TECHNOLOGICAL RESEARCH AND DEVELOPMENT CHALLENGES: THE WAY FORWARD♣

by

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NOVEMBER 13, 2019

♣ *Being the Lead Paper presented at the 14th Annual National Engineering Conference (ANEC) of the Federal Polytechnic Mubi, Adamawa State, Nigeria, on Wednesday the 13th of November, 2019*

PROLEGOMENA

In order to establish if a country is developing or not, pertinent questions are desirable. It has been contended that in determining a country's development, the state of poverty, unemployment and inequality must be addressed. If all three of these have declined from high levels, then beyond doubt this has been a period of development for the country concerned. If one or two of these central problems have been growing worse, especially if all three have, it would be strange to call the result development even if per capita income doubled (Seers, 1977)

One of the indices by which a nation's growth and advancement can be measured is by her technological endowment. A nation's economic efficiency is determined, measured, compared, classified and ranked by its technological advancement.

Human resource has been identified as one of the most important catalyst in a nation's development. In Nigeria, this important and critical resource has not been fully developed, managed and utilized in such a manner that would engender development.

There are no economic gains from technological R&D unless the outputs (including patents) are exploited. Translation of technological R&D to innovation occurs through entrepreneurial activities that deal with marketing needs. R&D is profitable when it is innovative and solves real life problems. In the prevalent competitive environment where speed and flexibility are critical success factors, a holistic approach that makes use of "local content" must be adopted.

In this paper, the technological R&D challenges responsible for Nigeria's under-development have been found to include; the near nonexistence of philosophy for national development, non-conducive working environment, reluctant attitude towards policy implementation, insecurity and non-application of appropriate technology. The way forward was suggested as: Establishing a philosophy for national development and virile national innovation system (NIS), individual and institutional re-orientation, functional Government-Research Institutes-Industry Linkage and effective appropriate technology transfer.

1.0 INTRODUCTION

Knowledge, in particular scientific knowledge, is one of the key factors in the evolution of our societies. It is by sharing knowledge and adapting scientific culture that we create value not only on the economic but also the human level.

One of the indices by which a nation's growth and advancement can be measured is by her technological endowment; not by the level of her endowment in natural and human resources. A nation's economic efficiency is determined, measured, compared, classified and ranked by its technological advancement.

In order to meet the great challenges in environmental protection, health, new technologies, and more generally quality of life, one country alone is not enough. Knowledge can only be enriched by cooperation, which does not exclude the fact that each country is engaged in a logic of competition that encourages emulation and therefore the pursuit of excellence.

Meeting the challenges of sustainable development requires placing man at the heart of our concerns while respecting present and future generations. The emphasis placed on renewable energies in the framework of vast international programmes of new energy technologies as well as research in the fields of non-polluting transportation and environment-friendly production methods are all part of this vision of a modern and realistic ecology.

In economic terms, Nigeria is **underdeveloped,** because all signs of underdevelopment are staring glaringly in our face as a nation. Manufacturing as an aspect of development simply refers to the transformation of raw materials into finished products usually on a large scale. Manufacturing quality focuses on **tangible** product features while Service organizations produce **intangible** products that must be experienced. Nigeria is endowed with human and raw material resources and yet Nigeria is classified as "developing" after fifty – nine years of self governance (Independence).

Nigeria as a country has no doubt had a series of "development plans." These include: the 1946 10-year Development and Welfare Plan for Nigeria, the First, Second and Third National Development Plans of 1962 – 68, 1970 – 74, and 1975 – 80 respectively. The Colonial Development and Welfare Plan had some credit in such programmes as Niger Agricultural Project, the Shendam Agricultural Project, and expansion of export crop production, establishment of a "model village" and enactment of the 1946 Town and Country Planning, Ordinance, among others.

Infrastructure is the life blood of any economy. No economy can grow and develop without a reasonable stock of critical infrastructure. This presupposes that where infrastructure is inadequate or lacking, the cost of doing business will be high, growth and people's standard of living will be negatively impacted. We must be able to fix our power sector and the transportation sector as a whole so that our manufacturing sector will thrive. Our infrastructure level must be dynamic and functional to move goods around and help people create wealth. From all indications, infrastructural deficit in the country may not be a thing of the past any time soon. This is because the Federal Government's allocation to infrastructure in its annual budget is a far cry from the required amount to meet the need.

