SCIENCE AND TECHNOLOGY AS A MAJOR TOOL FOR SUSTAINABLE DEVELOPMENT (A CASE STUDY OF NATIONAL AGENCY FOR SCIENCE AND ENGINEERING INFRASTRUCTURE (NASENI))

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Abstract
Science and Technology plays a crucial role in the development of any nation as evidenced in developed countries like America, Japan, Germany and France. The application of Science and Technology in all facets of national development and growth has greatly improved the living conditions of those societies, thus becoming imperative for developing nations to embrace Science and Technology in its entirety in order to compete favorably internationally. In pursuit of Sustainable development in our contemporary world, Science and Technology can be applied to create a synergy between environment, society, and economy in a way that meets the need of the present generation without jeopardizing the needs of future generations. Global environmental problems arising from unwholesome industrial developmental patterns, resource degradation and depletion and resource-driven conflicts can be addressed through this approach of Sustainable Development. Nigeria's experience showed that prior to the year 1992 there was no concerted effort by private or public sector in the push to adopt science and technology. After a survey conducted to ascertain the dearth and extent of work needed to jump start such development it was decided that the government would be better positioned to drive such efforts. In light of this, NASENI was established and mandated to create the enabling environment for different aspects of Science and technology tailored towards Sustainable Development. In this paper, various science and engineering techniques introduced by NASENI towards fast tracking Scientific and Technological methods for better economic and sustainable development of the country is presented. Projects embarked on includes but not limited to; Advanced Manufacturing Technology (AMT), Nanotechnology, Reverse Engineering and Development of Science Kits for schools, etc. We also show what gains have been achieved since NASENI's inception. It is hoped that science and technology will be explored to cater for the needs of Nigeria in addition to solving its problems and challenges in a sustainable way. The multiplier effect of this approach will be creation of jobs and wealth, use of local content, reduced importation, increased exportation and improved growth of all facets of National Development through creating a niche for sustainably driven Science and Technological innovations in the future to thrive.

Keywords: *Science, Technology, Sustainable Development, Nanotechnology, Advanced Manufacturing Technology*

Background to the Study

Science and technology has been described as the major driver of development in any country willing to break away from the shackles of poverty and dependence on subsistence means of survival. The acquisition and use of science and technology have a profound and long term impact on income distribution, economic growth, employment, trade, environment, industrial structure and defense and security matters (Ahmed and Stein, 2004). The meager existence tied to countries that have not mastered the "art" of science and

technology clearly shows the benefits that accrue to those other countries on the other side of the technological divide which have made the practice of science and technology the mainstay of the economic development (William et. al, 2002). This is evident in the USA which has been largely self-sufficient as a nation as well as a world leader in the production and application of new knowledge (Gilberto, 2004). According to Adewoye, 2006, 50 leading science and technology countries have enjoyed long-term economic growth much higher than other countries of the rest of the world. The Average economic wealth per capital of these 50 countries has grown by 1.1% per year. On the other hand, the per capital income of the rest which performed less well in education, science and technology has fallen over the same period by 1.5% per year. These benefits which are too numerous to mention, can be seen to pervade all aspects of the lives of developing countries with life quality indices such as (life expectancy, infant mortality, poverty index, disease & access to affordable health care) clearly shows the reason why there is a wide gap between countries that are developed and those which are underdeveloped is principally the level of practice of science and technology. Butt (2013) relayed that countries such as Japan, Singapore, Korea Malaysia, Taiwan and Thailand are well advanced despite the absence of natural resources as a result of a well-established S & T culture. It must however be borne in mind that the extent of science and technological development cannot always be equated to the extent of sustainable development. This is because certain developmental trends are clearly unsustainable ecologically, socially& economically. The need for change in direction was officially recognized at the United Nations Conference on Environment and Development that took place in Rio de Janeiro in June 1992, and reconfirmed at the World Summit on Sustainable Development in Johannesburg in September 2002 (Gilberto, 2004).

