



Revitalizing Science Research for Sustainable Development: Fostering Inclusive Practices

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ABSTRACT

This paper explores the necessity and potential for revitalizing science research for sustainable development through the implementation of innovative strategies which embrace inclusive practices. Sustainable development is a key component of modern development, which requires the integration of economic growth, social progress and environmental protection, as well as encompassing diversity and inclusion, and equity across generations to reflect its five pillars. Science research plays a key role in this process, since it provides the necessary tools and knowledge to develop innovative solutions to current multidimensional challenges confronting humanity, including the management of diversity through inclusion of diverse stakeholders.

Examination of inclusive practices in the context of sustainable science research is made. In particular, it assesses the potential of such practices to promote the effective engagement of stakeholders from diverse backgrounds. It argues that inclusive practices are essential for promoting effective scientific research, since they have the potential to enable the integration of multiple views and approaches into the research process, making it imperative to undertake rigorous stakeholder analysis from the outset.

The paper further explores the challenges that need to be addressed in order to ensure the successful adoption and implementation of inclusive practices in science research. In this regard, the paper argues for some critical policy reforms, funding and capacity building initiatives, as well as the use of digital technologies.

Finally, the paper contends that the successful implementation of inclusive practices in science research requires the development of appropriate institutional arrangements and the active engagement of stakeholders from diverse backgrounds, entailing a holistic approach to sustainable development. It concludes by emphasizing the need to improve the engagement of relevant stakeholders in the development of sustainable science research and to foster the successful adoption of inclusive practices.

INTRODUCTION

The subsisting underdevelopment of Nigeria continues to worry academics, development practitioners and agencies. The phenomenon is accentuated by the lack of commensurate contribution by our higher education institutions (HEIs) and research/innovation establishments to national development. In 2018, the National Universities Commission (NUC) commissioned its Strategic Advisory Committee (STRADVCOM) to undertake a thorough

diagnostic review of the operations of the Nigerian University system (NUS) to identify the critical challenges that must be overcome to revitalize the system. The outcome was the Blueprint for Revitalization 2019-2023 developed as a tool for implementing the necessary reforms. Twelve strategic goals were formulated to include strengthening and deepening research in the system, and ensuring diversity and inclusion to allow commensurate participation of women in the affairs of the universities. Of interest is the diagnostic assessment in collaboration with some external agencies such as the World Bank, the Quality Assurance Agencies of the UK and Egypt, as well as the Nigerian Economic Summit Group (NESG) to bring on board the perspectives of the industry. The diagnostic analysis identified two imperative pillars of the reform agenda, namely (i) the critical mass of high-level manpower with requisite knowledge and skills and competences and (ii) the critical mass of relevant research as precursor of innovation and increased productivity in the knowledge ecosystem. To attain these pillars, five major reforms were implicated; enhanced access to higher education institutions (HEIs), improved quality and relevance of higher education, development of sustainable financing strategy, modernization of governance and management of the institutions and more importantly, strengthening research and research output uptake/diffusion/commercialization. The central essence of the revitalization agenda is to make HEIs and knowledge more relevant to the local context that also makes them more competitive globally. The relevance of African HEIs is better captured by the seven aspirations and 20 goals in the African Agenda 2063, and its globalized form in the 17 sustainable development goals (SDGs). Without science, technology and innovation sustainable development will remain a mirage, hence revitalizing science research is key.

THE CONCEPT OF SUSTAINABLE DEVELOPMENT AND ITS AFRICAN DIMENSION

Sustainable development means meeting the needs of today's generation without harming the ability of future generations to meet their own needs (Emas, 2015). It involves the balancing of economic, social, and environmental considerations to create a better world for all. In short, sustainable development implies making sure that the things we do today don't hurt the world we live in tomorrow.

The following are the five pillars of sustainable development as depicted in Figure 1.

1. **Economic Sustainability:** This involves promoting structural and economic transformation, growth and development in ways that are environmentally and socially responsible, and that benefit both present and future generations. Examples of these, among others, include issues such as:
 - (i) **Circular economy:** an economic system that keeps resources in use for as long as possible in order to eliminate waste. This involves designing products to be reused or recycled, thereby promoting closed-loop systems that reduce waste and pollution.
 - (ii) **Sustainable tourism:** aimed at minimising the negative impacts of tourism on the environment and local communities by adopting responsible travel practices, such as using eco-friendly accommodations, and promotion of cultural awareness and preservation, as well as supporting local economies.
2. **Environmental Sustainability:** entails the reduction of the negative impact of human activities on the environment, as well as conservation of natural resources and promoting use of renewable energy sources. Examples of sustainable solutions that could preserve the environment include:

- a) Renewable energy sources such as wind, solar, hydro, geothermal power, and biomass/biogas from wastes. These sources of energy are sustainable, resource-conserving clean, and do not produce greenhouse gas emissions, which contribute to climate change.
- b) Sustainable or conservation agricultural practices, which reduce the environmental impact of farming by adopting cultural practices that promote soil health, conserve water resources, reduce chemical inputs, and support biodiversity. Such practices include crop rotation, intercropping, shifting cultivation, terracing, integrated pest management, water harvesting, organic farming, vertical farming and smart irrigation.
- c) The concept of green building, which involves the design and construction of buildings for energy-efficiency, environmental friendliness, and well-being of occupants. Such solutions should therefore involve the use of sustainable building materials, efficient heating and cooling systems, and renewable energy sources.
- d) Waste reduction, which entails minimising the amount of waste produced and discarded by individuals, businesses, and society as a whole. It is therefore expedient for engineering students to tailor solutions towards reduction in waste generation, bringing innovation into the processes involved in recycling, including materials' composting.