Even if the development of a socio-economic system can be viewed as a holistic exercise, i.e. as an all-encompassing endeavour; for practical purposes, in particular for policy making and development management, the focus of the agents aiming at development is almost always on selected parts of the system or on specific features. A summary (non-exhaustive) list of possible qualifications comprises (Lorenzo, 2011):

i. **Economic development**: improvement in the way endowments and goods and services are used within (or by) the system to generate new goods and services in order to provide additional consumption and/or investment possibilities to the members of the system.

ii. **Human development**: people-centred development, where the focus is placed on the improvement of the various dimensions affecting the well-being of individuals and their relationships with the society (health, education, entitlements, capabilities, empowerment etc.)
iii. **Sustainable development**: development which considers the long term perspectives of the socio-economic system, to ensure that improvements occurring in the short term will not be detrimental to the future status or development potential of the system, i.e. development will be "sustainable" on environmental, social, financial and other grounds.
iv. **Territorial development**: development of a specific region (space) achievable by exploiting the specific socio-economic, environmental and institutional potential of the area, and its relationships with external subjects

2.0 RESEARCH AND DEVELOPMENT (R&D)

In today's increasingly knowledge-driven world, science and technology (S&T) are the inseparable twin keys to progress and industrial growth as against the resource endowment of the past. Apparently, without scientific knowledge and its application the economy of a nation or an organisation either remains stagnant or declines. Consequently, most countries of the world now devote an increasing proportion of their resources to S&T and associated research and development (R&D), in an attempt to build competitive advantage or to catch up with others who have already done so.

R&D, most especially in S&T, has become one of the most enduring and effective means of improving sustainable economic development and re-enforcing competitiveness in industries in a rapidly changing world. Productive R&D is expected to lead to new

products or improvement of existing products, new process development or improvement of existing processes and generation/creation of new knowledge, patents, copyrights and publications. Publications are an indicator of quality invention and research outputs while patents, copyrights, and funding from companies are an indicator that those inventions have market potential (Carneiro, 2000; Werner and Souder, 1997; in Numprasertchai and Igel, 2005).

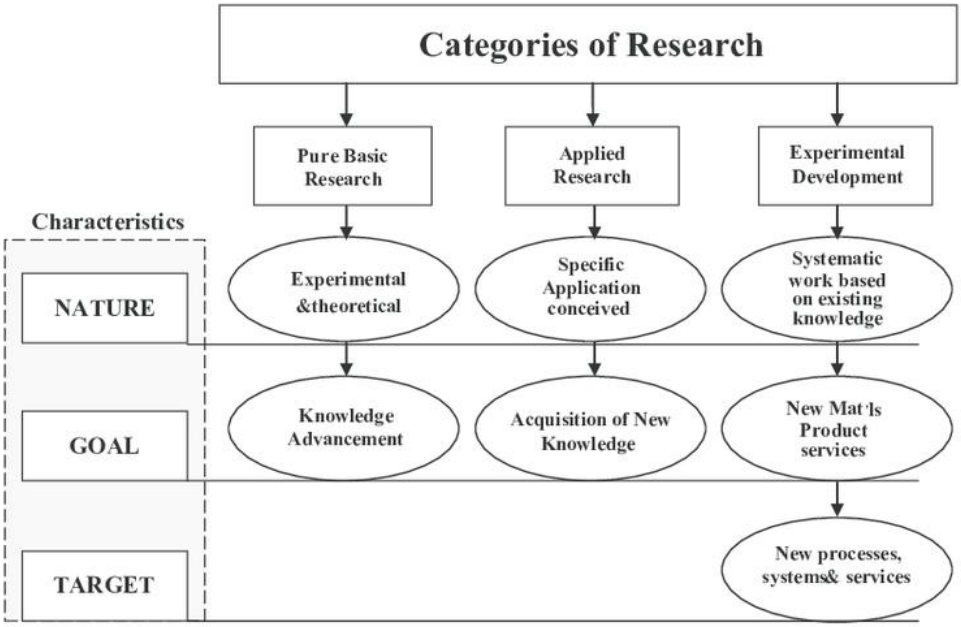
However, global experiences have shown that the conduct of scientific R&D does not robotically translate into development. For R&D to have any economic impact; R&D activities must be creative, innovative and exist within a strong national innovation system (NIS).

