



SCIENCE, TECHNOLOGY AND INNOVATION IN
AFRICA'S REGIONAL INTEGRATION
From Rhetoric to Practice



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Acronyms

ABI	African Biosciences Initiative
ACODE	Advocates Coalition for Development and Environment
ACP	African, Caribbean and Pacific
AfDB	African Development Bank
AIMS	African Institute for Mathematical Sciences
ALC	African Laser Centre
ASARECA	Association for Strengthening Agricultural Research in East and Central Africa
ASIF	African Science and Innovation Fund
ASTII	African Science, Technology and Innovation Indicators Initiative
AU	African Union
AVU	African Virtual University
COMESA	Common Market for Eastern and Southern Africa
CPA	Consolidated Plan of Action
CTA	Technical Centre for Agricultural and Rural Cooperation
CGIAR	Consultative Group on International Agricultural Research
CSIR	Council for Scientific and Industrial Research
CSTD	Commission on Science and Technology for Development
DST	Department of Science and Technology
EAC	East African Community
ECOWAS	Economic Community of West African States
EU	European Union
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
HSRC	Human Sciences Research Council
IAEA	International Atomic Energy Agency
ICEGB	International Centre for Genetic Engineering and Biotechnology

ICIPE	International Centre for Insect Physiology and Ecology
ICRAF	International Centre for Agroforestry
ICTs	Information and Communication Technologies
IDC	Industrial Development Corporation
ILRI	International Livestock Research Institute
KBS	Kenya Bureau of Standards
KEMRI	Kenya Medical Research Institute
KIST	Kigali Institute of Science and Technology
MDGs	Millennium Development Goals
NEPAD	New Partnership for Africa's Development
NGOs	Non Governmental Organisations
NRF	National Research Foundation
OECD	Organization for Economic Co-operation and Development
ORPS	Operational Policies and Compliance Department
PSI	Presidential Special Initiatives
PSTICB	Programme for Science and Technology Innovations and Capacity Building
SADC	Southern African Development Community
SMEs	Small and Medium Enterprises
ST-EAP	Science, Technology - Europe Africa Project
UN	United Nations
UNBS	Uganda National Bureau of Standards
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Program
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
WHO	World Health Organization

Acknowledgements

It is ACODE's strong belief that the structural transformation and development of African countries' economies and societies largely lies in the advancement of their scientific, technological and innovation capabilities. It is in this respect that this study was undertaken to assess the robustness of national innovation systems of selected African countries with a view to provide policy recommendations that can help to advance innovation and technological capacities for national and regional development.

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Executive Summary

Africa is exposed to a wide range of technological opportunities to address its human development challenges. Technologies such as information and communication technologies, biotechnology and nanotechnology can be harnessed and applied to increase food production, fight diseases such as malaria, tuberculosis and HIV/AIDS, and increase economic competitiveness of the continent. However, Africa's ability to tap the opportunities is undermined by relatively weak national innovation systems. Most African countries lack the requisite scientific and technological capabilities to effectively engage in the application of science, technology and innovation for development.

By analysing the concept of national system of innovation with reference to nineteen sub-Saharan countries i.e. Angola, Botswana, DRC, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Rwanda, Seychelles, South Africa, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe, this study provides insights on the state of Science, Technology and Innovation (STI) in Africa and how African countries and Africa's regional bodies are prioritising STI in their national and regional development agendas respectively. The study also provides some understanding of how STI is contributing to the advancement of Africa's regional economic integration agenda and the reverse.

The study shows that national systems of innovation of most African countries are relatively weak. While commendable efforts are being made, more needs to be done to enable these countries in particular, and the Africa continent in general to seize the grand opportunities that exist at the moment. Although there are a number of regional and international institutions with programmes focussing on helping African countries advance in the area of STI, such as the African Union (AU), the New Partnership for Africa's Development (NEPAD), the African Development Bank (AfDB), the World Bank and the United Nations Educational, Scientific and Cultural Organization (UNESCO), these institutions are not well coordinated as to add value to the building of national and regional systems of innovation.

It is also notable that most of the African countries' initiatives and efforts of regional bodies such as the East African Community (EAC), the Southern African Development Community (SADC), AU and NEPAD are largely focused on research and development. There is very little emphasis on issues of technological innovation. Yet technological innovation is key as far as turning scientific and technological knowledge into goods and services that boost economic development is concerned.

To foster STI in Africa, we recommend that African countries must first and foremost develop explicit national innovation policies with clear benchmarks and implementation strategies to address the weaknesses and foster the strength in their national

innovation systems. We also recommend that African countries must increase their spending on STI to at least 3% of their national budgets. Increased investment in science, engineering and entrepreneur skills training to address the challenge of skilled scientific manpower and improvement of R&D and science infrastructure is a must for the African countries to progress in the area of STI. Also recommended, is the idea of establishing funding agencies dedicated to funding both public and private R&D and innovation activities.

At the regional level, we recommend that countries in Africa should invest in capacity building in the area of innovation policy development and should promote regional innovation policy dialogue. African regional bodies such as the EAC should also invest in developing regional innovation strategies and building alliances for funding regional innovation activities. We believe that if the above proposals are given due consideration, African countries in particular and Africa in general can make it to higher heights in fostering STI for national and regional development.

1. INTRODUCTION

Africa today has many grand opportunities for economic transformation and development. First, macroeconomic and political conditions in many African countries are becoming more favourable to economic change and growth. Many African countries have experienced impressive economic growth in the past five years or so.¹ Foreign Direct Investment (FDI) inflows to the continent have increased. Trade between Africa and Asia is growing. Conditions for private capital investment are more favourable today compared to twenty years ago as most economies have been opened up and the investment climate has improved. There are few political and civil conflicts in Africa today compared to the situation in the 1970s and 1980s.²

Second, there is a wide range of new technologies available for increasing the productivity and diversity of African economies. The stock of knowledge and related innovations available to African countries is growing. Technological diversity and convergence make it relatively easy and cheaper to access and apply knowledge to add value to Africa's natural resources. For example, Information and Communication Technologies (ICTs) have converged with biotechnology to create bioinformatics that make it possible to improve biodiversity and mineral prospecting in Africa. The application of biosystematics and bacterial leaching will enable oil producing African countries to export high value oil products. Technology is breaking barriers to capital access and movement. Technological developments associated with mobile telephony make it possible to move or transfer capital to rural areas and across most of Africa in seconds.

Third, Africa has more institutional diversity today compared to twenty years ago. There is a growing private sector with a diverse range of industrial firms—small and large—engaged in various economic activities in many countries. African economies have many private enterprises co-evolving with public ones. Transnational corporations have increased their presence and activities in the continent over the past decade.

Box 1: Grand Opportunities for African Countries' Economic Transformation and Development

- Favourable macroeconomic conditions
- Improved political conditions
- Availability of a wide range of new technologies
- Institutional diversity
- Renewed focus on accelerating regional economic and political integration
- Appreciation on the part of African leaders of the role of STI in economic transformation

¹ See AfDB/OECD (2008), *African Economic Outlook*. African Development Bank and the Organisation for Economic Co-operation and Development. The first section of this study provides an overview of economic growth and investment trends in selected African countries.

² See Economic Intelligence Unit (2008), *Economic Intelligence Unit's Index of Democracy 2008*. The Economist and Economic Intelligence Unit.

Governments are no longer the main or sole agents of economic activities. There is also growth in numbers and diversity of knowledge, financial and technical institutions in the continent. There is a growing determination by many African countries to improve and/or develop their institutions for scientific research and promote technological innovation. This is manifested in the ongoing efforts by countries to review their R&D organizations, formulate new science and technology policies, and in many cases, develop science and technology strategies. Some of these efforts are receiving international support in the form of funding and technical assistance.