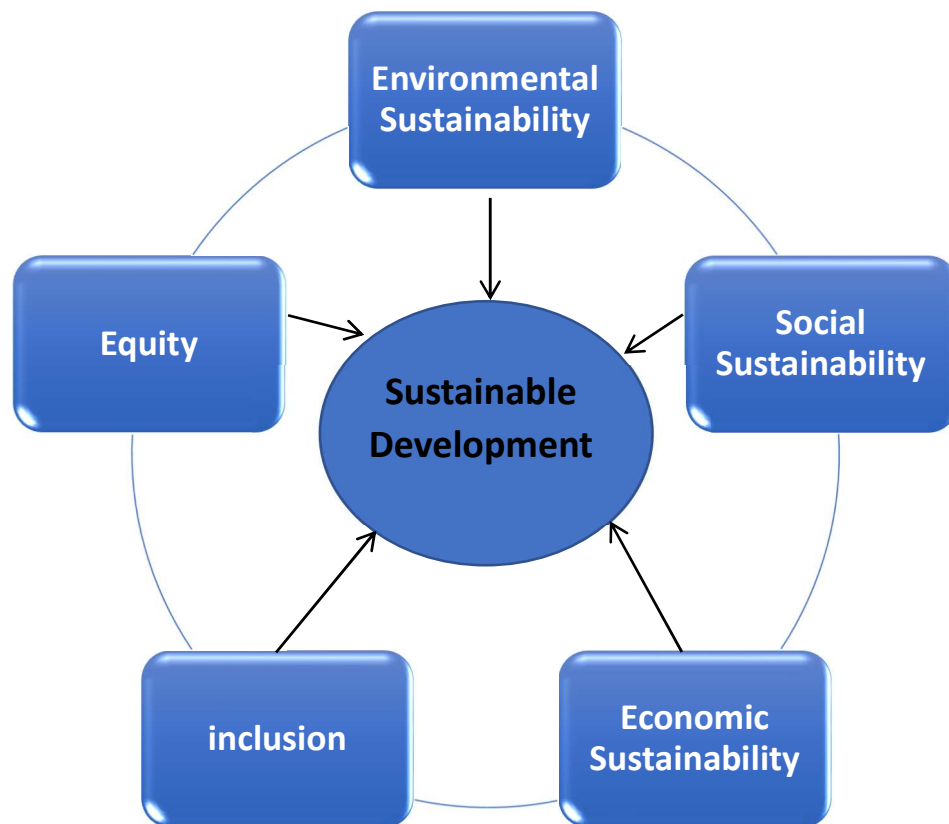


Figure1: The Five Pillars of Sustainable Development

3. **Social Sustainability:** Social sustainability is about making sure that everyone in a community has access to the basic things they need to live a decent and dignified life. It also entails the ability of a society to foster social cohesion and harmony, while concomitantly maintaining the well-being of its members over time. Social media is a technological innovation that has had significant impacts on society, and this also

presents an example of how technology can, and has contributed to social sustainability: in various ways. The manifestations of this include:

- (i) Increased access to information,
- (ii) Expanded communication,
- (iii) Enhanced collaboration,
- (iv) Increased civil engagements and,
- (v) Improved access to services.

Facebook, Twitter, You tube, WhatsApp, Instagram are examples of related solutions that were developed and deployed by Engineers in the global North. While these are excellent global technologies, the Chinese however have created similar indigenous solutions such as WeChat to replace Facebook and Sina Weibo to replace Twitter (Fitzgerald, Sandel & Wu, 2022). WeChat now has over 1.2 billion local users with over 100 million registered users outside China. It is therefore expedient for engineers and, in particular, engineering students in Nigeria to also ‘think globally while acting locally’. Our training in engineering must inspire us to want to emulate the developments in other climes where engineers are obsessed with creating sustainable solutions that impact and change the way we live globally.

4. **Diversity and Inclusion:** Entails engaging and involving all stakeholders in decision-making processes to ensure that diverse perspectives and needs are considered and addressed. Let’s consider the case of developing a digital solution for pest control and adaptation to assist small holder farmers for improved-quality agricultural produce. A solution of this nature should involve the smallholder farmers, the women farmers, youths and the grassroots in the community as well as representatives of the local government authorities, including personnel in the ministry of agriculture. These stakeholders are positioned to provide useful information. Since relevant people have been involved in the process from the beginning, the chances of resistance to the deployment of these solutions, their adoption and people buy-in are likely to be low, since their perspectives, core concerns and needs have been considered.
5. **Equity:** Inter-generational equity is a principle that involves ensuring that the needs and interests of future generations are considered in decision-making processes and that resources are managed in a way that allows for their sustainable use. For example, solutions that appear to be sustainable in the short-term may actually be detrimental to inter-generational equity. Meaning they unfairly burden future generations with negative consequences. An example of such a solution could be a country's decision to rely heavily on non-renewable resources, such as fossil fuels, to fuel its economy. While this may provide economic benefits in the short-term, it can have negative consequences for future generations, who will have to deal with the depletion of these resources and the environmental damage caused by their extraction and use.

The “Africa we want” is very elegantly captured in its 7 Aspirations (See **Box 1**, <https://au.int/agenda2063/aspirations>). By design at take-off in 2015, Agenda 2063 represented “Africa’s blueprint and master plan for transforming the continent into a global powerhouse of the future. It was Africa’s strategic framework that aimed to deliver on its goal for inclusive and sustainable development and was a concrete manifestation of the pan-African drive for unity, self-determination, freedom, progress and collective prosperity pursued under Pan-Africanism and African Renaissance. It envisioned a long-term 50-year development trajectory for Africa to engender a people centered development, gender equality and youth empowerment consistent with changing global contexts of increased globalization, the ICT revolution and the increased prospect of African unity, to make it a potential global power to be reckoned with and capable of rallying support around its own common agenda. The aim was to leverage emerging development and investment opportunities in areas such as agri-business, infrastructure development, health and education as well as the strategic value addition potential of African generous commodity endowments.

BOX 1: ASPIRATIONS AND KEY OUTCOMES OF AFRICA AGENDA 2063:

Aspiration 1: A prosperous Africa based on inclusive growth and sustainable development

Aspiration 2: An integrated Africa Agenda 2063 and the SDGed continent, politically united and based on the ideals of Pan-

Africanism and the vision of Africa’s Renaissance

Aspiration 3: An Africa of good governance, democracy, respect for human rights, justice and the rule of law

Aspiration 4: A peaceful and secure Africa

Aspiration 5: An Africa with a strong cultural identity, common heritage, shared values and ethics

Aspiration 6: An Africa, whose development is people-driven, relying on the potential of African people, especially its women and youth, and caring for children.

Aspiration 7: Africa as a strong, united, resilient and influential global player and partner.

Expected Outcome 1: Improvements in Living Standards

Expected Outcome 2: Transformed, Inclusive and Sustainable Economies

Expected Outcome 3: Integrated Africa

Expected Outcome 4: Empowered Women, Youth and Children

Expected Outcome 5: Well-governed, Peaceful and Cultural-Centric Africa in a

Agenda 2063 and the Global Sustainable Development Goals

The essence of the African development agenda becomes more compelling and reinforcing when crosschecked side-by-side with the global Sustainable Development Goals, SDGs, which encapsulate the subsisting global development agenda. The SDGs were adopted in 2016 to replace and complete the unfinished agenda of the 21st century Millennium Development Goals, MDGs, which ran from 2000-2015. The SDGs commenced in January 2016 for another 15 years till 2030, and by them, the world committed to “**ending poverty in all its forms and dimensions, including by eradicating extreme poverty by 2030**”. “All people must enjoy a basic standard of living, including through social protection systems, ending hunger and achieving food security as a matter of priority and ending all forms of malnutrition.

The comparison between the two development agendas is summarized as illustrated in Table 1, with good correspondence. However, there are some goals that are specific to Africa and not included in the SDGs. These are African goals 8, 9, 15 and 16. If anyone is in doubt as to the appropriateness of the aspirations and goals of the African Agenda 2063, then their resonance with the global goals reassures to the contrary. Hence the test of the African agenda is more in its implementation for which political will, strategy (deployment of STI) and funding are key.

Universities as Leader and Drivers of Sustainable Development

There is a growing emerging contention that higher education institutions must lead the implementation of the SDGs with scientific research and technological innovations. World university bodies, including the International Association of Universities (IAU), Association of Commonwealth Universities (ACU), the Association of African Universities (AAU), to mention the most prominent, have keyed into these commitments. A recent article in the University World news opined thus: *“To deliver the badly needed SDGs and targets, we need trustworthy, ethical, honest and impartial government institutions that exercise public power, oversee policies fairly and take into account their range, complexity and occasional incompatibility. These institutions are much more likely to promote trust and social capital which in turn improves health and well-being. Tackling corruption is vital. We also need higher education institutions that can teach the crucial necessary skills we have highlighted. These should be taught and implemented throughout people’s entire life span. It is crucially important that leading higher education institutions start leading by example to increase future decision-makers’ motivation and ability to act ethically”* (Levi and Rothstein, 2018).

