

# **STI Policy Research and the STI Policy Environment in Africa:**

## **A scoping paper for the IPS Program Area of IDRC**

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## Summary

The purpose of this paper is to present an overview of the state of science, technology, and innovation (STI) policy research in sub-Saharan Africa. It provides an understanding of how existing STI policy research contributes to enhancing innovation capabilities. The research finds that although a number of STI policy-research initiatives exist, they primarily focus on agriculture and health, with an inclination toward humanitarian interventions although they are progressively moving toward more sustainable research and policy activities.

STI policy research targeting the improvement of innovation capabilities related to entrepreneurial activities, particularly in the industrial and infrastructure sectors, is scant. A major short-coming of STI policy research is attributed to its failure to recognize the importance of this aspect in creating the ability to draw socioeconomic benefits from STI. More specifically, latent STI issues that relate to the development of technological competencies to transform existing knowledge to new configurations have remained in the periphery of STI policy research. The study contends that although such issues are generally difficult to address, they are key to promoting or undermining the ability to benefit from science, technology, and innovation.

The existing STI policy research appears to focus on providing policy guidance on technicalities of international laws that affect STI activities. Although the importance of these efforts can be justified, they address only part of the STI challenges in Africa. They are likely to have little impact on innovation dynamism unless inherent structural aspects are addressed.

## **Introduction**

The broad aim of this study was to give an overview of the state of science, technology, and innovation (STI) policy research in sub-Saharan Africa. It looked at how STI policy research has developed. This involved an assessment of: the STI policy environment in which STI research is embedded; and how STI policy research has attempted to understand the dynamics of the STI process and provided a basis for designing and implementing policies that target STI benefits for development. Technological transformations are modifying dynamics at the global level. Arguably, differences in the ability of economies to draw technological benefits may be influenced by the STI policy environment. STI policy research can be an important tool in guiding economies to understand changing dynamics and derive technological gains. Nonetheless, the STI policy environment and STI policy research are correlated. The policy environment may also promote or limit the quality and relevance of policy research. This research placed emphasis on the nature of the environment in which STI policy research is undertaken.

The study focused on two main research aspects that are concerned with the nature and extent to which STI policy research provides explanations of the impacts of STI activities on human welfare: key STI policy research areas; and STI policy research organizations and networks. It provides an understanding of the existing STI policy-research activities and their relevance to the current technological dynamics. The research specifically addresses the following questions: What role do existing STI policy-research arrangements play in enhancing innovation capabilities in sub-Saharan Africa? To what extent does STI policy research address technological learning or development of core innovative capabilities?

### **Rationale for the study**

STI policy research seeks to provide an informed analysis of important issues of STI activities to support government interventions, through STI policy that is designed to enhance socioeconomic development. Although STI policy research relates to scientific research, it is not concerned with the direct examination of scientific discoveries. Rather, it examines how STI policy research has attempted to address the socioeconomic impacts of STI activities on the structure of an economy (Adeboye and Clark 1997). The aim of this paper is to understand how STI policy research has attempted to analyze the process of knowledge acquisition, improvement, and dissemination in the African context.

To a large extent, this refers to the exploitation of existing technologies and involves a substantial amount of learning within firms.

