 1980, the Lagos Plan of Action for the economic development of Africa was adopted by Heads of States across the continent who committed to "put science and technology in the service of development by reinforcing the autonomous capacity of our countries in this field"[2]. Member states also recommended that at least 1% of GDPs be allocated to research and development. Notwithstanding this recommendation and its consequent reiteration over the years, Africa still has the lowest investment in research and development globally (Figure 2).

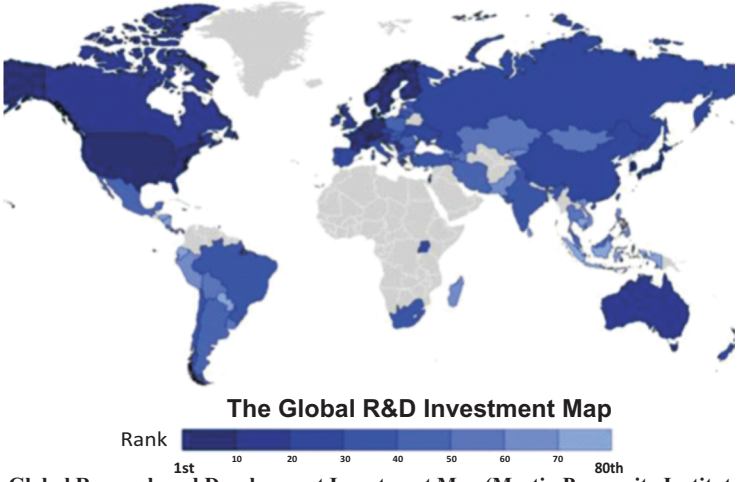

Figure 2: Global Research and Development Investment Map (Martin Prosperity Institute, 2011)

[2] Lagos Plan of Action for economic development in Africa 1980-2000.

In 1987 during the first congress of scientists in Africa, the Parliament of the Union of Science and Technology (PUST) declared the 30th of June as the Science and Technology Renaissance day in Africa. By 2005, following a series of continental and regional workshops, a Consolidated Plan of Action (CPA) was developed to articulate and reaffirm Africa's common goal of socio-economic transformation through science and technology . Then in 2014, a new strategy was put forward by the African Union (AU). This strategy; Science, Technology, and Innovation Strategy for Africa (STISA) 2024, is a long term plan to use STI as a tool for continental development . Aside from the aforementioned African policies, Nigeria as a country has had several polices for national development. The country does not need any new plans or documents. Much time and effort have been expended in discussing the country's challenges and proffering solutions. It is time for action.

The current African STI policy, feeds into the vision of the AU 2063 Agenda for "an integrated, prosperous, and peaceful Africa driven and managed by its own citizens and representing a dynamic force in the international arena". The strategy seeks to achieve this vision by accelerating Africa's transition to an innovation-led, knowledge-based economy. As laid out in the strategy, improving STI infrastructure and manpower will enable Africa set priorities and implement effectively managed programmes to meet the needs of Africans. The key pillars of STISA 2024 are the building of research infrastructure, enhancement of technical and professional competencies, the promotion of innovation and entrepreneurship, as well as the creation of an enabling environment for STI. The implementation of STISA will proceed in five stages (Figure 3) and will address the issues of hunger eradication and food security, wealth creation, disease prevention and control, communication, building peaceful societies, and the protection of African space.

[3] Africa's science and technology Consolidated Plan of Action 2006.

[4] Science, Technology, and Innovation Strategy for Africa (STISA) 2024. African Union Commission 2014.

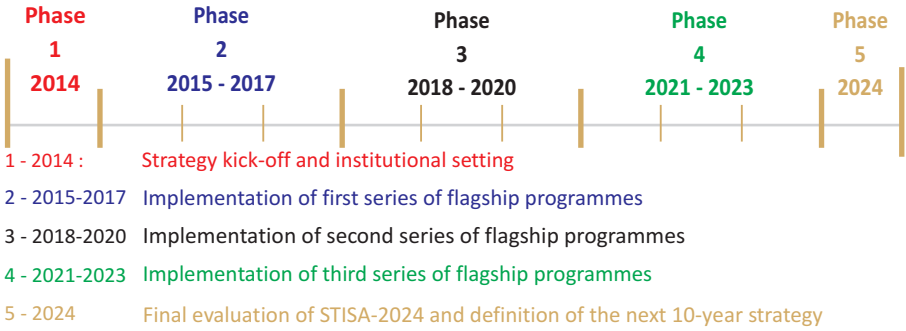

Figure 3: Implementation phases of STISA 2024 (STISA -2024)

Due to the difficulties and shortcomings in the implementation of the CPA of 2005, a policy analysis of STISA was designed and conducted to ensure the domestication and implementation of the strategy by Member States and Regional Economic Communities (RECs). The policy analysis exercise was designed considering the following factors:

- The implementation of STISA 2024 required a minimum set of requisite infrastructure and human resource with necessary skills, and an enabling environment
- AU Member States and RECs are at different stages of readiness in terms of infrastructure human, and organizational capacity to properly undertake actions that address the STISA priority areas
- The first phase of STISA 2024's implementation focuses on putting in place required institutions at national, regional, and continental levels to facilitate the integration of the strategy in national and regional STI processes

Using problem tree methodology, each of the STISA pillars were analyzed and the needed sub-pillars were identified to ensure that they are in place to achieve the required output. The output of the analysis identified thirteen policies and seven institutional arrangements that do not exist in the majority of AU member states and/or RECs. These policies and institutions (Table 1) are pertinent for STISA 2024's integration into national and regional STI processes.

Table 1: Policies and institutions pertinent to STISA 2024 integration

Policies	Institutions
• Investment policy on research and development infrastructure • Science Park promotion policy • National policy on community innovation hubs • Reviews of national higher education policies • Policy on technology transfer, adoption, and acquisition • AU policy guideline on professional and practitioners regulatory bodies • Policy on lifelong learning • Policy on knowledge exchange and brain circulation • Policy on research commercialization • Policy on inclusive innovation • Policy on green innovation • National strategy on creative thinking and innovation capacity building • Intra-Africa Triad	• Science park at member states level • Community innovation hubs • Joint council of industry and higher education/ research • Office of technology transfer and acquisition • AU network of scientists • National Centre for Development and Promotion of Entrepreneurship and Enterprise (CDPEE) • African Union Trade Office (AUTO)

STISA 2024 is currently in the first phase of implementation. Its success at this stage hinges on:

1. The development of a concise summary (fish document) of each of the policies and institutions.
2. Consultative meeting with member states, RECs, and other key stakeholders to present the final output of the analysis.
3. Meeting with members' STI ministries and RECs with a view of having a common understanding of the implementation process and procedures.
4. Resource mobilization for implementation.

Audience reflections

- Action and implementation is what Nigeria needs to ensure national development through STI
- This Summit is a good first step. Scientists need to talk to each other before involving other stakeholders
- Scientists have failed to package science properly. Also sub-cadres of scientists should be included in such gatherings
- In-breeding is a growing problem in Nigerian universities and multidisciplinary research is not being carried out as regularly as should be. Nigerian scientists need to take the gown to the town; scientists should work to impact the society rather than for themselves
- The spirit of patriotism must be grown in Nigeria
- Scientific research should be designed to meet the country's specific developmental aspirations rather than for narrow or personal career goals
- This summit should be institutionalised as an annual event for advocating issues on STI
- Deliberate effort should be made to bring industries, universities, and research institutes together
- Researches, with social implications, should be designed bearing in mind the contexts, needs, and cultural milieu of the target users
- Incentives should be provided to attract and retain science teachers and scientists
- Science-based facilities should define and set research goals and targets
- NAS should provide yearly fact sheets of researches conducted and also obtain basic data from Ministries, Departments, and Agencies (MDAs) for research

CHAPTER TWO
SCIENCE AND THE SOCIETY

STI AND INDUSTRIAL DEVELOPMENT IN NIGERIA

Dr. Bamidele Makanjuola
Chairman, Vitafoam Nigeria Plc

Industrialization and economic development is the availability of economic activity in relatively large units of production, making use of machinery and other capital assets, with the task of labour finely divided and the relationships of employment formalized. Nigeria today cannot really be said to be industrializing; there are very few industries and even fewer managed by Nigerians. A common misconception is that the private sector does not welcome input from Nigerian scientists, this is not the case. Natural sciences being taught in Nigerian schools are hampered by poor infrastructure, particularly science laboratories. Consequently, the quality of scientists available for recruitment is compromised and this is why the importation of scientific expertise by Nigerian industries is common. Aside from the quality of science education in Nigeria, there are other challenges facing Nigerian industries. These include poor management, low investment, suboptimal industrial capacity utilization, severe economic and environmental conditions, as well as a decreasing contribution to the GDP by the manufacturing sector.

Nigeria has in place a detailed and ambitious science policy that gives hope for the development of the Nigerian industrial sector. However the quality of any policy is not as important as the quality of its implementation. Some of the intentions of the STI policy issued by the federal government are:

1. Formulation of strategies to encourage reward for intellectual properties.
2. Creative management and funding of patented innovations.
3. Establishment of more technology incubation centres across the country, and improved planning and management of existing centres.
4. Provision of venture risk capitals within the economy, through deliberate efforts of national economic planners, and the translation of innovation and creativity into real material benefits.

5. Improved and deepened symbiotic relationship between the society and academia.
6. Supporting universities and research institutes in the establishment of technology incubation centres and science parks for the commercialization of research and development results.
7. Competitive awarding of grants and endowments to individuals and institutions to actively engage in research and development.
8. Establishment of a NRIF with a minimum of 1% of GDP strategically sourced from the public sector, private sector, and internationally.

Alongside the national STI policy, there is a National Strategic Industrial Development Master Plan (NSIDMP) formulated by the National Council of Commerce and Industry in 2010 to provide the road map for industrial development in Nigeria. The outcome of this is a new industrial strategy; the Cluster Concept. Industry clusters are groups of similar and related firms in a defined geographical area that share common markets, technologies, and workers skill while often linked by buyer-seller relationships. Clusters stimulate regional competitiveness in three ways: by increasing business productivity, by boosting their innovation capacity which supports future productivity growth, and by stimulating formation of new businesses which expand and strengthen the cluster. Firms that are part of a cluster are expected to operate more efficiently when sourcing inputs, accessing information, technology and institutions, cooperating with related firms, and measuring their performances against other firms. Despite the good intention of adopting this strategy, not one of such clusters has been established in Nigeria.

Moving forward, the following steps are necessary and should be reviewed:

1. The provision of incentives to raw material exporters by the government should be reconsidered. This step taken to boost non-oil exports does not encourage the growth of indigenous industries.

2. The existence of too many regulatory agencies in Nigeria burdens the private sector. A comprehensive audit of the regulatory environment is necessary.
3. The state of implementation of the cluster concept should be assessed and necessary action points mapped out.
4. Technological advancement alone does not translate into industrialisation. It is only when it is fuelled by government, that industrial growth and standards of living are raised.
5. In a bid to support the growth of local technology, Nigeria should not try to re-invent the wheel; developed countries are already adopting 'smart manufacturing and robotics'.
6. One of the ways the government can assist Nigerian manufacturers to operate at global standards is to upgrade 'national quality infrastructure'.

SCIENCE IN THE SOCIAL SCIENCES

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Social sciences are rooted in the early 19th century philosophy of science, and by the mid-20th century, the term "social science" has come to be referred more generally, not just to Sociology, but to all those disciplines which analyse society and culture, including Economics, Psychology, Anthropology, Demography, Politics, and Media Studies. Social sciences deal with human society, social groups, and individuals in their social relationship, institutions of society, as well as material and cultural goods as expression of the coexistence of human beings. The goal of the social sciences is recognizing patterns of collective actions to which individuals contribute through their independent actions. Ontologically, the natural sciences discovered natural laws of phenomena in the physical world while the social sciences focus on understanding the social aspect in human interaction. Science is analytic; a complex system which focuses on single elements whereas social science is synthetic; focusing on a complex system; the individual. The object of study in the natural sciences focuses on nature whereas social sciences focus on social actors. Methodologically, both fields focus on the inductive generation of theories; where science captures empirical testing mainly quantitatively and social science captures empirical testing qualitatively and quantitatively. The scientific outcome of both fields capture fallible and infallible theories where natural science focuses on gradual improvements of formalism and stepwise evolution of world views and the social sciences focus on heuristics; a method of problem solving for which no formula exists and employing a form of trial and error iteration.

Both science and the social sciences are similar to the extent that they both adopt scientific ways of knowing about the world, different from other forms of knowledge. Both are however

differentiated based on their subject matter. While the natural sciences largely deal with non-human phenomena, the social sciences deal with human action and behaviour. This distinction is often seen as crude, since their respective subject matters sometimes over-lap. For example, some subjects in the natural sciences deal with human biology, while some approaches in the social sciences treat human action as an object of study just as natural scientists would treat plants, rocks, or atoms. The growing use of quantitative methodology in many of the social sciences' sub-fields, encouraging inter-disciplinary and cross-disciplinary scientific inquiry into human behaviour, is now blurring the boundaries which used to exist between natural and social sciences. This has led to the emergence of such disciplines as social medicine, sociobiology, neuropsychology, bio-economics, and the sociology of science. More important is the blurring of lines between quantitative and qualitative methods in the social sciences, whereby both are used in conjunction rather than as separate entities.

Notably, societies have changed over time, and consequently, so has science. As a result of the accelerating development of the human capacity to remake the world, it is obvious that in re-making the external world, the social world is greatly impacted upon. This synchronous phenomenon appears in the social relations between persons, as well as in the powers of human knowledge, the values chosen, and the aesthetic needs, among others. Therefore, the natural sciences are internally related to the social sciences. Natural scientists are not merely outside observers of the phenomena of nature, and human activity. On the other hand, social scientists cannot merely observe social phenomena; the various kinds of activity in creating human history proceed only in conditions which enable persons to remake nature and undertake social production.

Social science disciplines, though united in basic scientific justification and approaches, differ in terms of concepts, questions raised, results, and explanations. A broad consensus by researchers acknowledges that an enduring understanding of

social phenomena is what could invariably qualify social science as 'science'[5]. The scientific status of the social science disciplines have been queried based on the extent to which they are able to achieve 'objectivity' and 'value-free' in their enquiries of the social world. Popular debates around the scientific status of social science disciplines have been around the binary divisions as: positivism versus interpretivism, objectivity versus subjectivity, universalism versus relativism, deductive versus inductive reasoning, quantitative versus qualitative methodologies, among others.