Table 1: The Correspondence between Agenda 2063 and the SDGs

AFRICA’S AGENDA 2063		GLOBAL SUSTAINABLE DEVELOPMENT GOALS
Goals	Priority Areas	
1. A high standard of living, quality of life and well-being for all citizens.	<ul style="list-style-type: none"> • Incomes, jobs and decent work • Poverty, inequality and hunger • Social security and protection, including persons with disabilities • Modern, affordable and livable habitats and quality basic services 	1. End poverty in all its forms everywhere in the world 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture. 8. Promote sustained, inclusive and sustainable Economic growth, full and productive employment and decent work for all. 11. Make cities and human settlements inclusive, safe, resilient and sustainable.
2. Well educated citizens and skills revolution under-pinned by STI.	<ul style="list-style-type: none"> • Education and science, technology and innovation (STI) driven skills revolution 	4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
3. Healthy and well-nourished citizens.	<ul style="list-style-type: none"> • Health and nutrition 	3. Ensure healthy lives and promote well-being for all at all ages.
4. Transformed economies	<ul style="list-style-type: none"> • Sustainable and inclusive economic growth • STI driven manufacturing, industrialization and value addition 	8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

	<ul style="list-style-type: none"> Economic diversification and resilience 	9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
5. Modern agriculture for increased productivity and production	<ul style="list-style-type: none"> Agricultural productivity and production 	2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
6. Blue/Ocean economy for accelerated economic growth	<ul style="list-style-type: none"> Marine resources / energy Port operations and marine transport 	14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
7. Environmentally sustainable and climate resilient economies and communities.	<ul style="list-style-type: none"> Bio-diversity, conservation and Sustainable natural resource management. Water security Climate resilience and natural disasters preparedness 	6. Ensure availability and sustainable management of water and sanitation for all. 7. Ensure access to affordable, reliable, sustainable and modern energy for all. 13. Take urgent action to combat climate change and its impacts. 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
8. A United Africa (Federal or Confederate)	<ul style="list-style-type: none"> Frameworks and Institutions for a United Africa 	--
9. Performing continental financial and monetary institutions	<ul style="list-style-type: none"> Financial and Monetary Institutions 	--
10. World class infrastructure crisscrosses Africa	<ul style="list-style-type: none"> Communications and infrastructure connectivity. 	9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
11. Democratic values, practices, universal principles of human rights, justice and the rule of law entrenched.	<ul style="list-style-type: none"> Democracy and good governance Human rights, justice and the rule of law 	16. Promote peaceful and inclusive societies for sustainable development, with access to justice for all. Build effective, accountable and inclusive institutions. at all levels.
12. Capable institutions and transformative leadership in place	<ul style="list-style-type: none"> Institutions and leadership Participatory development and local governance. 	16. Promote peaceful and inclusive societies for sustainable development, with access to justice for all. Build effective, accountable and inclusive institutions.
13. Peace, security and stability is preserved.	<ul style="list-style-type: none"> Maintenance and preservation of peace and security 	16. Promote peaceful and inclusive societies for sustainable development, with access to justice for all. Build effective, accountable and inclusive institutions.
14. A stable and peaceful Africa.	<ul style="list-style-type: none"> Institutional structure for AU instruments on peace and security Defense, security and peace 	16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.

15. A fully functional and operational Africa Peace and Security Architecture (APSA)	<ul style="list-style-type: none"> Fully operational and functional APSA all pillars 	--
16. African cultural renaissance is pre-eminent.	<ul style="list-style-type: none"> Values and ideals of Pan Africanism, Cultural African Renaissance Cultural heritage, creative arts and businesses 	--
17. Full gender equality in all spheres of life.	<ul style="list-style-type: none"> Empower Women and girl's Violence and discrimination against women and girls 	5. Achieve gender equality and empower all women and girls
18. Engaged and empowered youth and children.	<ul style="list-style-type: none"> Youth empowerment and children's rights 	4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities. 5. Achieve gender equality. Empower women
19. Africa as a major partner in global affairs and peaceful co-existence	<ul style="list-style-type: none"> Africa's place in global affairs Partnerships 	17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.
20. Africa takes full responsibility for financing her development Goals.	<ul style="list-style-type: none"> African capital markets Fiscal systems and public sector revenue Development assistance 	10. Reduce inequality within and among countries. 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.

(<https://au.int/agenda2063/goals>)

As summarized in Table 2, the SDGs are closely linked to key functions of the university system, including preparing skilled and knowledgeable manpower and professionals for various sectors of the economy, generating and disseminating knowledge through research engagements for institutional development as well as building the capacity of professionals, and imbuing them with values and citizenship skills which would navigate them through life as global citizens, solving larger-than-life developmental problems.

Table 2: How Universities can lead the Implementation of the SDGs

SDGs	Preparation of Skilled Professionals	Knowledge Generation, Adaptation & Diffusion	Institutional Development & Capacity Building	Values & Citizenship Skills
1. Poverty Ended	X	X	X	X
2. Sustainable Agriculture to End Hunger	X	X	X	
3. Healthy Lives	X	X	X	X
4. Inclusive & Equitable Quality Education	X	X	X	X
5. Achieve Gender Equality	X		X	X
6. Water & Sanitation for All	X	X	X	X
7. Sustainable Energy	X	X	X	
8. Inclusive & Sustainable Economic Growth	X	X	X	
9. Resilient Infrastructure	X	X	X	
10. Reduced Inequality	X			X
11. Sustainable Cities	X	X	X	X
12. Sustainable Consumption & Production		X		X
13. Managed Climate Change		X	X	X
14. Sustainable Marine Resources	X	X	X	X
15. Sustainable Use of Terrestrial Systems	X	X	X	X
16. Peaceful & Inclusive Societies		X	X	X
17. Global Partnership for Sustainable Development			X	X

The 17 goals, their 169 targets and means of measurements that have been painstakingly developed, provide us with frameworks and templates for monitoring progress. Several UN Agencies and the SDG-Sustainable Development Network (SDG-SDN) have developed annual monitors published in annual reports¹, such that we do not need to re-invent the wheel in rendering monitoring, guiding and leadership obligations to enable our universities assist Nigeria to pragmatically implement and achieve the goals, though we are already lagging behind in important milestones. The universities can work with the professional bodies and other higher education institutions to provide leadership in driving the SDGs. For example, all tertiary level students must understand what the SDGs are and how their attainment is central to Nigeria/Africa's sustainable development and prosperity. Happily, the teaching of values and citizenship skills has now been embedded in our newly revised curriculum.

The Significance of Science Research to Sustainable Development

¹ The Annual State of the World Hunger Report (FAO, UNICEF, IFAD, WFP, &WHO). The UNDP Annual World Reports, the AfDB Annual African Reports, the SDG-Sustainable Development Network (SDGSDN Annual Reports). World Population Bureau Reports and Worldometer, www.worldometers.info

The Royal Society of the UK in its 2011 publication, “Knowledge, Networks and Nations”, asserted that “science is not a luxury which is the preserve of developed countries”,....that “technology and innovation are key to achieving long-term economic and social development”, and that science and innovation are recognised the world over as crucial to economic competitiveness” using examples and case studies from several jurisdictions. Science research is at the root of inventions, innovations, technological progress and sustainable economic/social development of nations. The issue of inclusion has gained considerable currency in modern times, as emblemized by the establishment of bodies and organisations such as OWSD. It is apt at this point to acknowledge the impressive range of activities and undertakings which have become the hallmark of OWSD. Needless to add that this gathering and conference is well conceived.

