

Development and Position of Africa in Science and Technology Today

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Abstract

Science and technology capabilities are fundamental for social and economic progress in African countries and they are crucial components aimed at fostering growth and development of every nation as they create impact on the various sectors of governments. Maintaining and Strengthening the contributions of science and technology become more important for Africa in addressing traditional development issues and successful application of science and technology entails establishing effective institutional framework and linkages so that the various science and technology institutions and the productive sectors work in a system that is focused on achieving developmental goals without undue duplication and completion. Unfortunately, many developing countries especially the poor countries in West Africa do not have human resources, physical and economic infrastructures and access to capital to take full advantage of the science and technology expertise and achievements of the developed countries like the USA, China, and Korea etc. Conclusively, it is imperative for Africa especially West African countries to embrace science and technology as a vital tool for accelerating their socio-economic development as science and technology enhances its international competitiveness and more importantly its position in the world economy.

Keywords: Science, Technology, National Development, Economic Development and Technological creativity.

1. Introduction

Africa, especially the West African countries is challenged with a lot of crisis. The immediate problems have made it difficult for this continent to enjoy certain values and comfort. Due to the over grown population, people are in constant conflicts for the quest of resources and raw materials, there is an increase in disease affluence especially the communicable diseases. Poor agricultural yield due to climate change has promoted hunger and starvation. These impediments have led to socioeconomic problems, political instability and poverty which have prevented the development of this continent.

Science and technology is one of the major aspects in which most developed nations have highly promoted to foster their development. Though science and technology began as far back as in the time of the first existing human beings, its evolution has greatly revolutionized the world to suit man's desire, improve on his well-being and

comfort. Prior to development, certain key elements such as research, biomimetic, communication, partnership etc. are very essential in the advancement of science and technology. These key elements are critical for the growth of science and development in Africa. Science sets out what could be done and technology shows how to do it. Science and technology are day to day activities that deliver the food we eat on our tables, make beds we sleep in, build the houses we live in, make the clothe we wear, transport us daily, provide the seat we are using, make communications faster and more importantly organize our daily lives. In a nutshell, technology provides man with the life support system that maintains him on the planet. In spite the positive contributions of science and technology to development, the detrimental effects to the society cannot be underestimated. Global warming, depletion of natural resources destruction of the environment and ecosystem and sophisticated weapons are all outcomes of science and technology which are against the promotion and sustenance of humanity. In this era, the way forward is to promote those technologies that ensure a sustainable development; that is those technologies that will eliminate the detrimental effects in the society and promote life.

2. Evolution of Science and Technology

Sciences and technology began as early as the ancient days of the early man who produced fire from sparks of stones which he used for cooking and heating as a means for survival. In this Paleolithic age, stone was the material used for most of the items they produced. Even though an explanation on how this happened was unknown, the application was very vital for their sustenance. Since then, man continued to acquire knowledge on how to exploit his natural environment for survival until the Neolithic days of early civilization with a rise in technology where blacksmith used metal such as iron, zinc to produce weapons against wars.

With the gradual rise of civilizations in the river valleys of Egypt, Babylonia and other kingdoms, knowledge became too complicated to transmit directly from person to person and from generation to generation. For man to thrive in this complex society, he needed some way of accumulating, recording, and preserving his cultural heritage and pass up to his generations. By 300 BC with the rise of trade, government, and formal religion, man invented writings a way to document his activities and culture.

Because first-hand experience in everyday living could not teach such skills as writing and reading, a place devoted exclusively to learning; the school appeared. As schools appeared, a group of adults specially designated as teachers (the scribes of the court and the priests of the temple) passed across this information. The children were either in the vast majority who continued to learn exclusively by an informal apprenticeship or the tiny minority who received formal schooling.