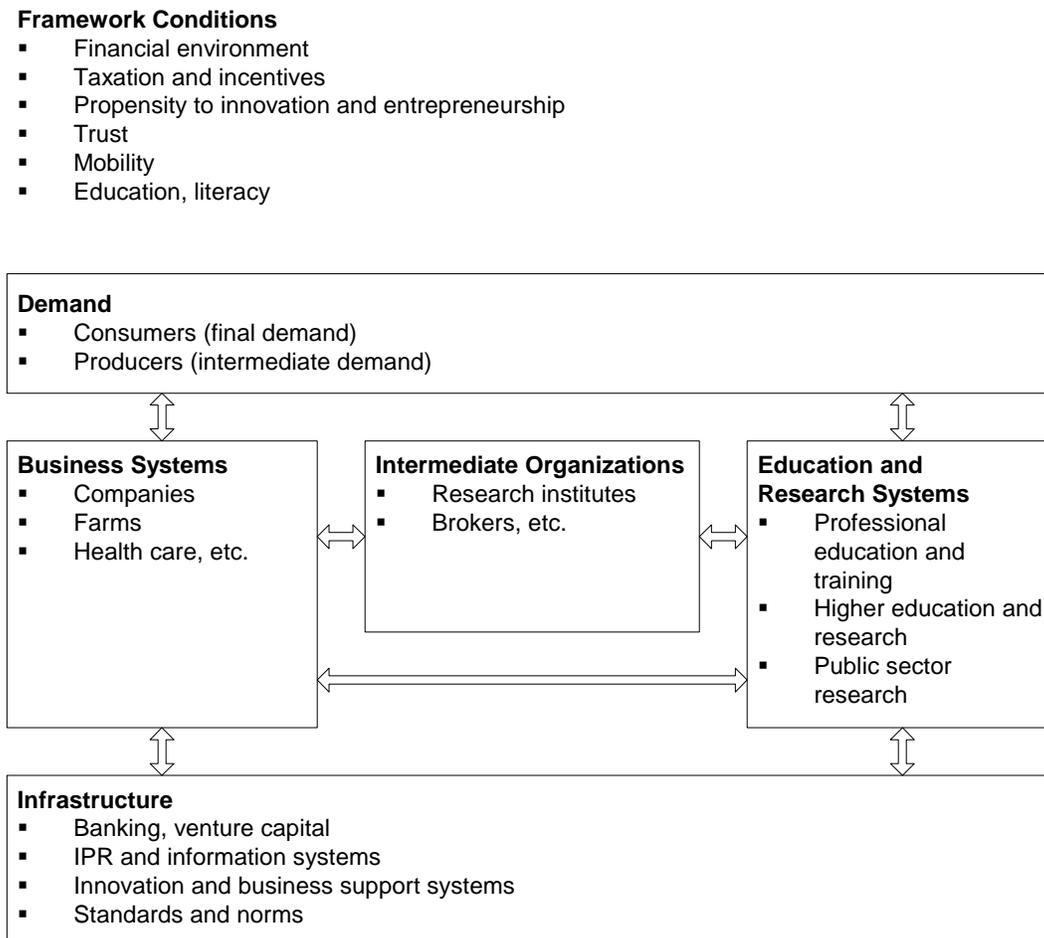
STI policy research recognizes that governments face important strategic decisions with regard to enabling STI activities to attain the desired outcomes. Informed policy plays a significant role in facilitating desirable outcomes and limiting less desirable aspects of STI activities. STI policy research may provide effective evidenced-based support to policymaking and therefore promote good governance. However, the ability for STI policy research to provide effective support depends to some extent on the framework within which the research is performed.

### ***Framework for analysis***

An analysis of the role of STI policy research in providing guidance to STI policy requires a framework that addresses the dynamics of STI-led growth. The realization, that funding science does not imply enhanced innovation and economic development, lead to a shift in the 1990s toward the National Systems of Innovation (NSI). This approach encompasses the need to provide a better understanding of actors and activities, as well as the complex relationships among them, for enhanced economic performance. Metcalfe (1995) defines the systems of innovation as *a set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which government form and implement policies to influence the innovation process*. STI policy research is an element of this framework that seeks to improve the functioning of the NIS, particularly by providing guidance to STI policy.

Within the NIS approach, STI policy research has a complex role that involves identifying and articulating relevant STI policy implications for innovation and socioeconomic development. In particular, the link between technological learning and innovation in the development of innovative capabilities appears to be central to STI policy research. These two elements (technological learning and innovation) lie at the heart of the dynamics of technological progress because they influence the process of technological capability building. In the case of many African countries, it is argued that the benefits that could accrue from exploiting and applying existing knowledge to achieve the desired outcomes are substantial. However, the ability to exploit knowledge is contingent on the technological learning process and involves engagement in innovation activities. On the whole, STI policy research should be able to provide an understanding of the various actors, activities, and interactions that

**Figure 1:** Major components of the National Innovation System (Arnold and Bell 2001).



influence the STI environment and, in particular, the challenges and opportunities that arise.

Arnold and Bell (2001) attempted to capture the main components of the NIS (see Figure 1). A well-informed STI policy may effectively promote the functioning of the different components and linkages of the NIS. Adequate STI policy interventions are necessary to create demand and strengthen the supply of science and technology (S&T) to attain strategically designed structural changes within the system. This involves providing the necessary infrastructure and framework conditions that act as incentives for STI activities.

Firms play a central role in technological transformations by virtue of the fact that innovation or commercialization of inventions, takes place within them. Bell and Pavitt (1993) point out that *failure to recognize the firm as the central player in the accumulation of technology has been the major short-coming of*

*technology policy*. In addition, successful entrepreneurship requires policy intervention that nurtures learning to upgrade technological capabilities and infrastructure (Katz 1987; Lall and Pietrobelli 2002). Learning through engagement in innovative activities, particularly within firms, is viewed as important in providing a basis for technology acquisition that targets economic development (Hobday 1995; Stiglitz 1996; Kim 1997; Nelson and Pack 1999). However, effective technological learning through innovation largely depends on both local and global networks and linkages. Therefore, the extent to which networks and linkages among actors are effective in promoting knowledge generation is an important aspect in achieving STI-related benefits.

