Science, Technology, and Public Policy in Africa: A Framework for Action

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Underdevelopment in Africa continues to be one of the most perplexing issues of this century. Conventional development policies have failed throughout the continent, and lack of scientific and technological capabilities is considered among the primary causes of the prevailing crisis. Attempts to address underdevelopment have been conducted in terms of what is scientifically and technically feasible in industrialized countries instead of what is socioeconomically and culturally desirable in Africa. Undue reliance on foreign scientific and technological expertise hinders local innovation and creativity, which are crucial to self-sustained development. Redefinition of science and technology policies is urgently needed. Africa should not circumvent the use of science and technology in the quest for development, but it is crucial that African policy makers determine in whose interests science and technology will be developed.

A Kenyan proverb says, "When elephants fight, it is the grass that suffers." Africa's past reads like a catalog of conflict: slavery, colonialism, ethnic clashes, and political upheavals. And because of this, the science and technology "grass" has suffered tremendously. This article provides an overview of the current science and technology policy situation in Africa. It is a modest attempt to capture the emerging science and technology policy issues currently facing this heterogeneous continent that consists of many countries with a variety of political, socioeconomic, and natural resource systems.

In 1978 Edem Kodjo, then secretary general of the Organization of African Unity (OAU), deplored at an OAU heads-of-state summit, "Our ancient continent is now on the brink of disaster, it is hurtling towards the abyss of confrontation, caught in the grip of violence, sinking into the dark night of bloodshed." Although lamented two decades ago, these conditions remain in Africa currently, and in some cases the situation has become much worse. The continent has experienced a series of civil wars, political chaos, instability, and the decay of infrastructure across the board, from telecommunications systems that do not work to deteriorating educational systems.

Clearly, Africa's problems are due to a combination of ill-conceived foreign and domestic policies. The severity of the crisis in Africa has defied both traditional and nontraditional methods of economic development. Although there is little consensus in the solutions offered, it is widely accepted that science and technology play a critical role in economic growth and development, and that Africa's lack of a homegrown science and technology capacity limits socioeconomic development.

Definitions and Distinctions

The terms *science* and *technology* mean different things to different people. For present purposes, science will be defined as the understanding of nature by employing experimentation and logical means. Technology, by contrast, is the use of precise knowledge to manipulate nature to obtain specific results. Science in the purest sense and technology strictly defined are nevertheless located at the extreme ends of a continuum of overlapping knowledge. These two extremes are often united in what is called the research and development (R&D) process, where scientific research is conceived as leading to technological and economic development. But pure science does not always lead to technical advance, while new technologies can be invented without science. Additionally, technological challenges can lead to new scientific knowledge. Suffice it is to say that science and technology are in constant interaction with each other, and

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it is often difficult to specify borders around these wide-ranging social activities.

A further distinction with regard to science and technology is historical. The extensive interactions that are increasingly characteristic of science and technology in Europe since the Renaissance define a kind of science and technology that is often called modern. But it is a mistake to think of science and technology as only modern phenomena. Science and technology in premodern, traditional, or indigenous forms are present in all human cultures.

In academia, discussions concerning science and technology, both modern and premodern, have traditionally been subdivided among specific disciplines, on the one hand, and into various policy perspectives, on the other. Scientists and engineers, philosophers, political scientists, historians, sociologists, and economists have unique concepts of science and technology. For example, whereas scientists are concerned with generating scientific ideas and expanding scientific knowledge, philosophers think about or reflect on scientific ideas. Historians study the social history of these ideas. Economists focus on the dissemination of new technologies, understood as both products and processes. Collaboration among these disciplines is thus rare. Although the number of interdisciplinary research groups is growing, they remain the exception and not the rule (examples of interdisciplinary research groups include the United Nations Economic Commissions for Africa, African Technology Policy Studies Network, the African Academy of Sciences, the African Center for Technology Studies, and the Third World Academy of Sciences).

The result of this fragmented approach is that the role of science and technology in development is observed through particular disciplinary and ideological lenses. This makes the issue of harnessing science and technology for development both problematic and elusive. Even the standard distinction between research and development need not always apply. What then is the most appropriate way of organizing science and technology, especially in underdeveloped regions such as Africa?

