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INVESTING IN SCIENCE AND TECHNOLOGY IN AFRICA: POLICY ISSUES AND OPTIONS FOR THE 21ST CENTURY

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Introduction

It is important to note that science and technology policy goes beyond the rhetoric discussion of research and development (R&D). Science and technology policy is a much wider subject matter incorporating issues such as opportunities and constraints affecting individuals and institutions in the development process. It also includes the behaviour, forces, challenges and circumstances of such individuals and institutions working in a particular socio-economic environment.

Based on this broad notion of science and technology policy, this report will discuss the major science and technology policy issues and options for the 21st century in Africa.

The report is organised into three parts. The first part outlines some recent, international community-initiated activities to improve the continent's science and technology. In the second part on Africa' current situation concerning science and technology (S&T), the report indicates that despite the increasing awareness of the important role of science and technology for development, African countries do not invest much in research and development and training of the skilled personnel to sustain scientific creativity and technological innovation. The third part then examines the present policy issues and problems, so as to outline the future policy options.

1. Science and Technology for Development in Africa: Recent Activities

The need for science and technology in development is not a new philosophy in Africa. It had been discussed in various levels of government even before many countries gained political independence in the late 1950s and 1960s. However, during the colonial period, most of the scientific and technological activities were concentrated in research on export crops (cotton, coffee, cocoa, and palm oil), which were intended to supply the factories of the colonial powers with raw materials from agriculture and forestry. It was only after the Second World War that food crops became the subjects of research programmes. The other areas of research were medicine and human sciences, with almost no interest in industrial sciences.

It should also be noted that there were no radical changes in the situation during the first decade after political independence in Africa. Research programmes on new and renewable sources of energy, building materials, processing of agricultural products and adopting of technologies made their appearance only in the late 1960s.

New and appreciable efforts to enhance the development of science and technology in Africa emerged from the 1970s. For instance, in 1973, Economic Commission for

Africa (ECA) of the United Nations organised an Intergovernmental Committee of Experts for Science and Technology for Development (IGCESTD), which advises on science and technology issues for African development. In 1974, the ECA advocated for an African Regional Plan for Action towards the application of science and technology. This led to the two conferences of ministers responsible for the application of science and technology to development in Africa (CASTAFRICA I and II).

The Dakar Conference of Ministers of January 1974 (CASTAFRICA I) recommended that each country in Africa should have at least a department responsible for formulating and co-ordinating science and technology policies and the related activities. Since then, the ECA has facilitated the establishment of various regional science and technology bodies, including African Regional Organisation for Standardisation (ARSO) in Nairobi; African Institute for Higher Technical Training and Research (AIHTTR) in Nairobi; African Regional Centre for Technology (ARCT) in Dakar; African Regional Centre for Engineering, Design and Manufacture (ARCEDEM) in Ibiden; and African Regional Industrial Property Organisation (ARIPO) in Harare.

The Arusha Conference of Ministers of 1987 (CASTAFRICA II) was based on the ideas that emerged from the review of the achievements of CASTAFRICA I. It came up with a set of 15 recommendations, which comprises the issues such as science and technology policy and planning; institutional structures for science and technology; financial resources for research and development; women in science and technology; social status of scientists and the brain drain problem; development of human resources for research and development; network project on combating desertification; non-governmental scientific association; science and technology information; science and technology for rural development; science and technology for industrial development; science and technology education and training for development; scientific and technological co-operation; and follow-up mechanisms.

As a result of the CASTAFRICA conferences, many African countries established national policy mechanisms for science and technology. For example, national research councils were set up in Ghana, Mali, Niger, Sudan and Egypt. Ministries for science and technology were formed in Senegal, Burkina Faso, Cameroon, Benin, Kenya and Nigeria. commissions for science and technology were created in Ethiopia and Tanzania, and Morocco set up the National Centre for Co-ordinating and Planning Scientific and Technological Research. In effect, between the CASTAFRICA I (1974) and CASTAFRICA II (1987), the number of African countries with science and technology institutions rose from only four to twenty eight.