Science technology and innovation (STI) has become the engine driving modern sustainable development. In spite of the enormous challenges of population growth, urbanization, poor infrastructure for education, health, sanitation, housing, and increasing multidimensional poverty that Nigeria is facing as a nation we can leverage STI, hence science research to unleash our hidden talents and potentials. For example innovation mediated by science research can assist in bridging the shortages in the scarce resources by deploying state-of-the-art technologies, e-learning, telemedicine, as well as information and management systems that can close some of the gaps and even enable us to leapfrog as happened with the mobile communication networks since 2001. We can indeed cover the broad spectrum of the SDGs from eliminating poverty to mitigating hunger, health and other challenges by using scientific research and digital/advanced technologies for smart farming (planting, fertilizer application, irrigation, harvesting), storage, designing new foods and food products to double food production and hence food security, while simultaneously do this while ensuring environmental preservation through conservation agricultural practices and forestry development and management programmes. We can protect our natural environments scientifically through water resources and waste water management, reducing water shortages and improving water quality. Our knowledge of green energy can boost the capacity towards energy transition and help save the planet, marching towards more sustainable life of dignity.

A necessary component of science research is the effective uptake, communication, diffusion and utilization/commercialization of the products of science research to develop entrepreneurship, evolve start-ups and SMEs to instigate development. The reputation of institutions and nations is measured by how much this has been done successfully. Nations that have mastered the art of coupling their science research to the real sectors of their economy are more competitive and are regarded as developed, whilst developing and underdeveloped states grapple with inability to harness its promise and immense potentials. Inclusion of diverse groups, including women, youth and other segments of the society as one of the sustainability pillars is fundamental to sustainable development. Society losses, when all human potentials are not harnessed for development.

FOSTERING INCLUSION FOR SUSTAINABLE DEVELOPMENT

The sustainable development goal No 5 specifically targets Gender Equity as one of the manifestations of inclusion. Marginalization of the women is one of the “tyrannies of the obvious” in our daily official, professional and academic engagements. This corresponds to the

Gender-Blind state, which ignores the set of economic, social, political roles; rights; entitlements; responsibilities; and obligations associated with being female and male as well as power dynamics between and among men and women, boys and girls. The flipside is being Gender-aware or conscious, with the goal of gender equality and better development outcomes for society. Between the two extremes we can identify and map some tendencies, which can determine the corrective strategies to adopt.

Gender Integration Continuum Mapping

Gender Blind	Ignores: the set of economic, social, political roles; rights; entitlements; responsibilities; and obligations associated with being female and male as well as power dynamics between and among men and women, boys and girls.
Exploitative	Reinforces or takes advantage of gender inequalities and stereotypes
Accommodating	Works around existing gender differences and inequalities.
Transformative	<ul style="list-style-type: none"> • Fosters critical examination of gender norms and dynamics. • Strengthens or creates systems that support gender equality. • Strengthens or creates equitable gender norms and dynamics. • Changes inequitable gender norms and dynamics.
Gender Aware	Goal: gender equality and better development outcomes for society

The Necessity for Fostering Inclusion

Worldwide, the average of women’s human development is behind men’s by 5.7% as a whole, based on the ability to:

- lead a long and healthy life, measured by life expectancy at birth;
- acquire knowledge, measured by mean years of schooling and expected years of schooling; and
- achieve a decent standard of living, measured by gross national income per capita.

On all development indices, Nigerian women and girls fare worse than their male counterparts.

- Nigeria has a very low gender equality score of only 0.372 on the composite Africa Gender Index, where 1 represents gender parity across a range of social, economic and empowerment and representation indicators. In this index, Nigeria scores 0.627 on economic and business variables (female labour force participation, work in vulnerable employment, access to finance, time spent in unpaid work, etc) and 0.952 on social variables (primary, secondary and tertiary education completion and school dropout rates); while on the empowerment and representation indicators (reflecting women’s roles in political and business leadership), Nigeria scores particularly low, at 0.086.
- Nigeria ranks 139 out of 156 countries on the Global Gender Gap index. This index measures women’s economic participation and opportunity, educational attainment, health and survival, and political empowerment.
- There are regional differences in girls’ access to education and vocational guidance and training.

In all southern regions, there is gender parity in school enrolment, while in the northern states,

Strategies for Inclusive Engagement

It is important to identify elements and grievous aspects of marginalization that must be cured. A basic principle of inclusion and the embrace of diversity is to factor it in at every stage of the scientific research process, from constitution research partnerships, through identification of

leaders, grant seeking processes, project implementation, again, from inception activities, including stakeholder analysis, through the actual laboratory or field works for data gathering, data analysis, report writing and the development of publications, output uptake and research communication activities, till project closure. There must be consciousness of diversity and inclusion all through.

The following are some suggested strategies to improve both Gender participation in science research and overall gender equality:

- **Reaching out and involving women and women's groups in capacity building trainings**, so that women attain collective consciousness, competence and dexterity in science research and the bargaining power and influence to entrench parity and equity. To participate and compete favourably, women must be competent and acquire necessary research skills (as listed in the outline of this 5th pre-conference workshop)
- **Supporting women to adopt and secure leadership roles in research, research partnerships** and research-based academic institutions, so as to place them at the commanding heights of decision- and policy-making. This along with their competence, gives them the confidence to dare attempts at marginalization.
- **Involving both women and men as beneficiaries in capacity building trainings** so that there is transparency and co-ownership between the sexes regarding contributions to and benefits from the programme.
- In all, there must be **consciousness, determination, shrewdness and creativity** in working towards equal participation.

Recommended Inclusive Tendencies and Practices

As earlier indicated, a fascinating aspect of outcome uptake, diffusion and commercialization relates to spinning off start-ups and other enterprises from a scientific research project, leading to business partnerships. However, one of the critical deficits in tech-ecosystem development in Africa/Nigeria is shortage of talents, mentors and understanding venture capitalists. Addressing this problem can take two broad partnership forms, namely bringing in experts from outside and knowledge exchange/exposure. Viable multilateral and bilateral partnerships can be built to foster the growth of entrepreneurship and their transition to startups. Several development partners and countries are interested and some already active. There is also a great scope here for the African Diaspora to exploit their Networks to facilitate such partnerships. For example, the Swedish embassy has promised to leverage the experience of their tech ecosystem in a way that can support the ideas of the VFA (see later) and also open the possibility of knowledge exchange that will allow Nigerian fledgling startup entrepreneurs spend quality industrial exposure in the Swedish ecosystem. Swedish startups present at the Nigeria Digital Economy Summit in Abuja in November 2019 and who have expressed interest include:

- Grace Health: <https://www.grace.health/>
- Stockholm Tech Fest: <https://sthlm-tech-fest-2019.confetti.events/>
- Hyper Island: <https://www.hyperisland.com/>
- War on Cancer: <https://waroncancer.com/>
- EQT: <https://www.eqtgroup.com/>
- Hack for Sweden: <https://hackforsweden.se/>
- The Park: <https://thepark.se/>

The Venture for Africa Initiative

Venture for Africa (VFA) is an initiative created to fill talent gaps at African Startups through a 3-month immersion fellowship. Essentially to respond to the challenge startups in Africa face

in filling talent gaps. During the programme, fellows work with startup partners who are hiring now to access workshops from expert mentors in their field, work on real project deliverables for their assigned startup, gain local, in-market context in a startup environment, and get fast-tracked through application processes for a potential full-time role. In the interest of filling roles as soon as possible, the VFA team and participating startups have committed to expedite normal application timelines and allow candidates know whether they have been fast-tracked within two weeks of applying. The programme was designed for African nationals contemplating moving from corporate to startup, Africans in the Diaspora wishing to return home, and foreign nationals finding meaningful work at an African startup.