R&D is a post Second World War phenomenon, and absorbs a sizeable proportion of corporate and public funds in the developed countries. It is largely carried out by researchers in higher educational institutions (HEIs), research institutes (public and private), and industrial firms. R&D comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of individuals, culture and society, and the use of this stock to devise new applications (OECD, 2002). It involves three main activities: basic research, applied research and experimental development (Figure 1).

i. **Basic (fundamental or pure) research** refers to experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts without any particular application or use in mind
ii. **Applied research is** also original investigation undertaken in order to acquire new knowledge (OECD, 2002). It is, however, directed primarily towards a specific practical aim or objective and undertaken either to determine possible uses

for the findings of basic research or to determine new methods or ways of achieving specific and predetermined objectives.

iii. **Experimental development** concerns systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed toward producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed (OECD, 2002).

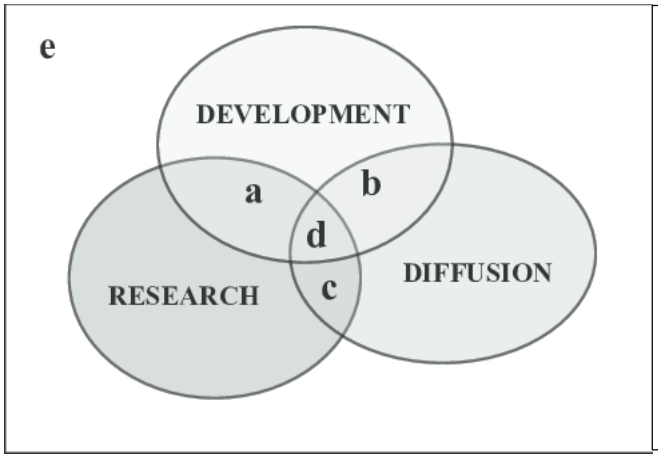


Source: (Siyanbola et al 2011)

Fig. 1: Categories of R&D

Economic benefits from R&D largely depend on the interaction of three key components: research, development and diffusion (Figure 2) within the National Innovation System (NIS). Today, economic globalisation has changed the world economic order, bringing new opportunities and new challenges (Commission of the European Communities, 2006) with dire consequences for developing countries. In this new economic order, developing nations can no longer compete on the basis of their natural resource endowments and locational advantages alone. For a

nation to withstand competition in this era of globalisation there is need to identify niche areas and build on it by the application of scientific methods. The experiences of Brazil with sugarcane (Goldemberg, 1998), Malaysia with oil palm (Adebowale, 2008) and Ethiopia with cut flowers have shown that building scientific capacity and competences in the fields of natural resource endowment and locational advantages is a surer way to development.



a. Research and Development
b. Commercialisation
c. Publication, etc
d. Research, Development and Diffusion
e. NIS, the domain in which all activities take place

Source: (Siyanbola et al 2011)

Fig. 2: Model for the relationship among Research, Development and Diffusion

3.0 R&D IN NIGERIA

The key players in R&D in Nigeria are the higher educational institutions (HEIs), the research institutes (RIs), the private research establishments, government agencies with R&D mandates, etc. Presently, there are nine hundred and seventy-six (976) institutions, broken down as in table2:

Table 1: R&D Institutions in Nigeria

S/No	INSTITUTIONS	Federal	State	Private	Total
1	Universities	43	52	79	174
2	Polytechnics	29	48	57	134
3	Colleges of Agriculture	19	14	-	33
4	Monotechnic/Specialised Institutions	25	3	3	31
5	Technical Colleges				119
6	Innovation Enterprise Institutions (IEIs)				153
7	Vocational Enterprise Institutions (VEIs)				82
8	Colleges of Education				153
9	Research Institutes				36
10	School of Health Technology/Allied Institution	25	18	7	50
11	Distance learning Centres				11

Sources: NUC; NBTE; NCCE; Nexus Commonwealth Network (Data received as at 8th November, 2019)

There are at least 55 colleges of education that are affiliated to 15 universities. In spite of this somewhat extensive institutional framework, cases of specific potentially effective technological R&D breakthroughs are rather few and far between (Siyanbola, 2008). It has been established both empirically and qualitatively that technological R&D in Nigeria is well characterised by an inherent discontinuity among the research activities in institutions, the development activities required to produce artefacts and subsequent manufacturing and marketing of these artefacts (Siyanbola et al. 2011). Contrary to the current global vogue, researchers in Nigeria still tend to adopt a 'linear' approach to their research without due recourse to the complementary activities that will guarantee the social usefulness of such research results. Resources available for technological R&D are too thin and are spread on numerous independent research projects running concurrently.