A national science and technology policy is generally thought to incorporate several related elements. Ideally, it ought to have a general direction and an established set of priorities conducted under the state's legal and executive guidelines. These priorities include R&D, the development of a cadre of scientific and technical personnel, and economic incentives to promote science and technology for social benefit. Distinctions are often made in terms of the functional areas and societal sectors. Functional areas include fields such as basic science, applied science, and industrial research, whereas societal sectors include areas such as communications, agriculture, energy, education, defense, and health. Whether and to what extent such disciplines apply or ought to apply in African countries remains unclear.

Contemporary Situation

It is widely acknowledged that science and technology are essential to the vitality of national economies. But globally, Africa is viewed as a scientific and technological backwater. Consider that of the world's 36 least developed countries, 26 are in Africa. The severity of the political, social, ecological, and economic crises in these sub-Saharan African countries needs no introduction. Many African countries have served as centers of extensive inquiry from which have emerged a host of models and empirical studies to analyze causes of underdevelopment. Policy recommendations from these studies frequently emphasize the critical role of science and technology in promoting socioeconomic development.

But African countries currently lack the infrastructure essential for achieving technological leverage. The capacity to formulate science and technology policies is overwhelmingly viewed as external to the African milieu, and the region as a whole is heavily reliant on foreign technologies. These technologies are imported under unfavorable terms and at costs that cannot be economically sustained. For example, foreign aid is often tied to the use of donor services and technologies. These technologies are often either obsolete or ill suited to the local conditions. Overdependence on foreign technologies and expertise frustrates both the development of indigenous technologies and the innovative capacity for generating new technologies. In addition, the ability to adapt foreign technologies to the local situation is highly compromised.

Serious discrepancies exist between the needs of national and socioeconomic development and the direction of scientific research, and many institutes conduct research that is incompatible with the basic requirements of national economies. Strategies aimed at enhancing the technological situation in Africa have merely focused on providing a cadre of scientists and engineers. The result has been that despite some worthy achievements in the fields of agriculture, entomol-

ogy, and medicine, in particular, scientists and engineers have contributed little to the transformation of the region's raw materials and upgrading of its products. Efforts to generate and nurture local demand for science and technology have been minimal, which has resulted in little connection between the generators of technology and the productive sector, and often the liaison between policy makers and R&D institutions is diffuse. In the final analysis, African countries have been unable to exploit, judiciously, their own natural resources.

Africa's contribution to global R&D is 0.3%, the lowest in the world. Naturally, this does not bode well for Africa's share of the world trade, which stands at roughly 2.5%. Africa makes the smallest human resource contribution to R&D and spends the least on R&D ventures. The continent also suffers from a shortage of scientists and engineers. According to the 1998 UNESCO World Science Report, in 1992 there were only 20,000 scientists and engineers in Africa, representing a paltry 0.36% of the world's scientists and engineers. The shortage of science and technology personnel is due to a variety of factors including limited higher education and research facilities, curricula that focus on science and technology issues that are incompatible with national socioeconomic needs, and the brain drain to industrialized countries.

There are other factors that stunt science and technology development. Generally, the private sector does not reinforce R&D, nor does it strengthen, deliberately, science and technology infrastructure. Financial institutions' provision for venture capital for new technologies is limited. Therefore, there is little or no insurance for entrepreneurs against the risk of using unproven local expertise and technologies. In a nutshell, the critical role of science and technology in development is either not appreciated or deliberately sabotaged.

During the past 20 years, international investments in science and technology in most African countries have decreased considerably. In addition, structural adjustment programs have replaced development policies. Almost all new investment projects have been canceled, and the restoration of existing installations has been postponed. Several restrictions have been imposed on the importation of spare parts, equipment, technical assistance, and training of personnel both locally and overseas. The infrastructure is therefore unchanged, whereas in some areas the technical performance in some industries has deteriorated.

Africa exports more capital, in the form of debt service, than it receives in the form of aid and other investments. The challenges for capacity building for science and technology in Africa are basically the challenges of an international economic environment in which African countries have no leverage. As previously mentioned, most African countries rely not only on foreign technologies for the exploitation of their natural resources but also on foreign advice as to what should be exploited, by whom, when, and with what technology.