Other important deliberations regarding science and technology include the United Nations Conference on Science and Technology for Development (UNCSTD) held in Vienna in 1979, which advocated the conceptualisation and implementation of explicit national science and technology policies to accelerate the development process of Africa. There is also the Lagos Plan of Action for the Development of Africa (1980-2000) of April 1980; the African Priority Programme for Economic Recovery (1986-1990) of 1985; and the Brazzaville Congress of African Scientist of

1987, which led to the establishment of the Pan African Union of Science and Technology (PUST). PUST is aimed at enhancing the integration of science and technology in development planning and management. Similarly, there is the May 1993 Treaty establishing the African Economic Community, with Articles 51 and 52 dealing specifically with science and technology.

The latest attempts to sensitise the role of science and technology in the continent is the holding of annual "Presidential Forums" for the management of science and technology in Africa, under the auspices of the Research and Development Forum for Science-Led Development in Africa (RANDFORUM). The Presidential Forums held in Gaborone (1993), Maputo (1994), and Kampala (1995) started to crop the interest of Heads of States and Governments in Africa to the centrality of science and technology in the development processes.

Several other events such as the Science and Technology Protocol of the African Economic Community have taken place with the aim of bringing science and technology closer to the development planning of African countries. The aim of this Protocol is to:

(a) Strengthen scientific and technological capabilities of member States through programmes aiming at the proper application of science and technology for development in different sectors;
(b) Promote co-operation among member States in all aspects of fostering the application of science and technology for the development of African societies, the acquisition and assimilation of environmentally agricultural and industrial technology and its adaptation to local conditions;
(c) Harmonise intellectual property laws and practices in order to promote the development of science and technology within the Community; and
(d) Strengthen national, regional and sub-regional scientific and technological institutions, including those concerned with intellectual property laws and practices, as well as patent information services.

The most recent initiative at the continental level is the establishment of the African Regional Conference on Science and Technology (ARCST) by ECA. The ARCST, the only subsidiary of ECA in the area of science and technology, replaced two former committees: the Intergovernmental Committee of Experts on Science and Technology for Development (IGCESTD) and the Technical Advisory Committee on Nuclear Science Technology in Africa (TACNUSTA). ARCST held its first meeting in November 1995. The aim of the Conference is to provide an opportunity for high level African policymakers and ministers responsible for science and technology to deliberate on the application of science and technology to development. The terms of reference for ARCST were spelt out, as follows:

- To assist ECA in the definition and periodic review of strategies and programmes for the development and application of science and technology (including nuclear science and technology) in the African region;

- To examine and advise the Executive Secretary of ECA on specific issues bearing on the implementation of such strategies;
- In general, to actively pursue the promotion of science and technology and the formulation of measures to ensure their effective application to national, sub-regional and regional development;
- To give special consideration in its activities to the needs of the least developed member States, and to the application and impact of new and emerging technologies; and
- To advice the Executive Secretary of ECA on ways and means of mobilising resources of all kinds for the implementation of strategies, programmes and projects for the development and application of science and technology within the region.

2. The Current Situation

The problem is that despite the awareness of the importance of science and technology for development, African countries do not invest much in research and development and training of the skilled personnel to sustain scientific creativity and technological innovation. UNESCO's data reveals that Africa has always ranked at the bottom of all geographical areas of the world in terms of research and development expenditure. Similarly, many countries in Africa spend less than the recommended rate of 1.0% of GNP on research and development, compared to an average of 2.23% in the developed world (see various issues of UNESCO's Statistical Yearbook).

Although many African countries have realised that it is the availability of adequate human potential, which is the basis for any progress in science and technology, only a minority of the graduates from the institutes of higher learning are usually from areas of science and technology (e.g., natural sciences, engineering, medicine and agricultural sciences).

One of the recommendations of CASTAFRICA I (1974) was that African countries should take the necessary measures to attain certain numbers of scientists and engineers, but by the time CASTAFRICA II was being held (1987), only six African countries (Algeria, Egypt, Libya, Rwanda, Seychelles and Sierra Leone) had reached or exceeded their target numbers. Even in all these countries (except Sierra Leone), the percentage of the scientific personnel engaged in research and development was lower than 5 per cent. Only Algeria, Cape Verde and Morocco had reached or exceeded the desirable level of two technicians to every researcher engaged in research and development.