4.0 R&D AND NATIONAL GROWTH

Table 2 presents some basic indicators of national wealth for a selected group of countries including Nigeria. One important fact from the table is that however wealth is defined Nigeria is not one of the nations considered to be wealthy. Besides low Gross Domestic Product (GDP) per capita, only 1 out of every 5 Nigerian can boast of earning even 2 US dollars per day despite the country's heavy crude oil endowment (Siyanbola et al., 2011).

The prosperity of many developed nations and the expansion in the economies of the Asian tigers have been largely determined by their ability to transform their economies through research in S&T and industrial production (Bamiro et al, 2008). Numprasertchai and Igel (2005) opined that R&D units in developing countries (particularly Africa and South America) have many disadvantages compared to newly industrialised countries (NICs) and developed countries in terms of knowledge base, experts, researchers and infrastructure.

Table 2: Some basic indicators of national wealth for selected countries

Rank	Country	Human Development Index (HDI)	Life expectancy at birth(years) SDG3	Expected years of schooling Years) SDG4.3	Mean years of schooling (years) SDG4.6	Gross National Income (GNI) per Capita (PPP$) SDG8.5
9	Singapore	0.932	83.2	16.2	11.5	82,503
57	Malaysia	0.802	75.5	13.7	10.2	26,107
113	South Africa	0.699	63.4	13.3	10.1	11,923
140	Ghana	0.592	63.0	11.6	7.1	4,650
157	Nigeria	0.532	53.9	10.0	6.2	5,231
167	Sudan	0.502	64.7	7.4	3.7	4,119

Source: HDI Ranking: 2018 statistical updates (out of 189 countries)

4.1 The Human Development Index (HDI)

The Human Development Index – or simply, HDI – is a statistic composite index that is used to rank countries based on human development. Human Development Index is scored using indicators including life expectancy, per capita income and education.

Most countries that are "developed countries" have an HDI score of 0.8 or above (in the very high human development tier). These countries have stable governments, widespread education and healthcare, high life expectancies, and growing powerful economies.

The least developed countries (LDCs) in the world have HDI scores in the low human development tiers with HDI scores below 0.55. LDCs face unstable governments, widespread poverty, lack of access to healthcare, and poor education. Additionally, these countries have low income and low life expectancies coupled with high birth rates. The HDI helps the United Nations determine which countries need assistance, specifically LDCs. Nigeria's population is currently estimated at **200,963,599;** HDI is below 0.55 hence, the UN's constant assistance and interventions.

4.2 The Global Competitiveness index (GCI)

Global Competitiveness index measures national competitiveness – defined as a set of institutions, policies and factors that determine the level of productivity. The framework used are stated in table 3.

In 2019, The World Economic Forum Global Competitiveness Index placed Nigeria as number 116 overall out of the 141 countries sampled with a score of 48.3% (the highest Nigeria has ever attained). As at 2018 Nigeria was at number 115. Nigeria's Ease of Doing Business Rank is 145 in the world.

In the 12th pillar (Innovation capability) of the GCI, Nigeria is ranked at number 94 with a score of 32.2% with Germany leading. Under

this pillar, Nigeria's Research and Development results for 2019 showed that a precise value for the economy under review was not recorded but the economy's progress score was 23.6% and ranked 78th among the 141 economies considered with Japan leading. The lack of data for the value of the economy may be due to uncertainties in some sectors in the country. Research and Development expenditure was just a mere 0.22% of GDP value as at 2007 (TCdata360.worldbank.org.indicators). In 2019, R&D expenditure has a score of 11.1% of GDP while R&D institutions prominence had an economy value of 0.03 out of 100 with a score of 7.2 (on a scale of 0 – 100) and placed at number 50.