Women in Startups and Entrepreneurship

As noted elsewhere, there is a paucity of women in entrepreneurship and startups leadership and founding, though there are some inspiring natural exceptions, success stories (Kene Okafor, 2020), as well as those who have taken advantage of subtle affirmative actions. Our work on the characteristics of hubs, revealed that “gender preferences in start-ups support was low as only about 18.5 % of responding hubs preferred to support start-ups focused on women, while 27% prefer to support those with women founders”, thereby accentuating the biases already consciously or unconsciously inflicted by their gender. Little wonder that fewer women succeed in the risky business of start-ups development through the tortuous pathway to maturity.

Global studies on women research, innovation, and business progress such as by the Kauffman Foundation and others (Hanna and Guilliani, 2020) have shown that early in the startup process, women take fewer steps to position themselves to start high-growth companies. A particular study on “Gender Differences in Patenting in the Academic Life Sciences,” (Mitchell, 2011) a landmark study released in 2006, tracked the careers of more than 4,000 life science research faculty at U.S. universities over 30 years. While women tended to produce research that was equal to or slightly better than men’s, female faculty patented their research at only about 40 % of the rate of their male colleagues. They also tended to rely on formal university conduits to help them commercialize their research, rather than making connections and seeking guidance from private industry. In addition to more actively reaching out to establish new networks – a critical step for would-be entrepreneurs – men had more exposure to industry earlier in the process, with 93 % of them serving on the advisory boards of high-tech companies, as compared to only 6.5 % for women.

Other studies show that women might be more inclined to seek work/life balance and therefore shy away from establishing innovative firms that aim for global scale. They also have greater difficulty raising investment capital than men do. Despite their increasing presence in top positions in startups, women still trail men on key measures of startup activity, and their firms tend not to grow or prosper nearly as much. Typically, this is seen as “women’s issue”. It is framed as a problem to be dealt with for the benefit of women, in the interest of gender equality. Some steps prescribed to **boost female entrepreneurship**, learning from the US example are:

- Not-for-profit initiatives that advance opportunities for high-growth women entrepreneurs need greater funding and support from women executives, philanthropy leaders and industry. Networking and collaborative events between startup founders and big companies are critical to provide women entrepreneurs access to networks that can produce potential customers.

- Successful women entrepreneurs and inventors should make themselves visible and available. Role models are critical to young women considering entrepreneurship.
- Women must be invited at a much higher rate to join the advisory boards of high-tech and high net-worth companies, such as Shell, MTN, Globacom etc.
- Recognizing the special innate endowments of women in entrepreneurship and the unique role they play in communities and society at large dictate according them as much importance as being advocated for startups in economic transformation. If policy makers are convinced of the centrality of startups as advocated, then greater recognition must be deliberately ascribed to the significance of making special provisions for inclusive and equitable women participation. Women entrepreneurship had represented a major family and community stabilizing force in African societies for it to be factored into economic transformation strategies.

REVITALIZING RESEARCH FOR NATIONAL SUSTAINABLE DEVELOPMENT

Understanding the Value of Research and Knowledge as National Policy Imperative

There is need for a renewed appreciation of the value of education and especially research and its innovation outputs as a major driver of national development. For example, the Cambridge University Report titled “The economic impact of the University of Cambridge”, released in March 2023 is breath-taking in its assertions on the economic value of the university, and hence knowledge, to national economic development. The study was contracted to the London School of economics which concluded thus *“On the aggregate economic impact of the University of Cambridge: The total economic impact on the UK economy associated with the University of Cambridge’s activities in 2020-21 was estimated at approximately £29.8 billion. Compared to the University of Cambridge’s total operational costs of approximately £2.543 billion in 2020-21⁶, this corresponds to a benefit to cost ratio of 11.7:1.* www.teachingtimes.com/the-economic-impact-of-the-university-of-cambridge/

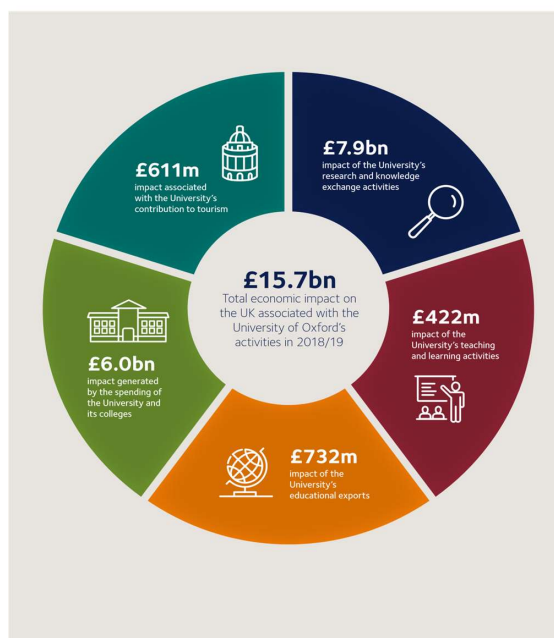
A similar exercise for Oxford University asserted that for every £1 invested in University of Oxford, research and knowledge exchange activities generated £10.3 for the UK national economy in 2018/19. The University, in aggregate terms, contributed a total of £15.7 billion to the UK economy in 2018/19.

(See Figure 1). www.teachingtimes.com/the-economic-impact-of-the-university-of-oxford/

Planning to Manage Wealth Vs Poverty? The Promise of Science Research

The state that the Nigerian economy is at the moment requires a major change of approach to development from managing poverty to managing wealth. A good starting point is to consider the trajectory of the growth of Brazil and South Korea since the mid-60s by comparing their per capita income growth. In 1965, they had the same per capita income, while by 2003, the

Economic impact
of the University of Oxford



year of analysis, Korea’s per capita income had risen to 4.7 times that of Brazil. The reason for the big difference is that Korea has had a higher rate of investment to GDP in (higher) education and was also better at harnessing knowledge—both technical and policy knowledge—for its development. In Figure 2, we decompose the per capita income growth for Korea into that which can be explained by increases in the labor force and in capital. The per capita income that would result from simple factor accumulation is shown by the red line. The difference between the red line and the actual per capita income growth in Korea can be attributed broadly to better use of knowledge---both technical and policy knowledge. The key point here is that the effective use of knowledge, which depends on knowledge, skills and innovation, can make a very big impact on growth performance. Brazil needs to do more to improve the effectiveness with which it uses knowledge for its growth and development.

The explanation of the indication of effective use of knowledge is contained in Figures 3-5 the relative investments in the various levels of education, the ratio of research scientists in industrial innovation environments as opposed to academics, and the resultant impact on the volume and quality of research outputs and innovation. Figure 2 is copiously indicative of the value of knowledge and its effective utilization in unleashing the development capabilities of a knowledge system, and that is why South Korea is today a highly developed country. The emphasis on tertiary education is obvious from the dynamics of Figure 3, and this is indicative of the level of education to which development attention must be focused. The World Bank had earlier misguided developing nations, including Nigeria to focus more on basic education to the neglect and detriment of higher education.