Most African countries rely on the export of basic raw materials and minerals. However, the ability to transform and upgrade these commodities has been constrained by the declining prices of these commodities in international markets. Consider that 92% of Africa's total export earnings are procured from the sale of primary commodities. Yet, between 1957 and 1992 the price of these commodities fell by more than 50%. To exacerbate the situation and further reduce the continent's earnings is the fact that the region is strained by repayment of external debts that increased from U.S.$185 billion in 1985 to U.S.$275 billion in 1992 to $400 billion in 1996. Even though only half of the outstanding debts are being paid currently, 40% of Africa's export revenue goes toward servicing debts. Furthermore, the official development assistance decreased to U.S.$19.7 billion in 1992 from U.S.$28.2 billion in 1991, and as a result African countries have been unable to invest in science and technology, nor have African governments been able to contribute 1% of their gross domestic product to science and technology as agreed in the Lagos Plan of Action in 1980.

Geographical and Historical Background

Before attempting to answer the policy question of the most appropriate way to organize science and technology in Africa, it is useful to address a historical question. Why, historically, have modern science and technology not developed in Africa? The historical fact is that modern science developed initially in Western Europe beginning in the 16th and 17th centuries. Modern industrial technology developed in the 18th and 19th centuries. Despite many historical precursors to such developments in Asia, Africa, and Central and South America, the question must be asked, Why did modern science and technology not find as natural a home elsewhere? Why in most instances have they had to be imported or transferred from Europe?

With regard to Africa, the historian and political scientist Ali Mazrui (1980) has raised these questions. Is it possible that the richness of the continent has made an aggressive science and technology seem unnecessary? Mazrui postulated that if necessity is the mother of invention, then abundance is the mother of inertia. Africa was well endowed with natural resources. Therefore, there was no incentive to develop a variety of technologies. In addition, when resources are ample, the need for centralized states and kingdoms is lessened. Advanced innovations are not as highly valued in an informal social fabric as they are in centralized and formal ones. Additionally, is it possible that Africa's tropical climate has hindered technological innovation? The closer one is to the equator, the less one needs complicated tools. Conversely, engineering advances are necessary for people living in cold climates. For example, they must be innovative enough to survive the cold temperatures and grow adequate food in a short growing season.

Humanity's first home was probably in the tropical environments of Africa. This is where the first human beings are thought to have created the earliest tools and even used fire. But people gradually migrated from Africa to other parts of the world and are, currently, faring better than Africans. Africa is in the grip of severe economic, development, and environmental crises. And many Africans are living in poverty and deprivation with virtually no future prospects. Mazrui (1980) referred to this condition as the paradox of the Garden of Eden in decay. Did Africa simply experience a false start, or is the continent's miserable state related to the region's experience under colonialism? The Conference of Berlin was held in 1884. It was convened to finalize the terms of agreement for the European partition of Africa. As a result of the conference, Africa was divided into colonies and protectorates of mainly Britain, France, Belgium, Germany, Portugal, Spain, and Italy.

In an attempt to answer the question about the effect of colonialism, Thomas Odhiambo, former president of the African Academy of Sciences, looked even earlier in history and blamed not only colonialism but also the beginning of the slave trade in the 15th century for thrusting Africa into five centuries of darkness and despair. He underscored that science has always been in Africa, but the slave trade dismembered and destroyed Africa's centers of civilization and wiped out achievements in astronomy, agriculture, mathematics, metallurgy, and medicine. Examples of these centers of scholarship include Alexandria in Egypt, Axum in Ethiopia, Benin in Nigeria, Lamu in Kenya, and Timbuktu in Mali. Africa's dark age was exacerbated by the colonial blight of European imperialism, which lasted for 150 years. During this time, Africans were barred from any meaningful participation in world culture, science, and technology. Furthermore, the indigenous science and technology that Africans had accumulated were treated as inferior and were gradually lost (American Association for the Advancement in Science, 1994).