For positivists, their major assumptions are that the social world could be studied and understood using the same explanatory tools as those produced in the natural sciences both for constructing, and/or testing of hypothesis. Objectivism in the social sciences puts emphasis on such terms as 'structure', 'totality', 'determinants' and 'macro systems', while the subjective grouping includes terms such as 'agency', 'individual', 'spontaneity' and 'micro systems'[6]. Grieffenhagen and Sharrok[6] firmly conceptualised the difference between subjectivism and objectivism by positing that the difference between the two often boils down to the question, 'Is reality represented in individuals perceptions or is reality something external to them?' The humanist tradition in the social sciences presents a different argument on the subjective nature of social sciences. The humanists are subjective in their reasoning, preferring an interpretive option. They therefore criticize the use of the natural sciences as a model for social research. While positivists (structuralists) tend to start with assumptions about, and questions relating to, the structure and functioning of collections of societies, humanists in general tend to start with assumptions about, and questions relating to, a 'human' as a social being with understanding, capable of manipulating and/or altering his/her own situation in non-predetermined ways.

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[5] Meyers, P. (1999, November). An Essay in the Philosophy of Social Science. Retrieved July 27, 2015.

[6] Greiffenhagen, C. and Sharrock, W. (2008) Where do the Limits of Experience Lie? Abandoning the dualism of objectivity and subjectivity. History of the Human Sciences 21 (3):70-93.

Attempts have been made severally to transcend the objective-subjective argument as both approaches have been criticized as being reductionist. Arguments have been made for preference to a 'critical tradition', whereby a view is opened up to scrutiny, to vigorous examination, and challenge[7,8]. When a view has been forced to face the demands of reason and of evidence, there is some assurance that it is not a mere view reflecting the whim or bias of some individual or group but that it has respectable warrant. The presence of a 'critical tradition' would, as is argued, safeguard objectivity by social scientists, by sending work to blind peer review, answering to critics, acquainting themselves to methodological and substantive literature, and by refuting their own beliefs. The emergence of a number of critical traditions - feminist standpoints; postmodernist tradition; and post-structuralists - in the social science is gradually blurring the gully between objectivism and subjectivism traditions.

Science as presented in the various social science traditions is not merely a set of inviolable and desiccated rules; rather it involves questions of belief and persuasion as well as proof and experiment. Whether in the natural or the social sciences, a central focus of research and scientific endeavour is to explain, understand, and predict both the world of nature, and the social world; and more importantly, use research findings to reshape our world and make the world a better place to live. The clarion call is for scholars across natural and social sciences disciplines to further explore areas of overlaps rather than differences: cooperate and complement rather than contradict and/or compete. Both the natural and the social science disciplines, including the humanities are vital drivers of human progress. A society without thriving social sciences and humanities risks achieving at best only an arid kind of prosperity, far less rich than creative human culture deserves - and at worst confusion, apathy, decline, and conflict. Circumstances and events in the world continue to point

[7] Popper, K. Objective Knowledge. (Oxford: The Clarendon Press, 1972).
[8] Scheffler, I. Science and Subjectivity (Hackett Publishing Company 1982).

to a merger of interests across natural and social science disciplines as most scientific inventions do not only have social implications, but steer human lives both positively and sometimes negatively. Both natural and social scientists must be adaptive in the use of research strategies and research outcomes. More importantly, the subject of research - whether human or material in nature - must be treated with respect, with a greater concern for ethics in research, and a more participatory orientation in the design and operation of research strategies. More efforts are needed in the area of collaborative and multi-disciplinary research, to help espouse more scientific 'truths' both in the natural and the social sciences.

EDUCATION FOR SCIENCE: THE FINNISH EXPERIENCE

Ms. Pirjo Suomela-Chowdhury
Her Excellency, the Finnish Ambassador to Nigeria

Finland like many countries across the globe has a strong appreciation for education and learning. In the country, education is perceived as a means of social and personal mobility. It may not result in monetary gains but can lead to good prospects in career and life in general. Finland provides all its citizens with free, quality, and standard education thereby ensuring the same opportunities are available to all. A lot of emphasis is placed on teacher training resulting in a crop of qualified and professional teachers and teaching is a respected and popular profession. Within the national guidelines for education, allowances are made for schools, teachers, and students to determine how teaching is organized. The approach to education is flexible and student-centred, and students can change their educational path at any stage of education. Furthermore, individual support is provided for each student as much as possible. Education begins with pre-primary education at age six. Compulsory education commences at seven and continues till age sixteen. This is followed by upper secondary school or vocational school. The last level in the education structure is tertiary education in universities or polytechnics (universities for applied sciences). Although education officially begins at six, a lot is done at the early childhood phase to prepare children for learning. This system has resulted in high performance in international rankings including science, mathematics, and literacy.

The education policy in Finland is based on the principle of lifelong learning and science education is regarded as a lifetime endeavour with competencies being developed from early childhood. It is not seen as a professional or academic issue but a life issue. Learning, information processing, and problem-solving are considered life skills for every citizen. Also, the Finnish people have a very high

level of trust in their scientists and science education promotes the credibility of scientific data. Science education is not a specific or separate entity but is integrated into the curriculum through teaching materials, teaching methods, teacher training, content, targets, and evaluation. There are also additional activities such as science clubs, excursions events, and theme days. In addition to the conventional approaches to science education, there are a few slightly unconventional methods that have been adopted in the country. A few of these include Luonnontieteet Matematiikka (LUMA) Centres at universities to encourage children into Science, Technology, Engineering, and Mathematics (STEM) subjects, researchers presenting their work at shopping centres, students collecting data for the Finnish Meteorological Institute, the 'Little engineers' program in which polytechnics cooperate with schools, as well as the annual SLUSH conference for technological start-ups.

Part of the Finnish science scene is a variety of organizations and agencies that serve as partners in promoting science and innovation. These include: the Academy of Finland, Sitra (Parliament-steered Fund), Finnish Funding Agency for Technology and Innovation (TEKES), Technology Research Centre of Finland, Research and Innovation Council, Finnvera Export Credit Agency, Ministry of Education, universities, polytechnics, and schools. Finland also has avenues for international collaboration. One of such collaborations is the Informatics Development for Health in Africa (INDEHLA) Initiative which began as a partnership between the University of Kuopio, Finland, and the Obafemi Awolowo University (OAU), Nigeria. This initiative focuses on health informatics and how it contributes to socio-economic and human development. Also, researchers from the University of Jyväskylä, Finland have worked with the Center for Sustainable Development, University of Ibadan to study the factors influencing e-waste management in both countries. Other examples are international projects of the Academy of Finland, TEKES funding for international research, and the BEAM programme.

Recently, a Finnish Government working group was commissioned to look into the development of science education for children. Some of the Group's recommendations that may be useful to Nigeria are as follows:

1. Focus should be placed on critical, analytical, and creative, thinking as well as argumentation skills.
2. Active learning, e.g. research projects should be promoted.
3. Efforts should be made to bridge the gap between the education system and 'digital natives'.
4. International cooperation and mobility in science education should be encouraged.
5. Training should be made available for science club instructors.
6. Learning environments should be updated.
7. Web-based science hubs for youngsters should be established.
8. Quality science journalism should be promoted through training and cooperation.
9. Researchers should be encouraged to communicate.

ENGAGING THE INTEREST OF THE MEDIA AND THE NIGERIAN PUBLIC IN SCIENCE

Mrs Moji Makanjuola
Journalist

Science journalism in Nigeria is not yet fully developed. It is of great concern that science and science-related issues are underreported and what is mostly being promoted now is information related to disease outbreaks, with little attention to research, statistics, or the basic knowledge of science. Medicine and health receive the most coverage and it is the common assumption that the average Nigerian is not interested in receiving information about other aspects of science.

Despite this observed trend, a few strides have been made in the promotion of science journalism in Nigeria. In a few print media publications, there are dedicated science pages for science stories, though these are usually technical and difficult to understand by everyday Nigerians. This may be because the journalists themselves do not quite understand the message that scientists want to pass across. Additionally, the African Federation of Science Journalists (AFSJ) was established in 2004 to push for better understanding of science among journalists and to inspire the next generation of African science journalists. Though this step is laudable, its progress has been a bit slow.

Journalists in Nigeria face a myriad of challenges when covering science. First is the belief that science stories don't sell as much as the coverage of business and politics and, as such, science stories are usually relegated to the background. There is also the issue of poor pay and incentives for journalists, as well as lack of proper training. The journalists-scientists relationship in Nigeria is also fraught with many problems. Some scientists are hostile towards journalists and this attitude is counterproductive to effective science journalism. It is time for Nigerian scientists to leave their ivory tower and speak the language of journalists. Also, scientists

do not involve journalists from the onset of their research, and so the majority of science stories just state the claims or result of research with little information on how these were arrived at. This lack of proper engagement makes understanding and disseminating scientific information difficult for journalists.

Some suggestions on how the current state of science journalism in Nigeria can be improved upon are:

1. Cultivating interest in science reporting; media outfits should encourage science reporting by creating science desks in their establishment.
2. Science-based organizations should undertake training in science journalism for media personnel, reporters, and editors.
3. Scientists need to become proactive and engage journalists from the onset of research activities.
4. Organizing fora where scientists and journalists can interact on a personal basis.
5. Government bodies and science institutions should train journalists and have budgets for working with the media to ensure open access to research work.
6. Science institutions should create strong media/ communications departments not just for event coverage, but also for strategic information dissemination.
7. NAS should help facilitate capacity building as well as encourage mass communication departments in Nigerian universities to promote specialization in various fields, including science.
8. Incentives for media practitioners/media houses should be instituted.

SCIENCE IN EARLY CHILDHOOD EDUCATION

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Founder, Okebukola Science Foundation

It is expected that, in fifty years, the current dispensation of Nigerian scientists would have passed on the torch to a new crop of scientists who would be responsible for setting the scientific direction of Nigeria. It is therefore important to secure the scientific future of the country. A close look at the early beginnings of the world's greatest scientists shows that introduction to science in early childhood education is crucial to a sustained interest and the pursuit of excellence in the field later in life. When the interest of children is stimulated to explore the world around them, they are exposed to rudimentary skills in science, and when this interest is sustained through the formal education system, it is likely that the quality and quantity of scientists in the general population would be elevated.

In Nigeria, the pre-primary education enrolment ratio is less the 20%, with little improvement between 1999 and 2012[9]. Furthermore, only 18% of the population have access to early childhood care and education. In terms of quality, early childhood education in Nigeria is characterized by poor curriculum delivery, as well as inadequate number of qualified caregivers and teachers. About two years ago, the Nigerian educational system was changed to a 1-6-3-3-4 system to address the lack of content at the pre-primary stage. A curriculum was developed but its scientific content is very sparse and the majority of the teachers are science illiterates. In developed countries, such as the United Kingdom, the United States of America, and Japan, early childhood education is exploration-focused and caregivers and teachers are well trained with continuous professional development. When compared with Ghana and South Africa, Nigeria is behind with regards to the access and quality of early childhood education (Figure 4).

[9] UNESCO Education for All Monitoring Report 2015

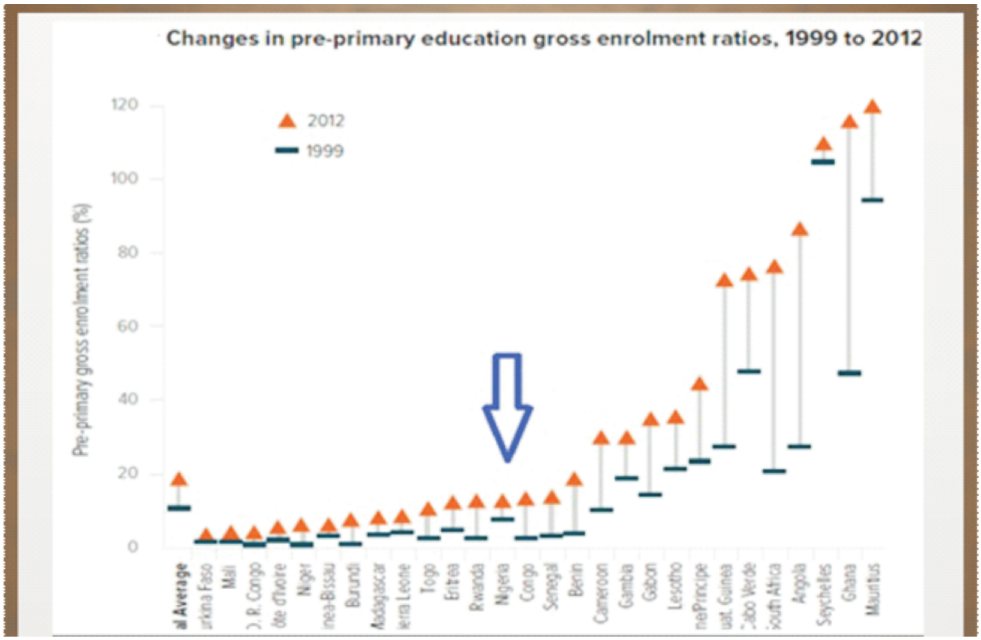

Figure 4: Changes in Pre-primary gross enrolment ratios 1999-2012 (UNESCO, 2015)

To bridge the gaps identified, Nigeria should:

1. Adopt the Ghana model of free pre-primary education for all citizens.
2. Improve the quality of early childhood education by enhancing the curriculum with science topics, trained caregivers and teachers to effectively deliver the science-laden curriculum.
3. Strengthen the inspectorate and monitoring services, and undertake better resourcing of primary school for science teaching and learning.
4. Create science classes that will excite the Nigeria child. These classes should be activity packed with the play-way method, answer everyday questions, expose the children to how scientists work, have computers for learning and play, include programme for relaxation, as well as emphasize safety in science.

NAS and SAN also have roles to play in bridging the gaps in early childhood education. These organizations should work with the Science Teachers Association of Nigeria (STAN) to improve the existing curriculum and send relevant recommendations to the National Education Research and Development Council (NERDC). Both bodies also have a role to play in mentorship. This may be in the form of projects to inspire young scientists or special prizes for deserving students. Efforts should also be made to meet the young people where they live i.e. engage them through social media platforms.

BRIDGING THE SCIENCE TO POLICY GAP

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It has become increasingly important to use scientific evidence to inform practice and policy, as improvement in any system depends upon identifying and applying what works[10]. Evidence-informed policymaking is an approach to policy decisions that aims to ensure that decision-making is well informed by the best available evidence. It is a systematic approach of identifying relevant evidence, appraising this evidence, and appropriately using it to influence policy decisions. An element of transparency is required in the process so that others can examine that research evidence was used to inform policy-decisions, as well as make judgements about the evidence and its implications. An understanding of the concept; "science to policy", is necessary to enable the proffering of solutions that could contribute to bridging the gap. This concept, which is also referred to as getting research into policy and practice (GRIPP) is the process of using scientific evidence of what works to make policy decisions, review existing policies/decisions, and ultimately improve practice. The actual process of GRIPP, however, is more complex in practice than this definition suggests.