Sustainable Development is the name given to the quest for such a solution, in which 'development' is understood to be the genesis and unfolding of qualitative potential- not just the pursuit of quantitative growth- and 'sustainability' covers the ecological, economic and social dimensions.Paraphrasing The Brundtland Commission's brief definition of sustainable development as the “ability to make development sustainable – to ensure that it meets present needs without compromising the ability of future generations to meet theirs” is surely the standard definition when judged by its widespread use and frequency of citation (Robert et al, 2005). Since the industrial revolution, we as a people have become disconnected from the very life forces that sustain us. This is evident in the indiscriminate manner in which environmental resources were utilized and exploited for economic activities to cater for societal needs (Haruna, 2013). The end of the industrial revolution marked a tremendous reduction in earth's resources with significantly high negative environmental impact such as the depletion of the ozone layer, contamination of water bodies, deforestation, with resulting loss of fauna and flora, environmental oil spillage, extinction of species and emergence of new diseases in addition to high prevalence of old ones such as cancer. As indicated by mounting scientific research from all corners of the globe, this approach is simply not sustainable, and our current way of living must be overhauled (Millennium Ecosystem Assessment, 2005). It has indeed become increasingly clear that human kind will have to drastically alter fundamental ways of thinking and operating in order to survive. It has also become important to protect the earth and its resources whilst catering for the needs of society and promoting economic growth. Many researchers and activists have pointed out that if we rid the earth of all its resources, we will invariably leave ourselves without a place to live hence the emergence of the philosophy of sustainable development (Haruna, 2013). S & T has greatly contributed to the problems encountered by sustainable development. Ironically S & T exposed the extent of damage and called for intervention. Amazingly S & T can contribute to solving the challenges faced by Sustainable Development.

Literature Review

Looking at developed countries all around the world and also countries in the Brazil, Russia, India, China and South Africa (BRICS) group which are determinately vying for position of technologically sustainable economies, we see a clear trend in the ideas and policy decisions which are acted upon to create an enabling environment for the thriving of science and technology. Summarizing the chief actors in this push for Sustainable development driven by ST, we see a strong emphasis on education at all levels of primary, secondary and tertiary institutions with equal importance given to professional and technical knowledge acquisition (Okunola, 2013). As against individual countries setting the standards for ST development with bias towards whatever each country deems convenient in terms of standards; be they issues of weather, pollution and degradation which affects us on a global scale. Global coordination has necessitated the shift in policy formulation from solely national to global actors such as the UN.

History of Technological Development in Nigeria

Nigeria as a country traces the inception of S&T to even before the arrival of the colonialists with their more sophisticated mechanical devices and machines. Early versions of S&T prowess in Nigeria could be found in its cloth industry, metal making etc. (Uwaifo and Uddin, 2009). The methods adopted were low on output but also low in pollutants. With the coming of the colonialists came a shift to more mechanized tools and use of coal in generating power and steam engines for transport. But post-independence, many of the former systems were either suspended or stopped for reasons of neglect, disrepair, unavailability of spare parts etc. (Adewoye, 2006).

In the 1970s, Nigeria practiced an agrarian economy. As a major agricultural country, its production was for internal usage as well as for exportation. By 1990, Agricultural production had shifted to a mono-economic product found in crude oil (Okunola, 2013). This came with grave of consequences, not only on the national psyche but also on the environmental level, with incessant pollution of streams and creeks and soils and polluted air from gas flaring and other unwholesome extraction practices which were freely done without complaint either from the host communities or international business concerns that aided and abetted such sordid developments. In a nutshell, the only governmental policy which held sacrosanct for the military government of the day was that which ensured the continuous flow of crude oil at whatever the cost to humans, plants or the environment at large. Calls for strengthening S & T programs bearing on sustainable development built slowly during the 1990s following the UN Conference on Environment and Development (UNCED) in RIO (William et al. 2002). This coincided with the release of the White paper on establishment of Infrastructure in Nigeria which gave rise to the establishment of the National Agency for Science and Engineering Infrastructure (NASENI) in 1992 (NASENI, 2012).