In the early days when the word science was not coined, the discipline was term philosophy of nature which was referred to as the way of pursuing knowledge from nature. The early Greek philosophers such as Socrates, Isocrates, and Aristotle thought arithmetic, astrology, philosophy, music, dancing, and gymnastics, physical health and others. Among these philosophers, some were basically interested in the knowledge of nature and the material things which are true for every community which separated them from those who used a specialized way for the pursuit of this knowledge.

These two schools of thoughts shaped the field of science and philosophy respectively. By the middle age period, sciences became documented; theories were developed and tested experimentally to prove them. In trying to use the knowledge of nature to imitate nature, these philosophers discovered a new field which they named called technology. From this era, scientist began to develop laws and theory such as the laws of nature, newton's laws of motion etc. It is during this period that the word "science" gradually became more commonly used to refer to a type of pursuit of knowledge which focuses on nature and material objects.

Around the 17th and 18th centuries, new laws of nature were develop which led to rapid scientific advancement and the successful development of new types of natural science namely mathematics, physics, geology, chemistry, biology etc. The interdependence between science and technology in this era called the industrial revolution marked a tremendous rise in the invention of machines and creation of industries. This era was marked by great achievements in material sciences with the production of various materials that were paramount to the development of the globe.

By the 20th century the world observed the era of the second industrial revolution with the expansion of information science and rise in information technology. Today, the world we live in is a computerized one where any activity of human engagement can be programmed to facilitate labour and communication. Thanks to globalization of the 21st century, science and technology is readily made available to everyone in the society.

3. Relationship between Science, Technology and Development

It is obvious when one thinks of development, the terms science and technology cannot be set apart. Sometimes, the terms, science and technology are interchangeably used in normal day life to describe certain activities simply

because they are interdependent on each other. To clearly understand the relationship between science, technology and development, one needs to define them individually and link them up to understand their coexistence.

Science from Latin *scientia*, meaning "knowledge" is a field that systematically builds and organizes knowledge in the form of testable explanations and predictions about the universe. In an older and closely related meaning, "science" also refers to a body of knowledge that can be rationally explained and reliably applied. Two aspects of sciences that are fundamental to its definition is the ability of a concept to be tested and provide result using a scientific method. A scientific result could be such that no application is attributed but may apply to the basic underlining concepts of the field. On the other hand, some scientific studies or research may produce results which have an immediate application in real life. This application is that which drives us to the term technology. Technology is mostly described as applied science which can be organized to have practical implication in life. However, because technology must satisfy societal requirements and values such as utility, usability and safety, technology cannot be consider as an exclusive product from science. Most technologies in the past were discovered without a scientific background. One of such was the production of fire or heat energy from sparks of stones without any scientific dependence. Also, the invention of stone weapons for wars and stones axes as agricultural tools were the technologies within the Paleolithic era when the basic concepts of sciences were not yet laid. Today, because of the advancement in science, almost all recent technologies have a scientific background. When a new technology is discovered, it needs to be made available to the society. This process of providing a technology or its product to the masses is what is known as engineering. Engineering is therefore the goal-oriented process of designing and making tools and systems to exploit natural phenomena for practical human means, often (but not always) using results and techniques from science. The fundamental objective of developing a technology is to provide good or services that will meet the demands or improve on the needs of the society, hence development. This implies that for development to be achieved there must be some inputs which will have a positive impact or changes to improve on the well-being of man, some of such inputs are applied science and technology. Thus science, technology and development are symbiotic in their relationship as they are interdependent to each other.

4. Roles of Science and Technology in Nation Development in Western African Countries

The vital role of science and technology in socio-economic development of any nation is acknowledged all over the world by all in both developed and developing nations. It is therefore imperative for developing countries especially West African countries to embrace science and technology as a vital tool for accelerating their socio-economic development. It is becoming increasingly clear that development in science and technology is not only an important determinant of a country's level of development but also enhances its international competitiveness and more importantly its position in the world economy. The importance of science and technology in increasing responsiveness to changing world environment cannot be overemphasized.