Fourth, there is a renewed focus on accelerating regional economic and political integration. African countries are integrating their economies through institutional arrangements such as the Common Market for Eastern and Southern Africa (COMESA), EAC, Economic Community of West African States (ECOWAS) and SADC. Regional economic integration makes it possible for African countries to pool their economic diversity and assets together and build bigger markets as well as trading blocs. It is also an important mechanism for assembling resources for the production of regional public goods. The EAC created the East African Science and Technology Council in 2007. SADC established a desk dedicated to science and technology and is finalizing a protocol to promote cooperation in science and technology. In 2005, ECOWAS designed a framework for common science and technology programmes. COMESA has been implementing programmes to harmonize regulatory measures for biotechnology and ICT development. These are indicative of what countries can do through regional economic integration to foster technological innovation.³

Fifth, many African leaders and the international community are increasingly recognizing that Science, Technology and Innovation (STI) are critical for the transformation of economies, reduction of poverty, attainment of the Millennium Development Goals (MDGs) and integration of the continent into the global knowledge economy. For example, in January 2007, African leaders dedicated their African Union (AU) Summit to discussing ways to promote the development and application of science and technology for development. Through the AU and NEPAD, a high level council of ministers of science and technology was established in 2003, and since then a number of framework programmes have been developed. Development agencies such as the AfDB and international institutions such as the World Bank and UNESCO have designed frameworks to guide their support to Africa's scientific and technological development. These efforts may increase financial resources for research and innovation activities in Africa.

³ See Juma, C., and Serageldin, I., *et al.* (2007), *Freedom to Innovate: Biotechnology in African Development*. Report of the High-level Panel on Biotechnology of the African Union and the New Partnership for Africa's Development; and Mugabe, J. 'Regionalism and science and technology development in Africa' in Louk Box and Rutger Engelhard, eds., (2006), *Science and Technology Policy for Development: Dialogues at the Interface*. Anthem Press, UK for a detailed analysis of how regional integration can be used to promote technological innovation for development.

The important question to ask is – Are African countries prepared to take advantage of these grand opportunities in fostering STI to solve their various development challenges and transform their economies? This study assesses the state of STI in Africa and makes recommendations on what needs to be done to help the continent in general and African countries in particular to advance in the field of STI. The study begins by examining national systems of innovation of different countries to assess the state of STI in Africa. It then examines regional and international initiatives for promoting STI in Africa. The study concludes by making recommendations on what needs to be done to improve the state of STI in African countries in particular, and Africa in general.

2. NATIONAL SYSTEMS OF INNOVATION IN AFRICA

The concept of a national system of innovation has gained currency and is now widely used in academic and policy circles. It is used to study technological performance and innovative capacities of countries. A national system of innovation is a network of institutions that are organized through linkages “to relate to each other as elements of a collective system of knowledge creation and use as well as the technologies they use.”⁴ It promotes interactive activities between and among institutions in order to generate and use new products, processes and organizational practices.

The main institutional actors in the national system of innovation include universities, public R&D institutes, private enterprises, financial institutions such as commercial banks, technology support agencies, policy-making bodies and the government in general. Understanding the linkages among the institutional actors involved in innovation activities or processes is crucial to improving a country's technological and economic performance.

Box 2: Major Institutional Actors in a National System of Innovation

- Universities
- Public R&D institutions
- Private enterprises
- Financial institutions
- Technology support agencies
- Policy making bodies
- Government

Linkages in a national system of innovation usually take different forms, including: joint research projects among public R&D institutions, joint technology development and transfer activities between public and private sector institutions, mobility and exchange of scientists and engineers, technology licensing agreements, and the sharing of information and technology infrastructure. Assessing the performance of a national system of innovation entails tracing the various institutional links and measuring the intensity of the interactions among various knowledge producers and economic actors.

The interactions are supposed to be continuous and characterized by positive feedback. The linkages and interactions among the various institutions in a national system of innovation are purposefully stimulated and nurtured by public policies and various incentives that the government puts in place. Public policies pertaining to intellectual property protection, competition, FDI, taxes, mobility of scientists and engineers, and technology regulation and licensing influence the evolution and growth of a national system of innovation.

The performance of a national system of innovation is also influenced by political, economic and social conditions. Open and democratic political systems are likely to

⁴ OECD (1997), *National Innovation Systems*, Organisation for Economic Co-operation and Development, Paris, p.9.

encourage the search for new information, introduction of new knowledge and promote learning capabilities.⁵ Institutional linkages and interactions, including positive feedback and general exchange of information, tend to flourish in countries where policies and political practices encourage open dialogue and debate.

National systems of innovation are open systems.⁶ They are characterized by in-flow and out-flow of information, skills and technology. The main activity in the national systems of innovation is learning. This involves interactions between people and between institutions. The learning is interactive, characterized by positive feedback. The feedback takes place between economic firms and consumers; between R&D institutions and industry; between R&D institutions and financial bodies; between policy-making bodies and R&D institutions; between policy-making institutions and private firms; and between education and training institutions and industrial firms.

The capacity of countries or economies to innovate is also dependent on existing physical infrastructure and how that infrastructure is used.⁷ Infrastructure defined to include laboratories for scientific research, electricity, telecommunications and internet connectivity is critical for industrial firms to be able to design and develop new products and processes, or even to use existing technologies. The state of infrastructure impacts the institutions' ability to produce and apply knowledge. The World Economic Forum has identified infrastructure as one of the pillars of economic competitiveness of countries.⁸

Box 3: Major Features of National Systems of Innovation in Africa

- Science and technology is narrowly defined to mean R&D.
- There is little emphasis on innovation aspects such as technology prospecting, procurement and diffusion
- No explicit innovation policies
- Few and weak institutional linkages and collaboration
- Weak engineering and entrepreneurship capabilities
- Limited financial resources for technological innovation
- Low levels of technological readiness and innovation capacities
- R&D infrastructure is generally poor and neglected

Thus in assessing national systems of innovation, attention should be paid to the state of infrastructure.

⁵Lundvall, B.-A., et. al. (2002), 'National systems of production, innovation and competence building', *Research Policy* 31(2002) 213-231. Elsevier.

⁶Lundvall, B.A, (1992), 'Introduction', p.2-13 in Lundvall, B.A., ed., (1992), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. Pinter Publishers, London.

⁷Juma, C., and Yee-Cheong, L., (2005), *Innovation: Applying Knowledge in Development*. Earthscan, UK.

⁸See World Economic Forum (2008), *The Global Competitiveness Report 2008-2009*. World Economic Forum, Geneva.

Other important aspects/determinants of innovation systems include: research and innovation priorities; policies for R&D and innovation; quality of scientific research institutions; public and private sector investment in R&D; protection of intellectual property rights; institutional linkages particularly university-industry collaborations; availability and utilization of skills in science, engineering and entrepreneurship fields; existence and use of technology standards and regulatory agencies and the participation of countries in regional and international programmes. The next sub-sections focus on R&D—the knowledge production parts of a national system of innovation. It deals with R&D priority setting, institutions for R&D, funding of R&D and related institutions, and then policy instruments for promoting R&D.

2.1. National Research & Development Priorities and Capacities

There are a number of studies that have reviewed the national R&D systems of the 19 Sub Saharan countries that this study focuses on.⁹ There are also new initiatives to conduct national R&D surveys. For example, NEPAD is supporting most of these countries to conduct surveys. Individual countries have also initiated activities to set their R&D priorities and formulate related science and technology policies. These efforts vary from one country to another. Some countries (for example Botswana, Mozambique, Mauritius and South Africa) have already outlined R&D priorities in their science and technology strategies or plans. Others, such as Ghana and Kenya, have R&D priorities in draft science and technology policy documents. Other countries, such as Swaziland, have recently launched national R&D priority setting and policy formulation exercises.

Many approaches are used by African countries to set their R&D priorities. In many cases, there are no organized national R&D priority setting processes. Priorities of R&D seem to emerge from political statements. For most countries, R&D priorities are often set by or at the level of individual research institutions based on the institutions' anticipation of funding from national governments or international donors. R&D priorities are also set within sectors such as agriculture and health, and at the level of individual departments or ministries. There have been efforts to set R&D priorities in specific technology fields such as biotechnology, nanotechnology and nuclear sciences. In the area of biotechnology, for example, most of the countries have identified needs and set R&D priorities. National biotechnology R&D priority setting exercises have been undertaken in Ghana, Kenya, Namibia, South Africa, Uganda, Tanzania, and Zimbabwe in the past five years or so. The extent to which these exercises have influenced the direction of research and funding decisions remains unclear.

⁹ See for example SARUA (2008), *A Baseline Study on Science and Technology and Higher Education in the SADC*. See also UNESCO (2005), *State of Science and Technology Training Institutions in Africa*, United Nations Educational, Scientific and Cultural Organisation and the African Network of Scientific and Technological Institutions.