The colonies and protectorates were administered differently according to the preferences of the mother country. For example, the French mission was to assimilate the colonies into French culture and civilization. French colonies were therefore treated as overseas provinces of France. The British, on the other hand, adopted the policy of indirect rule. The British considered colonies as separate entities and not overseas provinces of Britain. The colonies' administrative policies and most laws were issued by the governors and their councils and not by the British Parliament. But irrespective of administrative style, colonial policy deliberately retarded science and technology. It also used science and technology as instruments for demonstrating the gap between the colonizer and the colonized as more value was placed on science and technology solutions to European problems and not African ones. Furthermore, the extractive nature of colonial commercial interests in Africa did not require much scientific research, and few research institutions were set up.

Science and technology in Anglophone countries dovetailed the colonial policy of indirect rule. Scientific research was carried out by the settler community in the colonies. The British government financed the research and organized it on a regional basis to encourage better coordination of government services. Examples include the East Africa Metrological Department in Nairobi, the Federal Agricultural Research Council of Rhodesia and Nyasaland, and the Forestry and Agricultural Organization of the East African Community. The West Africa Research Organization conducted research and provided extension services in Gambia, Ghana, Nigeria, and Sierra Leone. Although African participation was kept at a minimum, the emergence of these institutions enabled scientists from various countries to meet and network.

Science developed more slowly and along different lines in Francophone Africa. The Pasteur Institute established research branches in Algiers, Madagascar, Tunis, Brazzavile, and Dakar. But compared with the

British, these initiatives were kept modest and regional cooperation was not encouraged. It was not until after World War I that the French set up the Académie des Sciences Coloniale, the Ecole Supérieure d'Agriculture Tropicale, and the Insitut Français d'Afrique Noire. Later, the French colonies themselves (such as Cameroon, Togo, and Ivory Coast) assumed more responsibility for research funding but were still subject to French prejudice and the politics of assimilation. Also, the number of Africans involved in scientific research in Francophone countries was small compared with the number in Anglophone countries. For example, it has been noted that during the interwar years, Francophone West Africa had 100 scientists, fewer than in Kenya alone at the time.

The Belgian and Portuguese research strategies differed from those of both the British and the French. The Belgian colony of Congo and the Portuguese colonies of Angola and Mozambique were expected to finance their own research institutions. The Belgian Congo, therefore, set up research organizations such as the Institut pour la Recherche Scientifique en Afrique Centrale, which provided Belgian researchers and universities with access to tropical environments. The Institut de Recherche Agronomique du Mozambique was set up along the same lines in both Mozambique and Angola.

Although Africa was divided under colonialism, it is worth pointing out that the continent is fragmented in other ways. It consists of approximately 50 countries with more than 800 ethnic and linguistic groups. It comprises three major religions—African traditional beliefs, Islam, and Christianity.

Several international languages are spoken, predominantly English, French, Arabic, and Portuguese. Political traditions in Africa include capitalism, nationalism, socialism, conservatism, and military regimes. These either follow the colonial heritage or oppose the hegemony exerted by the former colonial powers. As mentioned previously, the problem with this fragmentation is that regional cooperation has been constrained.

Science and Technology Policy Initiatives for Africa

There have been some worthy attempts to improve science and technology policy and planning agencies in some African countries. Between 1979 and 1984, the number of countries with ministries of science and technology increased from 9 to 17. Although there are approximately 13 countries with a central science and technology agency (5 with multisectorial science and technology coordination bodies), there are still several countries without a central science and technology body. The creation of science and technology agencies, however, is a clear indication that the importance of science and technology in socioeconomic development is recognized. However, there are still several obstacles. Consider that because of policy disaggregation, science and technology policy agencies are not linked to national research institutions, which are subsumed under other ministries. Duties of science and technology have been relegated to ministries with other significant national problems, typically ministries of education. Ultimately, coordination of various research areas in terms of program budgeting, priority setting, and program implementation becomes extremely difficult.

Recently, a study on the performance of science and technology policy institutions in several countries including Ghana, Kenya, Nigeria, Tanzania, Madagascar, Malawi, Senegal, Zimbabwe, Guinea, Gambia, and Sierra Leone was conducted by the United Nations Economic Commission for Africa (UNECA). The purpose of the study was to evaluate the functions, powers, organizational structures, and resources available to these national institutions. In all cases, it was clear that the interpretation of science and technology was too narrow and that there was an urgent need for a major policy overhaul.