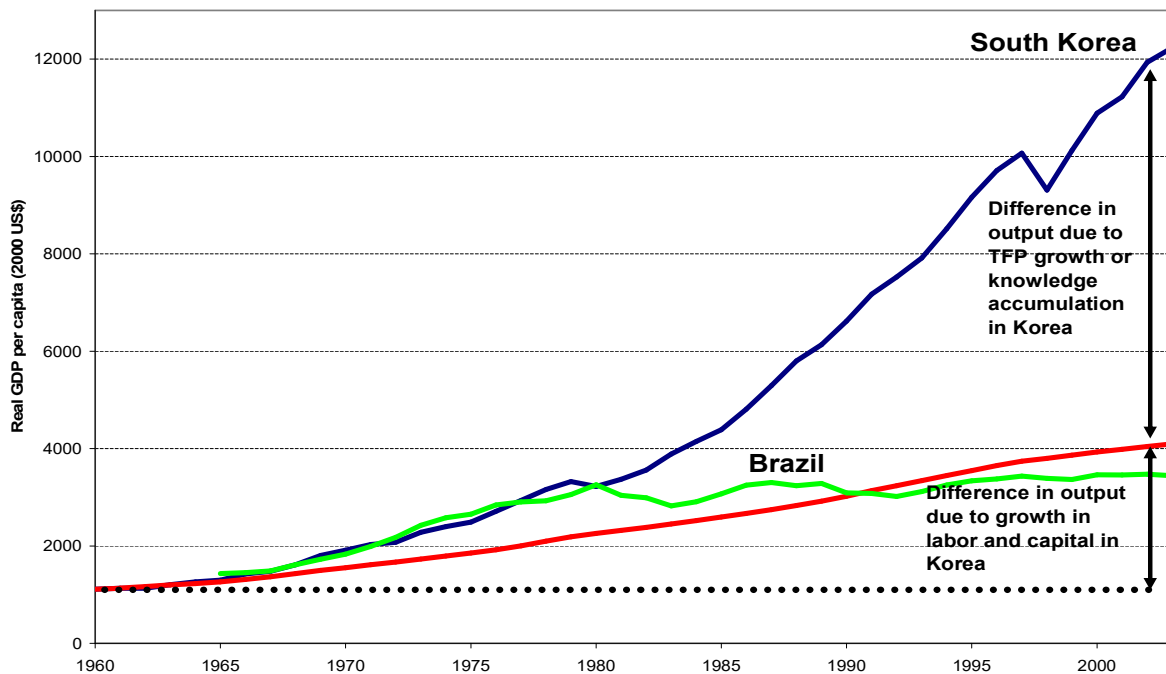


Fig 2: The Per Capital Income Growth Trajectory of Brazil and South Korea, 1965-2005

It was not until the early 2000, through the persistent work of the likes of Jamil Salmi that this silly position was reviewed in favour of investment in functional higher education and essential

skills for the work of life. Also very significantly, Figure 4 shows the role of the collaboration between knowledge centers (HEIs and research institutes) and SMEs and Start-ups in vigorously fostering innovation with more of high-level scientists and researchers coupled to the industrial production sectors, resulting in the high level patent of patent registration recorded. This is further illustrated in Figure 6 which demonstrates the importance of industrial innovation by firms/start-ups as a logical transition from an innovation ecosystem to a start-up ecosystem. These have salutary implications to the evolution of entrepreneurial and innovation driven universities and knowledge societies.