The degree of sophistication of R&D priority setting varies from country to country. In some countries, priority setting is done through stakeholders' meetings or consultations. This largely involves getting scientists, NGOs, business representatives and government officials into workshops to identify national R&D priorities. In some cases, background studies may be prepared for the workshops. Stakeholders' meetings or workshops are the most common approach for R&D priority setting in most African countries.

Despite the differences in approach to R&D priority setting, countries have identified a number of common areas for R&D focus. In the area of agriculture, all African countries have for a long time identified crop breeding (with an emphasis on cereals) and livestock disease research. Ghana has placed emphasis on research to improve varieties of cassava in order to increase its capacity for industrial starch production. Ghana, Kenya, Mauritius, Mozambique, Seychelles, South Africa and Tanzania have over many years prioritised research on the conservation and use of marine resources. A growing number of the countries are starting to identify agricultural biotechnology as a priority. These include Botswana, Ghana, Kenya, Uganda, Tanzania, Namibia, Malawi, Mozambique, Mauritius, Rwanda, South Africa and Zimbabwe. Some of these countries have even identified specific crops and/or traits upon which biotechnology R&D should focus. For example, Mauritius has identified sugarcane, while Zimbabwe has identified tobacco and cereals.

2.2. Public Expenditure on Research & Development

Statistics or data on public expenditure on R&D in most African countries is scanty. Majority of these countries do not have institutions and/or programmes that undertake R&D surveys and collect data on R&D expenditure. National statistics offices do not seem to have a focus on surveying or collecting statistics on expenditure on R&D. Of all African countries, South Africa has the most advanced institutional and programmatic activities on R&D surveys. Its Centre for Science, Technology and Innovation Indicators of the Human Sciences Research Council (HSRC) is specifically funded by the Department of Science and Technology (DST) to undertake R&D and innovation surveys on a regular basis.

There are various attempts at collecting statistics on R&D expenditure in the other countries. The UNESCO Institute for Statistics conducts R&D surveys in some of the countries which this study focuses on. NEPAD is supporting Angola, Ghana, Kenya, Lesotho, Malawi, Mozambique, Uganda, Tanzania and Zambia to undertake R&D surveys, with an emphasis on collecting data on expenditure on R&D. Studies such as SARUA (2008)¹⁰ have generated estimates of public expenditure on R&D for some of the SADC countries. These estimates show that none of the countries under study expends 1 percent of its GDP on R&D. According UNESCO (2007)¹¹, R&D intensity in Sub-Saharan Africa

¹⁰ Ibid

¹¹ UNESCO (2007), Ghana's Science and Technology Profile.

(excluding South Africa) is less than 0.3 percent. Table 1 below provides an overview of public R&D expenditure in the 19 Sub-Saharan African countries. It is based on different sources and different years.

Table 1: Public Expenditure on R&D as a Percentage of National GDP

Angola	N/a
Botswana	0.4% (2005)
DRC	0.5% (2005)
Ghana	0.3% (2007)
Kenya	N/a
Lesotho	0.1% (2004)
Madagascar	0.2% (2005)
Malawi	N/a
Mauritius	0.5% (2005)
Mozambique	0.2% (2002)
Namibia	N/a
Rwanda	N/a
Seychelles	0.4% (2005)
South Africa	0.9% (2005)
Swaziland	N/a
Tanzania	0.35% (2005)
Uganda	0.2% (2005)
Zambia	0.0% (2005)
Zimbabwe	N/a

Sources: SARUA (2008), UNESCO (2007) Ghana's Science and Technology Profile; and UNESCO Institute for Statistics <http://stats.uis.unesco.org>

In comparison to the rest of the world, in 2000, Africa as a whole accounted for less than 1 percent of the world's expenditure on R&D. Asia accounted for 30.5 percent, North America 37.2 percent, Europe 27.2 percent and Latin America and the Caribbean for 2.9 percent of the total world expenditure on R&D.¹² It is important to note that for most African countries, data on public expenditure on R&D is too aggregated to tell us how resources are allocated across R&D areas or much about the relevance, quality and effectiveness of the research projects and activities that get funded. What is clear though is that the limited expenditure on R&D is to a great extent spent on small research projects and staff salaries in the institutions. In many countries, a very small portion of

¹² UNESCO (2004), A Decade of Investment in Research and Development (R&D): 1990 and 2000. *UIS Bulletin on Science and Technology Statistics Issue, No. 1, April 2004.*

the R&D expenditure is directed towards building or improving infrastructure, such as equipping laboratories and buying international journals for libraries.

2.3. Institutional Arrangements for Public Research & Development

Most African countries have created institutions for R&D. Universities and other institutions of higher learning also conduct R&D in addition to their core business of education and training. A baseline study of science and technology conducted for SARUA in 2008 provides a good profile of R&D institutions in 14 SADC countries.¹³ UNESCO has also commissioned and undertaken surveys that provide profiles of R&D or related institutions in Africa.¹⁴ These studies or profiles are mainly regional in coverage and do not discuss specific institutions in the different countries. There have been a number of more detailed specific reviews of some countries' STI systems.¹⁵ These reviews show that African countries have various institutional arrangements for STI in general and R&D in particular.

Some countries have concentrated their R&D activities in universities. Examples of such countries are Angola, Botswana, Lesotho, Mauritius, Mozambique, Namibia, and Swaziland. Some countries have sectoral R&D activities concentrated in public research institutes. For example, in Kenya, R&D in the area of health is largely concentrated in the Kenya Medical Research Institute (KEMRI). Other countries (for example South Africa) have R&D efforts spread across universities, public R&D institutions and the private sector. In Ghana, most of the R&D activities are concentrated in the Council for Scientific and Industrial Research (CSIR) and a few other research institutes.

Ghana, Kenya and South Africa have the highest concentration of relatively large public R&D institutions and universities. Ghana has seven public universities three of which specifically focus on scientific R&D. In addition, Ghana has more than 15 research institutes. Kenya has seven public universities (most of them with faculties of science and some related R&D activities) and at least seven public R&D institutes. It hosts headquarters and laboratories of the International Centre for Agroforestry (ICRAF), the International Livestock Research Institute (ILRI) and the International Centre for Insect Physiology and Ecology (ICIPE) as well as several regional research programmes.

South Africa has the highest concentration of R&D institutions and R&D-performing universities in Sub-Saharan Africa. It has seven large science councils with numerous research institutes and 18 public universities of which five are dedicated to scientific

¹³ SARUA (2008), *supra* note 9.

¹⁴ In particular, see UNESCO (2005), *supra* note 9 and UNESCO (2008), Regional Report on Sub-Saharan Africa: A Study of National Research Systems by Johann Mouton.

¹⁵ See for example UNCTAD (2008) 'Science, Technology and Innovation Policy (STIP) Review of Angola'; Mugabe, J., (2008), 'A Review of Ghana's Science, Technology and Innovation System'; and CSIR (2005), 'Botswana National Research, Science and Technology Plan'. Prepared for the Ministry of Communications, Science and Technology, Botswana.

research and technology. The country also has specialized national laboratories or facilities that are managed by the National Research Foundation (NRF). It hosts the African-component of the International Centre for Genetic Engineering and Biotechnology (ICEGB), the African Institute for Mathematical Sciences (AIMS) and the Southern Africa Biosciences (SANBio) Hub of NEPAD.

The Global Competitiveness Report 2007¹⁶ ranked 128 countries based on the quality of their scientific institutions. The ranking is based on an executive opinion survey undertaken in 2006. The scoring is 1 to 7; with 1 where there are no scientific institutions and 7 for countries with institutions that are the best in their fields internationally. Generally, Sub-Saharan African countries scored and ranked very low. Of the African countries that this study focuses on, 14 were covered by the opinion survey. South Africa and Kenya are first and second respectively in terms of the quality of their scientific research institutions. Table 2 provides a compilation of the scoring and ranking of 14 African countries based on the quality of their scientific research institutions.