The process of GRIPP involves four main actors that can be reached through different networks: researchers, policymakers, implementers (street-level bureaucrats), and other users such as civil society actors. It is important to establish and enhance linkages between researchers, policymakers, and other stakeholders to build an environment supportive of evidence-informed policymaking. GRIPP involves the strengthening of the complex system of interactions among users, researchers, and

[10] Armstrong, R., Waters, E., Crockett, B. and Keleher, H. (2007) The nature of evidence resources and knowledge translation for health promotion practitioners. Health Promot Int, 22: 254-60.11Green, Andrew et al. (2007) Sound Choices. Enhancing

policymakers to accelerate the capture of the benefits of research. It is hard to extract conclusions and general lessons on what factors facilitate or hinder the use of research evidence in policymaking since results from studies are contradictory[11]. In order to develop a strategy for getting research into policy and practice, an understanding of the policy process in the specific context is essential so that the points at which networking and research-evidence contributions can be most influential are identified [11].

Research in most cases is divorced from implementation which raises a lot of concern on how to get research into practice. Well-informed decisions about policies are more likely to achieve desired goals than uninformed or misinformed decisions. Although research findings are most often regarded as highly objective, their use for decision making may be a matter of actors' interests. Policy-makers select, use, and interpret evidence in different ways depending on the policy process and context, and their interpretation is influenced by personal beliefs and values. For research to be translated to policy and practice, many researchers have argued that bridges need to be built between research and policy. Studies have shown that researchers are often willing to communicate their results to decision makers; and are of the opinion that if their research is of good quality, then it would influence policy[12]. This is not necessarily so, as policymakers often have to consider other types of evidence such as programme reports and 'expert' opinions/views, which may constitute worthy contenders with scientific evidence for policymaking. Policy makers may also require rapid and final research answers to help with decision making, rather than inconclusive results that require further research[12]. They may also question the credibility of the scientific evidence and its context appropriateness, hence

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[11] Capacity for Evidence-Informed Health Policy. Geneva: WHO/AHPSR.

[12] Trostle, J., Bronfman, M. and Langer, A. (1999). How do researchers influence decision-makers? Case studies of Mexican policies. Health Policy and Planning 14: 103-114.

limiting uptake of scientific evidence for policymaking. These barriers imply that there may be more to evidence-informed policymaking than the availability of scientific evidence. Davis and Howden-Chapman[13] suggest that collaboration of researchers with policymakers may prove helpful in the science to policy process; particularly when the policymakers are made a part of the research process from the onset, rather than just presenting them with scientific evidence[13].

The linear model of translating scientific evidence into policy and practice shows a smooth process that goes from synthesis of scientific evidence through making of recommendations to using recommendations for policy/decision making and improvement in practice. In practice, the science to policy process is iterative in nature, interspersed with multiple layers of actor engagements and interfaces. Knowledge brokers who attempt to navigate the complexities of the process and bridge the science to policy gap often encounter some barriers. The communication of scientific evidence to meet the target audience is very important since wrongfully targeting an audience may result in non-utilization of findings. When scientific evidence is presented in a complex manner that uses long narratives of professional jargon, it becomes difficult for policymakers to understand. It therefore behoves the researcher (synthesiser of evidence) to analyse his/her audience and explore the best possible communication strategy to meet this audience.

Another major barrier to research utilization may be related to work organization that relates to timing and motivation to critically appraise research findings, evidence use culture, and leadership practice[14,15]. It may actually be difficult for any uptake of

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[13] Davis, P. and Howden-Chapman, P. (1996). Translating research findings into health policy. Social Science Medicine, 43:865-872.

[14] Cavanagh, SJ. and Tross, G. (1996). Utilizing research findings in nursing: policy and practice considerations. *J Adv Nurs,* 24**:** 1083-8.

[15] Chummun, H. and Tiran, D. (2008). Increasing research evidence in practice: a possible role for the consultant nurse. *J Nurs Manag,* 16**:** 327-33.

scientific evidence for policymaking to occur when the environment is less inclined to research utilization. The use of scientific evidence has not been the culture of policymakers in Nigeria because this culture is non-institutionalized in our decision-making process. Being that it could be easier, shorter, and clearly quicker to make policies and decisions without the rigorous process of synthesizing new evidence or identifying existing ones, people may want to hold on to their old and comfortable ways of doing things rather than venture into unfamiliar terrain. Research evidence is often created for different purposes and the academic definition of the problem does not always match the political definition. Academics need to understand that social research is a process, informed by systematically arranging the ideas of both those who create knowledge and those who use knowledge. While researchers pursue research in the hope of advancing knowledge, policy makers want knowledge that buys votes or political support. Again, different groups of people have different ideologies, which imply that there can be different perspectives or definitions of problems. This may lead to difficulty in reaching consensus on the interpretations and implications of certain evidence and also on the importance and validity of a certain methodology. Finally, researchers are often hesitant to provide concrete suggestions and options of actions, which is what policy makers actually require. The policymaking process is bound by time limits and therefore the dissemination of evidence needs to coincide with policy cycles.

Despite efforts to improve the utilization of research findings, the gap between research and practice has continued to widen[16]. A narrowing of this gap will depend on mutual agreement between researchers and policymakers in the market context of buyer/seller relationship. Getting research evidence into policy and practice is a tasking exercise which must be done if we seek improvements in policy decisions. Care must be taken to manage

[16] Jack, SM. (2006) Utility of Qualitative Research Findings in Evidence-Based Public Health Practice. *Public Health Nursing,* 23**:** 277-283.

diverse actors and their socio-cultural and political interests. Five key GRIPP elements have been proposed by the Alliance for Health Policy and System Research (AHPSR) for use when conceptualising how to bridge the research to policy gap They are:

1. Improving the capacity of decision-makers to recognize the benefits of, and identify and use, research information to strengthen health policies and practices;
2. Identifying and updating research priorities with participation from key stakeholders, and applying financial and human resources to address the priority agenda;
3. Producing good quality, timely, and credible research outputs for the identified priority agenda, including realistic recommendations that reflect understanding of the policy context and constraints, and synthesizing research into evidence that can support decision-making;
4. Communicating evidence in ways appropriate to audience needs, using advocacy strategies including mobilizing the influence of networks and key stakeholders to convey critical evidence to decision-makers; and
5. Recognising the pressures and elements that influence policy-making, and being opportunistic and enterprising in inserting evidence into decision-making processes.

In order to increase research practice, Kottke *et.al*[17] have suggested that research agenda should be defined by both clinicians and researchers working together as this practice can enhance research utilization. On the other hand, Jack[16] and Kearney[18] have shown that researchers need to conduct studies that are relevant to decision makers in order for the findings to be utilized. They pointed out the need for researchers to educate decision makers and practitioners about the relevance of the study and also develop

[17] Kottke, TE., Solberg, LI., Nelson, AF., Belcher, DW., Caplan, W., Green, LW., Lydick, E., Magid, DJ., Rolnick, SJ. and Woolf, SH. (2008) Optimizing practice through research: a new perspective to solve an old problem. Ann Fam Med, 6: 459-62.

[18] Kearney, MH. (2001) Levels and applications of qualitative research evidence. . Research in Nursing and Health, 24:145-153.

context specific strategies explaining how the findings could be utilized in practice. They also stress the need for strengthened interpersonal relationship between the researchers, policymakers, and practitioners, as a tool for bridging the research to policy gap[19].There are several frameworks, strategies and tools that may inspire and facilitate the development of a research to policy strategy at the national and sub-national levels. For example, a framework has been suggested [20,21], for identifying the supportive elements that are already in place and the missing elements that need to be strengthened or developed in order to link research to action. The framework focuses on general climate, production of relevant and reliable research, and mix of clusters of activities used to link research to action. Funding is an essential component that might pose challenges, especially to low- and middle-income countries, where funding comes from external actors as well as national bodies. External actors, such as international foundations or agencies, might have international goals instead of nationally-focused research goals.

Green et al.[22] suggest strategies and types of interventions to promote the use of evidence in policy-making. These are:

- Enhance supply of policy-relevant research products
  - o Ensure relevance of health policy and systems research: promote joint priority-setting exercises; translate policy problems into research questions and agendas

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[19] Lomas, J. (2007). The in-between world of knowledge brokering. BMJ. 334:129-132.

[20] Lavis, JN., Oxman, AD., Lewin, S. and Fretheim, A. (2009). Support tools for evidence informed health policy-making. Health Research policy and System [7]11.

[21] SUPPORT Tools for evidence-informed health Policymaking: http://www.health-policy-systems.com/supplements/7/s1. The complete series of 18 articles address challenges in supporting research use is published in the journal Health Research Policy and Systems, 2009 (edited by Andy Oxman and Stephen Hanney).

[22] Green, Andrew et al. (2007) Sound Choices. Enhancing Capacity for Evidence-Informed Health Policy. Geneva: WHO/AHPSR.

- Increase production and accessibility of evidence-based briefs: support development of policy briefs; support development of systematic reviews; publish briefs, evidence syntheses, and research summaries in an easily accessible form

- Enhance capacity of policy-making organizations to use evidence
  - Strengthen individual staff skills and institutional behaviours: provide training and mentoring in use of research evidence; create stronger incentives for evidence use
  - Increase financing for functions related to evidence use
  - Enhance access to evidence: improve access to research resources through improved internet access; development of low-cost databases of research evidence
- Establish new organizational mechanisms to support evidence use in policy
  - Develop and support knowledge broker capacity: establish knowledge broker organizations; establish networks for training and exchange of experience
  - Build health research capacity in, or close to policy organizations: establish health systems research units in health ministry or in organizations with links to ministries.
  - Promote formation of researcher-policymaker-practitioner networks for knowledge sharing for improved practice.

Crucial GRIPP strategies that have been identified for success are: research quality assurance, stakeholder involvement, as well as presentation and communication. Evidence-informed policymaking can be institutionalized through a formal process that begins with having and widely disseminating an evidence-to-policy strategic document, so that people could be held accountable for the policies and decisions they make.

Audience reflections

- Emphasis should be placed on the science content and teaching at the secondary school level and beyond. There are post graduate students with little practical exposure. Nigeria needs to go back to the basics of science. The country once had science clubs at the primary and secondary school levels; for the most part these are no longer available
- The need for capacity building in proposal writing, report writing, and product creativity should urgently be addressed
- Industries do not necessarily have to make the first step to approach scientists. Scientists need to sell themselves to the industry. Scientists have to practise research for the market place
- Entrepreneurship education is very important. Nigerian students should be made into employers
- Courses on communication for science students can help improve the journalist-scientist relationship in Nigeria.
- Standards and regulation are key. There is a need for equity in access and quality of education across the country.
- Majority of the publications produced by Nigerian universities are not demand driven.
- There is a need to work with communities when bringing innovation. Most of the time governments act as benefactors and not development partners. Nigeria's leaders need to realize that the country's purse belongs to all Nigerians. The spirit of nationalism needs to be created in the minds of every Nigerian. This will promote ownership of initiatives
- There should be greater collaboration among scientists on one hand, and between scientists and social scientists on the other

- Science journalism should be promoted and made more effective especially through collaboration between NAS and the Nigerian Institute of Journalism (NIJ).
- Science education at the early age of pre-primary, primary, and secondary school levels should be promoted
- Policymakers need to be educated through knowledge management on the principles of evidence generation. It will be helpful to involve them right from the conceptualization and design phases of research so they can advise on priority problem areas. Science without societal relevance is no science
- Extension agents should be widely employed and deployed to facilitate access and usage of research reports
- Efforts should be made to bridge the gap between science and policy formulation

CHAPTER THREE
THE STATE OF HEALTH, BIOLOGICAL, AND AGRICULTURAL SCIENCES IN NIGERIA

THE STATE OF HEALTH SCIENCES IN NIGERIA

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Health sciences provide the means of acquiring knowledge through teaching, learning, and research for the improvement of animal and human health. The application of this knowledge is through the healthcare delivery system. While the goal of health science is the improvement of health, how this knowledge is acquired, structured, disseminated, and utilized affects the health status of the population as well as the operations of the healthcare delivery system.

There are a few theories of disease causation. The sin/supernatural theory; where diseases are believed to be as a result of sin or supernatural forces. Although culture and beliefs play an important role in health, particularly mental health, this theory is not helpful in solving the challenges in the Nigerian health system. The crime theory of disease calls for the detention of infected individuals. In some cases, such as the recent Ebola Virus Disease (EVD) outbreak, quarantine of infected individuals is called for as they constitute a public health threat. However, treating victims of disease as culprits would not be of any benefit to public health. More cogent theories of disease include the germ theory of disease as well as the agent-host-environment concept which are generally more accepted theories. The germ theory of disease presupposed that for every illness there must be an agent of disease which is transmissible from one person to another. This theory has been helpful in throwing more light on communicable diseases but does not explain non-communicable diseases. In the agent-host-environment concept, disease occurs when there is an epidemiological triad of causal factors; disease spread requires a susceptible host and an infective agent, in an environment that brings them together.

Orthodox medicine came to Nigeria via the European traders and colonialists. The first true hospital in Nigeria was established by Reverend Father Juan Marie Coquard in 1895 and still exists today as Sacred Heart Hospital, Abeokuta. Between 1946 and 2014 a lot of health plans have been formulated to improve the Nigerian health system including the Walter-Harkness Ten-Year Plan of 1946, the first to fifth national plans spanning 1960-1995, the National Health Policy promulgated in 1988, and the National Health Act signed into law, December 2014. A common thread flows through these plans as they all seek to address the same problems. This implies that Nigeria has been unable to get a proper handle on the issues facing its health sector.

The Nigerian health system is organized in three levels; primary, secondary, and tertiary. The local government is the implementing level for primary health care, while both the state and federal governments are expected to provide both technical and financial support. State governments are expected to be responsible for secondary health care facilities while the federal government is expected to provide tertiary health facilities. Other principal actors in the system include; academic centres and teaching hospitals, research institutes, and private sector /non-governmental organizations.

The National Health Act signed into law in December 2014 has made legal provisions for the funding of basic and emergency health packages among others but it remains to be seen how faithfully the law will be implemented. A review of the allocation for health between 2012 and 2015 shows the maximum proportion of the national budget assigned to health was 6.1% in 2012 (Table 2). Over 80% of this allocation goes towards recurrent expenditure; essentially to pay salaries of health workers with little left over for operationalizing the system and capital development. Aside from the issue of inadequacy of funds, misuse and wastages are also prevailing factors. Furthermore, the health per capita expenditure of Nigeria is relatively low when compared with countries in the developed world (Table 3). It is therefore not surprising that there

are gaps in the quality of healthcare delivery and the health outcomes (Table 4). Other challenges facing the Nigerian health system include inefficient utilization of resources -both allocative inefficiency and disruptive utilization of resources, insufficient inter-sectoral collaboration, and top-down planning as opposed to bottom-up planning. Despite these challenges, there have been a few surprising achievements: On the 15th of January 2014, Nigeria was certified as a guinea worm-free country and the country was certified Ebola-Free on 23rd October 2014 within 3 months of the importation of EVD into Lagos.