In many African countries, innovation (and by extension technological learning and technological capability building) that takes place within firms is low (30–40% funding compared with 60–70% for public research institutes). The implication in developing countries is that firms are not able to generate adequate technological capabilities to make use of new knowledge (technology) — including that which is produced by public research institutes. Although the structure of developed countries varies significantly from that of developing countries, it is important to note that in industrialized countries, the bulk of new knowledge required by firms is generated in-house; sourcing new knowledge from research institutions is limited. It is no wonder that the contribution of the knowledge produced by public research institutes to socioeconomic development is estimated as small, (Arnold and Bell 2001).

The linkages between the different components of the NIS affect the ability of firms to access, exploit, generate, and diffuse knowledge. However, the industrial structure of an economy may determine the importance of different linkages for developing capabilities to exploit knowledge within firms. For example, the linkages between firms and intermediate organizations, in the form of organized research and technology associations, federations, and networks, appear to have had an important role in assisting firms to develop relevant technological capabilities in SME-dominated economies (e.g., Taiwan). The development of technological capabilities involves greater innovation among firms and an improved ability of the firms to draw knowledge from external sources.

In the areas of industry and infrastructure, hardly anything can be said about public research institutes providing STI policy direction to technological learning or the development of innovative capacities. The creation of new knowledge in these sectors arguably draws less attention than in health and agriculture. Innovation in industry and infrastructure has a significant

potential to offer substantial benefits to African countries. However, the relatively low profile accorded to innovation limits the ability to make significant progress in these two sectors. On the whole, improvement of innovative capacities is viewed purely as an issue of strengthening education systems; whereas, the issue of technological learning remains unexplored. In addition, support by public research institutes to business systems (companies, farms, and health care) as the main intermediate organizations appears fairly limited. Other intermediate organizations (e.g., professional associations and business advisory services that are important for knowledge sharing, for supporting firms to respond to changing standards and norms, and for strengthening marketing arrangements) are either absent or weak. Their influence on STI policymaking or political lobbying is also limited. More importantly, national policy-research institutes that can provide targeted contributions on STI issues barely exist, and the impacts of regional or international STI policy-research institutes on STI policy direction are limited. Table 1 presents a brief analysis of how some of the issues are treated.

The quasi absence of STI policy research on a range of critical issues specific to African countries is a major hindrance in generating evidence-based research for policy direction on the functioning of the various elements of the major components of the innovations system. In particular, the weak linkages within

**Table 1.** Some STI issues in policy documents — the case of Kenya (Kenya National STI policy, unpublished).

An analysis of the STI policy in Kenya reveals that public research institutions are the main purveyors and developers of knowledge. They double as elements of both the education and research systems and intermediate organizations. Although a number of successes have been reported, particularly in health and agriculture, their impact as intermediate organizations is less obvious. The successes, for the most part, have not been translated into generalized use and application that can be associated with increased dynamism of the innovation system. Public research institutes are major contributors to STI policymaking, but their contribution to STI policy tends to focus on more funds for basic and applied research. Some commercialization of health and agricultural inventions has occurred. However, greater emphasis appears to remain on S&T rather than on innovation or the general application and commercialization of the outputs of S&T.

With regard to promoting innovation within industry, the draft policy pays considerable attention to the production of technical skills through the strengthening of technical training colleges and polytechnics. However, no consideration is given to the importance of further development of these skills within industry. In addition, the issue of strengthening engineering capabilities is not explicitly addressed.

the business system as well as between the business system and the other major components (e.g., intermediate organizations, education and research systems, infrastructure, and demand and framework conditions) have received limited focus in STI policy. Although it may be difficult to generalize the Kenyan case across Africa, the information presented in Table 1 may illustrate the challenges to strengthening NIS in Africa.

Has STI policy research in Africa failed to provide an informed analysis of the important issues of STI activities in the context of specific countries? Has it therefore failed to assist government interventions to enhance the innovation capabilities of firms? The proportion of innovation funds in firms compared with those in public institutions is by no means adequate to determine whether STI policy research in Africa has failed in one of its most critical areas. However, it is reasonable to assume that STI policies in many African countries lack adequate support from evidence-based research to realize their desired outcomes. This is neither intended to imply that STI policy research does not exist nor that a well-informed STI policy is on its own sufficient to achieve economic development. Implicit policies that affect the macroeconomic environment, cultural aspects, financial systems, and physical infrastructure also influence the effectiveness of STI policy intervention. Rather, the concern is on the extent to which STI policy research has been able to provide guidance for enhanced technological capability building.

STI policy research can improve our knowledge and understanding of how STI policies can influence development challenges in Africa by addressing the various aspects of a NIS. Because of the central role of firms in generating innovation, this study placed emphasis on STI policy research designed to develop the technological capabilities of firms within the NIS. STI policy research on other components of the NIS is analyzed with respect to the development of the technological capabilities of firms. A well-designed technology policy is underpinned by well designed measures for addressing technological learning, innovation, and dissemination of technology. Although an analysis of the extent to which STI policy research has been effective in guiding STI policy to promote innovation within firms is important, it lies outside the scope of this study. This study assessed STI policy research in terms of the issues addressed and their centrality to technological capability building within firms. It did not attempt to assess whether that research has actually fed into STI policy.