Similarly, an observation of the distribution of scientists and engineers engaged in R&D between different fields of study reveals a serious imbalance to the disadvantage of the engineering-based sciences (see UNESCO, Statistical Yearbook Various issues). The imbalance in the distribution of scientists and engineers appears again,

when considered by the sectors of activity. Higher education and the general service sector (ministries, public bodies and institutions) absorb most scientists and engineers.

As far as the institutional base is concerned, the broadening of the institutional base in most African countries has tended to weaken the system as a whole; instead of strengthening national science and technology capabilities. It is because new institutions have seldom been established on a planned basis with due attention to existing structures and medium- and long-term requirements. The increasing number of institutions has therefore often led to the dispersal of scarce resources among projects and programmes with similar objectives. As a result, a widespread lack of effectiveness is to be observed.

At the same time, interactions between industry, the science and technology system, the economy, education and training policies are fragmented and uncoordinated. In many African countries, a substantial part of government sector resources has been channelled to military purchases with negligible benefits, or even counter-benefits, for the civilian populations.

The present science and technology system, its structure, operation and utilisation in many African countries is also distorted and cannot respond to the new national and international challenges, including those related to improving the quality of life of its masses. It is not well positioned to address new developments and opportunities, especially in the international science and technology arena, where the African continent has to take its place in the global scientific community and deal with new technological opportunities in fields such as information technology and biotechnology.

A new vision and a new strategy to deal with changes and new challenges are therefore urgently needed. In the following part, we will identify the major policy issues and options, while drawing on the experience of the ECA member States and other developing regions, which have grappled with similar issues.

3. Policy Issues and Options in Science and Technology in Africa

3.1 Scientific and Technological Institutions and the Productive Sector

The experience of the industrialised countries has shown that there is an inseparable linkage between research and development institutions and industry. However, unfortunately, the scientific and technological institutions in Africa are typically disconnected from the productive sector. The lack of contact has been explained by historical factors.

In the first instance, most African countries inherited a skewed education system, which was only aimed at producing technocrats and bureaucrats to service the administrative set-up of the colonial governments. The education system thus never

incorporated the practical orientation needed to make scientists and engineers relevant to the needs of the indigenous agricultural and industrial sectors. Secondly, as African countries became independent, many new governments saw industrialisation as an indispensable strategy to accelerate economic change and development and reduce dependence on the developed world. Most African countries followed the import-substitution industrialisation strategy with the objective of locally producing finished consumer goods to compete and displace expensive imports. This industrialisation strategy necessitated heavy importation of machinery, equipment and high level management and technical personnel. There was no pressure for local entrepreneurs to look for local inputs and to build capacity for experts.

Many studies of technology policies of industrial countries have shown that research institutions have played an important role in facilitating technological development. African countries, therefore, need to find the improved means of increasing the flow of technology from the universities and other research institutions to the industrial sector.

What measures can be taken to ensure that research in universities and other S&T institutions is more effectively linked to the private sector? To this end, a three-fold strategy can be pursued, which consists of: (i) promotion of bridge-building institutions, (ii) implementation of industrial policies to stimulate firm level R&D activities, and (iii) creation of an enabling environment for R&D.

(i) Promotion of bridge-building institutions:

Studies have shown that there exists a gap between the productive sector and the scientific institutions in many African countries. The solution could therefore have been to bridge this lacuna by promoting another bridging institution. There are several types of these institutions. For example, these are technology information units, consulting engineering centres involved with design and fabrication capabilities, science parks, innovation centres, industrial liaison units, and so on. Beyond the existence of effective bridges between the academic institutions and the productive sector, the outcome of such interactive mechanisms is the continued interest between researchers and entrepreneurs to maintain such interactions. This continued interest depends, to a large extent, on the financial expectations. Since the possibility of increasing the allocation of research funds from the central governments is limited, the S&T units have to initiate mechanisms of identifying new and diverse sources of income and increasing the quality of services offered to industrial clients. This can be achieved by transforming the units into semi-independent institutions and allowing them to commercialise their R&D and technical services. This could have the effect of augmenting the revenues received from central governments as well as of increasing internal efficiency of the units.