Table 2: Federal Health Budget 2012-2015 (Source: Annual Budgets from Budget Office of the Federation)

Year	Amount Appropriated to Health	Recurrent as proportion of Health (N Billion)	Capital as proportion of Health Budget (N Billion)	Health Budget as Proportion of Total Federal Budget
2012	284.9 Billion	224 (78.6%)	60.9 (21.4%)	284.9/4,690 (6.1%)
2013	279.8 Billion	219.7 (78.5%)	60.1 (21.5%)	279.8/4,980 (5.6%)
2014	263 Billion	214.9 (81.7%)	49.3 (18.3%)	263/4,600 (5.71%)
2015	257 Billion	237 (92.2%)	20 (7.8%)	257/4,300 (5.97%)

Table 3: Comparison of Health Expenditure of Selected Countries (WHO Statistics 2014)

Country	Per Capita Health Expenditure (US$)	Government Expenditure as % of Total Health Expenditure	Private Expenditure as % of Total Health Expenditure	Out-of-Pocket Expenditure as a % of Private Expenditure on Health
Sweden	5,419	81.6	81.6	81.6
Netherlands	5,997	79.5	79.5	79.5
United Kingdom	3,659	82.8	82.8	82.8
United States of America	8,467	47.8	47.8	47.8
South Africa	670	47.7	47.7	47.7
Ghana	83	55.9	55.9	55.9
Liberia	59	29.7	29.7	29.7
Benin	34	52.1	52.1	52.1
Cameroon	64	34.7	34.7	34.7
Niger	25	33.2	33.2	33.2
Nigeria	85	34	34	34
Chad	25	29.6	29.6	29.6

Table 4: Comparison of Health Outcomes of Selected Countries (WHO Statistics 2014)

Country	Infant Mortality Rate /1000 Live Births	<5 Mortality Rate/1000 Live Births	Maternal Mortality Ratio/100,000 Live Births	Life Expectancy (years)
Sweden	2	3	4	82
Netherlands	3	4	6	81
United Kingdom	4	5	8	81
United States of America	6	7	28	79
South Africa	33	45	140	59
Ghana	49	72	280	62
Liberia	56	75	640	62
Benin	59	90	340	59
Cameroon	61	95	590	56
Niger	63	114	630	59
Nigeria	78	124	560	54
Chad	89	150	980	51

As Nigeria moves into the future, the focus of the health system should shift to preventive rather than curative care, healthcare decision making should be transferred to the local level. Telemedicine and related mobile-phone technology need to be more utilized as a dominant way of delivering healthcare advice and treatment. Public Private Partnership models should be adopted to enhance availability of quality and relevant health services, and there should be support for innovative financing mechanisms to enhance universal coverage, giving all Nigerians access to a basic package of benefits. A wholesale restructuring of Nigeria's healthcare systems will be necessary over the next ten years, including strong measures to expand access to healthcare, eradicate treatable illnesses, and manage chronic conditions. The science is already known but political will and commitment is required at all levels.

THE STATE OF BIOLOGICAL SCIENCES IN NIGERIA

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The biological sciences primarily comprise of botany, biochemistry, physiology, pharmacognosy, and zoology. Other science subjects usually considered under this grouping include agriculture, medicine, nature studies etc. An analysis of the current state of biological sciences at various levels in Nigeria reveals a system riddled with imperfections. At the primary level, nature studies have very nearly been jettisoned and early childhood biological sciences education is under developed. At the secondary level, the emphasis seems to be on passing examinations. Students are exposed to just enough science to get them through to the next level and science is not viewed as a tool for life. Biological science education at the tertiary level is marked by little practical exposure; teaching is largely theoretical (done in the classroom) and students spend little time in the available ill-equipped laboratories. Although the Student Industrial Work Experience Scheme (SIWES) is a good step to ensure that students are exposed to the practical applications of science, it is inadequate to imprint the desirable translational training as the foundation of science is already faulty.

Nigeria's present approach to biological science education and training is flawed and not based in reality. It thwarts the natural preparative imprint function of the formative years and produces unskilled and unemployable products. The implications of this broken system include: the production of youths and graduates that don't see the benefit of education, unengaged youth who have plenty of time for vices, national economic ineptitude and stagnation, dependence on other nations for food, medication and technology, unemployment, sedentary lifestyle, as well as poor health. It is therefore time for a national departure from the current system. A proposed alternative model is the Partial

Deschooling and Apprenticeship (PaDA) educational model. In this educational system, students would spend half a day in the classroom and the other half as apprentices with a producer-mentor. The ideology of PaDA is not new; it has existed since the 14th century where the goal was to be self-employed after apprenticeship. This is unlike the situation today where students view education as a means to be employed into a fantasy job. The millennia ahead provide the time and opportunity to initiate a change in biological sciences education. Failure to do this will subject future generations of Nigeria to undue hardship.

Primary school pupils are at the age of concrete operations. The more hands-on concrete operation they are engaged in, the easier it is to build the abstract operations stage at the secondary and tertiary levels. At the primary school level, pupils should be exposed to the 'hows' and 'whys' of hygiene, nature studies, domestic sciences, home biology, home chemistry, home physics. Secondary school is the age of abstract reasoning. In their transition from concrete to abstract operations, their biological sciences should be largely field/practical-based. Where a suitable field is not accessible they should be taught by audio-visual excursions into applicable and applied biological sciences. It may be necessary to rewrite textbooks designed for the PaDA model. Such books should take care of both the campus and field/workshop teaching and training instructions. In tertiary institutions (universities, polytechnics, Colleges of Education, Schools of Nursing, etc.) students should be taught and trained using the gown-town system. In the classroom they should be taught how biological systems work and in the field, they should be tasked and challenged to apply their classroom training to solving economic issues. During Masters Degrees education in a biological science, a candidate should choose a specialization, spend a semester as an apprentice understudying what professionals in that specialty do, how they do it, why they do it, and the limitations of their operations. The student then returns to the classroom/laboratory to practise solutions to the deficiencies earlier noticed. A PhD in a biological science should be jointly designed by the candidate, his or

her industry-based supervisors, and the university-based supervisors. An industrial issue must be addressed and translationally solved to be awarded a PhD. There will be a need to co-axiate the communication media. All available forms of media must be employed for the purpose of teaching/training.

The adoption of PaDA or a similar system would yield the following benefits:

1. Sequestration from realities during the formative years of life would be avoided.
2. Through the continuous interaction with production during the schooling years, every product/graduate would naturally adopt a profession and job of interest.
3. Job seeking, ineptitude, disinclination, and disorientation would be avoided.
4. Active engagement of students will result in lifestyle that would produce a healthy society.
5. National wealth would be guaranteed through creative production.
6. Gainful employment would reduce social stratification.
7. There would be decrease in social vices.

Decades after independence, Nigeria still needs to consider detachment from some vestigial components of colonial education. Nigeria does not have to adopt educational policies and practices of other nations when we can be ingenious to blaze the trail, at least at solving our own present and future needs. Nigeria's current biological sciences are taught to produce white-collared job seekers. There is a need to redefine and redirect our approach by PaDA, or some form of PaDA.

THE STATE OF AGRICULTURAL SCIENCES IN NIGERIA

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Nigeria is an agrarian country with agro-ecological zones suited to the production of diverse crops and livestock. In the 1960s, agriculture contributed 65 - 70% of Nigeria's total exports. This declined to 40% in the 1970s and to less than 2% in the 1990s. The reason for the sharp decline was the steep rise in crude oil revenue in the 1970s[23,24]. The state of the agricultural sciences in Nigeria can be evaluated based on the state of agricultural education, the state of agricultural research, and the state of agricultural productivity. In turn, these three are influenced by the political and socio-economic history of the country.

Between 1861 and 1960; the colonial period, there was no formal policy on agriculture and agricultural education in Nigeria. In 1893, the first major action was taken with the establishment of a botanical research station in Lagos which was later moved to Moor Plantation, Ibadan in 1905. In 1912, a department of agriculture was established in the Southern (Ibadan) and Northern (Samaru) protectorates. This was followed by the establishment of colleges at Moor Plantation and Samaru, Zaria in 1921 and 1931 respectively, as well as the Agricultural Oil Palm Research Station in 1939. Between 1950 and 1957, three commodity-based institutes were established to provide raw materials for the home industries of the colonial masters. These were the West African Institute for Oil Palm Research, West African Cocoa Research Institute, and the West African Stored Products Research Unit.

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[23] Omorogiuwa, O., Zivkovic, J. and Ademoh, F. (2014). The Role of Agriculture in the economic Development of Nigeria. European Scientific Journal. 10:133-146.

[24] NBS (2015) National Bureau of statistics: Agricultural Statistics. 2012-2014 http://nigerianstat.gov.ng/pa

Post-independence, more agricultural institutions have been added to the country's repertoire including the Institute for Agricultural Research (IAR), Nigerian Stored Products Research Institute (NSPRI), Cocoa Research Institute of Nigeria (CRIN), Nigerian Institute for Oil Palm Research (NIOPR), Rubber Research Institute of Nigeria (RRIN), Institute of Agricultural Research and Training, Nigerian Council for Science and Technology, Agricultural Research Council of Nigeria (ARCIN), National Cereals Research Institute (NCRI), National Horticultural Research Institute (NIHORT), Forestry Research Institute of Nigeria (FRIN), National Veterinary Research Institute (NVRI) etc. In addition to the agricultural institutions, federal, state, and private universities have faculties of Agriculture. There are federal and state Colleges of Agriculture that grant OND and HND certificates. Agricultural universities have been established in Abeokuta, Makurdi, Umudike, as well as Universities of Technology with faculties of Agriculture at Akure, Minna, and Owerri.

Western education was introduced in Nigeria with the coming of Christianity. In 1948, the Education Ordinance - the first educational legislation that covered the whole country was adopted and by1952 this Ordinance empowered the regions of the country to develop their educational policies. Between 1955 and 1957 education laws were promulgated in the regions and Lagos. Pre-independence, the colonial educational system had clearly defined roles for the state and missionaries in the governance of education and it was geared toward producing manpower for the civil service. Post-independence, the educational system was plagued by irrelevant curricula, obsolete methods, high drop-out and repetition rates, as well as graduates that were dependent and low on initiative. In 1969, a National Curriculum Conference took place to review the educational system and its goals as well as change the colonial orientation of the Nigerian education system. In 1973, a seminar was organized to deliberate on a truly Nigerian national education policy. A report of the outcomes of the seminar was presented as the draft National Education Policy. During this

period, the federal government took over mission schools and education was regarded as a huge government venture and no longer a private enterprise. Education was promoted as a huge government enterprise without consultation with local communities on children's education most suited to their peculiar circumstances e.g. Muslim north. There was a departure from the colonial educational policy of financing education/ cost sharing between the proprietary bodies, local community, parents/ guardians, and the government.

In 1979, the National Policy on Education was revised and education was placed on the concurrent legislative list. Primary education was now a joint venture between state and local governments, with the local governments responsible for teachers' salaries. The policy was again revised in 1981 and it was proposed that the government would make Universal Primary Education (UPE) compulsory as much as possible. The National Policy on Education was once again revised in 1998 and 2004. The latest revised educational policy; the 4th Edition, laid the foundation for the 6-3-3-4 system of education, and made education in Nigeria the government's responsibility in terms of centralized control and funding of education[23].

The consequences of the frequent changes of government and government policies on the performance of national agriculture programmes are shown in the Table 5.

Table 5: Performance of National Agricultural Programmes in Nigeria[26,27,28]

Year	Programme	Outcome
1972	National Accelerated Food Production Programme	Unsustainable because of funding withdrawal
1973	River Basing Development Authorities	Unsustainable because of intense political interference, wastage of funds
1975	Agricultural Development Projects	Initially successful, but later became ineffective for many reasons including shortage of funding and withdrawal of support by World Bank
1976	Operation Feed the Nation	Not sustainable because of indiscriminate use of farmlands and inexperienced and untrained participants
1980	Green Revolution, more or less a continuation of OFN	Not sustainable because of delay in executing projects, no monitoring, no evaluation, wastage of funds outcome
1986	Directorate of Food Road and Rural Infrastructure (DFRRI)	Failed because of poor infrastructure, mismanagement of funds, lack of focus and programme accountability
1992	National Fadama Development Project (NFDP)	Relatively successful counterpart funding provided by World Bank
2003	National Special Programme for Food Security (NSPFS)	Many problems including loan repayment default by beneficiaries complexity and incompatibility of innovation, high cost of farm inputs etc.

Currently, education in Nigeria has become a huge government enterprise with little participation by the private sector. This is in contrast to the cost-sharing formula of the colonial era and the period immediately after independence. The education sector

[26] Ojo, EO. and Adebayo, PF. (2012). Food Security in Nigeria: An overview. European Journal of Sustainable Development. 1:199-222.

[27] Sasson, A. (2012). Food Security for Africa: an urgent global challenge. Agriculture and Food Security 1:2 doi:10. 1186/2048-7010-1-2

[28] Agber, T., Iortima, PI. and Imbur, EN. (2013). Lessons from implementation of Nigeria's past National Agricultural programmes for the transformation agenda. American Journal of Research Communication. 1:213-253.

(including agricultural education and research) is in crisis due to grossly inadequate funding. Most importantly, there is a wide leadership deficit in the management of the Nigerian system, especially the agricultural system, with all the implications for political and socio-economic development of the country. Not surprisingly, the training and research institutions are not faring better. The inadequate and unsustainable patterns of funding have led to: student enrolment often greater than the capacity of the institutions to handle, general decline in the quality of education, decrepit infrastructure in the universities, colleges, and research institutes, as well as poor and outdated teaching and research facilities. All these have led to a lower level of research and teaching outcomes in the agricultural sciences[29].

Looking forward, both government and scientists have a role to play. For the Nigerian government:

1. There is a need for change in the governance system. It is generally believed that corruption is the bane of political and socio-economic underdevelopment of the country.
2. Government's role in agricultural research should be re-defined to include the decentralization of decision-making processes, identifying new funding sources and mechanisms.
3. The sustainability of the agricultural production programmes should not depend on donor agencies such as the World Bank. Donor funds should only supplement national efforts.
4. The role of the private sector should be defined and strengthened. For example, research on industrial crops should be funded and driven by local industries that use these crops.
5. The national agricultural research institutions should be strengthened in terms of infrastructure and especially in terms of high level manpower.
6. The mechanism for funding of education (including agricultural education) should be revisited. A cost-sharing system between government, parents/guardian, and the local community should be devised.