For a society to be described as developed there is a minimum level of comfort or well-being that is necessary to overcome the challenges incurred so as to meet the immediate demands and needs of the society. This minimum well-being is what I describe as development. Science and technology has contributed significantly in the development of most nations and society at various sectors which are of great importance to the society. Science and technological progress has had impact in sectors such as infrastructure, energy, industrial, health, education, communication, financial, entertainment, transport agricultural, and environmental protection to name a few. These effects have not been limited to the improvement of society's material wealth, but have also extended in altering the existing paradigms under which society operates.

Information Technology (IT) is one example of a paradigm-changing technology. The world has move from an analogue to a digital system where any information can be computerized and easily diffuse into the society. With information technology, new means of communication such as the internet, mobile phones have been introduced using satellite transmission in addition to the existing ones. These advances in mobility, joined with inventions in the area of telecommunications technology, such as the telephone and radio, have served to broaden the range of human activities and to expand the scope of human exchanges. Computerized programming has increase the versatility of machine to perform numerous and various functions improving on the efficiency and efficacy of production. Information technology and communication has greatly pronouns the entertainment industries in the world digitalizing the products as videos, audios etc.

Another area of changing paradigm is the medical or health sector. The shift of biomedical process from structural to molecular basis has greatly contributed in identifying new disease causing agents such as viruses and prions responsible for illnesses whose origin was unknown. The mode or mechanisms of action of most diseases processes have been established and new diagnostic methods of high throughput technologies with high sensitivity and specificity have been developed for various diseases and illnesses and made possible appropriate treatment.

New technologies also have identified new drug targets for Drug discovery and expanded the pharmaceutical industries.

The discovery of new sources of energy especially renewable sources has almost suppressed the myth of depleting ores of crude oil. Energy can readily be trapped from the sun, wind, water, vegetal organic sources and others natural renewable sources. Nuclear energy from nuclear plant and thermal energy are other new sources of energy which greatly meet the demands of the overgrown population.

Infrastructural development has risen substantially in the world. Intermesh transport systems of roads and rails as well as GPS technology have reduced traffic congestions. Cities with sophisticated buildings are well planned to reduce overcrowding and make them assessable to all.

Science and technology have laid the foundations for progress in society, and have helped to make people's lives more materially prosperous. In particular, after the industrial revolution, there has been a tremendous rise in the industrial sector. Industries of all sort of production are available today. The diversity of product has provided man with the utility to make choice to their desire. Industries have created new jobs and alleviate the state of unemployment. In addition, inventions in machine tools have been linked to advances in energy technology to achieve automation and acceleration of manufacturing processes. The result has been large-volume production of goods in ever shorter periods of time. Moreover, progress in materials technology has resulted in the ability to produce diverse types of material items. Progress in materials technologies has given rise to a variety of new transport modes, such as the railroad, the automobile, and the airplane, vastly improving human mobility in terms of both time and space.

The contributions of biotechnology and genetic engineering have massively improved the agricultural sectors in the continent. There is improvement in agricultural yield and the quality of food stuff to be resistant to diseases. This has reduced problems of food shortage and scarcity, as well as starvation and hunger in the globe. Furthermore, as progress in science and technology has broadened and enlivened human activity, new issues have appeared in society, and these have in turn led to demands for new sciences and technologies capable of resolving the new issues arising from the changes in society.

The advancement of science and technology has promoted education. New technologies have permitted the creation of new innovative academic field. The interdependence of science and technology, and the evolution of material to information science, new professional disciplines from the basic scientific fields such as chemistry, biology, physics, mathematics, geology have emerge to permit a mastery of the new technology and make them available to meet the demands of the challenging economic society. The new innovative academic fields include genetic engineering, nanotechnology, engineering, information technology, computer engineering etc. The creation of these new disciplines has greatly promoted literacy. More peoples can now read and write manipulate phones and computers and get connected in the global village. Above every other thing, the overall success of science and technology has been the economic and financial bloom of the entire globe. The most developed countries which are economically and financially stable are those ones with a strong scientific and technological background. The gross national income as well as the per capital income of these countries are usually high and sufficient enough to foot the bills of their basic needs.