It should, however, be noted that due to the low levels of economic development of some countries in Africa in general and the S&T institutions in particular, it would not be desirable to emulate the examples of countries in

Europe and North America in the establishment of rather comprehensive interactive mechanisms, such as science parks, research parks, or innovation centres. There is a need to create simplified bridging mechanisms such as industrial liaison units or offices. The establishment of industrial liaison offices can facilitate to bridge the gap and enhance the interaction between the research institutes and the end users, as long as they are adequately staffed and properly organised.

(ii) Stimulation of firm-level R&D activities:

As already noted, government sources for funding industrial R&D in Africa are limited. It is therefore important that manufacturing firms play an increasing role in augmenting their research expenditures. Firms' own R&D efforts will have positive effect on their competitiveness in the market. In addition, the development of in-house capabilities will enhance the likelihood of being able to participate more fully with local research units, thus able to take advantage of the local talents in the identification of appropriate sources of technology and markets.

(iii) Creation of enabling environment for R&D:

The two strategies stipulated above call for the formulation of comprehensive R&D policies aimed at the development of scientific and technological capabilities. Again, it is to be stressed that Africa needs systematic policies and a coherent institutional framework for accelerating the acquisition and development of technological capabilities through the promotion of the enabling environment.

3.2 Regional Collaboration

Given the magnitudes of investment required in science and technology, there is a need for collective self-reliance through the pooling of scientific and technological potential of countries with limited resources. This is particularly true, since much of the effort in science and technology required in African countries cover similar problems and issues. There are thus many opportunities through regional co-operation, to spread the load of investment necessary, so as to provide an adequate infrastructure of institutions and programmes.

The will for scientific and technological co-operation exists and has been demonstrated at many inter-governmental, regional and sub-regional meetings. These include the participation in regional conferences and symposia on science and technology issues, the establishment of regional science and technology institutions, and other forms of regional co-operation such as exchange of scientists between universities and creation of regional professional associations of scientists and technologists. However, despite the existence of the above efforts, the regional and sub-regional institutions have encountered several impediments. The main problems encountered are:

- Unsustained political support during the operation stage (lack of adequate financial support through non-payment or infrequent payment of membership dues);
- Host government failure to provide all the necessary physical facilities and support, which are normally pledged when bidding to host the institutions;
- Declining support by some member States due to siting of the headquarters of institutions and dissatisfaction with the filling of senior positions;
- Mushrooming of a multitude of regional co-operative institutions and organisations and their financial implications; and
- Social prejudice against the utilisation of the services and expertise provided by Africa's own regional institutes in favour of services traditionally provided by organisations, which are based in the developed world.

3.3 Establishment of Coherent National Science and Technology Policies

An overview of the status of scientific and technological research and a review of the scientific and technological history in the context of institutional and political change in Africa would clearly reveal the various efforts undertaken by governments in a bid to establish national science and technology policies. In many countries, these efforts, which were initiated right after gaining political independence, have resulted in the creations of numerous research establishments ranging from advisory research committees, research institutions, academies of sciences, national science councils to fully-fledged ministries. In fact, many African countries have diverse scientific and technological infrastructure due to the existence of a large research system consisting of universities, quasi-governmental, international and non-governmental institutions.

However, what has not been appreciated is the fact that the creation of a body or bodies alone does not cause social and economic development. In many of these countries, the establishment of the National Council for Science and Technology or the emergence of the Ministry of Research, Science and Technology has not resulted in any visible and definite defined missions to actively pursue national science policy statements. The main contention here is that most African countries lack systematic policies and coherent institutional frameworks for accelerating the acquisition and development of scientific and technological capacities and capabilities. There exist wide contradictions between the existing infrastructure and development goals and objectives. Accordingly, there is need for an immediate impartial review to rationalise the planning capacities for research and development and their application in many of the African countries that have not yet formulated explicit national policies in science and technology.

The following ideas are proposed for a well-functioning S&T policy environment in Africa:

- provision of coherent, co-ordinated and focused S&T activities by the establishment of regional, sub-regional and national social, environmental and economic goals;

- elaboration of a clear understanding of the roles, responsibilities and accountabilities of different stakeholders within the S&T system;
- redirecting military and defence expenditures to civil/commercial needs, and particularly into the S&T system;
- increase the economic productivity and employment capacity of the countries and ensure competitive productive structure within the regional and global economy, by applying science and technology;
- develop an all-encompassing and deliberate approach to policy decision-making and resource allocations to and within the S&T system;
- implement the principles of sustainable development and food security; and
- facilitate the creation of S&T and innovation culture within the African society so as to view the S&T system as an important source of informed choices about development.