Table 3: The Global Competitiveness Index 4.0 framework

Enabling Environment	Human Capital	Markets	Innovation Ecosystem
Pillar 1: Institutions	Pillar 5: Health	Pillar 7: Product market	Pillar 11: Business dynamism
Pillar 2: Infrastructure		Pillar 8: Labour market	
Pillar 3: ICT adoption	Pillar 6: Skills	Pillar 9: Financial system	Pillar 12: Innovation capability
Pillar 4: Macroeconomic stability		Pillar 10: Market size	

4.4 The global Multidimensional Poverty Index (MPI)

Sustainable Development Goal (SDG) 1 aims to end poverty in all its forms and dimensions. Although often defined according to income, poverty can also be defined in terms of the deprivations people face in their daily lives. The global Multidimensional Poverty Index (MPI) is one tool for measuring progress against SDG 1. It compares acute multidimensional poverty for more than 100 countries and 5.7 billion people and monitors changes over time. The global MPI scrutinizes a person's deprivations across 10 indicators in health, education and standard of living and offers a high-resolution lens to identify both who is poor and how they are poor. It complements the international $1.90 a day poverty rate by showing the nature and extent of overlapping deprivations for each person.

The world is increasingly troubled by inequality. Citizens recognize the growing inequality in many societies and its potential influence on political stability, economic growth, social cohesion and even happiness. In The data obtained for Nigeria (2016/2017), the Global Multidimensional Poverty Index 2019 compiled by Oxford Poverty & Human Development Initiative (OPHI) and supported by UNDP, ranked Nigeria very low:

i. Multidimensional Poverty Index: 0.291 with 51.4%
ii. Population in multidimensional poverty: 98,175,000
iii. Intensity of deprivation: 56.6%
iv. Inequality among the poor: 0.029
v. Population in severe multidimensional poverty 32.3%
vi. Population vulnerable to multidimensional poverty 16.8%
vii. Contribution of deprivation in dimension to overall multidimensional poverty: Health 27.0%; Education 32.2%; Standard of living 40.8%;
viii. Population living below income poverty line: National poverty line, 46.0%; (Purchasing Power Parity) PPP $1.90 a day, 53.5%

4.5 The Corruption Perceptions Index (CPI)

The Corruption Perceptions Index ranks countries and territories based on how corrupt their public sector is perceived to be. A country or territory's rank indicates its position relative to the other countries and territories in the index. Nigeria scored 27 points out of 100 on the 2018 CPI. In the country comparison, Nigeria ranked 144 out of 180 countries according to the 2018 CPI as opposed to 148 out of 180 countries in the 2017 CPI as reported by Transparency International (PremiumTimes, 2019). Megan (2019) in an article online reported that Nigeria occupies number four position in the top ten most corrupt country with Iraq occupying the first position. This means that Nigeria is still perceived as highly corrupt.

Transparency International in its 2017 report identified public procurement fraud as constituting a large chunk of corruption in

public service and recommended immediate constitution of public procurement council as one of the ways to address the menace. This is yet to be done.

Nigeria does not compare favourably with several other nations in terms of key R&D inputs. Besides being ranked as one of the least competitive nations in the Global Competitiveness Ranking, Nigeria is presented as having some of the weakest institutions and training systems. Nigeria, in terms of key R&D indicators: R&D expenditure as percentage of GDP, researchers in R&D per million people, royalties and license fees and patents to residents are rated very low among the countries compared. It is worth noting that countries better than Nigeria generally, have effectively demonstrated how science and technology can be harnessed to drive national development in record time.

5.0 TECHNOLOGICAL R&D CHALLENGES

5.1 Philosophy for national development

One major problem militating against scientific research in general and technological research in particular is the near absence of a clear cut philosophy for national development. A philosophy which should spell out the direction in which Nigeria wants to channel its development efforts; That should not change no matter how frequently political power changes hands.

With the frequent changes of political power in Nigeria and the attendant instability, inconsistency and incoherence in governmental policies and programmes, the practitioners and researchers are left confused. Most times, before the researcher concludes an evaluative study of a particular programme or policy, it is either discarded or replaced with a different, sometimes completely divergent policy or programme.

5.2 Conducive Environment

The proper environment for research is not yet available in Nigeria. A conducive environment is needed for growth and utilization of research. For this to happen, many things have to be considered; these include, adequate infrastructure, trained manpower, institutional capacity, and adequate financial support which in this case is lacking in Nigeria. Conducive environment also involves motivating the entire population to adopt a science culture as a pattern of life. The issue of improper placement of persons in headship positions is the non-utilization of services of well-trained personnel as majority of Nigerian scientist are either out of the country in search of greener pasture, roaming the street/idle or work in organizations where their scientific competences are not useful. This brings about corruption and Nigeria ranks highly in the Corruption Perception Index. This has a negative implication for investment i.e. the flow of local and foreign investment into the country

5.3 Attitude Towards Policy Implementation

A review of Nigeria's economic development between 2000 to date revealed that overall macroeconomic policies and development strategies have failed to provide an enabling environment that could alter the structure of production and consumption activities in order to diversify the economic base. The country has continued to be a mono-cultural economy, depending on oil, indicating that the export base is yet to be diversified. Lack of adequate implementation on the part of our leadership (very poor leadership) has been the bane of Nigeria's technological growth. Widening saving - investment gap, high rates of inflation, chronic balance of payment problems and underutilization of resources have continued to be the order of the day. This has contributed to poverty and inequality being wide spread.