National Agency for Science and Engineering Infrastructure (Naseni)

NASENI was established in 1992 by Decree No. 33 to make available, in the Nigerian market, the primary and intermediate capital products required for machine and equipment design, fabrication and mass production, in order to provide the enabling environment for a sustainable industrialization of the country (NASENI, 2012). The primary target is to empower SMEs through impartation of technologies, engineering principles and practices for the production of equipment that will meet international standards as well as flourish local capital goods industry. In its years of existence, nine Development Institutes which are mono-mandated as production arms of the Agency have been established. NASENI is aimed at promoting and supporting Sustainable Development and for this reason, has designed its projects and

programmes to intervene and contribute to all facets of National Development. This is in agreement with William et al, 2012 who believes that for S &T to contribute effectively to sustainable development; it will have to take society's goal for growth and development seriously. The sectors of intervention therefore include but are not limited to Energy, Agriculture, Education, Manufacturing, New Emerging Technologies, and Water Sector.

PROJECTS / PROGRAMMES BY NASENI		
1.	Manufacturing	• Advanced Manufacturing Technology (AMT) • Reverse Engineering • Forward Engineering
2.	Energy	• Solar Panel Production Plant • Small Hydro Power Project • Bio-Digester Development Project • Eco friendly smokeless smoke
3.	New Emerging Technologies	• Nanotechnology • Advanced Manufacturing Technology
4.	Waste to Wealth	• Mini Foundries • Processing of Plastic Waste
5.	Education	• Primary Science Kit (PSK) • Junior Science Kit (JSK) • Rotary Furnace for Tertiary Institution

Critical Achievement of Naseni

Advanced Manufacturing Technology (AMT)

Advanced Manufacturing Technology (AMT) is a modern method of production incorporating highly automated and sophisticated computerized design and operational systems.The focus of NASENI in the last few years has been on Advanced Manufacturing Technology (AMT). This is a paradigm shift from conventional manufacturing technology, for global competitiveness of industrial products, hence rapid industrial development. The thrust of the program is acquisition of technology, capacity development, diffusion and infusion of skills for the application and practice of advance manufacturing technologies in our industrial sector. The Agency's Headquarter and its developmental institutes are currently equipped with some level of AMT facilities which include Vertical Machining Centre, Computer Numerical Control lathe, Electro Discharge Machine, Surface Grinding Machine etc. This also include the necessary software for Computer Aided Design (CAD) such as Pro-Engineer, ComsolMultiphysics, Matlab/Matcad, Granta etc.

Small Hydro-Power Project

Energy generation and distribution in Nigeria requires attention to overcome the array of challenges facing it. Many people in communities far still lack electricity supply. This is in addition to the epileptic power supply experienced by those fortunate to benefit from the National Grid (Ajani, 2007). NASENI's intervention is aimed at tackling this problem through the development of local manufacturing capacity for SHP Equipment. Examples from Kenya and other developing countries like Peru, Indonesia and Sri Lanka have shown that Small Hydro-Power projects can be self-sustaining and profitable (NASENI, 2011), The heart of a SHP is the turbine. The manufacturing of the turbine by NASENI has leap-froged the process of rural electrification and will ultimately bring down the per kilowatt installation of Small Hydro Power Plant.

Nanotechnology

Nanotechnology represents the beginning of a revolutionary age with ability to manipulate materials on the Nano scale which is 10-9. The size of nanomaterials proffers improved properties and functionalities to nanostructures heretofore unavailable in conventional materials and devices (Dare, 2006). With application in Energy, Medicine, New materials, Environment, and Electronics, NASENI could not afford to leave Nigeria behind as such embarked on the Nigerian Nanotechnology Initiative (NNI) in 2006to successfully take off Nigeria's Nanotechnology and Advanced Materials Programmes. The achievement of NASENI in the establishment of an infrastructural base in Nigeria includes the establishment of a fully equipped Centre of Excellence in Advanced materials and Manufacturing Technology, Introduction of Masters in Nanotechnology and Structures materials at the ObafemiAwolowo University, Ile-Ife, Training of 20 participants on Nanotechnology at Princeton Univeristy USA, Award of Grants for research in Nanotechnology, International Conference of Nanotechnology.