Despite its positive growth trajectory, however, Africa's medium term prospects face a number of internal and external risks. This is because the current decline in oil and commodity prices, slow recovery in the Eurozone and Japan, and the decline in demand for commodities in China could potentially impact Africa's growth prospects negatively as trade weakens. Going forward, West Africa stands ready to enhance its productivity through structural transformation and the promotion of industrialization. Hence, central to Africa's future growth prospects is the role of science, technology and innovation (STI).

5. West African experience of science, technology and innovation policies National Approaches to Science and Technology in West Africa

Early on, newly independent African countries formulated national education and science and technology policies. The government of Ghana, for example, created the Ghana Research Council in 1959, barely two years after independence; Nigeria established the National Council for Scientific and Industrial Research in 1966 and Kenya established the National Council for Science and Technology in the late 1970s. Practically all science and technology policies were sectoral, carried out by government sectoral ministries and departments.

During the 1960s and 1970s, West African governments also established and expanded their higher education sectors by setting up universities and dedicated science and technology research institutes to tackle development challenges and, later, governance institutions to oversee national efforts. However, these efforts were generally poorly coordinated; institutions had inadequate funding and outcomes were often disappointing. Overtime, as the shortcomings of this vertical governance structure became obvious, some governments turned to horizontal

governance. Some created a super-ministry for science and technology, while others attached science and technology to an existing ministry.

Governments recognized these weaknesses in the sectoral framework as well as the failure of science and technology to contribute to development. In response African leaders met under the auspices of the Organization of African Unity in Monrovia, Liberia, in 1979.

There they adopted the Monrovia Declaration, in which they committed "individually and collectively on behalf of our governments to put science and technology in the service of development by reinforcing autonomous capacity in the field." This commitment was reaffirmed in the Lagos Plan of Action adopted at the end of the Organization of African Unity Extraordinary Summit in Lagos, Nigeria, in 1980. The Lagos Programme of Action called on member States to "formulate national policies on science and technology plans to be incorporated in the overall national development, as science and technology are a fundamental input to the development of all other sectors.

6. The Destructive Aspects of Science and Technology

Meanwhile, progress in science and technology has contributed enormously to the growth and development of the society; the detrimental aspects cannot be minimized. Science and technology, though worth meaning is one of the greatest challenges the world is facing. Advancement in nuclear technology has not only promoted the production of nuclear energy but also more sophisticated nuclear weapons which are responsible for major destructions. The rise in industries has increased the level of greenhouse gases that are released to the ecosystem and depleted the ozone layer. Global warming is one of the major problems of the society today as a result of technological growth.

The ecosystem has been destabilized; there is loss of variety and species of various biological flora, deforestation is highly promoted, natural resources are depleting and diminishing, environmental pollution is increasing all as a result of technology. In the healthcare and biotechnological sector, there are high risks of creating new infective strains of diseases with new available technology of genetic engineering in vaccine production and gene therapy. Genetically modified products continued to be questioned from the ethical point of view against nature. The rise in information technology and communication has increased crime wave using the internet and other social networks of communication. There is a discriminative balance of wealth and technology across the globe. The great nations that have developed the new technologies continue to exploit other nations who are in need. Good ones for sustainable development. Sustainable development implies those qualities and values that can continue to sustain the society in future will be properly managed and propagated. Science and technology can be made sustainable by managing and promoting those technologies that do not have detrimental impact in the environment and society but also eliminating the bad technologies and providing solutions.