Likewise, these recommendations will be useful for Nigerian universities and research institutes:

1. A culture of good governance must be entrenched in Nigerian training and research institutions in terms of transparency in the management and administration of resources.
2. The universities should articulate institutional goals and objectives that can be used to solicit for funding support from donors.
3. Universities should revisit their curricula with a view to introducing innovative courses that have entrepreneurial potential.
4. Faculties, Colleges, and Departments should be requested to set objectives for their research and outreach activities.
5. The managements of institutions should strive to improve the work environment in terms of provision of facilities for teaching, learning, research, and opportunities for professional improvement.

In conclusion, both government and the training and research institutions must address the problems facing agricultural sciences so that Nigeria does not continue to miss out on the modern cutting edge scientific advances that are being made in other regions of the world.

Audience reflections

- Presently, Nigeria's health system employs supply-side economics; with patients chasing the money, and not demand-side economics where the money chases the patients. So whether health care providers work or not, they are paid. If a different mechanism is used there may be different results. This would also help address the issues of frequent strikes in the health sector
- Ethics need to be emphasised in the training of health care professionals. If 10% ethics can be achieved, most of the problems in the sector would be resolved. The regulatory bodies charged with monitoring ethics should do what they have been mandated to do
- Nigerian scientists don't like to work in teams. It is time to stop pointing fingers outwards and for scientists to play their part
- Primary healthcare is the centre of any health system. A country that fails to step up primary health care is wasting time with any other health reform. This is the case with Nigeria. There is no functional primary health care in this country
- Nigeria's real problem in not fully understanding the meaning of team work. If this concept was truly understood, it would not be difficult for various cadres of health professionals to work together. If the various players in the health sector are duly integrated and recognized, the current challenges would be surmounted
- There is a need to go back and address the problems of the Nigerian health system from the ground up. Territorial and geographical responsibilities of health centres should be defined and local management allowed. This would reduce the burden on the tertiary institutions

- One of the outcomes of this summit should be to formulate strategies for interdisciplinary research between the life and applied sciences. It is only when this is done that true innovation can be achieved
- Agricultural research in Nigeria, more than any other discipline of science, should be demand-driven. Most of our challenges can be resolved by agriculture. But despite the volume of agricultural research, challenges remain
- The time and effort involved in the agricultural sciences seems to be a deterrent to prospective students. A reorientation is needed to change this
- Research should be intensified on Nigeria's biodiversity especially those of plant origin to establish their role in the causation and treatment of diseases.
- Inter-professional rivalry and animosity in science-based disciplines should be eschewed and replaced by greater harmony and cooperation

CHAPTER FOUR
THE STATE OF ENGINEERING, PHYSICAL, SPACE, AND MATHEMATICAL SCIENCES IN NIGERIA

THE STATE OF ENGINEERING SCIENCES IN NIGERIA

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Engineering has been defined as the application of the theory and principles of science and mathematics to research and development of economical solutions to technical problems[30]. Engineering practice involves the use of systematic processes to define and resolve problems, making use of specialized knowledge. Therefore, engineers receive professional education through which they acquire a body of specialized knowledge, problem-solving skills, and good judgement to serve the society. The specialized knowledge that an engineer requires for practice needs to be updated regularly through continuing professional education.

Science-based knowledge is generally called "engineering sciences." Engineering sciences provide mathematically-based and conceptual theoretical tools for the engineer and they consist of a "specific combination of mathematics and science around particular engineering domains"[30]. Thus, engineering sciences vary by engineering discipline. Based on the knowledge of engineering sciences, an engineering analyst uses models to analyse candidate solutions proffered for an engineering problem and to predict performance so that the best candidate solution can be selected. An engineer also uses the knowledge of engineering sciences to carry out detailed design calculations of components of an engineering system. It has been reported that engineering can be distinguished from physical sciences by observing that physical and chemical investigations do not aid in understanding the operational principle of a machine, structure, or an engineering

[30] Sheppard, S., Colby, A., Macatangay, K. and Sullivan, W. (2006). What is Engineering Practice? Int. Journal of Engineering Education. 22(3) : 429 - 438.

system[31]. Relevant engineering sciences help with understanding a machine as expressed by its operational principle.

There are five general areas of study for any engineering discipline at the undergraduate level; communications, social studies, and humanities; mathematics and basic sciences; the engineering sciences; design-systems synthesis and engineering specialization; and development of the capacity to solve complex technological problems through creative design and research[32]. In the first year of a five-year bachelor degree programme in an engineering discipline, a student takes courses in mathematics and natural sciences. From the second year, most of the courses taken are in the engineering sciences. Out of the 56 credits units prescribed as general engineering courses to be taken from 200 - 500 levels in the COREN Benchmark Minimum Academic Standards (BMAS)[33], 21 credits (37.5%) are for courses in engineering sciences while 12 credits (23%) are for mathematics and statistics courses. The percentage of engineering science courses listed in COREN BMAS varies from 55.2% for civil engineering to 88.8% for communication engineering showing that most of the hours spent by the students receiving lectures and carrying out practical work are spent on engineering sciences relevant to that discipline.

Many universities in Nigeria now run postgraduate programmes in engineering. The course work and research are largely in engineering sciences. Some postgraduate students go to research institutes to make use of state-of-the-art equipment not available in their universities. An example of such research institutes is Engineering Materials Development Institute (EMDI) at Akure,

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[31] Hoppmann, WH. II, Liu, JCC. and Rivello, JR.(1980). Models of Professions: Law, Medicine and Engineering. Mechanical Engineering

[32] Shanahan, WF. The Engineering Career Guide. (Arco Publishing, Inc., New York, 1982. P. 2).

[33] Council for the Regulation of Engineering in Nigeria (COREN), Benchmark Minimum Academic Standard (BMAS) and Accreditation Scoring Criteria for Undergraduate Engineering Programmes in Nigerian Universities, June, 2014.

one of the institutes established by National Agency for Science and Engineering Infrastructure (NASENI). Some universities, through the TETFUND project, are now acquiring some of these state-of-the-art equipment but academic and technical staff need to be trained to use the equipment. A few private laboratories are available in Nigeria to render laboratory services to postgraduate students and other researchers. COREN is compiling a list of state-of-the-art equipment available in Nigeria and where they are located to help researchers in engineering science know where they can go to make use of the equipment they need, if it is available in the country. Some postgraduate students in Nigerian universities are able to go to universities in developed countries for a few months to do some of their research work, especially laboratory work. Many universities, especially those who have signed Memoranda of Understanding (MoU) with Nigerian universities, have their doors open for such collaboration if funding is available for the researcher from Nigerian universities.

It has been observed that one of the mathematical difficulties that are encountered in engineering sciences is nonlinearity[34]. The nonlinear differential equations used to model complex engineering systems have usually been solved by numerical methods on computers. Several commercial numerical codes are now available. It appears there is a paradigm shift from the postgraduate student writing his own computer programme to making use of commercially available software packages in his research. Some lecturers believe that using commercial codes requires some skills too and that it frees the student from focusing on writing computer programme so that he can concentrate more on the engineering problem. However, the absence of supercomputers or high performance computing facilities in Nigeria still needs to be addressed.

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[34] Biot, MA. Applied Mathematics: An art and a science. Journal of the Aeronautical sciences. May 1956: 406 - 411.

Over the years the relationship between industries and academia in Nigeria has been very poor. Industrialists in Nigeria should stimulate research in engineering sciences relevant to their needs by making use of human resources in tertiary institutions of learning and research institutes to solve their problems. Such collaboration will also help to move what is developed through research in engineering sciences to marketable products. The current effort by the Committee of Deans of Engineering and Technology in Nigerian Universities (CODET) in reaching out to the Manufacturers Association of Nigeria (MAN) is a move in this direction.

Since many universities are now being approved for take-off and many of them are interested in running engineering programmes, there is a shortage of manpower for teaching engineering sciences. Training of more lecturers at the Ph.D. level can be accelerated by providing funding for Ph.D. students being trained in Nigerian universities to visit research laboratories for 3 to 6 months in foreign universities in order to carry out some of their work. Post-doctoral fellows who completed their Ph.D. work in Nigerian universities can also be sponsored for such visits to universities in developed countries. A lot more financial support by government and the private sector is necessary for engineers in Nigeria to make use of engineering science knowledge to solve Nigeria's problems.

THE STATE OF PHYSICAL AND SPACE SCIENCES IN NIGERIA

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The physical sciences consist of physics, chemistry, mathematics, computer science, geology, statistics, and space science. Physics, chemistry, and mathematics are the foundation on which science and engineering are built, while computer science and statistics are tools that simplify studies and research in science, engineering, and all human activities. The major tasks of the physical sciences in general are to conduct fundamental research to discover hidden phenomena in the universe and applied research utilizing these fundamental discoveries for technological, human, and economic development. These subjects are expected to play three roles:

1. Supply basic foundation to all other sciences and engineering subjects.
2. Create opportunities for conducting fundamental research to understand phenomena in the universe.
3. Enable applied research leading to technological and economic development.

The contributions of fundamental and applied research to mankind are enormous. Fundamental research in physics and astronomy led to the discovery that the moon is the natural satellite of the earth, to the discovery of solar cells by physicists, as well as the construction of rockets and missiles through the application of Newton's third law of motion. Applied research by physicists, computer scientists, and engineers led to the design and construction of artificial satellites that provide various services to mankind, and designs for collecting and storing solar energy for various uses.

There are quite a few challenges confronting the physical sciences

in Nigeria. These challenges can be divided into three categories, namely: science and engineering training challenges, fundamental research challenges, and applied research challenges. The science and engineering training challenges refers to issues surrounding Nigerian capacity to equip its would-be scientists and engineers with the satisfactory physics, chemistry, and mathematics foundation needed for their profession. Unfortunately, the country is currently unable to cope with the extremely large number of students due to poor infrastructural facilities, lack of modern devices, inadequate manpower, as well as a decline in the standard of teaching.

Very little is known about the universe and it is more than likely that there are many more valuable and revolutionary discoveries yet to come through fundamental research. Fundamental research requires standard relevant equipment and well trained human resource to conduct front-line research experiments and observations. In Nigeria, fundamental research is declining because of the less than supportive attitude of the government. They seem unable to see the economic benefits of fundamental research as they are usually long term endeavours which require patience. Long term investments in fundamental research will eventually lead to surprising results with tremendous unexpected spin offs, discoveries, capacity building, and economic value.

There are a number of researchers in Nigerian universities and research institutes doing well with a combination of facilities at home and abroad. They need support and encouragement from the government. Recently, Nigeria became an International Astronomical Union (IAU) Node in West Africa for training young astronomers. Also, the United Nations plans to make Nigeria a regional centre for space weather monitoring. The Obafemi Awolowo University (OAU) Ile-Ife has been serving as a Centre for Space Education in Africa for a number of years now. The Centre for Basic Space Science (CBSS) has also initiated an excellent collaboration with the military and China on Unmanned Aerial Vehicles. However, this project has been abandoned due to lack of funding. Furthermore, Lagos is the National Space Research and

Development Agency (NASRDA) centre for transport and propulsion but has not made much progress due to poor funding. The centre for Remote Sensing in Jos has carried out a lot of collaborative work with universities and other institutes in Nigeria and has produced valuable images. The Nigerian Meteorological Agency (NIMET) has made tremendous contributions in meteorology, Saharan aerosols, and weather forecasting research. Researchers in Nigerian universities have carried out research in atmospheric sciences, radio propagation, and climate changes through their own efforts and collaboration with foreign partners. A Nigerian woman, Professor Francisca Nneka Okeke from UNN, won the prestigious L'Oréal - UNESCO Award for Women in Science in the physical sciences in 2013. She is a laureate representing Africa and Arab states from the five continents in the world. The Award is for her discoveries in geomagnetism and their effects on climate change.

It is not easy to originate new applied research as defined above. Collaboration between universities, industries, research institutes, and oversea countries should be intensified for this to happen. A lot of effort is being put in, by bodies such as: NASENI, Scientific Equipment Development institute (SEDI), Projects Development Institute (PRODA), Raw Material Research and Development Council (RMRDC), and Energy Commission of Nigeria (ECN), though the output is not as expected. Part of the problem is poor allocation and non-release of funds. There is need to redefine priority areas and fund them fully. In general, Nigerian scientists are putting in a lot of effort but funding is extremely poor and there are difficulties in accessing budgeted funds.

To move the physical sciences forward in Nigeria, it is time for action and implementation. The government should set up a high powered committee made up of NAS, university experts, National Universities Commission (NUC), National Board for Technical Education (NBTE), research institutes, and industries to prepare a

10-year road map for the physical sciences. This committee would:

1. Identify the best way to lay a sound foundation for our scientists and engineers and how to cope with the ever increasing number of students.
2. Identify the research direction and priorities in the physical sciences, taking into consideration culture, environment, and local needs, as carried out recently in the Nigerian health care system by the World Health Organization (WHO) and NAS.
3. Consider the creation of six Centres of Excellence for physical sciences.
4. Create linkages between university, private/public industries, and local communities in order to make discoveries and innovations that will boost the economy.
5. Intensify efforts to embark on applied research, be it original or replication. There are a lot of opportunities in the areas of chemistry, computer science, and physics for manufacturing.

THE STATE OF MATHEMATICAL SCIENCES IN NIGERIA

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The mathematical sciences include mathematics and other academic disciplines that are primarily mathematical in nature but may not be universally considered subfields of mathematics proper. Statistics, for example, is mathematical in its methods but grew out of scientific observations which merged with inverse probability and grew through applications in the social sciences, some areas of physics, and biometrics to become its own separate (though closely allied) field. Computer science, computational science, population genetics, operations research, cryptology, econometrics, theoretical physics, and actuarial science are other fields that may be considered part of mathematical sciences. Mathematics is unquestionably the language of science and the only universal language. It is universally acknowledged that mathematics is the bedrock of all scientific and technological breakthrough and advancement. This indispensable subject area needed for any scientific and technological advancement has gradually developed over the years in Nigeria in both education and research.

The development of interest in mathematical sciences takes root at all levels of education. This needs to be planted in the pre-primary level (nursery), the germinated seed nurtured in a very tender and fragile manner in the primary level, while it is properly guarded and fertilized to grow in the secondary school level. Maturity and fruits will then be gladly expected in the tertiary level and beyond. A veteran Nigerian Mathematics educator, Professor R. Ogbonna Ohuche surveyed the achievements, trials, and tribulations of school mathematics in Nigeria for the period

[35] Ogbonna RO. (1978). Change in Mathematics Education since the Late 1950's: Ideas and Realizations: Educational Studies in Mathematics, An ICMI Report. Part II. 9(3): 271-281.