Table 2: Global Competitiveness Executive Opinion Survey of the Quality of Scientific Research Institutions

Country	Score/7	Rank/128	Rank in this group of African countries
Angola	2.5	122	14
Botswana	3.6	75	7
Kenya	4.5	31	2
Lesotho	2.8	115	13
Madagascar	3.2	94	9
Malawi	3.5	81	8
Mauritius	3.6	71	6
Mozambique	3.2	97	10
Namibia	3.0	105	12
South Africa	4.8	25	1
Tanzania	4.2	40	3
Uganda	4.3	34	4
Zambia	3.0	104	11
Zimbabwe	3.8	59	5

Sources: World Economic Forum (2007), *The Global Competitiveness Report 2006-2007*

¹⁶ World Economic Forum (2007), *The Global Competitiveness Report 2006-2007*

The state of R&D infrastructure in African institutions of science and technology training, mainly universities, was reviewed in a UNESCO 2005 report.¹⁷ The report's main findings include the following: only a few universities in Africa are in a position to boast of quality scientific journals in their libraries; few university staff have access to computers in their offices (even in computer science departments); many of the libraries in African universities do not have computers and are not computerized; and in old universities the age of equipment is about a quarter of a century old. The report establishes that engineering schools or university institutes are the ones most lacking in equipment compared to those for basic sciences. Its overall conclusion is: "the reported average age of laboratory equipment is too high (11.6 years for basic sciences and 15.8 years for engineering sciences). Significant changes in laboratory technology have occurred in the last 10 years. Hence African institutions are clearly lagging behind their counterparts in other continents in the areas of experimental science."¹⁸

2.4. Policy Instruments for Research & Development

African countries have different policy instruments for promoting scientific research. A growing number of countries use explicit policies written in science and technology specific policy and legal documents or frameworks to govern R&D activities. These tend to be articulated in legislation e.g. Kenya has a Science and Technology Act of 1977 (amended in 1980), plans and strategies, such as Botswana's National Research, Science and Technology Plan of 2005 and Mozambique's 2005 Science, Technology and Innovation Strategy and in white papers, such as South Africa's Science and Technology White Paper of 1996.

Some countries have multiple policy framework documents. For example, in addition to the 2005 National Research, Science and Technology Plan, Botswana has the Science and Technology Policy of 1998. Uganda has recently adopted a new National Science, Technology and Innovation policy in addition to other sectoral specific policies. South Africa has the National Research and Development Strategy of 2002, and the Ten-Year Innovation Plan of 2007 in addition to the white paper. Angola, Democratic Republic of Congo, Madagascar, Mauritius, Seychelles and Swaziland do not have science and technology specific policy frameworks but have explicit policies scattered in sectoral policy documents such as national plans for agriculture, national health policy, energy plans and strategies, ICT plans, etc.

Trade and industrial policy documents, annual national budget statements, investment policies and legislation, and intellectual property protection legislation also tend to contain explicit policies for R&D in most of the countries. All African countries' agricultural plans include policies for promoting R&D. Countries such as Botswana,

¹⁷ UNESCO (2005), supra note 9.

¹⁸ Ibid, p.54.

Ghana, Kenya, Mozambique, Namibia, Mauritius, Seychelles and South Africa have measures for promoting R&D in their ICT plans.

There are similarities among the science and technology specific policy frameworks of the different African countries. All of them put emphasis on strengthening national public R&D institutions by improving infrastructure, improving coordination of institutions, building and/or strengthening collaborations between public R&D institutions with private companies, increasing investments in R&D, promoting science and technology education and raising public awareness, and increasing and retaining numbers of scientists and engineers. Some of the policy and legal frameworks (such as Kenya's Science and Technology Act as amended in 1980 and Tanzania's Science and Technology Act of 1986) create institutions for coordinating science and technology and committees to provide leadership in specific fields of R&D.

African countries can also rely on a wide range of implicit policies to promote R&D and science and technology in general. These include tax regulations, customs and excise duties, immigration laws, fiscal policies, foreign affairs policies, industrial policies, health regulations, environmental impact regulations, and import and export regulations. There is no systematic review or assessment of how well African countries use implicit policies to promote R&D. A case-based review of the use of implicit policies may be useful to inform efforts aimed at integrating science and technology considerations into national economic policy frameworks. It may also be helpful in informing the reform or development of science and technology policies and legal frameworks.

Some of the countries have begun national processes to develop explicit science, technology and innovation policy frameworks. Angola's government has been working with UNCTAD to review its implicit policies and institutional landscape in order to identify gaps. In 2006, Swaziland was supported by UNESCO to hold national stakeholders' consultations to identify R&D priorities and establish a science and technology policy-making process. Ghana (since 2004) and Kenya (since 1998) have been investing in various studies and events to review and reform their STI policies.

2.5. Technological Readiness and Innovation Capacity

Several indices have been developed to measure and provide some assessment of countries' technological status and performance. These include the Technology Achievement Index (TAI) used in the United Nations Development Program (UNDP)'s Human Development Report 2001, the Industrial-Cum-Technological Advance Index (ITA) used by UNIDO's Industrial Development Report 2005, and Technological Readiness (TR) used by the World Economic Forum in the Global Competitiveness reports 2006-2007 and 2008-2009. TAI focuses on a country's innovative capacity. It is used to measure a country's ability to create new products and processes through R&D, and use new and old technologies to

increase economic productivity.¹⁹

According to the Human Development Report 2001 TAI ranking, the Organization for Economic Cooperation and Development (OECD) countries and a few developing countries are the main source of new technologies. OECD countries accounted for 86 percent of patent applications in 1998 and 85 percent of scientific and technical journal articles published worldwide.²⁰ African countries are not significant sources of technological innovations. They are not really engaged in the creation of technology. South Africa is the innovation hub in Africa. The UNDP Human Development Report 2001 ranked South Africa 39 out of 72 countries. It is one of the dynamic adopters of technology. Other countries are technologically marginalized. Zimbabwe was ranked 59, Ghana 67, Kenya 68, Mozambique 72, and the rest of the African countries are in the category of "others."²¹

TR "measures the ability with which an economy adopts existing technologies to enhance the productivity of its industries."²² It is an assessment of a country's preparedness to procure, absorb and use technology. Technological readiness is determined based on factors such as firm-level technology absorption, laws relating to information and communication technologies, FDI and technology transfer, personal computers per 100 inhabitants, and internet users and mobile phone subscribers. It is separate from innovation capacity, which is about the ability of a country to expand the frontiers of knowledge and create new technology.

Technological innovation is important for countries with diminishing possibilities of adopting and using existing technologies. In these circumstances, firms cannot increase their productivity by relying on or using existing technologies or by merely undertaking incremental innovations. They must push the frontiers of knowledge and create cutting-edge products and processes in order to be competitive. The Global Competitiveness Report 2008-2009 ranked the countries' competitiveness based on TR and innovative capacities. Most Sub-Saharan African countries are ranked very low. They have low levels of TR and innovative capacities. South Africa and Kenya are ranked 36 and 50 respectively out of 134 countries based on innovative capacity factors. In terms of TR, Kenya is ranked 93 and South Africa is ranked 49.

African countries are exposed to a wide range of technologies. These are embedded in foreign products. The share of imported high technology products in Sub-Saharan Africa has risen in the past decade or so. Between 2000 and 2004, high technology imports accounted for 4.5 percent of Sub-Saharan Africa's GDP having risen from 3.2 percent for

¹⁹ UNDP (2001), *Human Development Report 2001: Making New Technologies Work for Human Development*. United Nations Development Programme, New York.

²⁰ Ibid.

²¹ Ibid.

²² World Economic Forum (2008), *Global Competitiveness Report 2008-2009*, The World Economic Forum, Geneva, p.5.

the period 1994-1996. "Mauritius and South Africa import the most high-tech goods relative to the size of their economies, between 6 and 8 percent of GDP in any given year, while Somalia imports the least i.e. less than 1 percent of GDP"²³ However, most of the countries are not technologically ready to adopt, adapt and successfully apply the technologies in their economies. The explanations for this include low levels of education, lack of policies that deliberately promote technology diffusion and adaptation, and poor infrastructure.