The following measures can be implemented to ensure sustainable development.

a) Education and Public Awareness Educating and teaching the society on the nature of this interdependence of the ecosystems and human sustenance is fundamental for sustainable development. This understanding of the origins of the components of our urban environment can result in more careful utilization of natural resources and enable individuals to take informed and responsible decisions and actions, now and in the future by also realizing the impacts of their decisions on others. Improving awareness of sustainability includes such issues as the life-cycle impacts of human activities on Earth systems, control of greenhouse gases, land and energy use, consumption patterns, pollution and transport, all of which have direct connections to education for sustainable and responsible development. Promote new academic discipline in the area of sustainable development to develop ideas on how technology can be managed to ensure sustainable development.

b) Promote new Approaches to Sustainable Energy New forms of renewable resources of energy from water, land, air, soil, etc. form the basis of the entire living processes in the present and in the future.

More emphasis and focus should be laid on these new sources rather than relying on the non-renewable existing resources. This can be achieved by promoting sustainable scientific research which encourages more active and responsible investment in alternative energy even though this may not be currently profitable, but its continued development would be an important gift to future generations.

c) New Technologies for Pollution Reduction and Environmental Protection. Most existing technologies usually have negative impact on the environment especially by pollution. New technologies which can manage and reduce pollution should be promoted and made mandatory in industries as part of their quality control units. Technologies which can reduce the release of greenhouse gases should be introduced in the industrial sectors, automobiles industries and other sectors of related application.

d) Science, Technology and Ethics for Sustainability Ethics; the philosophical study of the moral value of human conduct and the rules and principles that ought to govern it allows us to better analyze such intergenerational interactions in the critical context of the social, economic and natural environment. Ethics monitors how the values at the core of our social contracts are evolving and can address the crucial issue of consumption of the present versus the needs of future generations. Promoting ethics both in research and education will guide scientist and technologist to consider human and ecological moral values when developing new technologies.

7. The Status and Challenges of Science, Technology and Development in West Africa

Science and technology among other things have contributed substantially to the development of the world. However, the distribution of this development is not evenly spread across the globe because some nations have intensively exploited this knowledge to enhance their well-being. These parts of the world, termed to be developed are well grounded with this knowledge of science and technology and practically manifest it to enhance their economic and financial status. Other emerging economies like China, United Arab Emirates, and Brazil are current utilizing this knowledge to improve on their level of the development. In Africa, except for South Africa and a few countries of the south African region which are exploiting the knowledge of science and technology to foster their development, most parts of Africa especially the sub-Saharan region are among the least developed nations with less focus and interest in science and technology.

Africa is one of the richest continents with natural reserves of raw materials, yet these resources are either exploited by foreigners of the developed world simply because the necessary technology to convert them to finish products are not available. This is as a result of certain challenges which impede the growth of science and technological advancements in the continent. The nature of West African political systems and governance greatly limits the growth of science and technology. Most policies of the government do not encourage investments and promotion in these sectors. Scientific projects are hardly supported due to the high cost of implementation. Corruption and poor governance is the key to the underdeveloped state of most of these nations.

Another critical factor for poor scientific and technological development is generally due to the African man's mentality towards science and technical education and scientific research. The West African mentality has mostly projected issues of social science than those of natural science and technology. Even when these nations promote natural science and technical education, most studies are theoretical and the practical applications are usually not implemented. One of such mentality is in the investment of scientific research.

Scientific research is one of the key aspects of development in the developed world. Billions of dollars are invested yearly in research both by the government and private institutions, organization or industries in most of the leading economies like, USA, England, Germany, France, Italy, Japan and in some emerging economies like China, India, Brazil etc. In Africa, such investment is equality observed in South Africa which is developed and has the strongest economy. One may think the other nations in the underdeveloped world do not have programmes that sponsor research or promote it at all but it is not the case. Most research in underdeveloped world are usually repetition of previous works or studies which do not contribute to the basic concepts or have an application and fall under category of this research.