It should however be mentioned that it is the responsibility of national governments to establish science and technology priorities in the context of the broader national values, goals and priorities. On this account, the role of government is to promote the optimal functioning of the S&T system. This is done by setting goals and priorities, by initiating activities and by monitoring performance and evaluation.

3.4 Application of Available Science and Technology

Africa's past activities in science and technology have produced mixed results. With the assistance of the Economic Commission for Africa, many countries have managed to register some successes in popularising a basic policy option centred mainly on application of available science and technology rather than on pure research. This fundamental change in the orientation of science and technology policies is evidenced by the comprehensive resolution adopted by the African Regional Conference on Science and Technology at its first meeting held in Addis Ababa in November 1995. The resolution does not stress simply research but the application aspects of available technology (e.g., investment, transfer, incentives, and diffusion). This represents a radical departure from traditional thinking, hence calling for the entirely different sets of policy instruments.

The effectiveness and full benefits of the new policy will require existing institutions and structures to become more flexible and responsive to changes in the national, regional and international situations. To achieve this ideal, all stakeholders will have to reassess their present understanding and expectations of S&T framework. They will have to accept the need for a greater measure of co-ordination in their policy-making and operational activities to ensure efficiency and overcome the identified inconsistencies.

A systematic effort is also required to strengthen technological innovation and entrepreneurship within the productive sector and research institutions. What should be noted in this context is that innovation is not confined to high technology, but it rather reaches through incremental steps across the entire spectrum of endeavours - from technology intensive companies and research organisations to natural resource

firms, service industries such as banks and insurance companies. Central to the success of this initiative is how best to assist small and medium enterprises to access knowledge, apply and adapt technology, and adopt best practices. Main concerns are how government can improve its support for industrial innovation and strengthen the linkages between the private sector and the other constituents of the national systems of innovation.

3.5 Human Resource Development

People are central to any effective system of innovation and unfortunately, as noted already, the area of human resource development has been greatly neglected in many countries in Africa. To lay a solid foundation in education will require a concerted effort, especially in science teaching. It is important to improve the public understanding of science and technology - with the aim of increasing the interest among students in science and technology.

While making school and university curriculum more responsive to local needs, special effort must be made to improve the quality of science and technology education and also to encourage female students to participate in such courses. Special programmes and the popularisation of science and technology must be aired in the local media.

3.6 Science and Technology Policy within the Context of Sustainable Development

Growing global awareness of the complementarity and tradeoffs between the national environment and current and future development, which the United Nations Conference on Environment and Development brought to the forefront of development thinking, has led many countries to recognise the need to pursue policies that promote the sustainability of agriculture and rural development. However, what has not been stated clearly is the way, how to incorporate sustainable development objectives into the mainstream of science and technology policy framework.

Due to the diversity of the subject matter of sustainable development and S&T policy framework, there is need for regional and sub-regional efforts for the conceptualisation and implementation of the integration process. The process could adopt the following objectives:

- identify pertinent sustainable development issues to be integrated in S&T policy analysis;
- discuss how the sustainable development issues could be incorporated in the policy and planning framework, including identification of the issues for appropriate methodologies that already exist;
- identify what ECA and other development agencies could immediately promote in African countries to improve integration of sustainable development concern in S&T analysis, and;

- develop a co-operative effort to apply the identified S&T development methods in Africa.

In particular, ECA can assist member countries in their efforts to integrate sustainable development in science and technology policy by:

- emphasising resource-use efficiency;
- addressing the technical problems of resource degradation, environmental damage, and mitigation;
- stressing on optimal investment policy;
- designing proper institutional arrangements; and
- promoting the application of environmentally appropriate technologies

3.7 Financing S&T Activities

S&T activities in Africa are financed from several sources. These largely include budget allocations from the central governments as well as grants and loans from bilateral and multilateral development agencies. Budget allocations by enterprises allocated from their commercial income, levy in various sectors to finance the designated activities, and contract revenues have not been fully exploited to support the national S&T activities.