5.4 Security

The internal security of Nigeria has become a very big challenge in recent times. Internal conflicts, kidnappings, insurgency, including religious, ethnic and economic crisis, have had effects on the economy, most notably by scaring away investors from within the country and the international community.

5.5 Appropriate Technology

The technology that suits one environment may not suit the other. There can even be differences between environments within a country. When a technology is sufficiently pure to be composed of the art and artifacts of a society, developed over the years among the people and peculiar to the people, it is referred to as indigenous. It is often an outstanding attribute of the society which is closely linked with specific areas of success in their lives. While indigenous technology can be considered location-specific, its spread will indicate the relatedness among people across a given geographic area.

If technology is needed by a set of people, it must be appropriate. In reference to developing countries, technology can be appropriate if it makes use of maximum available local raw materials. It must also be compatible with the **tradition and value system of the target population**. It must create maximum number of employment opportunity; demand minimum training and maintenance and it must be adopted by local firms constrained by poor financial, technical and managerial expertise. Technology must be in line with meeting the basic needs of the poorest members of the community in which it is to be applied. It must be decentralizable, efficient yet low cost and hence within the reach of the recipients – especially the poorest in the remotest area of the country concerned (Adisa, 2005). The two forms are often confused. It is necessary to compare and identify the technology systems vis-a-vis the environment and make sure the technology is appropriate for the country.

6.0 THE WAY FORWARD

Mentoring, quality funding, functional leadership capacity, people's attitudes towards innovative ideals, and competences of political leaders drives development initiatives, while ill-will bureaucrats and people's attitudes skewed towards more of consumption than production propels stagnation and underdevelopment. Nations peopled with progressive thoughts and development initiatives find ways in identifying possible hindrances to attaining desired development in order to proffer possible solutions to the observed constraints which is the true essence of research (Lucky and Samson, 2013)

6.1 Establishing a national Philosophy

In the light of Nigeria's current economic problems, and particularly its poverty situation and unimpressive rates of economic growth, educational/ technological research and development should be given utmost attention; this is to enhance sustainable technological and economic growth and development. It is a known fact that a healthy, well-educated, innovative people make an economy more productive, it is therefore important to note that capacity building through investment in human capital, particularly in science and technology education can enhance economic growth, alleviate poverty and protect the Nigerian economy from further distortions. There is need to critically examine the relationship between investment in education and economic growth in Nigeria, with a view to deriving implications for policy direction (Dauda 2010).

6.2 Virile National Innovation System (NIS)

Metcalfe (1995; in Sharif, 2006) described NIS as a "set of institutions that (jointly and individually) contribute to the development and diffusion of new technologies. These institutions provide the framework within which governments form and implement policies to influence the innovation process. As such, it is a system of

interconnected institutions (established) to create, store, and transfer the knowledge, skills, and artefacts which define new technologies". Nations that have successfully transformed their economies to compete and thrive in technology and knowledge intensive sectors have done so by creating and strengthening their NIS.

Finland was the first country to adopt the concept as a basic component of its science and technology policy; Sweden has given the concept legitimate status in its own right by naming a new central government institution the "Systems of Innovation Authority" (Sharif, 2006). Finland is currently listed as number eleven on the GCI scale while Sweden is ranked eighth (8^{th})

6.3 Individual re-orientation

The basis for any change in a systemic paradigm is a change in the individual paradigm. This means that for there to be technological R&D-driven growth in Nigeria, every researcher must improve in his/her orientation. The days of isolated, territorial research are long gone. Every serious researcher, rather than jealously concealing his/her own work, should be willing to share knowledge and work with others for the common good.

Personal changes are required in individual mind-set, ideology, orientation and value system. Every researcher must raise the level of his/her emotional intelligence. This should give rise to selfless, determined and visionary leadership in Nigeria; compulsory attributes for a technologically developed country.