Mini Foundries

Rotary furnaces are usually exist in large capacities of between 1000kg and 50 000kg in the industry. NASENI's achievements in this area include the scaling down of large capacity furnaces to 100kg which is especially suited for MSME. Through this program, scrap metal which makes up 40% of Nigeria waste deposition can be processed into material. NASENI's rotary furnace has been able to use scap metal to produce high grade grey cast iron. Further treatment of grey cast iron has been perfected to produce ductile iron which can be for the manufacture of automobile and ancillary components. This translates to the use of waste for wealth creation.

Primary and Junior Science Kits

Science and Technology Education in primary and secondary schools in Nigeria have always been hampered by the absence of functional laboratories that allow for practical lessons that enhance the active participation of students in science lessons (NASENI, 2012). This challenge propelled NASENI to proffer solution to the infrastructural gap in teaching and learning science and technology in the country. The Primary Science Kit (PSK) and Junior Science Kit (JSK) is a "lableѕs" laboratory kit comprising of items that can be used to teach science at primary schools and junior secondary schools respectively. This has yielded great results which will be highlighted later.

Research Methodology

The literature review was achieved by extensive use of the internet to obtain academic literature. To acquire adequate information for the research work, secondary data were sourced for from Publications of National Agency for Science and Engineering Infrastructure (NASENI). A descriptive research methodology was employed in the design of the study. The practice of project and programmes implementation was assessed through the use of secondary data as stated above and interview of the Executive Vice Chairman/Chief Executive of NASENI as a means of obtaining primary data.

Data Collection

Data collected is presented in the following pathway:

I. Identification of Project that will result to the betterment of society
II. Capacity Development
III. Establishment of Facility

IV. Acquisition of Technology
V. Reverse Engineering/Forward Engineering/Production
VI. Transfer of Technology to SMEs

Table 1 below shows that NASENI has intervened in diverse sectors of national development.

Table 1: Project/ Programme

S/NO	SECTOR OF NATIONAL DEVELOPMENT	PROJECT/PROGRAMME
1.	Manufacturing	AMT
2.	Energy	SHP
3.	New Emerging Technology	Nanotechnology
4.	Waste to Wealth	Mini foundries
5.	Education	PSK & JSK

Capacity development in projects and programmes embarked upon by NASENI yearly as depicted in figure 1 above

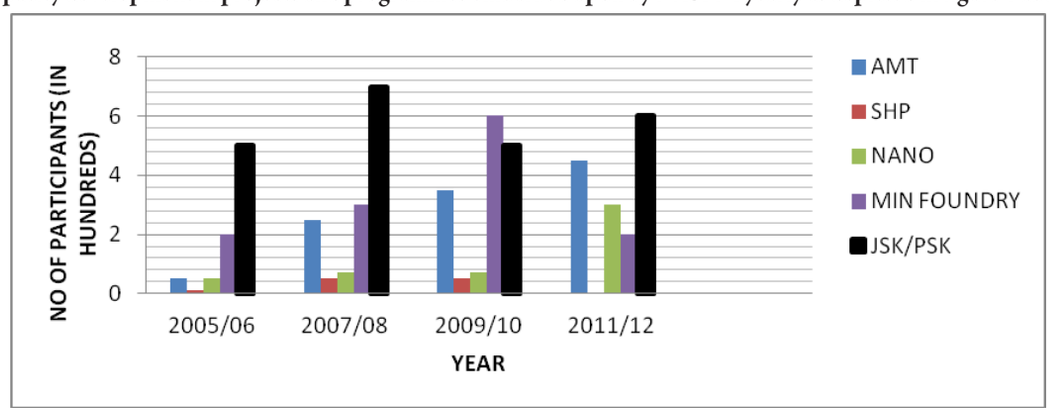
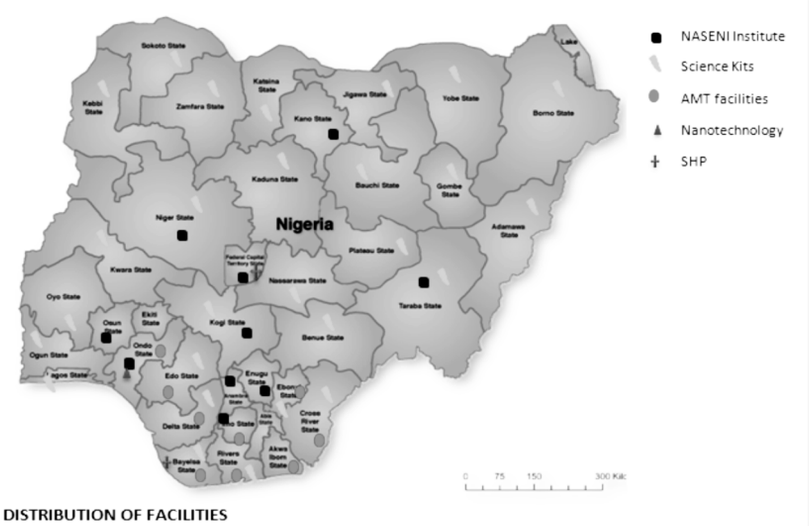