8. Measures to Improve and Ensure Development in West Africa through Science and Technology

To acquire a significant development through science and technology, the West African people must be willing and ready to change certain existing factors which restrain the progress of technology in the West African society. For this to be achieved, West African people should change the mentality of their immense phobia against sciences and technology. This should be accompanied by improving on the governance systems and policies which can promote and financially sponsor scientific and technological processes including research and scientific projects. Research especially empirical research needs to be encouraged and promoted to identify new technologies that can manage their immediate resources and place the economy in competition with other nations. Means by which future scientists can be trained and scientific ideas are projected and shared such as conference, seminars, convention, workshops should be promoted. Africans need to improve on the ways to communicate scientific ideas. The creation of scientific journals, documenting information in books and the internet will spread scientific information across borders and also more science journalists should be employed to communicate scientific information. This will help to popularize scientific ideas and create public awareness. Science and technological education which are practically oriented along with industrial attachments should be encouraged at the level of basic education on subjects such as physics, chemistry, mathematics, biology and at the secondary and tertiary level. Technical courses such as engineering and applied sciences at the tertiary level should be introduced as well as new emerging innovative academic fields. A global partnership with mother institutions, well establish industries and associations which can permit the transfer of information across will encourage technology transfer. Above all, the participation of

everybody and not only the government is paramount to foster development. With all this suggestion and the full commitment of the society, development can be achieved through sciences and development.

9. Making Science and Technology to Effectively Promote National Development in West African Countries

Science and technology policy and its impact on society depend on a number of factors that are related to contribution to development of fundamental knowledge and technology. Also, consideration is given to its contribution to development of scientific and technical human capital. These parameters are often used to evaluate the impact of science and technology policy on the society.

Science and technology policies are generated by both the internal stakeholders (S&T family) and the external stakeholders (end-users of S&T), while the successful implementation depends on the cooperation of all, including the greater society. The role of the institutional framework for policy implementation is very critical in determining impact of the policy on the user subsystem. It is obvious that the second subsystem (R&D institutions) must be able to play a key role in terms of institutional support to the productive sector and the society at large which form the user subsystem. If the second subsystem is weak or unable to discharge its functions effectively, the impact of the first subsystem (policy framework) cannot be felt and even measured. It is imperative therefore that the subsystems should interact on a continuous basis to achieve the desired impact. This concept provided the basis for the research methods and procedures for the study which focused on the impact of S&T policy on national development. Realities on the ground are indicating that for S&T, there some prospects towards meeting up with the challenge of making S&T to address developmental realities in Nigeria. The major indicators for this are:

[1] S&T are much closer to industry and markets than before. Industries are externalizing for the development of new management skills, processes and products. The fallout of these increase in R&D investments, the setting up of specialized laboratories and research departments and search for new linkages with universities.

[2] The pace of technical innovation and competition in industry accelerated, requiring from firms a permanent capability to change its organization, absorb new technologies and processes and generate new products.

[3] Science is now more global than ever as the speed, quality and low cost of international information flows brings researchers and research sites into immediate contact. It is now much easier to have access to the international scientific community than in the past.

[4] There is an emergence of scientific enterprises which is compelling R&D to be market-driven.

[5] There is a change in the old system of S&T development that starts with basic research to applied research/invention and terminates with entrepreneurial innovation; thereby creating new products and processes which can later be diffused through imitation or reverse engineering. The current situation is more complex with scientific discoveries assuming the context of application. The consequence of this changing landscape is the loss of support for basic research if it is not linked to identifiable products and results.

[6] New patterns of international scientific cooperation are emerging resulting in the establishment of large scale international ventures. Examples include human genome project, biotechnology and genetic engineering, global research activities in fields of meteorology, global climate change, renewable energy, etc. Such cooperation is characterized by large scientific installations and networks of scientists and research groups.

[7] Resulting from the above, considerable number of new activities and disciplines linked to scientific assessment emerged in areas such as technological forecasting, technology assessment and evaluation of environmental effects of innovation.