The other sources of funding and methods of encouraging S&T activities include:

(i) Funds from levy: Possibilities exist for tapping research funds from import or export levy on certain inputs, items and products. Such levy could be used to support well-designed science and technology projects. Industrial research, in particular, should benefit from funds obtained this way.

(ii) Private sector support: Opportunities exist for private sector firms to fund collaborative research with national research institutes and universities. In addition, modalities could be worked out, whereby entrepreneurs invest in research development or in application of strategic technology. These modalities include tax deductible and refundable grants for research and development activities.

(iii) Contract mechanism: Although there are marked differences between countries, it has been shown that probably the most preferred way of utilising public research establishments is by adopting a contract mechanism (see Gummett, 1980). Several examples from some advanced countries can elucidate, how the mechanism works. After the Second World War, the United States developed a deliberate policy to have more research performed by non-governmental bodies working under contract to the federal government. It was thought that the strategy was advantageous in that the government would not only have access to the wide spectrum of existing expertise, but would also enhance cross-fertilisation between competing institutions. This approach

proved successful and allowed more flexible response of the US system to changing programme and project requirements. More or less the same outcome can be observed in the United Kingdom. The notion of introducing contract mechanism, and thus competition, will have the advantage of boosting the dynamism of research institutions as well as the quality of their services.

(iv) Fiscal incentives for private sector innovation: Evidence has shown that the programme of fiscal incentives should be broadly based and aim at developing an indigenous innovation culture - a concept that would include incremental innovation. It should be coherent with other elements of the S&T system and encourage technical links with other R&D performers. It should establish performance benchmarks and a financial framework. A combination of tax credits for existing enterprises and rebates for start up companies is generally necessary, with as little emphasis as possible on rebates. The industrial community at large should be involved in the design and implementation of the scheme, and the appropriate auditing functions should be established beforehand. Most importantly, tight procedures for evaluating the system should be established at the outset, so as not to wane out the participation of firms.

(v) Other Sources of R&D Funding: These are, for example, significant reallocation of the existing government budget for S&T activities; use of tax incentives to promote greater investment by the private sector; targeting of some increased share of official development assistance to support innovative technology development and diffusion; and use of patents, industrial property and royalty systems for technologies provided by the R&D institutes.

3.8 Dealing with the Implications of the Uruguay Round

With the conclusion of the Uruguay Round of Multilateral Agreements, a more liberal and competitive international trading environment is emerging - a trend expected to accelerate. Many African countries are its signatories and are accordingly expected to make a transition towards a more open trading environment.

However, the envisaged liberalisation brings new dimensions to global competition that have both positive and negative effects on developing countries, particularly those in Sub-Saharan Africa. The Uruguay Round provisions lay down the framework under which countries will acquire, absorb, develop or apply technological capabilities. Whilst these measures appear to favour the technologically more advanced countries in maximising returns from the innovations, questions arise, as to whether the developing countries in Africa will benefit from it, especially given their low levels of technological development. This new environment is likely to promote trade, in particular, in high value-added manufactures and service products. On the other hand, international trade in raw materials and raw material-intensive commodities will grow much more slowly.

While the developed countries have generally welcomed it with plenty of optimism and even enthusiasm, the less developed countries, and in particular, the countries of sub-Saharan Africa have been less than enthusiastic in accepting its provisions. This was true, even after a number of special concessions have been granted to them to allay their fears. An important factor for their lack of enthusiasm was also the fact that this Round replaces the more favourable concessions that they received from the various Lome Conventions, which granted them special privileges in accessing the markets of the European Union, their most important trading partners. They thus stand to lose substantial existing benefits from special relations, while being unable to exploit, at least for the moment, the opportunities and benefits of this liberalisation process. Since technological capabilities have been identified as the most important determinant of global competitive advantage, whether sub-Saharan African countries can compete in the global economy will depend on their ability to exploit the opportunities offered by the Uruguay Round, while effectively coping with its new challenges.

While developed countries will reap the benefits resulting from it, the much-expected increase in technology transfer and diffusion to less developed countries from some of these provisions may not materialise even in the long run. It seems that the Uruguay Round will strengthen the global position of multinational corporations in trade as well as in technology. African countries therefore need to make careful strategic choices and seize new windows of opportunity, which may result from these multinational corporations' global innovation activities, in order to improve their own technological capabilities.

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