2.6. Technology Support and Regulatory Agencies

Standards, quality and metrology institutions are an important part of national systems of innovation. They are an aspect of technological infrastructure. These institutions support R&D and technological innovation. Some of the 19 Sub-Saharan African countries which this study focuses on have such institutions. Examples include Instituto Angolano Di Normailizacaoe Qualidade of Angola, Botswana Bureau of Standards, the Ghana Standards Board, the Kenya Bureau of Standards (KBS), Malawi Bureau of Standards, Mauritius Standards Bureau, National Institute for Standardization and Quality of Mozambique, Rwanda Bureau of Standards, Standards Authority of South Africa, National Metrology Institute of South Africa, Seychelles Bureau of Standards, Uganda National Bureau of Standards (UNBS), Tanzania Bureau of Standards, and Zambia Bureau of Standards. These institutions are supposed to have laboratories for metrology and technical standards assessments.

The quality of these institutions' infrastructure varies from one country to another. The Ghana Standards Board has relatively good laboratories for food standards testing. They have been accredited or certified by the European Union (EU), so that now Ghana can export fish to Europe. Two laboratories of the Kenya Bureau of Standards have been accredited by German calibration services. However, in some of the countries the standards and metrology institutions are weak. For example, UNBS is under-funded and lacks appropriate modern physical facilities.²⁴ Generally, most metrology, quality and standards institutions in Africa are under-resourced. Many of them rely on revenue from sale of services such as calibration and metrology. In most of the African countries, STI policies do not treat these institutions as important actors in R&D and innovation activities.

In addition to the technology support institutions, the countries under study have regulatory agencies that deal with FDI, technology procurement and licensing, environmental impact assessment, registration of new companies, biosafety,

²³ World Bank (2008), *Global Economic Prospects 2008: Technology Diffusion in the Developing World*, p. 112.

²⁴ UNCTAD (2003), *Africa's Technology Gap*. United Nations Conference on Trade and Development, Geneva.

clinical trials, registration of drugs and medicines and export processing zones, among many other aspects of economic activity. Regulatory agencies are an important part of national systems of innovation as many of them determine the types of technology a country gets exposed to. They can promote or hinder the procurement and diffusion of new technologies. For example, agencies for biosafety are critical in determining whether a country invests in modern biotechnology, and particularly whether it adopts products that may not be widely accepted as safe. There is need to carefully examine the role of regulatory agencies in building national systems of innovation in Africa. In many African countries, these agencies' mandates should be redefined to explicitly include promotion of technological innovation.

2.7. Institutional Arrangements for Financing Technological Innovation

Financial capital is critical in the promotion of technological innovation. It is important in the development of firms, particularly start-ups, which are the locus of innovation. Research and training institutions also require financial resources to be able to test their ideas, work with firms to commercialize research results, and generally turn their ideas into products and services. It can be argued that the lack of financial capital is one of the main barriers to technological innovation in Africa in general and in African countries in particular. Most African countries rely on a narrow range of institutional arrangements to finance innovation activities. They do not have institutions dedicated to funding commercialization of research findings, technology prospecting and diffusion, or even funding activities aimed at testing technologies.

Funding instruments such as venture capital are either underdeveloped or nonexistent in many of the countries. In most of the African countries, venture capital, tax relief and other instruments are not available to universities, Small and Medium Enterprises (SMEs) or R&D institutions. Private equity industry, commercial and development banks, microfinance institutions, private foundations, and even many bilateral and multilateral donors have not given attention to providing financial resources for technological innovation. Africa has few start-up firms in fields such as biotechnology and energy technology development. Early stage investment in such areas is often unattractive to banks, microfinance institutions and private foundations because it frequently involves higher risks: young companies often start off with business models that have not been proven and possess fewer tangible assets, and companies in such fields as biotechnology and life sciences generally take longer to develop.

Many African governments are increasingly recognizing that without the development of firms or companies that engage in innovation and without financial capital for commercializing new ideas from R&D institutions, their current meagre investments

in R&D will not contribute to technological development and economic growth. This recognition is articulated in some of the recent science and technology policies of countries such as Botswana, Ghana, Rwanda, Kenya, Mozambique, and South Africa. There is recognition of the need to develop a diverse range of financial instruments and funding institutions for innovation. In the past five years or so, some of the countries have established new public institutions for funding technological innovation. These include Botswana which established the Botswana Research, Science and Technology Investment Agency in 2006/7, South Africa which established the Innovation Fund and THRIP, which is administered by the NRF, Uganda which established the National Innovation Fund and Zimbabwe which established the Innovation Commercialization Fund.

Some countries have proposed or are creating such institutions. South Africa is currently creating another agency—the Technology Innovation Agency—which will have sole responsibility for funding and promoting technological innovation. Ghana and Kenya have launched efforts to establish new institutions for funding innovation. Both countries are establishing endowment funds for scientific research and technological innovation. The challenge for these countries is to ensure that adequate financial resources are available from national budgets or treasuries to build and sustain the endowment funds or agencies and to make sure that resources are allocated to innovation activities rather than locking or devoting most resources to scientific research. Countries will need to make good choices in order to balance funding allocations for scientific research versus investing in technological innovation activities such as promoting the creation of innovative firms or companies.

In addition to the current efforts of many African governments, some development banks are starting to focus more on supporting innovation creation and diffusion through companies. For example in Ghana, the Presidential Special Initiatives (PSI) was established five years ago to enable the Ministry of Trade, Industry, Private Sector Development and Presidential Special Initiatives to promote the emergence and growth of companies that work to add value to the country's cassava, cocoa and other natural resources. Specifically, the government is funding a number of companies to produce and export industrial starch from cassava. In South Africa, the Industrial Development Corporation (IDC) is engaged in funding start-up companies some of them linked to universities and the research councils.

In sum, national systems of innovation in Africa vary from country to country. Each system has its peculiarities that are largely based on national macroeconomic conditions, political histories and culture, resource endowments, stage of economic and technological development, and social systems and capabilities. Generally, African countries can be grouped into three categories based on the content, dynamism and capacities of their national systems of innovation. The first group is that of leading countries with well

established and relatively high quality research institutions, high level of technological readiness, explicit innovation policies, and agencies for funding innovation. The private sector is involved in funding R&D and collaborations between universities and industry are nurtured. South Africa is the only country in this group.

The second group is that of potential leaders. In this category are countries with low levels of technological readiness, research institutions that are weak but are being strengthened, science and technology policy regimes exist, there are processes to formulate explicit innovation policies, agencies for funding R&D have been or are being established, the private sector is weak and is not funding R&D and there are weak links between universities and industry. In this category are Botswana, Ghana, Kenya, Malawi, Mauritius, Madagascar, Rwanda, Seychelles, Uganda, Tanzania and Zambia. The level of technological readiness and innovation capacities of these countries are below that of middle-income economies.

The third group is that of countries with very poor research institutions. They have no STI policy regimes. STI institutions are few and weak, university-industry collaborations are non-existent, funding for R&D is too little, and the private sector is small and not participating in R&D. Countries in this group include Angola and Swaziland.

3. REGIONAL AND INTERNATIONAL INITIATIVES

3.1 Science, Technology and Innovation in Regional Economic Treaties

The past decade has witnessed renewed focus on the economic and political integration of Africa. African leaders and the international community have put more emphasis on building and strengthening regional economic communities and trading blocs in Africa. As a result, African countries have adopted a large number of regional cooperation and integration schemes. There are now more than 20 regional agreements concerning cooperation and economic integration at sub-regional and continental levels in Africa. They range from those that are aimed at promoting limited cooperation among neighbouring countries in specific areas of political and economic development, to the creation of a continental African Common Market. A common feature of these agreements is their explicit recognition of the role of STI in regional economic integration and development. Some of the agreements recognize that regional integration is being driven by advances in transport, ICTs, as well as in policy and politics. This is evident in the increasing trans-boundary movement of information, skills, finance and products across regions. There is also increasing intra-regional FDI flows in Africa, particularly in SADC and EAC regions.

African countries are now putting more emphasis on the need for bilateral and multilateral science and technology cooperation. Provisions for promoting science and technology cooperation are increasingly being written into bilateral and regional economic and trade agreements. At the continental level, measures for promoting science and technology cooperation can be found in the 2000 Constitutive Act of the AU. Article 13(i) of the Constitutive Act provides inter alia that the Executive Council of the AU shall coordinate and make decisions on policies in the areas of science and technology that are of common interest to the member states. Article 14(d) establishes a specialized committee (i.e. Committee on Industry, Science and Technology, Energy, Natural Resources and Environment) to deal with issues of science and technology among others. The Committee's functions include preparing AU projects and programmes dedicated to STI.