Figure 1: Capacity development in Projects and Programmes

As part of its fundamental mandate, NASENI has established facilities in strategic locations around the country. Figure 2 above shows the distribution of established facilities across Nigeria.



DISTRIBUTION OF FACILITIES

Figure 2: Establishment of facilities

The status of projects and programmes as regards actual manufacturing and production is shown in Table 2 above

Table 2: Reverse Engineering / Forward Engineering / Production

PROJECT	STATUS
AMT	Ongoing
SHP	Completed
Nanotechnology	Ongoing
Mini Foundries	Completed
JSK/PSK	Completed

The ultimate goal of NASENI is transfer of technology to SMEs to enhance economic and entrepreneurial growth. The current status of this phase is presented in Table 3 below.

Table 3: Transfer of Technology

PROJECT	STATUS
AMT	NO
SHP	NO
Nanotechnology	NO
Mini Foundries	YES
PSK/JSK	NO

Findings

In this section, the finding from the assessment of NASENI effort at impacting on the development of Nigeria through sustainable Science and Technology is presented. Table 1 shows that NASENI has made conscientious effort to contribute in at least one sector of national development. This reveals that the Agency has identified with the five priority areas which includes Water and Sanitation, Energy, Health, Agriculture and Bio-diversity protection and ecosystem management-known as the WEHAB initiatives for urgent actions which UN Secretary General, Kofi Annan (WEHAB Working Group, 2002) proposed as a means to Sustainable Development. S&T cannot effectively contribute to sustainable development without basic scientific and technological capacity. It is necessary to build capacity in interdisciplinary research, understanding complex systems, dealing with irreducible uncertainty, and to integrate across fields of knowledge, as well as harness and build capacity for technological innovation and diffusion in both the private and public sectors.(William et al,. 2002)

Based on National aspirations to grow and sustain institutions of world class category in pursuit for scientific and technological development, many of the countries in Africa have experimented with different approaches of institutional building (Mugabe,2013). Figure 1 show the extent to which NASENI have built capacity in various areas of science and technological endeavors. The number of people trained in AMT has grown with each passing year indicating that growing interest. This is in contrast to Nanotechnology which has the same year of duration but has not had significant number of people trained in the field. This can be attributed to the fact that NASENI focus is channeled towards actual research in Nanotechnology hence spends more on awarding grants to researchers than capacity development of the populace. The attention given to AMT can also be linked to the mandate of NASENI which emphasizes the need for the production of capital goods (Adewoye, 2006).

Investment of capacity building of SHP is the lowest when compared to what has been achieved in PSK/JSK. This is because the present stage is at the actual fabrication of turbine while PSK/JSK has been driven by the need to distribute kits to schools which runs concurrently with the capacity development of teachers in the use of PSK and JSK. Figure 2 shows the distribution of facilities across the country. Science kits are evenly distributed around the country as it is driven by immediate need to proffer learning and teaching skills to students and teachers respectively. It should be noted that all NASENI centers are established with all facilities for AMT, mini foundry.The concentration of AMT in the southern part of Nigeria is as a result of the Niger Delta Development Commission (NDDC) initiative to build infrastructure for development within the region (NASENI, 2012). This explains the absence of the initiative in the northern part of the country.