6.4 Institutional re-orientation

Despite the extensive institutional framework, R&D is not impacting on national development; this indicates that something is fundamentally wrong. It means that these institutions need to be reconfigured in their approach to work. As noted earlier, R&D is

under-funded in Nigeria, resulting from poorly funded institutions. Research institutions must therefore, be properly funded. This is best done through institution-based R&D grants. The benefit here is that institution can readily focus on areas of relative strength. Secondly, monitoring the use of such grants will be a lot easier as each institution can conveniently use its existing mechanisms to follow up on the R&D activities of its staff.

Every research institution needs to perform an internal analysis of its strength and weaknesses and accordingly create a pragmatic R&D agenda. Institutions put in place strong and virile research councils that will be responsible for overseeing R&D activities, to ensure that they are consistent with established priorities and that they yield appropriate results for investments. It should be noted that full attention must be paid to areas of national priorities. R&D activities must be highly connected to national priorities as articulated presently in the National Economic Empowerment and Development Strategies (NEEDS I and II), the 7-point agenda and the Vision 20-2020 initiative of the Nigerian government (Siyanbola et al., 2011). Technological R&D should prompt the urgent need to revamp steel industries.

6.5 Functional Government-Research Institutes-Industry Linkage

Networking is what ensures that resources are efficiently utilised and that personnel are effective. Historically, networking within Nigeria's NIS has been extremely difficult. Even within single institutions, researchers often find it difficult to work together due largely to distrust, territorial behaviour and a "go-it-alone" attitude. Multidisciplinary research is, therefore, at an all-time low in the country. Facilitating networks of researchers is particularly critical for technological R&D to have any meaningful impact on development in Nigeria. Government implementation will-power should be brought to bear for meaningful development to happen.

6.6 Effective Appropriate Technology Transfer

R&D outputs do not suddenly appear in the marketplace; a process must be followed to ensure first and foremost that the outputs meet market expectations and secondly to improve the prospect of success. Such processes will help in moderating and removing barriers as well as amplifying the profit and sustainability potentials of any technology. The model being advanced here (Fig 3) is one that begins the technology transfer management from the idea stage to ensure that the market is considered. Through Technology Transfer Offices (TTOs) and the activities of technological entrepreneurs (TE), organisational forms built around R&D outputs can then be taken through the incubation system and subsequently through the Science Park system before they are diffused into the open market. Ensure that appropriate technology with "local content" is applied.

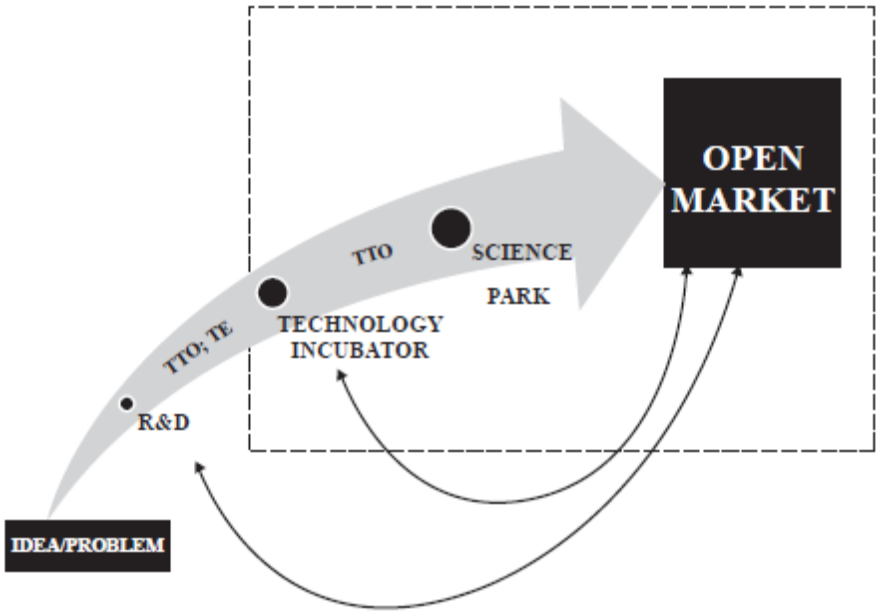


Fig 3: Model for effective technology transfer

7.0 TODAY'S TECHNOLOGIES THAT WILL SHAPE TOMORROW'S WORLD

A new report compiled by the World Economic Forum reveals some of the breakthrough innovations that are expected to radically impact the global social and economic order.