At the regional level, the Declaration and Treaty establishing SADC has provisions for promoting cooperation in the field of science and technology. Article 21(d) makes explicit reference to SADC member countries cooperating in science and technology as one of the major areas necessary for fostering regional development and integration. SADC's Protocol on Education and Training, ratified by at least eight countries, aims at promoting the development of a common science and technology policy, establishing joint research facilities and regional centres of excellence, and facilitating the movement of scientists in SADC countries. The EAC Treaty also contains several provisions on science and technology. Articles 5, 80 and 103 are explicit on the role of cooperation in

fostering the sub-region's scientific and technological development. In particular, Article 80(e) provides that the EAC shall "promote industrial research and development and the transfer, acquisition, adaptation and development of modern technology, training, management and consultancy services through the establishment of joint industrial institutions and other infrastructural facilities." In Article 103, member states commit themselves to "promote cooperation in the development of science and technology within the Community through: (a) the joint establishment and support of scientific and technological research and of institutions in the various disciplines of science and technology; (b) the creation of a conducive environment for the promotion of science and technology within the Community...and (i) the harmonisation of policies on commercialisation of technologies and promotion and protection of intellectual property rights." The Treaty establishing ECOWAS also has provisions on promoting cooperation in the area of STI. Article 3 of this Treaty outlines "harmonization and co-ordination of national policies and the promotion of integration programmes, projects and activities, particularly in food, agriculture and natural resources, ...science, technology..."

Similar provisions are found in the treaty creating the Common Market for Eastern and Southern African (COMESA). Article 100(d) calls on member countries to cooperate to promote "industrial research and development, the transfer, adaptation and development of technology, training, management and consultancy services through the establishment of joint industrial support institutions and other infrastructural facilities." The treaty also aims at promoting cooperation in the creation of an enabling environment for foreign, cross-border and domestic investment, including the joint promotion of research and adaptation of science, technology and innovation for development.

In summary, African regional economic and trade treaties recognize the importance of STI in promoting regional integration and development. The integration of these considerations into regional agreements is informed by the understanding that individual African countries' economies are small and unable to marshal scientific and technological resources for development. Many countries are poorly endowed with the human, physical and financial resources necessary to develop and harness knowledge and innovation for economic change and growth. Cooperation in STI is thus necessary to enable the countries to pool and share their scarce resources such as R&D infrastructure and skilled human resources.

With such cooperation, groups of countries are able to exploit economies of scale to undertake R&D and invest in technological innovation. Regional cooperation in STI is also important for collective technological learning and peer influence among the countries. Countries with weak and underdeveloped systems of innovation are able to learn from those that have better developed systems. They can share information and experiences on what works better in terms of designing and implementing STI policies; how to better organize their R&D institutions; and other aspects of governing STI.

3.2. Regional and International Institutions and Initiatives

To actualize or turn provisions of the regional treaties into concrete actions, countries must develop and implement programmatic activities. To do this, they require dedicated capable institutions. There must also be commitment and active engagement by the countries' political leaders, scientists, private sector, and the general public if STI cooperation is to work. Commitment and provision of adequate financial resources on a predictable basis is also crucial for the success of any regional STI cooperation initiative.

3.2.1. Initiatives of the East African Community

EAC countries have increased their cooperation in STI in the past decade. Since the mid-1990s, government officials, scientists and political leaders have held a series of workshops and conferences to promote cooperation in R&D and technological innovation. One of the main outputs of these meetings is the EAC Science, Technology and Innovation Protocol that was adopted in 2007. The Protocol is a framework for promoting cooperation in STI. It covers a wide range of objectives and measures including promoting the development, transfer and application of science and technology in member states, encouraging and facilitating the pooling of resources for R&D, promoting common R&D and innovation surveys, harmonizing policies and regulations for biotechnology and ICTs, and encouraging mobility of scientists and engineers in the region.

3.2.2. Efforts of the African Union and NEPAD

Under the auspices of the AU and NEPAD, in 2005, African countries designed and adopted Africa's Science and Technology Consolidated Plan of Action (now commonly referred to as the CPA). The CPA contains programmes for research in the areas of biotechnology, biodiversity and indigenous knowledge, water, energy, ICTs, drought and desertification, mathematical sciences, manufacturing, material sciences, laser and post-harvesting technologies, and space science. It also has programmes for improving the quality of STI policies and the establishment of science and innovation parks. The CPA was endorsed by African Heads of State and Government at the AU Summit in January 2006. Since then, the AU Commission and NEPAD Office of Science and Technology have used various means and processes to promote its implementation. NEPAD has established a number of networks of centres to implement specific research projects. These include the African Biosciences Initiative (ABI), AIMS, the African Laser Centre (ALC) and the African Science, Technology and Innovation Indicators Initiative (ASTII).

ABI is a network of centres dedicated to scientific research in biosciences in order to increase agricultural production, develop treatment for opportunistic infections associated with HIV/AIDS and conserve biological diversity. The initiative is largely focused on improving infrastructure for scientific research by upgrading laboratories at ILRI as the hub for

Eastern and Central Africa and making facilities easily available to African scientists. Some resources are also devoted to biotechnology and biosafety capacity building in the form of student fellowships and short courses. The hub for Southern Africa is at CSIR where research focuses on the use of traditional knowledge to develop treatment for HIV/AIDS opportunistic infections. The network hub for West Africa is at the Senegalese Agricultural Research Institute in Dakar focusing on crop biotechnology while that for North Africa is at the National Agricultural Research Council of Egypt. The main donors/funders of ABI are the governments of Canada and Finland and the Bill and Melinda Gates Foundation.

ALC is a collaboration involving 19 national laser centres and institutes, mainly in universities, from across the continent. It was established to enable African countries to exploit light to advance science and technology in medicine. The network is also engaged in promoting the application of laser technologies to develop medical equipments. ALC has developed research activities on nanotechnology as well. AIMS is dedicated to building capacity through postgraduate courses in mathematics. It aims at generating skills in areas such as biomathematics, bioinformatics and theoretical physics, which are crucial for pharmaceutical, ICT, electronics and other industries. AIMS produces about 100 graduates every year.

The policy initiative of NEPAD supports African countries to conduct R&D and innovation surveys with the aim of building information on the status and trends in public and private sector expenditure on R&D, number of scientists per million inhabitants, research productivity, and firm level innovation activities. It is anticipated that African policy-makers will use this information to make better investment decisions and improve the quality of their countries' STI policies. Other efforts of the AU and NEPAD are focused on building political constituencies for science and technology through conferences and summits of African Ministers and Presidents. Four ministerial conferences have been held since 2003 and one Presidential summit in 2007 to get high-level decisions made to promote STI for development. One of the key decisions made by the AU Summit in 2007 is that every African country should design and adopt a national innovation strategy. Many African countries are working to meet this commitment. South Africa and Mozambique have already adopted innovation strategies.

3.2.3. The African Development Bank's Strategic Focus

AfDB is one of the main sources of financial capital for African development. In 2007, AfDB adopted a strategic plan for investing in higher education, science and technology.²⁵ The strategy focuses on three aspects of institutional capacity building. These are (a) strengthening national and regional centres of excellence in science and technology; (b) building and/or rehabilitating science and technology infrastructure in tertiary and higher

²⁵AfDB (2007), *Strategy for Higher Education, Science and Technology*. Operational Policies and Compliance Department and Human Development Department, African Development Bank.

education institutions; and (c) linking higher education and science institutions to private sector. It also aims at assisting African countries to retain scientists and engineers in order to stem the brain drain, and promote cross-border exchange of expertise. Its approach is similar to AU and NEPAD in terms of promoting networks of centres of excellence as opposed to stand-alone institutions. It also puts emphasis on strengthening existing institutions instead of creating new ones.

The AfDB intends to work with regional centres of excellence and national governments to identify and develop projects or programmes to be funded through loans or non-loan arrangements. It has established the Division of Tertiary Education, Science and Technical, and Vocational Training to coordinate and provide technical leadership for the implementation of the strategy. AfDB is already working with a number of African countries to design projects based on its strategy. For example, in 2008, it approved funding for Rwanda to develop the Kigali Institute of Science and Technology (KIST) into a centre of excellence in science and technology. The funding will be used to upgrade infrastructure, establish a school of environmental sciences, and promote women's access to ICT.