South Korea and Brazil

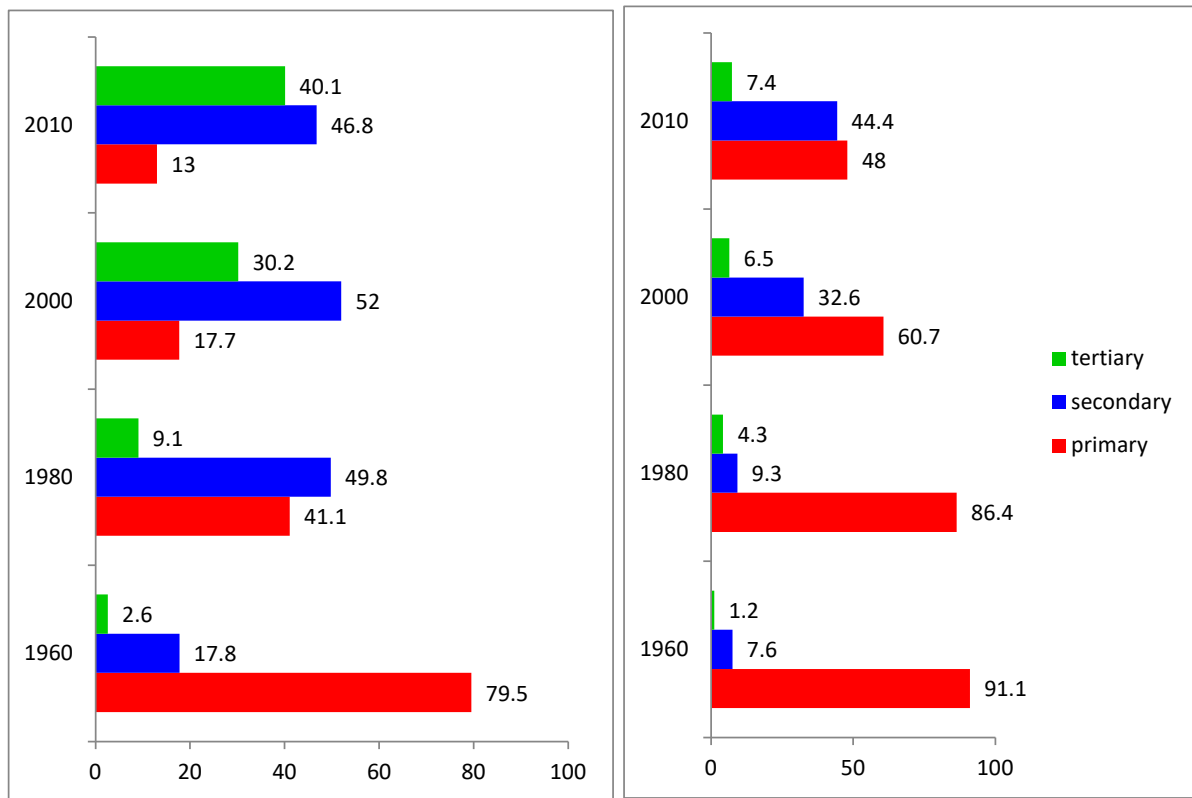


Fig 3: Relative Investment in Education at the Different Levels

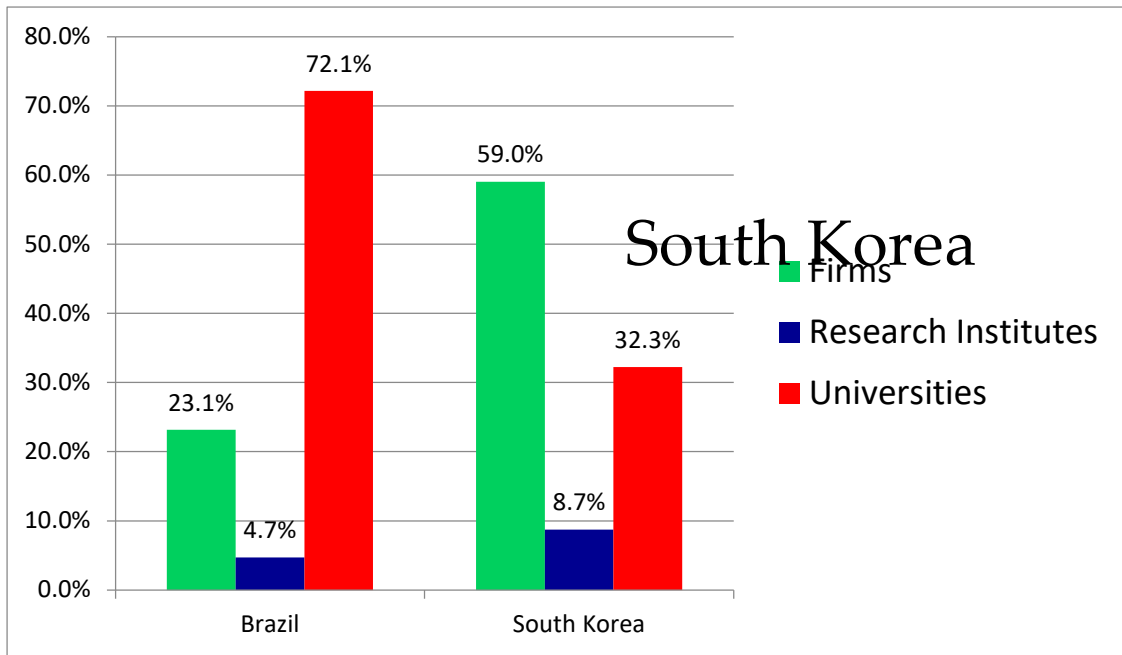


Fig 4: Ratio of Scientists Active in Research, Development & Innovation

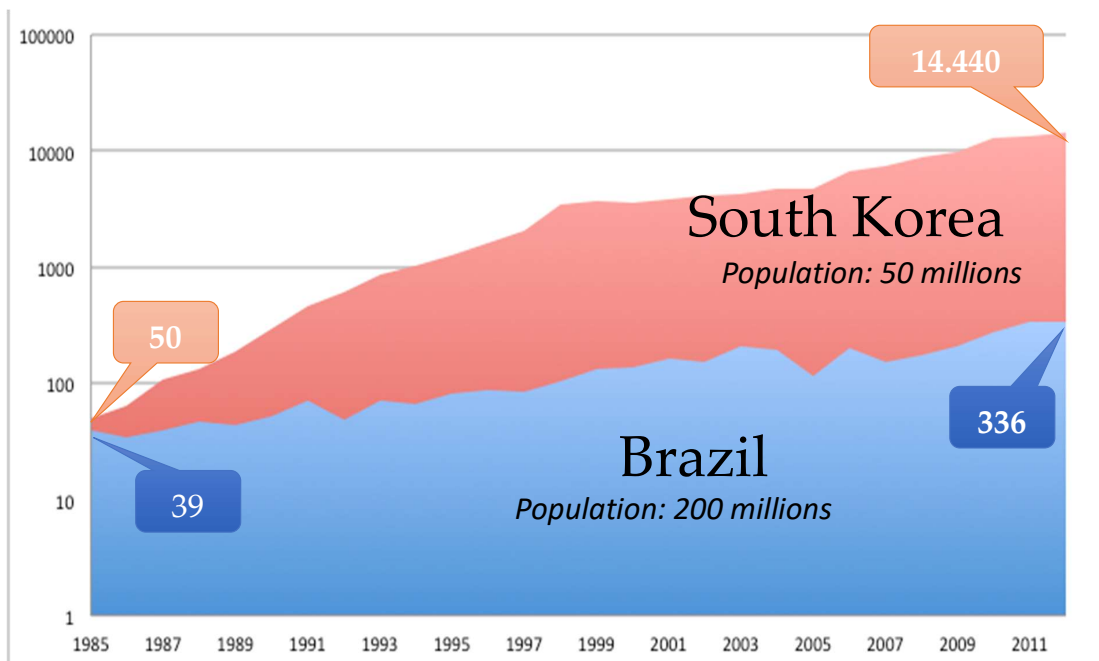


Fig 5: Number of Patents/USPTO, 1985-2012

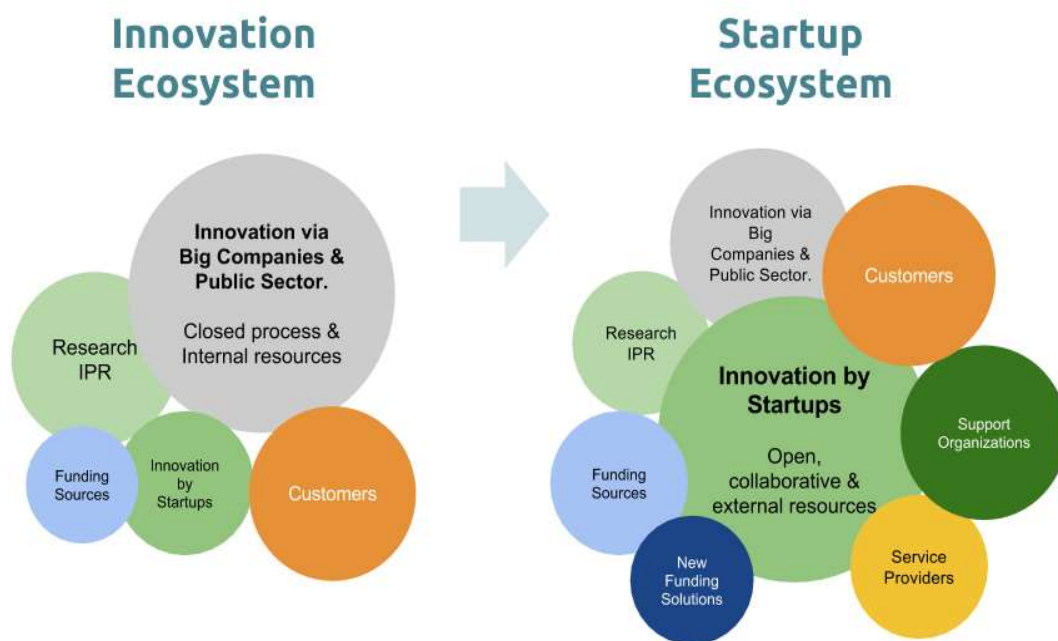


Fig. 6: Illustration of the importance of industrial innovation by firms/start-ups

Implications for the Way Forward

This necessary appreciation of the value of knowledge or HEIs should elicit the following reforms in the national research architecture:

- Articulating a 21st century national science and technology policy
- Modernizing research infrastructure for cutting-edge engagements.
- Accelerating the training of PhDs and consciously reducing inbreeding
- Professionalizing research governance; management and administration
- Facilitating technology/knowledge transfer and research/innovation uptake. The research and innovation uptake function requires specialised/independent structures (or Special Purpose University-Industry Vehicles, SPUVs). Such vehicles should not impair the basic research and development functions of universities. Hence, governance of such entities must be handled by experts, and separated from academic functions. Available frameworks/models include:
 - University ventures,
 - Industrial development centres
 - Incubation centres/hubs,
 - Start-ups and MSMEs
 - Science and Technology Parks,
 - Industrial Parks,
 - Knowledge parks, etc
- Greater national investment in Research and Development activities. The current spend on STI is only 0.11% of the GDP as against UNESCO recommended level of greater than 1%. This must be accompanied with provision of adequate competitive research funding on a competitive basis. TETFund is doing well in this regard, but things can be handled better with well-funded National Research Endowment.