The study noted that African governments have tried to mimic industrialized countries, where science and technology are construed as high-level R&D and training at tertiary and posttertiary levels. The UNECA study recommended that because of Africa's subordinate position in science and technology, emphasis ought to be placed on the application of "off-the-shelf" science and technology as a starting point. African governments must put more emphasis on the R&D component so that research results can be commercialized. The UNECA study also noted that emphasis on the development side of the R&D equation is weak. Most of the funds allocated to science and technology go toward research and high-level training, whereas development of science and technology receives limited resources.

These countries have also established national institutions in the form of councils, commissions, and ministries to coordinate science and technology activities. Previously, these science and technology bodies emphasized scientific research and were based on

British or French models of research councils. For example, in the Francophone countries they still take the form of ministries of scientific research and higher education. As an outcome of the study, it is now recognized in many African countries that science and technology policies should go hand in hand with fiscal policies, trade and industrial policies, educational policies, and so on. Moreover, it is now recognized that in the past, a crucial determinant of science and technology project failure was the perfunctory treatment of the cultural norms and practices of local people. Yet, these traditional practices (which include agricultural and traditional medical practices) must be regarded as assets and as key determinants of success without which the impact of science and technology policies on socioeconomic development will be minimal.

To cope with the deteriorating socioeconomic situation, African countries must promote science and technology innovation. But in so doing, policy makers must realize that Africa has both urban and modern sectors as well as rural and traditional sectors. The simplistic view of Saharan Africa as a less developed model of industrialized countries is ill conceived. It is now clear that science and technology policies drawn from the development experience of industrialized countries are not entirely conducive to providing the intellectual framework necessary for addressing the deteriorating socioeconomic situation. Because science and technology policies are largely the responsibilities of governments, the poor science and technology capacity and the misuse of scarce resources can be attributed directly to governments. It is therefore incumbent on African governments to facilitate the formulation and execution of clearly enunciated science and technology goals. In this regard, concerted efforts should be made to narrow the gap between science and technology policy and socioeconomic policy.

The African academic community should assume a more active role in improving science and technology throughout the curricula, promoting the public's understanding of science and technology, and demystifying existing views of science and technology by highlighting the scientific basis of most traditional practices. The morale of the research community must be boosted by providing adequate financial resources and environments conducive to science and technology research. At the regional level, more institutions such as the African Foundation for Research and Development, the African Technology Policy Studies Network, and the African Academy of Sciences should be established. These institutions will go a long way in ameliorating our unfortunate history in which Africa was divided into two main zones of communication with the international scientific community, Anglophone and Francophone.

Financial, fiscal, and institutional incentives should be offered to the practitioners of science and technology. The educational system must be made more accessible to—and guarantee scientific confidence in—the practitioners of science and technology. It should also provide incentives to local scientists, engineers, and technicians so that they can willingly contribute to national development. Innovative mechanisms to generate funds for the development and application of science and technology should be encouraged and provided by regional institutions such as the African Development Bank.

African countries should take advantage of—and keep abreast of—the latest developments in science and technology to increase agricultural productivity and boost industrial development. Bureaucratic controls that hamper entrepreneurship should also be revoked.

Conclusion

Africa lags behind the rest of the world in science and technology and therefore faces tremendous challenges in science and technology capacity building. The overall aim of science and technology policy for development is to improve standards of living by enhancing the indigenous capacity of African countries to help themselves. However, in Africa science and technology were never considered vital elements in the development process, and the legacy of slavery, colonialism, and current political chaos stunted an already fragile science and technology base. Reliance on European experts precluded broad African participation in even the limited R&D infrastructure created during colonialism. African countries were simply suppliers of raw materials and consumers of manufactured goods and foreign technology. This situation still exists. African governments must therefore accord priority to developing a local science and technology capacity, since it is a prerequisite for the development of appropriate science and technology policies. Although some form of international assistance will be required, the region cannot hope to solve its science and technology problems by relying solely on the international community. African policy makers must therefore assume a leadership role in ascertaining that the benefits of science and technology are accrued

locally. Science and technology should not be viewed as a set of elitist activities the exclusive province of which is universities and research facilities; rather, the significance of these activities in many traditional practices should be conveyed.

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