"From income inequality to climate change, technology will play a critical role in finding solutions to all the challenges our world faces today," says Jeremy Jurgens, Chief Technology Officer at the World Economic Forum. "This year's emerging technologies demonstrate the rapid pace of human innovation and offer a glimpse into what a sustainable, inclusive future will look like."

Making the list involves more than promising major benefits to the world. The emerging technologies must positively disrupt the existing order, be attractive to investors and researchers, and expect to achieve considerable scale within the coming 5 years.

These are the top 10 emerging technologies for 2019 (Johnny, 2019):

1. Bioplastics for a circular economy

Less than 15% of the world's plastic is recycled, with the rest incinerated, abandoned or sent to landfill. Biodegradable plastic offers a solution, but lacks the strength of conventional materials. A breakthrough idea promotes the circular economy by using cellulose or lignin from plant waste, which increases material strength without using crops that could otherwise be used for food.

2. Social robots

Today's robots can recognise voices, faces and emotions, interpret speech patterns and gestures, and even make eye contact. Droid friends and assistants are becoming part of everyday life, and are being used increasingly to care of the elderly, educate children and undertake all sorts of tasks in between.

3. Metalenses

Making the lenses used by mobile phones, computers and other electronic devices smaller has been beyond the capabilities of traditional glass cutting and glass curving techniques. But advances in physics have led to miniaturised, lighter alternatives to established lenses, called metalenses. These tiny, thin, flat lenses could replace existing bulky glass lenses and allow further miniaturization in sensors and medical imaging devices.

4. Disordered proteins as drug targets

"Intrinsically disordered proteins" are proteins that can cause cancer and other diseases. Unlike conventional proteins, they lack a rigid structure so change shape, making them difficult to treat. Now scientists have found a way to prevent their shape-shifting long enough for treatment to take effect, offering new possibilities for patients.

5. Smarter fertilizers

Recent improvements in fertilizers have focused on their ability to slowly release nutrients when needed. However, they still contain ammonia, urea and potash which damage the environment. New fertilizers use more ecologically friendly sources of nitrogen, and microorganisms that improve take-up by plants.

6. Collaborative telepresence

Imagine a video conference where you not only feel like you're in the same room as the other attendees, you can actually feel one another's touch. A mix of Augmented Reality (AR), Virtual Reality (AR), 5G networks and advanced sensors, mean business people in different locations can physically exchange handshakes, and medical practitioners are able to work remotely with patients as though they are in the same room.

7. Advanced food tracking and packaging

About 600 million people eat contaminated food each year and it's essential to locate the source of an outbreak immediately. What used to take days or even weeks to trace can now be tracked in minutes, using blockchain technology to monitor every step of a food item's progress through the supply chain. Meanwhile, sensors in packaging can indicate when food is about to spoil, reducing the need to waste whole batches once an expiry date is reached.

8. Safer nuclear reactors

Although nuclear power emits no carbon dioxide, reactors come with a safety risk that fuel rods can overheat and, when mixed with water, produce hydrogen, which can then explode. But new fuels are emerging that are much less likely to overheat, and if they do, will produce little or no hydrogen. These new configurations can replace existing fuel rods with little modification.

9. DNA data storage

Our data storage systems use a lot of energy and can't keep up with the vast - and ever-increasing - quantities of data we produce. In less than a century they are set to reach capacity. But breakthrough research is using DNA-based data storage, as a low-energy alternative to computer hard drives, with huge capacity: One estimate suggests all the world's data for a year could be stored on a cube of DNA measuring just a square metre.

10. Utility-scale storage of renewable energy

But storing energy generated by renewables for when there is no sun or wind has been a barrier to increased take-up. Lithium-ion batteries are set to dominate storage technology over the coming decade, and continuing advances should result in batteries that can store up to eight hours of energy – long enough to allow solar-generated power to meet peak evening demand.

CONCLUSION

A new research culture must emerge in the country if ever Nigeria is going to be termed "developed country". Our research must be structured, our talents must be mobilised, our knowledge must be shared and the entrepreneurial spirit must be stimulated around a true culture of projects, which complements the notion of programme and encourages us to take into account concrete objectives in priority areas. Individuals, institutions and companies must unite today to provide solutions to the great problems of our time.

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