- Research Communication, Output Uptake and Commercialization – Leveraging the Triple Helix
- Instigating a major review of the Nigerian knowledge and Innovation ecosystem to integrate, streamline, and couple/consolidate the over-stratified research formations and the universities to prevent so much waste, idleness, underutilization of expertise and expensive facilities in the country’s many research laboratories and ‘complexes’. If the present status quo of keeping HEIs under the Ministry of Education is to be sustained, then there must be proper affiliation of MDA Research and Development (R&D) institutes with universities and adoption of the Triple Helix development model of collaboration between Government MDAs-HEIs-Industry as obtains in some other jurisdictions such as USA, Canada and some Europe countries. Researchers in the MDA R&D Institutes must be affiliated with HEIs as research Fellows to collaborate and co-supervise research while lecturers in the HEIs are made Research Fellows in the MDA Research Institutes similar to the model used in running Teaching Hospitals.

Departmental-Level Reforms and Individual Researcher Actions

Academics and researchers must reappraise and rededicate themselves in line with the global quality standard of a researcher (<https://www.wikihow.com>):

- ❖ Creativity: to develop unique project proposals
- ❖ Possession of grant writing skills: needed to create compelling proposals and obtain substantial capital from various organizations.
- ❖ Public speaking: ability to present findings at conferences and to give lectures in large lecture theatres.
- ❖ Analytical thinking: ability to identify patterns in studies and for validating the credibility of existing literature.
- ❖ Attention to details: essential for monitoring experiments and supervising research assistants, and to publish organized, error-free papers.
- ❖ An **information professional** who expands the frontiers of knowledge, using **objective methods** to **collect data** and **publish** their findings which build the reputation of their university, assuring students enhanced careers after graduation.
- ❖ A good researcher would be a good teacher because she would be abreast of current knowledge of the field/subject. The converse is not true of someone who devotes total focus to teaching. She will be poor in research, as well as in effective 21st century teaching.

Challenges to Academic Research:

Okoduwa et al (2018) and Igiri (2021) presented results of a survey of activities considered to have affected the the research and research productivity of academics to include:

	Okoduwa	Igiri
Lack of funding	72%	43%
Lack of professional mentoring	84%	-
Inadequate research facilities	89%	-
Lack of motivation	-	26%

Other Challenges recorded by Igiri: family challenges, inadequate research skills, inadequate training, too many administrative duties, heavy workload (leaving little time for research), inadequate research grants, infrastructural inadequacy, research misconduct, and inadequate information resources in the library.

As regards lack of success with publications, 57% of Okoduwa’s researchers had no single publication for high publishing charges (80%), no writing experience (96%) and long publication processing/waiting period for peer reviewing (97%).

Barnes et al, 2022 were more analytical, categorising the factors into individual (motivation, gender, age, research knowledge and skills, academic rank, research orientation, and attitude towards collaboration) and environmental (institutional leadership, availability of resources, institutional missions, orientation, rewards, mentoring programs, and institutional research policy).

Engaging the African Diaspora

The role of Africans in the diaspora in science research and transformative change has a long history and has long been recognized. Article 3 (q) of the AU's Constitutive Act Amendments formally defines the role of the African diaspora, stating that it shall "*invite and encourage the full participation of the African diaspora as an important part of our Continent, in the building of the African Union*". In 2003, at the end of the AU Summit, the **African Union symbolically declared the diaspora to be its sixth region** as a way to recognize its political, economic and strategic importance and the unique role it is playing in Africa's development.

Today, the African diaspora is serving as a focal point for rebuilding the global African family and has championed numerous developmental initiatives at the continental level. Within academia, many African diaspora academics are making invaluable contributions within the diaspora and across the African continent. African diaspora academics represent a huge asset for the continent in meeting the challenges of African higher education. Collaboration between African and academic institutions in the diaspora has led to the revitalization of some universities within continental Africa. Through teaching, research, public service, faculty exchanges, mentorship programs, knowledge transfer, intellectual remittances, diaspora academics have become indispensable players in Africa's rapidly growing and increasingly diversified education sector. The expanding use of information technology in academia has created new avenues to facilitate the involvement of the diaspora in academic initiatives on the continent. The COVID-19 pandemic was, in this regard a blessing, despite its monumental impact on our planet and the way we now live. Many institutions in Africa, particularly in Nigeria, who hitherto had been reluctant in adopting e-learning were literally forced to shape up. The technology now makes it possible to promote virtual teaching and explore new pedagogical options. Through technology, diaspora academics are promoting online teaching and learning, virtual faculty exchange, implementation of learning management systems, research collaboration, and the use of various classroom technologies in teaching and learning. What is left is for the proprietors of the institutions, and perhaps the Diaspora can help, to fully embrace the new development and provide all necessary infrastructure and personnel to equip their schools. We must embrace the new normal, and this will be a worthy contribution.

The Association of African Universities, seeking to accentuate Diaspora contribution in the HE-sector especially in the areas of emerging technologies at its recent Annual Conference in July, 2021 concluded and recommended as follows:

- i. The Diaspora can help facilitate and strengthen private sector and university linkages in Africa, while encouraging joint action on similar and shared socio-economic challenges on which they work together.
- ii. There is also the commonalities between Africans and the Diaspora in Science, Technology and Innovation (e.g. nanotechnology; artificial intelligence; youth population; climate change; natural, socio-economic, and cultural resources; governance); Agriculture and Food security (promoting work on crops like cassava, maize, legumes/beans); Nutrition and Health (e.g., sickle cell anemia, overweight and obesity). We need to foster strong research

and innovation partnerships in using these tools for change and transformation both on the continent and the Diaspora.

iii. Mobility partnerships are particularly important, noting the following:

- a) Need for more scholarly and cultural exchanges for staff and students at higher education institutions (Africa to the diaspora and vice versa).
- b) Deepening some mobility programs which are already in place - Carnegie African Fellowship Program (CAFP). CODESRIA African Academic Diaspora Support for African Universities, Training of African medical students in the Caribbean (UWI, SGU etc.).
- c) More engagement from the Diaspora through a clearly outlined system of rewards and incentives, as Africa sends nearly three times as many students to American universities as America sends to sub-Saharan African universities.

CONCLUSION AND RECOMMENDATION

Conclusions

Nigeria's economy, STI ecosystem, STEM ecosystem, vis-a-vis science research is in need of a major change/transformation, a big-bang disruption that will change our development paradigm from the management of poverty to a mindset of wealth management. This will entail harnessing the creativity vortex of the youth, her knowledge ecosystem, global talents and the diaspora, including its lost sheep of "misguided eccentrics", who attract bad labels for the citizenry, for a new dawn. Female scientists must not be found wanting in this definitive forward march, and our universities must rise up to the occasion to imprint their value on national development.

The success of Nollywood, the Nigerian movie industry, provides a model of how we can compete favorably and upstage the global market place with our human and material endowments. Now, this is escalating to the fashion and music industries. Surely, our agricultural and STI innovation sectors must emulate these developments in the Nollywood, and turn Nigeria into a global powerhouse of sustainable development.

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