The AfDB also invests in agricultural research programmes implemented by institutions such as the Consultative Group on International Agricultural Research (CGIAR). It has a large portfolio of projects for infrastructure development, including energy, roads and water. The Bank has provided a grant to the African Virtual University (AVU) to build capacity in ICT training and long distance education. It is also working with the AU Commission and NEPAD to explore the feasibility of creating an African Science and Innovation Fund (ASIF) as a continental mechanism for funding R&D and innovation activities on the continent.

3.2.4. European Union-Africa Science and Technology Cooperation

The EU has provided funding for R&D in many African countries. It is one of the largest donors to agricultural research undertaken by institutions such as the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA), the CGIAR and national agricultural research institutes. The EU also supports the Technical Centre for Agricultural and Rural Cooperation (CTA), which is an initiative of the African, Caribbean and Pacific (ACP) countries and the EU. The EU, through the EuropeAid Cooperation Office, established the Programme for Science and Technology Innovations and Capacity Building (PSTICB) to support ACP countries in building their capacities to assess R&D needs and formulate or reform STI policies, and review and strengthen intellectual property protection legislation. The programme also aims at supporting ACP countries to establish and/or strengthen research networks, build centres of excellence in R&D and promote exchange of expertise within ACP countries and between EU and the ACP countries.

Another initiative of the EU is the Science and Technology-Europe Africa Project (ST-EAP) which was developed under the 6th Framework Programme to increase science and technology cooperation between Africa and Europe. The project is administered by CSIR of South Africa and the African Academy of Sciences. It aims at strengthening the capacity of African researchers to participate in Framework Programmes (FPs) of the EU by disseminating information to them and organizing workshops on proposal writing.

In December 2007, the Council of the EU adopted "The Africa-EU Strategic Partnership: A Joint Africa-EU Strategy" that identifies STI as a priority in EU-Africa cooperation. Paragraph 84 of the joint strategy states: "Africa and the EU will strengthen their cooperation in building knowledge-based societies and economies. Both sides recognise that the development of STI is one of the essential engines of socio-economic growth and sustainable development in Africa; that competitiveness in the global economy is increasingly dependent on knowledge and innovative ways of applying modern technology, especially ICT; and that meeting the MDGs requires a special global effort to build scientific and technological capacities in Africa. Thus, partnerships and investments advancing access to ICT infrastructure, access to quality education, and the development of STI systems in Africa are crucial for attaining all other development goals."²⁶

The EU's future investments in STI in Africa will focus on promoting the establishment and strengthening of centres and networks of excellence in ICT, laser manufacturing and satellite communications. Other priority areas are technical and vocational training, research on clinical effectiveness of traditional medicine, development of vaccines and new medicines for both major and neglected diseases, promoting technologies for adaptation to and mitigation of climate change, and cooperation in the field of space science and technology.²⁷

3.2.5. International Initiatives

At the International level, the United Nations (UN) has a number of initiatives aimed at promoting STI in Africa. UN agencies and programmes have many STI activities in Africa. A detailed mapping of science and technology activities in Africa was done in 2005.²⁸ It shows that there are thousands of different activities of the UN that pertain to or promote STI globally. Many UN agencies have activities in the African countries that this study focuses on. The activities range from agricultural research to promotion of space technologies. The main activities can be grouped as: (a) spreading or promoting the diffusion of existing agricultural, health and energy technologies; (b) provision of policy information and statistics on science, technology and innovation to decision-makers; (c)

²⁶ Council of the European Union (2007), *The Africa-EU Strategic Partnership: A Joint Africa-EU Strategy*. Lisbon, 9 December 2007.

²⁷ Ibid.

²⁸ UK National Commission for UNESCO (2005), *Mapping of Science and Technology Activities in Sub-Saharan Africa*.

strengthening national quality standards and metrology institutions;

(d) support to countries to strengthen intellectual property protection legislation and offices; (e) environmental technology assessments and generation of scientific information on climate change, trends in biological diversity, land degradation and depletion of the ozone layer; and (f) strengthening educational and training institutions.

UNESCO is one of the main UN agencies with an explicit mandate for the promotion of science and technology for development. UNESCO is the UN's focal point for science and technology activities in Africa. It has a regional office dedicated to the development, implementation and promotion of science and technology activities in Africa. It has programmes for education and science and technology in Africa. It has supported many African countries to develop science and technology policies and establish related institutions. Its Institute for Statistics is a source of information and data on the status of and trends in science and technology both in Africa and globally. UNESCO is currently supporting Ghana, Swaziland and Tanzania to develop STI policies.

The other major UN agency promoting STI in Africa is the United Nations Conference on Trade and Development (UNCTAD). UNCTAD is the secretariat of the Commission on Science and Technology for Development (CSTD). It has supported Angola and Ghana to conduct STI policy reviews. UNCTAD also conducts investment policy reviews that are a source of information on FDI and innovation activities in many African countries. In the past decade or so, it has concluded such reviews for Botswana, Ghana, Kenya, Mauritius, Tanzania and Zambia. Other UN institutions that have activities that promote STI in Africa are the Food and Agriculture Organization (FAO), International Atomic Energy Agency (IAEA), UNIDO, the World Health Organization (WHO), the United Nations Environment Programme (UNEP) and UNDP.

From the foregoing discussion and analysis, it is clear that there are many initiatives aimed at promoting STI in Africa in general and in African countries in particular. African countries are intensifying cooperation in STI through the EAC, AU, NEPAD and SADC as well as other regional economic communities. Three important things are worth noting about these initiatives. First, most of these initiatives are largely reliant on external funding from development partners. This raises the important question of sustainability. Second, most emphasis in many of these initiatives is on R&D. There is very little emphasis on issues of technological innovation. Finally, the initiatives are not well coordinated so as to add value to the building of robust national and regional systems of innovation. A number of them seem to be focusing on similar things which leads to duplication of efforts.

4. FROM RHETORIC TO PRACTICE

4.1. Developing Innovation Policies

Few countries have explicit national innovation policies and strategies. As stated earlier, many countries' current national science and technology policies are outdated and are largely focused on promoting scientific research. They are weak on measures to promote technological innovation in public and private enterprises for economic growth. To have a sharp national focus on innovation, countries need policy regimes that guide them to make strategic choices for R&D; take a long-term anticipatory approach to technology development; invest in technology foresights, prospecting and procurement; and create appropriate incentives for private sector in-house R&D. Good national innovation policies should also contain specific measures to promote long-term capacity building in industrial firms and wider parts of societies. They should encompass "a wide range of policies including social policy, labour market policy, educational policy, industrial policy, energy policy, environmental policy and science and technology."²⁹ In this way, national innovation policies are regimes.

Coordination of such regimes' design and implementation requires high-level executive authority. It cannot be left to ministries or departments of science and technology. For innovation policies to be effective, leadership for their coordination and implementation should be vested with the Presidents' offices of the different countries. To ensure that national innovation policies are implemented, countries need to develop and use clear multi-year (e.g. 10 years) rolling implementation strategies. The strategies should have clear benchmarks and articulation of institutional responsibilities.

4.2. Increasing Government Spending on Science, Technology and Innovation

It has been indicated that there is hardly any African country which spends at least 1% of its GDP on R&D. In 2000, Africa as a whole accounted for less than 1% of the world's expenditure on R&D. This shows how STI issues rank low in these countries' priorities. Other factors remaining constant, for African countries to make recognisable progress in fostering STI, they must spend and invest at least 3% of their national budgets on R&D and innovation activities. In expending this money, innovation activities must be given equal emphasis as R&D.

²⁹ Lundvall, B.-A., *et al.*, (2002), *supra* note 5, p. 227.

4.3. Investing in Science, Engineering and Entrepreneurship Skills

Africa's educational and training institutions are not producing enough skilled manpower to meet market demands for skills in science and engineering. There is shortage of skilled scientists and engineers in most of the African countries. This is a major barrier to improving national technological performance and growing national systems of innovation. This has been recognized by many African governments. Some countries, such as Ghana, Kenya, Mozambique and South Africa, are undertaking various reforms of their education and training systems. For example, in 2008, Ghana adopted a national science and technology education policy. This policy emphasises improving the education curriculum to increase and improve science and engineering content, doubling the number of science teachers in primary and secondary schools, promoting science clubs in schools and equipping laboratories in the schools. South Africa has, through the NRF, created a fund dedicated to training at PhD level in science and engineering. Funding has also been made available to the NRF to create research chairs at universities.