10. There is however some fundamental challenges that need to be faced squarely for us to reach the Promised Land:

[1] The very foundation upon which S&T started in West African countries which include Nigeria was faulty. The foundation was laid during the colonial period to put in place structure that very much satisfies the international system and the country remaining as peripheral dependent economy, exporting raw materials and importing manufactured goods from the large industrial countries of the world. The country is to serve as source of raw materials for foreign enterprises and to enjoy limited industrialization to produce a few basic consumer goods. These schemes of development generated no local scientific and technological demand. Invariably, there was no stimulus for development of technological research, with basic research mainly related to few disciplines with social demand such as medicine and agriculture.

[2] The reduction of resources for most existing S&T programmes largely as a fallout of declining national resource base.

[3] Lack of perspective for new projects and initiatives even when multilateral assistances which require matching funds were concerned.

- [4] Institutional and financial instability. At certain point in time, the agency established for S&T development changed name and status several times;
- [5] Budget allocated to S&T institutions fluctuated and actual delivery of the funds was not guaranteed.
- [6] Lack of consensus in government, public opinion or international agencies about the importance and role of scientific research.
- [7] S&T agencies have limited capacities to grant resources for research projects.
- [8] The administration of some federal agencies for S&T suffered from the effects of over bloated bureaucracies, low salaries, low morale and political militancy of employees reflected in terms of number of labour strikes or work-to- rule. Some agencies were under staffed and unable to recruit competent persons to fill the vacancies. Operational activities were paralyzed by lack of resources and incentives.
- [9] Emigration of skilled researchers from West African countries in search of greener pastures. It has been reported that “there are as many West African Scientists in the West as expatriate living and working as there are Europeans in West African countries especially Nigeria.
- [10] The public institutions which were mainly funded by the West of African government were poor payers compared with the private sector or even the private universities. This situation resulted in the flight of skilled and experienced researchers to the private sector and private universities, leading to what is termed “internal brain drain”

11. Conclusion

Science and technology cannot be denied to have immensely contributed to development. The evolution of science and technology has witnessed so many revolutions from the Neolithic to industrial and now to the present computer age. There has been great achievement of science and technology in various sectors such as the medical, industrial, entertainment, education, infrastructure for development whose success lies on the key elements such as research, global partnership, new disciplines etc. Most of the countries that have exploited this knowledge and technique have seen their socio economic and financial status improved along development. Though science and technology has some detrimental effects to the society, the way forward is to promote sustainable development; a strategy to separate the bad from the good technology and promote good one is presently been encourage worldwide for effective development that will support the sustenance of man and his environment. In addition to the challenges faced in Africa, the advancement of science and technology will only be achieved if Africans can change their mentality and lay emphasis on those key elements and measures that are paramount for development.

12. Recommendation

To achieve sustainable science and technology research and development in Africa certain strategic steps must be taken or adopted by African countries. It is important that partnership and linkages be established between various sectors within each country, and African countries.

These interactions should involve exchange programmes, cooperation between industries and educational institutions, linkages in research facilities, and identifications of other mechanisms and sources of assistance and support. These interactions should be promoted at all levels of national, regional and international.

Also, there must be a commitment towards increasing the level of literacy and numeracy by all nations. Indeed, this should be a prime requirement. Towards this end, African countries must establish, through their national education policies, strong links between stakeholders in their educational system to ensure curriculum development that is science and technology based across the full educational process.

Also, African countries should seek more sponsorship or assistance from international donor agencies and from the private sector, recognizing the fact that African's local resources are inadequate. There should be a determined effort by African countries to close the gap between African's educational system and that of the developed world.

Again, West African countries must raise the level of awareness of the value of science and technology research among the general population and among those that influence educational policies.

Scientists and technologists from educational institutions and industries should be included in designing the curriculum. The curriculum should basically be designed to meet the needs of Africa and address the immediate needs that include awareness of the environment. Topics such as pollution, hydro climate variability, conservation, use of natural resources and soil erosion should be included. The curriculum for early study years should emphasize mathematics and science which is to ensure that all students are given the opportunity to study science later.

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