October 1, 1957-September 30, 1977[35]. During the period of Ohuche's review, Nigeria was going back and forth on whether to teach modern mathematics curriculum in primary and secondary schools or to suspend it at primary school and teach arithmetic; and de-emphasize it in secondary school. Ohuche concluded "Yet we need to introduce system-wide in our educational institutions the type of mathematics curriculum which should ensure that Nigeria be not left behind by other countries as the countries of the world strive in their various ways to maximize the fruits of technology. What Nigeria should do is to use the NERC to plan and implement a teacher education programme that would help to teach the mathematics demanded of the age. Nothing short of this can suffice". In 1981, Professor Sam O. Ale[36] complemented Professor Ohuche's result by considering the problems of school and university mathematics as they relate to teachers. Ale corroborated Ohuche's conclusion and further noted that "if mathematics education is to be encouraged, then massive expansions in educational programmes (as in the case of Nigeria) calls for massive mathematics teacher education programmes. Not until then will the difficulties facing the teachers (and, consequently, the teaching) of mathematics be solved". Since then, a lot of positive and negative changes have taken place in Nigeria's educational system and mathematics education has also been so affected.

Currently, mathematics curriculum at the various levels of education is no longer the main problem given the amount of positive reforms that have been injected into it. The first national mathematics curricula for primary and secondary schools used in the country were developed in 1979 when Nigeria operated the 6-5-4 (6 years of primary, 5 years of secondary and 4 years of tertiary) system. In 1982, the 6-3-3-4 (6 years of primary, 3 years of junior secondary, 3 years of senior secondary and 4 years of tertiary) system was introduced and, consequently, in 1986 the secondary school curriculum (including mathematics) was revised to be consistent with the 6-3-3-4 system. The 6-3-3-4 system, according

[36] Ale, SO. (1981). Difficulties facing mathematics teachers in developing countries: A case study of Nigeria. Educational Studies in Mathematics. 12 (4).

to experts, was designed to inject functionality into the Nigerian school system, by producing graduates who would be able to make use of their hands, head, and heart (the 3Hs of education). In 1999, the government launched the Universal Basic Education System (UBE) which stipulated 9 years of uninterrupted schooling consisting of 6 years of primary school, 3 years of junior secondary school, then a follow up 3 years of senior secondary, and 4 years of tertiary education. Thus, in 2007 a new national mathematics curriculum for basic education (the first compulsory 9 years of 6 years primary and 3 years junior secondary) was developed. The 9-year Basic Education Curriculum (BEC) in all subjects, including mathematics, came into use in Nigerian schools in September 2008 starting with Primary 1 and Junior Secondary 1 classes. Targets of the National Economic Empowerment and Development Strategies (NEEDS), the Millennium Development Goals (MDGs), and Education For All (EFA) were included to ensure that the curriculum reflected global best practices.

Feedback in the implementation of BEC suggested that the curriculum was overloaded in terms of the number of subjects offered at the basic education levels. Besides, a major outcome of the Presidential Summit on the state of education in Nigeria, held on the 4th and 5th of October 2010, was the need to reduce the curriculum subjects at the basic education level in line with international best practices. In some countries such as Kenya, Tanzania, USA, Malaysia, and Indonesia, subjects offered range between 6 and 9. Consequently, NERDC was mandated to revise the 9-year BEC in line with the recommendation of the Summit. In the process, mathematics retained its stand-alone status because it is a fundamental discipline for scientific and technological development and is important in everyday life. The resulting revised mathematics curriculum for basic education was focused on giving children the opportunity to acquire the mathematical literacy necessary to function in the information age, cultivate the understanding and application of mathematics skill and concepts necessary to thrive in the ever changing technological world, develop the essential elements of problem solving, communication, reasoning, and connection, as well as understand the major ideals

of mathematics.

Great emphasis is placed on quantitative reasoning and application of mathematics contents to everyday life. Hence the inclusion of recent national and global issues such as security education, disaster risks reduction, education, and climate change. The Revised BEC 2012 came into effect in Nigeria in Primary 1 and JSS1 in September 2014 and is being implemented progressively and step-wise annually. Similarly, the senior secondary school curriculum has undergone a series of revisions; the latest being the revision in line with the 6-3-3-4 model. The revised SSS mathematics curriculum was prepared to ensure a smooth transition from secondary level to tertiary level of mathematics curriculum, and to remove the dichotomy between the old senior secondary Mathematics curriculum and the Mathematics curriculum of commercial, technical, and vocational schools. The following are the unique features of the content areas of the revised curriculum:

1. The senior secondary school mathematics curriculum has been infused with modern topics which are relevant to the global world and meet up with the challenges of the MDGs. Obsolete techniques in the old curriculum such as the use of slide rules have been dropped while the logarithm table as calculating aid is being de-emphasized with the hope of totally replacing it with scientific calculators and other modern calculating devices and computer-assisted instructional materials like semi-programmable calculators.
2. The revised senior secondary school mathematics curriculum includes some topics in logic, matrices, modular arithmetic, and scientific calculators which in the old curriculum were restricted to Further Mathematics but which will enhance the competence of students in the various vocations they will pursue at the tertiary level. It accommodates the needs of students in the commercial and technical subject areas by including such content areas as annuities, amortization, and sinking funds.
3. The curriculum reflects continuity with those used in

universities, polytechnics, Colleges of Education and Colleges of Science and Technology. In general, the revised curriculum aims at linking the knowledge of mathematics to industry. Hence, applications of mathematics to health, finance, population, capital market, and commercial activities are required in the curriculum.

4. Although both the old and the revised mathematics curricula are thematic, in the revised curriculum, the themes have been rearranged into four instead of the six themes in the old curriculum. Plane geometry, trigonometry, and mensuration have been merged to form Geometry. Also, Probability is now contained in statistics.
5. Computer Studies/ Information and Communication Technology (ICT) was also introduced as one of the five compulsory subjects.

In evaluating the state of mathematical sciences education, the contributions of associations like the STAN (formed in 1957) and the Mathematical Association of Nigeria (MAN) (formed in 1962) cannot be overlooked. STAN and MAN have contributed greatly in nurturing the curriculum as well as providing interesting and inspiring textbooks in mathematical sciences especially at the primary and secondary school levels.

In spite of the development and introduction of robust education curriculum in mathematical sciences at these levels of education, poor management and implementation of policies has left Nigeria struggling. The system seems to be ailing especially in the area of motivating and inspiring trained mathematical science educators and teachers and in the area of aggressive development of qualified manpower to handle the curriculum. Nigeria is in a situation where there is a general agreement that the country is not yet where it wants to be and there is still much room for improvement.

The teaching of all programmes in Nigerian universities is regulated and, to a large extent, overseen by the NUC. The NUC usually assembles experts to prepare BMAS for each programme and regularly enforces the teaching of such programmes through

the accreditation exercise. The introduction of new programmes is also usually through NUC after approval by the University Senate. The quality of teaching depends on many variables and varies from university to university. Areas of strength depend on manpower and certainly there is no university that can boast of complete and adequate manpower. Recently, the NUC has also started accreditation of postgraduate programmes in Nigerian Universities. They started in August 2014 with Administration and it is based on the BMAS which became operational in 2011. The result of this initial exercise is not out. The BMAS for mathematical sciences programmes, like M.Sc. and Ph.D. in mathematics, statistics, computer science, and other related areas, are also available. The NSM has raised many salient issues on the BMAS for M.Sc. in Mathematics although these have not been relayed to the NUC. A very important question that must be answered is "how will the universities obtain the manpower to adequately teach those programmes?" Certainly, a good M.Sc. programme must adequately cover the core areas of mathematics-Abstract Algebra, Real Analysis, Topology, and Complex Analysis. Unfortunately, no Nigerian university has Ph.D. holders who are current with the trend of things in these four areas. Many of the universities do not have a Ph.D. holder in any of the core areas.

Just as NUC regulates universities, polytechnics and Colleges of Education have their regulating bodies-National Board for Technical Education NBTE and the National Commission for Colleges of Education (NCCE) respectively. The problem remains the inadequate number of motivated and inspired manpower to deliver the courses in the programmes.

Indigenous contemporary mathematics research activities in modern Nigeria were pioneered by Professor Chike Obi (April 17, 1921 - March 13, 2008), Professor Adegoke Olubummo (April 19, 1923 - October 26, 1992), and Professor James Ezeilo (January 17, 1930- January 14, 2013) who obtained their doctorates in mathematics from British universities in the 1950's. Obi and Ezeilo specialized in ordinary differential equations and

Olubummo in Analysis. The very high quality of the research activities of these pioneers has been a potent motivating force for many Nigerian mathematicians and the trio influenced research and research areas in mathematical sciences in Nigeria. Many of the early Nigerians who obtained Ph.D. degrees in mathematical sciences were influenced by the trio and hence many specialized in Ordinary Differential Equations or Analysis or very closely related areas. Subsequently, other great mathematicians developed interest and indeed made eloquent contributions in other important areas of mathematics and mathematical sciences. Many Nigerians both those at home and in diaspora have made outstanding contributions in various areas of mathematical sciences. Of recent, majority of the young people who opt to obtain a research degree in mathematical sciences are going more into the areas of mathematical modelling, operations research, and financial mathematics.

Many of the Associations in mathematical sciences; notably the Nigerian Mathematical Society (NMS), the Nigerian Statistical Association (NSA), the Nigeria Computer Society (NCS) and the Computer Association of Nigeria (COAN), are playing leading roles in motivating and inspiring research in mathematical sciences. The Journal of the Nigerian Mathematical Society is one of the six Nigerian-based national journals that were selected by the NUC in its partnership with Elsevier, and the journal is now hosted in Science Direct. The National Mathematical Centre (NMC) is also presently trying to a large extent to fulfil its mandate. MAN and STAN are also propelling research in mathematical sciences education. In general, one can say that Nigeria and Nigerians are making noticeable contributions in Africa and beyond in mathematical sciences research.

The challenges facing the research and teaching of the mathematical sciences are phobia and hate, lack of adequate manpower, lack of motivation and poor remuneration of the few in the discipline, lack of facilities and basic amenities, lack of adequate mentorship and abandonment of research after

attaining professorship, lack of adequate collaboration among researchers and industries, as well as poor implementation of education policies. Recommendations for the advancement of the mathematical sciences are as follows:

1. Adequate remuneration of mathematical sciences educators: Efforts should be made to improve the social and economic status of teachers in Nigeria. The Teachers Salary Scale (TSS) approved by the Federal Government should be adequately implemented in all the states of the federation. The TSS is overdue for review to adequately motivate and inspire teachers and encourage young ones to develop interest in teaching. No teacher in Nigeria, at any level, is supposed to have an annual pay package that is less than the annual salary of a Local Government Councillor. Apart from adequate allowances for mathematical sciences teachers, an enhanced salary scale should apply to mathematical sciences teachers at recruitment. This will certainly encourage good candidates to opt for mathematical sciences in tertiary institutions.
2. Develop an effective means of teaching the core areas of mathematical science courses at the M.Sc. and Ph.D. levels: The Federal Ministry of Education, Federal Ministry of Science and Technology, NUC, NMS, NMC, MAN, STAN, NSA, NCS, and COAN must put heads together to determine how to teach the core courses in the M.Sc. and Ph.D. programmes especially those areas where many universities lack Ph.D. holders that are in tune with the current trends in research. It may be better to assemble students geographically or centrally at the NMC and gather the experts to teach them.
3. Aggressive recruitment of mathematical sciences teachers: Schools should be encouraged to recruit qualified mathematical sciences teachers and maintain appropriate staff-student ratio in all mathematical sciences class. If schools could recruit an adequate number of qualified mathematical sciences teachers, then no qualified mathematical sciences teacher will be unemployed.
4. Aggressive training and retraining of mathematical sciences

teachers: Aggressive effort should be made to retrain the teachers already in the system in line with the current trend of development in teaching and research in mathematical sciences. This could be through conferences, workshops, and schools. Aggressive effort should also be made to train more hands in the discipline.

5. Setting out a percentage of TETFund for research in mathematical sciences: Many important results in mathematical sciences, especially in the core areas of mathematics, do not yield to immediate applications. Many of their interesting applications usually unfold with time. Thus, on many occasions, proposals in these core areas do not compete favourably with those in applied sciences like medical and biological sciences, pharmacy, and engineering. It may be better if proposals in core mathematical sciences compete among related proposals.
6. Automatic scholarship for M.Sc. and Ph.D. programmes in mathematical sciences in Nigerian universities: Government should waive tuition fees for qualified Nigerian candidates who opt to register for M.Sc. and Ph.D. programmes in mathematical sciences in Nigerian universities. This will encourage more young people to pursue a career in mathematical sciences.
7. Government should adequately support scientific organizations and unions: Government should show more interest in supporting all our scientific organizations and unions. Conferences, workshops, schools, summits, etc. should be supported adequately and annual dues of our unions and other financial obligations to relevant international unions should be borne by the government.
8. Intensify awareness of the beauty and importance of mathematical sciences: The government through its relevant ministries and agencies, and relevant scientific organizations, must intensify efforts to diffuse the phobia and hate for the mathematical sciences (especially mathematics and statistics). The indispensability of mathematical sciences in scientific and

technological breakthrough must be brought to bear.

DEVELOPING WORLD CLASS EXCELLENCE IN MATHEMATICAL SCIENCES IN NIGERIA

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Modern economies are built based on the creation of a robust and sustainable knowledge-based economy rooted in excellence in science and technology. Mathematics is at the core of science and technology and industrialized nations are well aware of this and invest fully in mathematics and other STEM disciplines. Mathematics plays a vital role in most of modern life featuring in key areas, such as ICT, engineering, medicine, public health, economics, finance, demographics and planning, nano-technologies, genetics etc. Unfortunately, when excellence in mathematical science is discussed, Nigeria is hardly mentioned. The only way to ensure that Nigeria takes its rightful place in mathematical sciences on the continent, and indeed globally, is by truly achieving world class excellence in the mathematical sciences. Nigeria needs to become a world-class centre for training and research in mathematical sciences; this is crucial for sustainable socio-economic development. Multidisciplinary collaboration in Nigeria is also important. The era of scientists working separately is over and Nigeria has to realize this. The need for collaboration also extends to the social sciences which are essential to presenting research outcomes in a way that can be easily transmitted to the general public.

In the 1970s, the quality of mathematical science programmes in the country was high with seasoned mathematicians who had proven themselves locally and internationally. What Nigeria needs now is a "mathematical renaissance". Key components of this renaissance are: education reform, investment (by government/industry/TETFUND), centres of research excellence, training centres, reward for world-class excellence (incentivized mathematics), strategic linkages with foreign institutions and

centres of research excellence (greater Diaspora engagement), stakeholder engagement (through workshops, conferences, short courses, foundation, courses, and summer schools), early childhood learning, effective mentoring and outreach programs, as well as infrastructure.