But increasing enrolment in science and engineering courses at African universities and other institutions of higher learning requires a wide range of measures including increasing universities' capacities by building more and better laboratories, increasing lecturers and technicians in faculties of science and engineering, and encouraging private universities to develop and offer science and engineering courses. These measures could be promoted through special tax relief for universities that offer those courses.

It is necessary to take a holistic approach to building science and engineering skills. Single short-term interventions will be inadequate. For example, putting emphasis on increasing student enrolments without adequate focus on creating employment opportunities in businesses is unlikely to work, at least in the long run. Increasing investments in science and engineering training should go hand-in-hand with concerted efforts to develop the private sector, improve physical infrastructure, create more jobs and grow the economy as a whole. Thus, African countries should avoid taking single isolated interventions in their efforts to improve science and engineering skills production. A suite of well organized or sequenced measures are necessary in order to improve systems of science and engineering training.

A recent study by the World Bank emphasises an integrated approach to strengthening tertiary education and training in Africa.³⁰ This report argues that measures aimed at improving tertiary education should be part and parcel of overall national efforts to fight poverty, grow the economy, promote human development, and increase economic competitiveness. Investments in tertiary education, particularly in science and engineering, should be treated as part of building national systems of innovation and promoting

³⁰World Bank (2009), *Accelerating Catch-Up: Tertiary Education for Growth in Sub-Saharan Africa*. World Bank, Washington DC.

technological catch-up in Africa.

A key aspect of building science and engineering skills in Africa should be the promotion of entrepreneurship.

Many studies have identified the weak entrepreneurial culture among graduates as one of the barriers to increased business development and job creation in the countries. Many graduates of African universities and polytechnics enter the labour market unprepared to manage businesses and take risks. Universities, polytechnics and other institutions of higher learning need to introduce courses in entrepreneurship in their curricula. They could team up with businesses and business schools to design and offer such courses.

African countries need clear strategies for building and utilizing science and engineering skills. These strategies should be an integral part of explicit national innovation policies and implementation strategies. We recommend that as part of national processes to design explicit national innovation policies, countries should conduct comprehensive assessments of science and engineering capacity needs of public and private sectors, including of training institutions. Such assessments would provide a clear picture of disciplinary gaps (whether electronics, mechanics, etc) and potentials of specific universities and polytechnics.

4.4. Improving R&D and Science Infrastructure

Although African countries have many institutional arrangements for STI in general and R&D in particular, the quality of these institutions is generally poor. For instance, as earlier pointed out, laboratories of most of African countries' R&D institutions are not well equipped and the average age of their existing equipment is very high. With this state of affairs, African countries cannot advance much in the area of STI. African countries must therefore make substantial investment in improving their science infrastructure.

4.5. Building Funding Institutions and Instruments

African countries require institutions and instruments for funding R&D and innovation activities. Most of the countries focused on in this study do not have innovation funding agencies. Where such institutions exist, they tend to be weak because they lack adequate funds. Instruments such as venture capital are not developed in most of the countries. Generally, scientists and entrepreneurs do not have access to financial capital to establish businesses and develop technologies. Countries need to explore various options and establish agencies that are dedicated to developing funding instruments and business tools for innovation. Such institutions should have legal authority and autonomy to work directly with private sector and invest public resources. They need to be aligned with offices responsible for safe guarding intellectual property rights as well as those for

promoting FDI.

4.6. Strategic Regional Initiatives

At the regional level, African countries can take the following strategic initiatives to improve and strengthen their STI capabilities

4.6.1. Building Capacities for Innovation Policy Development

Skills/expertise for innovation policy analysis and development are in very short supply in most African countries. There are very few African researchers and policy practitioners who have built enough experience in innovation policy design. There is no African university that has a coherent programme for STI policy studies. African countries that formulate STI tend to rely on consultants. But because government ministries and departments have limited in-house expertise, they face difficulties implementing policies that outside consultants design. African countries need to build in-house expertise in ministries and departments, so that they can technically spearhead innovation policy design and implementation.

To support this, the World Bank and bilateral donors should consider providing technical and financial support to develop an African programme for innovation policy capacity building. Such a programme can be designed to have clusters of interrelated activities such as short (e.g. 2-3 weeks) training workshops for government officials, postgraduate (MSc and PhD) studies in science and innovation policy, and exchange and dissemination of information on experiences in STI policy making. The World Bank can also facilitate the organization of study tours and policy dialogues. The tours can be organized for African government officials to visit selected countries that have mature or dynamic national systems of innovation to learn about such systems and related processes of policy-making and implementation. The Bank should consider supporting the establishment of innovation policy dialogues in Africa. It would start off by supporting EAC and other regional bodies to develop a Regional Innovation Policy Dialogue. In addition, the Bank can be a source of material and documentation for such dialogues. It would promote the documentation of good practices of innovation policy-making and innovation promotion around the world.

4.6.2. Developing Regional Innovation Strategies

Regional bodies such as EAC and SADC need coherent strategies for building regional systems of innovation as nested networks of national systems of innovation with differentiated capabilities and competitiveness. Such strategies should focus on promoting the establishment of shared/regional R&D infrastructure, and harmonization of technical standards and research regulations. They should also aim at facilitating

mobility of scientists, engineers and business-people, promoting regional universities collaborations, encouraging public-private partnerships across national borders, causing the adoption of regional intellectual property rights protection frameworks, facilitating the setting-up of transnational innovative firms, creating financial instruments for innovation, and generally improving the climate for regional innovation activities. The newly established East Africa Science and Technology Council should for instance work with institutions such as ACODE to spearhead the process of designing an EAC regional innovation strategy. The process should be knowledge-based, open and participatory and involve private sector, R&D institutions, politicians and officials from departments from science, technology, foreign affairs, trade and industry, and treasuries. An EAC regional innovation strategy with clear deliverables and time-frames would enable countries to sharply focus on common priorities and measure progress in achieving goals articulated in the EAC Protocol on STI.

4.6.3. An Alliance for Funding Regional Innovation Activities

One of the barriers to regionalism in general and the implementation of regional R&D and innovation programmes in Africa in particular is the limited (and in many cases the complete lack of) funding. In many cases, it is also the lack of capacities among regional institutions to raise or mobilize funding. Many AU, NEPAD, EAC, SADC and other regional initiatives are underfunded. Generally, the production of regional public goods is underfunded. Financial contributions from national governments tend to be low and unpredictable. There are few external donors funding regional programmes, particularly those dedicated to promoting technological innovation. Many of these donors tend to fund a few projects as opposed to whole programmes.

The success of African regional programmes for R&D and technological innovation will depend on new kinds of funding alliances involving governments, bilateral and multilateral donors, private foundations, and businesses. In the past, African governments have tended to design programmes and create new institutions without having clear strategies and agreements on sources and levels of funding. African countries have also tended to adopt programmes with many projects—often long lists of activities—without funding. It is crucial that regional bodies such as EAC draw lessons from the past efforts. Lessons should also be learnt from such initiatives as the proposed ASIF and the African Foundation for Research and Development (Afrand) which after many years of talking, have not taken off.

5. CONCLUSION

This study has reviewed national and regional STI policies, programmes and priorities of African countries in general and 19 Sub Saharan countries in particular. Emphasis was placed on the strengths and features of national systems of innovation as well as efforts to develop regional STI cooperation in EAC, SADC and other regional bodies. The study shows that there are efforts by many countries in africa to strengthen their systems of innovation. This is manifested in the high number of countries that are designing new policies, reforming their education systems, establishing institutions or instruments for funding R&D and creating new institutions.

Despite these efforts, national systems of innovation of many African countries are still weak. Many African countries cannot adequately take advantage of the new opportunities that are arising with the rapid scientific and technological development, intensifying regionalization and globalization, increased FDI flows, political stability and better macroeconomic conditions in Africa. We have recommended activities and actions that are required in order to strengthen national and regional systems of innovation and generally improve the technological performance of African countries. If taken on and effectively implemented, the strategic interventions proposed can go a long way in fostering STI in national and regional development of African states.

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