It is presently the case that most of the interaction between the agency and those who should drive this push in Sustainable S&T development is mostly done on the platform of Seminars, trade fairs, conferences where NASENI disseminates most of the information concerning its current work to the interested public and through these different forums, simultaneously receives feedback on what current S and T practices are involved in the market.

Policy Implications

There is no established criterion for the use of S & T in solving Sustainable Development. It is imperative to create a tradition that will invariably represent an opportunity for international cooperation within Africa. Standard must be generated endogenously in a nation.

Conclusion

From this paper , it is seen that NASENI's role in engendering the right environment for the thriving of sustainable S&T development has clearly impacted positively on the livelihoods of Nigerians and contributed in no small way to pointing a better way towards ST development.

It must also be stated that Government support in terms of continued financing will go long way to ensure that ongoing and future projects are carried all the way to completion.

Reference

Adewoye O. O (2006) "Advanced Manufacturing Technology for Endogenous Development and Global Competitiveness" Proceedings of Advanced Manufacturing Technology workshop held in 2006, Abuja, Nigeria.

Ahmed A: and Stein J.A (2004) "Science, technology and sustainable development: a world review", World Review of science, Technology and sustainable development, Vol. 1, No.1, pp.5-24.

Ajani E. A (2007) "Development of Small Hydropower (SHP) Technology in Nigeria: NASENI Intervention". NASENI"s In-House Seminar Proceedings – Vol. 1

Butt N. M (2013), "Sustainable Development: Quality of Research in R & D Institutions".www.sciencevision.org.pk/BackIssues/Vol7/Vol7No1-2/Vol71&2_S&T_STD_NMButt.pdf Accessed on 17/7/2013

Dare E.O (2006) "Nanotechnology and its application: Revolutionary New Age Industrial material Process". Proceedings of Advanced Manufacturing Technology Workshop held in 2006, Abuja

Gilberto Gallopin (2004) "Sustainable Development: Epistemological Challenges to Science and Technology. Background paper prepared for the workshop on "Sustainable Development: Epistemological Challenges to Science and Technology", ECLAC, Santiago de Chile, 13-14 October, 2004

Haruna M. S (2013) "Invited talk on Green Design". International Conference on NanoScience and Advanced Manufacturing, Africa University for Science and Technology.

Millenium Ecosystem Assessment (2005). "Global Assessment Reports." www.milleniumassessment.org/documents, Accessed on 11/4/2013

Mugabe J. (2013) "Centers of Excellence in Science and Technology for Africa"s Sustainable Development: Towards new forms of Regional and Sub-Regional Networks" African Ministerial Conference on Science and Technology for Development. www.nepadst.org Accessed on 10/4/2013

NASENI (2011), "NASENI Intervention in our National Development: Status of Projects and Programmes". www.naseni.org

NASENI (2012), NASENI"s Intervention in the Educational Sector.www.naseni.org

Okunola Philip Olayide (2013) "Science and Technology Reforms and Development: The Nigeria Experience" Towards quality in African Higher Education.

Robert N. Kates, Thomas M. Parris, and Anthony A. Leiserowitz. (2005) "What is Sustainable Development? Goals,Indicators, Values, and Practice". April 2005 issue of environment: Science and Policy for sustainable Development, Volume 47, Number 3, pages 8 – 21.Global competitiveness.Proceedings of Advanced Manufacturing Technology Workshop held in 2006, Abuja.

Uwaifo V.O and Uddin P.S.O (2009) "Technology and Development in Nigeria: The Missing Link". J Hum Ecol, 28(2): 107 – 111 (2001)

WEHAB Working Group (2002), "A Framework for Action on Energy" World Summit on Sustainable Development, Johannnesburg". www.un.org/jsummit/html/documents/summit_docs/wehab_papers/wehab_energy.pdf, United Nations.

William Clark et al. 2002. "Science and Technology for sustainable Development: Consensus Report of the Mexico City Synthesis Workshop, 20-23 May 2002." Cambridge M.A: Initiative on Science and Technology for sustainability.