To achieve world class excellence in the mathematical sciences, Nigeria needs to build indigenous world-class capacity in pure (basic) and applied mathematics with a multi-faceted emphasis on rigour, critical thinking, problem-solving skills, real world application, innovation, and where possible, entrepreneurship. Nigeria also needs multiple quality mathematical institutes. These institutes will compete for funding from government agencies, affiliate universities, and international organizations. Furthermore, mathematical societies (particularly, Nigerian Mathematical Society) need to be empowered. Nigerian mathematicians on their part need to provide mathematical solutions to problems of national need/priority including oil and gas, ICT, the banking sector, public health, economics, social sciences, data analysis, optimal control, medical sciences etc. It is also crucial to foster collaboration with industries as doing so would create opportunities for job creation and funding for research and training. Universities should set up Smart Parks such as the Malaysia's Multimedia Super-Corridor and Silicon Valley that will offer consultancy services to industries.

There are lessons to be learnt from the steps taken to develop mathematical sciences in South Africa. One of the features of this model is the establishment of the National Research Foundation (NRF) which promotes and supports indigenous research through funding, human resource development, and the provision of research facilities for all fields of science and technology. Another key institution that was established is the African Institute of Mathematical Sciences (AIMS) which promotes excellence in postgraduate education and research in the mathematical sciences. Funding was also made available for strategic centres of excellence such as the South African Centre for Epidemiological Modelling and Analysis (SACEMA). Other steps taken by South

Africa are the adoption of a rating system of academics, incentives for publication in quality journals, student evaluation, and a presence of a vibrant and world-class South African Mathematical Society (SAMS).

If South Africa can do it, Nigeria can as well and even better.

Audience reflections

- The current state of Nigerian universities does not indicate a desire to achieve quality by design. This principle is very important in the pharmaceutical world and should be extended to all branches of science education
- Multidisciplinary research is becoming more and more important and as such cannot be over emphasized. There is a need for more collaboration between the life sciences and the applied sciences even as new disciplines begin to emerge
- Although the creation of centres of excellence is important, the driving forces behind such institutions i.e. the leadership should also be considered. A world class facility without world class leadership will be unable to do much
- Nigeria has to rehabilitate science teachers at the secondary and primary levels. If the foundation is faulty little can be achieved at the higher levels.

CHAPTER FIVE
THE STATE OF CHEMICAL, EARTH, AND ENVIRONMENTAL SCIENCES IN NIGERIA

THE STATE OF CHEMICAL, ENVIRONMENTAL, AND EARTH SCIENCES IN NIGERIA

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The pure and applied sciences provide most of the basic courses for teaching and learning in technology and engineering programmes. The purpose and scope of activities of science in human existence is the outcome of complex interactions between the thoughts and acts of living beings (biota); with particular reference to man, and non-living things (abiota) within the total environment. The state of existence of the pure and applied (chemical, biological, environmental, earth/geological) sciences, their multiple/complex network of use and disuse in relation to social case-work in the total environment of Nigeria, and beyond require deep appreciation, reflection, evaluation, and analyses.

The basic or pure sciences emanate from deep philosophical thoughts and human intellectual gestation with the use of appropriate scientific methods of investigations and metamorphose into various arms of the applied sciences that build up environmental matters/structures which develop into resultant entrepreneurial and solid substances of technology and engineering; all of which are eventually-channelled into different aspects of progressive living enterprises or retrogressive decay and demise. The human elements of the arts and humanities through durable social case-work of development, private and public participation, management, and transport, put the products of science into proper use or precipitate destructive disuse during the entire exercise. Hence, the totality of the lives of all living and non-living things are based on the use and disuse of the products science. Thus, without any iota of doubt or pretences of any kind, the biotic and abiotic beings of the planet earth seriously depend on the actions and reactions of the myriad of professional scientists

in the fields of pure sciences, applied sciences, technology and engineering. Through their potential activities, life can go on, be extinguished, or become nullity. Pure and applied scientists build bridges and provide the basic component foundation materials of life as well as socioeconomic supports for human development and growth. Chemical, Environmental, and Earth Sciences (CEES) which have their roots in the pure sciences, are applied sciences that work together as the bedrock foundation elements in different programmes of technology and engineering. CEESs as a unit forms a composite structure of any aspect or part of the earth's matter, structure, and materials; be they biotic (living) or abiotic (non-living).

Many business ventures have high input elements or impact from applied sciences, technology, and engineering. The principles and practices of entrepreneurship must therefore form part of the science education curricula at the secondary schools and tertiary education (polytechnics and universities) levels of training. Scientists and science professionals must not downplay or minimize the import/impact of their roles and durable importance in these various fields of endeavour such as engineering, technology, medicine, pharmacy, geology and mining, water resources, water pollution/contamination/waste management, public health and management, agriculture, flooding, erosion, desertification etc. In each of these fields of enterprise, scientists work quietly singly or in collaboration with others, and sometimes unnoticeably in the offices or laboratories, to proffer solutions to the environmental problems and bring up the success of events and projects on the short and long run. In each of these areas of studies, entrepreneurial programmes or courses can be developed for further higher education and training for professional or industrial practices. Development of such courses in tertiary education programmes may involve integrated arrangements between the core sciences and programmes/courses from the management sciences. Such programmes would broaden the base of knowledge for graduates and provide them with more job opportunities.

The state of information, understanding, knowledge, and professional practices of CEESs in Nigeria is not encouraging and is equally not positively recognized and appreciated. Nigerian scientists seem not to be forceful enough in the way and manner they train their products from the secondary schools to the tertiary level of education. There are many prohibitive and debilitating problems in the successful execution of projects/programmes in terms of existence of adequate infrastructure in the form of buildings, laboratories, laboratory consumables, water supplies, electricity/power supplies, hygiene and sanitation, poor funding etc. There is poor coordination in planning and design of appropriate curricula and teaching materials. Many academic and technical staff are not well-trained in the teaching and management of science subjects/courses. Furthermore, students reluctantly study science courses because of these problems. Sometimes, these students are forced or cajoled to study science subjects with inadequate facilities and lack of the will to do so. The most unfortunate aspect is that these poorly-brought up science students at the secondary level are uploaded into the universities and polytechnics to study science subjects. Even the 60%:40% ratio approved to be compulsory by the Federal Government for admissions into the universities in favour of science courses is hardly-carried out because there are comparatively fewer students for science-related courses when compared to those in the arts and humanities; that is, there are not enough candidates to provide for the 60% admission spaces as compulsorily-required. Also, science education and research at various levels of teaching and learning are poorly-funded in Nigeria. The society at large hardly realizes and appreciates the mammoth roles and contributions of scientists in the socio-economy; their contributions are taken for granted and, hence, resulting in poor recognition and remunerations paid to them by the society.

The following recommendations may be considered for possible use and necessary action:

1. Poor funding and support are the root causes for poor performances in science education and development in Nigeria.

The provision of special financial allocations as well as adequate and continuously sources of funds and other material resources are required for the upgrade, development, and growth of various levels of scientific projects, teaching, learning-pursuits, and research. Better funding will result in improved infrastructure, training and hiring of qualified staff, building and equipping of laboratories and libraries, carrying out needed research, attendance to conferences/seminars /symposia etc. Sustained and credible funding would encourage continuous production of excellent scientific/technological results in the form of quality personnel and academic materials. Funding must not be left to the Government sources alone. The public and private sectors of the economy must be encouraged to partner with and work closely together with the government in the training and education of scientists and the related professionals.

2. The curricula for the teaching and study of science in Nigeria require streamlining, updating, and modernization. Some of the teachers have no relevant training in science subjects, practice poor teaching method, as well as use poor spoken/written English language and basic teaching skills. There is a need to have coordinated skills, techniques, and integrated approach on a broad regional scale to be incorporated in the teaching curricula for the sciences.
3. The state, scope, and purpose of science teaching and learning should be enlarged by broadening the knowledge and practice in the field of entrepreneurial ventures and practices. There is a great need for emphasis in the entrepreneurial aspects of the sciences. Introducing entrepreneurship into the sciences has tremendous socioeconomic values. It would broaden the scope of professional practices, usher-in employment opportunities and wealth creation for young scientist-entrepreneurs. Basic courses in entrepreneurship should be incorporated and be taught side by side with professional courses in the sciences. In other words, scientists can be veritable job and wealth creators as well as being beneficiaries.

4. Most of the country's universities run postgraduate programmes in the pure and applied sciences in their Schools/Faculties of Postgraduate Studies nationwide. The programmes are run side by side with research and academic mentorship. There is need to encourage national and international academic/research linkages/exchanges /collaborative ventures during the postgraduate studies-process. A mentorship programme of studies and learning for young scholars should be planned and be run side by side with the postgraduate training and research.
5. There are many nationally and externally based organizations that have programmes for promotion or support of science education/events/projects in the country. Such organizations and their support modes must always be studied critically.
6. The sciences are closely-related to one another in one way or the other and may therefore be used singly, or jointly. Research should become multi-technique, multi-varied, multi-objective, and integrated using holistic and system's approach during the process of investigation. Pure and applied scientists must emphasize their important roles in driving the machineries of the various fields of technology and engineering through their inter-relationships. The appropriate educational methods and strategies ought to emphasize such relationships during teaching and research. These relationships may be continuous and tenuous in teaching, learning, and research with complex branching modules in form of ideas, actions, and results.
7. The libraries and ICT centres must be well-stocked with basic and advanced literature with relevant books/hardware/ software materials that would cover almost all areas of scientific endeavour in teaching, learning, laboratory studies, research. and professional practices in the sciences and science-related fields of studies and research; they make learning and research healthy and productive.
8. There are many groups, organizations, and associations that carry out different activities in different aspects of science and related areas. These activities include teaching, research,

consultancy services, meetings, seminars, conferences, symposia, colloquia etc. There is a great need to create more of such bodies to promote the various scientific events in the country by different societies and associations. There is a great need to have a census of all science and science-related associations/organizations in order to be able to effectively-monitor what they are doing and improve on their various activities nationwide. The Nigerian Academy of Science in collaboration with the Science Association of Nigeria could ably serve as a Monitor/Coordinator of the different roles and practices of these bodies to ensure that they conform to the desired norms and quality assurance and also ensure that all maintain the internationally-required/accepted best practices that are in vogue worldwide.

9. Science groups, associations etc. should organize regular annual or biennial meetings, conferences, seminars, symposia, colloquia etc. in collaboration with national or international science-related bodies or agencies. These meets would promote provision and exchange of veritable information/ideas on teaching, learning and research in the fields of the sciences and related areas of knowledge. Funding for organizing such scientific get-togethers may be sourced from governments, national, and international aid agencies.
10. The establishment of a Committee for the award of the NAS Science Prize to distinguished scientists by NAS that is now being planned is a laudable and worthy venture for the development and progress of the sciences and the related fields of knowledge. It is an excellent step being taken in the right direction. The annual or biennial award will encourage Nigerian scientists to develop keen competitive scientific spirits in order to excel in their teaching, research and professional activities in the promotion of the development and growth of the sciences. This will also enable NAS to have regular information on the rate, progress and performance being made annually or biennially in various fields of science in Nigeria.

THE STATE OF THE CHEMICAL SCIENCES IN NIGERIA

Professor Grace Obuzor
President, Chemical Society of Nigeria

Industrial development is indelibly linked to the application of the principles of the chemical sciences and various issues in sustainable development appear to find solutions in the chemical sciences. It is therefore accurate to say that any country that does not develop its chemical sciences is not ready to develop indigenous products. The state of chemical sciences in Nigeria cannot be completely divorced from the state of the sciences generally in the country (of which chemical science is a subset). Despite the best intentions of the successive Nigerian governments, science education programs, including the chemical sciences, are characterized by issues of responsibility and control of the society's education, inadequate political will by the various governments, deficient curriculum and policy, underfunding of the education sector, poor staff motivation, unstable academic calendar, misplacement of priority, as well as the inadequacy of staff and staff training in the face of ever changing technology. Also confronting the state of the chemical sciences in Nigeria is the total loss of hope and lack of a future for the graduates which have resulted in loss of interest in the field by the younger generation. These challenges have potential impacts on education tourism and revenue, self-esteem, and industrial development.

The challenges currently facing education, research, and innovation in the chemical sciences include underfunding, lack of proper laboratories, and non-commercialization. Physical facilities for teaching and learning in the public universities are inadequate, dilapidated, over-stretched, and improvised. Laboratories and workshops equipment as well as consumables are either absent, inadequate or outdated. In instances where equipment are available, they are obsolete. For example, kerosene stoves are being used as Bunsen burners in some universities. Many science-based

faculties are running what is referred to as a "Dry Lab," due to the lack of reagents and tools to conduct real experiments. The national policy on education stipulates a 60:40 enrolment in favour of science-based programs, however, 66.1% of students are studying arts, social sciences, management, and education courses.

Key recommendations to moving the chemical sciences in Nigeria forward include professionalization of the chemistry profession, teaching of chemistry as an experimental science, provision of funding with control for the nation's education sector, setting up dynamic curriculum and policy, establishment of standard laboratories, manpower capacity building, as well as the periodic re-certification of secondary school teachers.

THE STATE OF ENVIRONMENTAL AND EARTH SCIENCES IN NIGERIA

Professor Clifford Teme
Immediate Past President, Nigerian Mining and Geosciences Society

Earth science is the study of the earth and its atmosphere, hydrosphere, lithosphere, and biosphere utilizing the knowledge of physics, chemistry, biology, chronology and mathematics to build a quantitative understanding of how the earth system works. The following fields of science are generally categorized within the earth sciences:

(a) Geography; specifically, physical geography which covers aspects of geomorphology, soil study, hydrology, meteorology, climatology, and biogeography.
(b) Geology which describes the rocky parts of the earth's crust and its historic development.
(c) Geophysics and Geodesy which aid in investigating the shape of the earth, its reaction to forces, its magnetic and gravity fields, the earth's interior (mantle and core), as well as give an explanation of the seismic and tectonic activities of the Lithosphere (crust).

Environmental science is a multidisciplinary and integrated subject that involves the physical, biological, and chemical sciences in the study and mitigation of hazards to the environment arising from anthropogenic and natural activities. Key areas of focus in environmental science include: environmental chemistry, physics, zoology, mineralogy, oceanology, limnology, soil science, geology, geography, environmental engineering, atmospheric sciences, mathematical modelling, and sustainable systems. Environmental concerns studied under this subject are atmospheric emissions, water pollutants in surface and groundwater, solid and hazardous wastes, hazardous solid wastes, medical wastes, non-hazardous wastes, non-hazardous total Resource Conservation and Recovery Act (CRCRA) solid wastes, as well as radioactive wastes.

In moving the earth and environmental sciences forward in Nigeria, there is a need for the creation of Research and Development Centres in each geo-political zone of Nigeria. The education curricula at the secondary and tertiary levels also need to be improved with opportunities for field (hands-on) training. Government agencies and institutions also need to be strengthened with the provision of adequate funding. Aside of infrastructure and capacity building, policies and programmes on earth and environmental sciences in Nigeria should be formulated. Policies and programmes for the earth sciences should include those for solid minerals, fuel and energy minerals, and earth materials for construction. Collaborative synergy amongst key science stakeholders in national development is also necessary. The earth and environmental scientists should collaborate with relevant stakeholders and scientific communities in Nigeria to build and strengthen capacity in science and technology. Stakeholders include: science institutions, tertiary institutions, and national science associations in Nigeria, Nigerian Mining and Geosciences Society (NMGS), MDAs, private sector, manufacturing sector, transportation sector, communication sector, as well as the agricultural sector.

Audience reflections

- The results of poor environmental management have far reaching impacts on humans and animals. There is therefore a need for collaboration between the environmental sciences and the biological sciences
- Water is an important issue that cuts across several disciplines of science. Almost every Nigerian home provides its own water, the safety of which is uncertain and should be monitored
- The issue of pollution with polyethene bags needs to be addressed by scientists and policy makers. Biodegradable packaging may be a solution for this
- Biodiversity is a strength in Nigeria. However there is a heavy loss in this sector. Efforts need to be made in conservation and documentation of the country's biodiversity

Appendix 1: Summit Agenda

DAY ONE

Opening Session

8.30-9.00 **Arrival and registration**

9.00-9.10 **Welcome/opening remarks**
Professor Oyewale Tomori FAS
President, NAS

9.10-9.25 **Goodwill messages from key stakeholders**

9.25-9.40 **Overview of Summit objectives**
Dr. M. Oladoyin Odubanjo
Executive Secretary, NAS

9.40-10.10 **Keynote addresses: Collaborative science and technology initiatives for national development**
Dr. Umar Bindir
Director General, National Office for Technology Acquisition and Promotion (NOTAP)

10.10-10.25 **Discussion**

10.25-10.45 **Tea break**

Session 1: Science and the society

Session Chair: Professor Mosto Onuoha, FAS

Objectives

- To discuss the relationship between science and science education, industry, the economy, the society, and the media
- To prescribe solutions for strengthening these relationships

10.45 -11.15 **Science and industrial development in Nigeria**
Dr. Bamidele Makanjuola
Chairman, Vitafoam Nigeria Plc

11.15-11.25 **Discussion**

11.25-11.45 **Science in the social sciences**
Professor Olabisi Aina
Professor of Sociology/Gender Studies,
Obafemi Awolowo University

11.45-11.55 **Discussion**

11.55-12.15 **Education for science**
Ms. Pirjo Suomela-Chowdhury
Her Excellency, the Finnish Ambassador to Nigeria

12.15-12.25 **Discussion**

12.25-12.45 **Engaging the interest of the media, and the Nigerian public in science**
Mrs Moji Makanjuola
Journalist

12.45-12.55 **Discussion**

12.55-13.15 **Research and Innovation for sustainable development: Africa on the wings of innovation**
Dr. Mohammed Kyari
Senior Scientific Officer Coordination African Union, Scientific, Technical and Research Commission (AUSTRC)

13.15-13.25 **Discussion**

13.25-14.25 **Lunch**

14.25 -14.45 **Science in early childhood education**
Professor Peter Okebukola
Lagos State University

14.45-14.55 **Discussion**

Session 2: Stakeholders' roles in Nigerian scientific advancement
Session Chair: Professor Domingo Okorie, FAS

Objectives
- To identify the roles of stakeholders in national development

14.55-15.55 **Discussion**

15.55-16.00 **Closing Remarks**

16.00 **Departure/Tea break**

DAY TWO

8.30-9.00 **Arrival and registration**

Session 3: Health, biological, and agricultural sciences in Nigeria
Session Chair: Professor Fola Esan, FAS

Objectives
- To discuss the state of health, biological, and agricultural sciences
- To identify current challenges in education and research in these fields
- To recommend action points for stakeholders

9.00-9.20 **The state of health sciences in Nigeria**
Professor Akin Osibogun
Consultant Public Health Physician,
Lagos University Teaching Hospital

9.20.9.30 **Discussion**

9.30-9.50 **The state of biological sciences in Nigeria**
Professor Stephen Owa
President, Science Association of Nigeria SAN

9.50-10.00 **Discussion**

10.00-10.20 **The state of agricultural sciences in Nigeria**
Professor Iyiola Fawole
Bells University of Technology

10.20-10.30 **Discussion**

10.30-10.50 **Bridging the science to policy gap**
Dr. Benjamin Anyene
Chairman, HERFON

10.50-11.00 **Discussion**

11.00-11.20 **Tea break**

Session 4: Engineering, physical, space and mathematical sciences in Nigeria
Session Chair: Professor Rafui Salawu, FAS

Objectives

- To discuss the state of engineering, physical, space, and mathematical sciences
- To identify current challenges in education and research in these fields
- To recommend action points for stakeholders

11.20-11.40 **The state of engineering sciences in Nigeria**
Engr. Kashim Ali
President, COREN

11.40-11.50 **Discussion**

11.50-12.10 **The state of physical and space sciences in Nigeria**
Professor Pius Okeke FAS
Professor Emeritus of Physics University of Nigeria/ President, African Astronomical Society

12.10-12.20 **Discussion**

12.20-12.40 **The state of mathematical sciences in Nigeria**
Professor Micah Osilike
President, the Nigerian Society of Mathematics

12.40-12.55 **Developing mathematical sciences in Nigeria**
Professor Abba Gumel FAS
Arizona State University

12.55-13.10 **Discussion**
13.10-14.15 **Lunch**

Session 5: Chemical, environmental, and earth sciences in Nigeria
Professor Boniface Egboka FAS

Objectives
- To discuss the state of chemical, environmental, and earth sciences
- To identify current challenges in education and research
- To recommend action points for stakeholders

14.15-14.35 **The state of chemical sciences in Nigeria**
Professor Grace Obuzor
President, Chemical Society of Nigeria

14.35-14.45 **Discussion**

14.45-15.05 **The state of environmental and earth sciences in Nigeria**
Professor Clifford Teme
Immediate Past President, Nigerian Mining and Geosciences Society

15.05-15.15 **Discussion**

Session 6: General discussion
Session Chair: Professor Oyewale Tomori FAS

Objectives
- To discuss scientific challenges in Nigeria in the 21st century
- To highlight approaches for moving science forward in Nigeria
- To identify strategies for fostering better collaboration in the Nigerian Scientific community
- To recommend strategies for improving science, technology, and innovation in Nigeria

15.15-15.45 **General Discussion**

15.45-15.50 **Closing remarks/Vote of thanks**
Professor Oyewale Tomori, FAS

15.55 **Teabreak / Departure**

Appendix 2: Participants List

SN	NAME	AFFILIATION
1.	Professor Akin Osibogun	Lagos University Teaching Hospital
2.	Professor Iyiola Fawole	SAN
3.	Professor. J. A. Olorunmaiye	Council for the Regulation of Engineering in Nigeria
4.	Professor Pius .N. Okeke	NAS
5.	Dr. Umar Bindir	National Office for Technology Acquisition and Promotion (NOTAP)
6.	Professor Clifford Teme	Nigerian Mining and Geosciences Society
7.	Professor Grace U. Obuzor	Chemical Society of Nigeria
8.	Professor Stephen Owa	SAN
9.	Professor Peter Okebukola	Crawford University
10.	Professor Olabisi Aina	Obafemi Awolowo University
11.	Mrs Moji Makanjuola	Bronz and Onyx International Limited
12.	Dr. Bamidele Makanjuola	Vitafoam Nigeria Plc
13.	Professor Micah O. Osilike	Nigerian Mathematical Society (NMS)
14.	Professor Abba Gumel	NAS
15.	Ms. Pirjo Suomela-Chowdhury	Finnish Embassy
16.	Dr. Benjamin Anyenne	Health Reform Foundation of Nigeria (HERFON)
17.	Dr. Edgar Amos Sunday	Nigerian Veterinary Medical Association (NVMA)
18.	Pharmacist Olumide Akintayo	Pharmaceutical Society of Nigeria (PSN)
19.	Professor Ifeoma Enweani	Nigerian Society for Microbiology (NSM)
20.	Professor Michael Asuzu	Nigeria Medical Association (NMA)
21.	Professor Constantine C. Mbajiorgu	Nigerian Association of Hydrological Sciences (NAHS)
22.	Professor Sebastian Nwosu	Ophthalmological Society of Nigeria (OSN)
23.	Professor Tanimola M. Akande	Association of Public Health Physicians of Nigeria (APHPN)
24.	Dr. Kenneth C. Iregbu	Association of Pathologists of Nigeria (ASSOPAN)
25.	Dr. Modupe Kuti	ASSOPAN
26.	Professor Olusegun Ojo	Society of Gastroenterology and Hepatology of Nigeria (SOGHIN)
27.	Mr. Adeoye Taiwo Adetoyi	Animal Science Association of Nigeria (ASAN)
28.	Professor Augustine O. Isichei	Botanical Society of Nigeria (BSN)
29.	Dr. Damian Echendu	Nigerian Optometric Association (NOA)
30.	Professor Arthur Nwafor	Physiology Society of Nigeria (PSN)
31.	Dr. M.M. Tumala	Nigerian Statistical Association (NSA)
32.	Dr. Bala M. Giginyu	Horticultural Society of Nigeria (HORTSON)
33.	Professor Ngozi Odiaka	HORTSON
34.	Alhaji Toyosi Raheem	Association of Medical Laboratory Scientists of Nigeria (AMLSN)

35.	Professor Oluyemi Akinloye	AMLSN
36.	Professor Obi U Njoku	Nigerian Society of Biochemistry and Molecular Biology (NSBMB)
37.	Dr Iretiola Babaniyi	Paediatric Association of Nigeria (PAN)
38.	Dr. Akeem A. Oyerinde	Entomological Society of Nigeria (ESN)
39.	Professor David Malgwi	Nigerian Institute of Physics (NIP)
40.	Dr. Hycienth Ogbu Aboh	Nigerian Institute of Physics (NIP)
41.	Dr Bisola Onajin- Obembe	Nigerian Society of Anaesthetists
42.	Dr. Mohammed Yerima	Biotechnology Society of Nigeria (BSN)
43.	Dr. Anthony Negedu	Mycotoxicology Society of Nigeria
44.	Dr. Charles E. Ejiofor	University of Abuja
45.	Professor Innocent Ujah	Nigerian Institute of Medical Research (NIMR)
46.	Dr. Anthony Anuforum	Nigerian Meteorological Agency (NiMet)
47.	Professor K.S. Gamaniel	National Institute for Pharmaceutical Research and Development (NIPRD)
48.	Dr. Adeola Jegede	NIPRD
49.	Dr. Vivian N. Iwar	ECOWAS Commission
50.	Dr. Akin Oyemakinde	Nigeria Centre for Disease Control, Federal Ministry of Health
51.	Dr. Bibiana Igbabul	University of Agriculture, Benue State
52.	Dr. Agu Collins Agu	National Information Technology Development Agency (NITDA)/Nigerian Communication Satellite Limited (NIGCOMSAT)
53.	Dr. Abidemi Akindele	President/Nigerian Young Academy
54.	Dr. Ernest Aubee	ECOWAS Commission
55.	Dr. Godwin Brooks	Federal Ministry of Health
56.	Professor Iyorhemba Ate	Dean, College of Veterinary Medicine/University of Agriculture, Makurdi Nigeria
57.	Dr. Mohammed Kyari	African Union Scientific Technical Research Commission (AU STRC)
58.	Dr. S.O. Olufeagba	Biotechnology Society of Nigeria (BSN)
59.	Dr. Mohammed S. Ahmed	National Veterinary Research Institute
60.	Professor Turner Isoun	NAS
61.	Professor Oyewale Tomori	NAS
62.	Professor Mosto Onuoha	NAS
63.	Professor Fola Esan	NAS
64.	Professor Rafui Salawu	NAS
65.	Professor Boniface Egboka	NAS
66.	Professor Temitayo Shokunbi	NAS
67.	Professor Soga Sofola	NAS
68.	Professor Babajide Alo	NAS
69.	Professor Olaitan Soyannwo	NAS

70.	Professor Sunday Atawodi	NAS
71.	Professor Oyebiodun Longe	NAS
72.	Professor Paul Okonkwo	NAS
73.	Professor Njidda Gadzama	NAS
74.	Professor Olusegun Ekundayo	NAS
75.	Professor Gabriel Ogunmola	NAS
76.	Professor Ikenna Onyido	NAS
77.	Professor Timothy Obi	NAS
78.	Professor Awele Maduemezia	NAS
79.	Professor Francisca N. Okeke	NAS
80.	Professor Akinyinka Afolayan	NAS
81.	Professor Patience Osadebe	NAS
82.	Professor E.D. Mshelia	NAS
83.	Professor Alex Acholonu	NAS
84.	Professor Augustine Esogbue	NAS
85.	Professor Israel Adu	NAS
86.	Professor Dennis Agbonlahor	NAS
87.	Professor Oye Ibidapo-Obe	NAS
88.	Professor J.C. Amazigo	NAS
89.	Professor Uche Amazigo	NAS
90.	Dr. John Momoh	National Space Research and Development Agency
91.	Ms. Palang Kewa	Bronz and Onyx International Limited
92.	Dr. Adeniyi Ogunjobi	SAN
93.	Folayan Seyi	Bronz and Onyx International Limited
94.	Likuna Julius	NPC
95.	Pharmacist Ivan Odiahe	Elbe Pharma Nigeria Limited
96.	Nwaosu Beta	Guardian Newspaper
97.	Nkechi Issac	Leadership Newspaper
98.	Zakariyga Adaramola	Daily Trust Newspaper
99.	Olatunji Obasa	Punch Newspaper
100.	Friday Oloko	Punch Newspaper
101.	Dr. S.T. Anjorin	Mycotoxicology Society of Nigeria
102.	Dr. Maimuna A. Habah	Mycotoxicology Society of Nigeria
103.	Regina Olokpa	National Mirror
104.	Dr. Farida Habib	University of Abuja Teaching Hospital
105.	Folu Duke	Bronz and Onyx International Limited
106.	Engineer A.J. Agabi	COREN
107.	Professor Seidu Mohammed	NASDRA
108.	Mr. Itah Abutu	NASDRA
109.	Fawehinmi Akin	CSN
110.	Dr. Dahiru Adamu	Agricultural Research Council of Nigeria
111.	Mr. Nicolas Ibeh	NAS

112.	Dr. Francis Chisea	NASDRA
113.	O.T. Elenuole	NASDRA
114.	Professor Musa Momoh	SAN
115.	Mrs Scholastica M. Lan	NAS
116.	Mr. Sammy Shofuyi	NAS
117.	Dr. Doyin Odubanjo	NAS
118.	Mrs Ife Edawole	NAS
119.	Ms. Bolaji Dasaolu	NAS
120.	Ms. Anjola Olanipekun	NAS

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