### **Addressing STI capability through STI policy research**

In Africa, a key challenge to the realization of STI goals articulated in the past has been the formulation and implementation of specific policies and programs that effectively address development concerns. In other words, it is not sufficient to recognize that STI is important in the development process in Africa. The challenge lies in identifying and implementing interventions that adequately take into account the issue of technological capability building within the context of early development stages. In this stage of development, technological capability building based on firms or business systems, rather than on formal research, may be more beneficial in making the desired progress. Although this argument is based on the assumption that the bulk of existing knowledge provides opportunities for engaging in technological growth, it recognizes that significant investment in innovative activities is a prerequisite for technological capability building.

This discussion also recognizes that technological capability building, in some areas in which vast amounts of knowledge do not exist, requires considerable basic research due to the nature of the underlying development challenge. For example, basic research in certain areas of health and agriculture may be critical to addressing specific problems peculiar to the African context. That notwithstanding, the discussion of STI policy research in this study focuses on how technological capability building in firms has been addressed. STI activities that promote technological development in developing countries differ from those in technologically advanced countries, where the concern is with advancing the technology frontier. The existing bulk of knowledge offers a large potential for technological learning and innovation in many African countries.

The exploitation of existing knowledge may enhance the ability to adapt and improve the particular technology in use, and therefore, contribute significantly to the improvement of products and process. Technical and operating capabilities and, in particular, design and engineering skills contribute significantly to this process of knowledge acquisition. Bell (2007) distinguishes operating capabilities (those required *for using knowledge that is embodied in, or closely associated with, existing production systems and facilities*) from design and engineering capabilities (those required *for transforming existing knowledge into new, often innovative, configurations for new or changed production systems*). The cumulative process of knowledge exploitation depends largely on technical and operating capabilities embodied in people, and it provides an opportunity to deepen these capabilities and expand them to cover an increasing variety of economic activities across sectors.

The contribution of STI policy research to STI policy in developing countries is likely to be considerably beneficial if it is able to provide adequate guidance on technological learning and innovation within firms. In the existing literature, technical and operating capabilities that contribute significantly to the development of technological capabilities have received scant attention. The question that begs attention is: how can STI policy research address this issue? One step in addressing this question would involve an assessment of the nature and extent of STI capability building in different sectors, and an identification of interventions to enhance capability building, including technological learning.

## **STI policy research and the STI policy environment in Africa**

STI policy research can play a critical role in identifying core issues for STI policy formulation, implementation, and monitoring, and therefore in facilitating positive socioeconomic outcomes of STI policy. However, the STI governance context affects the extent and direction of STI policy research. This section traces the environment in which STI policy and research have emerged in sub-Saharan African countries. It revealed that STI policy and research can at best be viewed as nascent.

### **STI policy context in Africa**

The need to create a framework for coordinating scientific efforts across Africa emerged as far back as the late 1920s and led to the *African Survey* in 1936 (Gruhn 1971). The emphasis was on creating a framework that was limited to the exchange of technical and scientific information in sub-Saharan Africa. These efforts led to the creation of the Scientific Council for Africa South of the Sahara (CSA) in 1949, and the Commission for Technical Co-operation in Africa and Scientific Council for Africa South of the Sahara (CCTA) in 1950. The organizations primarily aimed at establishing a common communications network that could enhance utilization of resources in Africa. They were not intended to create a vehicle to integrate scientific and technical matters.

CSA focused on scientific data collection and exchange; whereas, CCTA engaged scientists, technicians, administrators, and political leaders on common scientific problems. Programs and projects on human diseases, animal diseases, education, and housing were developed. Some of the successful CCTA projects included a rinderpest control project and a fisheries survey on the coast of West Africa. Although some research in climate-specific aspects, particularly in agriculture and health, may have been carried out locally, the research targeted the creation of new knowledge for colonial exploitation and was mainly conducted outside the continent. The establishment of a process for knowledge generation, with a local STI capability within the continent to address the socioeconomic issues of the indigenous populations, was never the intention. CSA and CCTA activities were highly politically inclined; technical and scientific projects could only be carried out after political authorization was granted by the governing powers of the time. This situation intensified with the independence of African States.

The Organization of African Unity, a pan-African organization created in 1963 and later abolished to form the African Union (AU) in 2000, absorbed CCTA and CSA to form the Scientific, Technical and Research Commission (STRC) in

1964. The STRC continues to exist under the umbrella of the African Union and has its headquarters in Lagos. It is now making explicit attempts to strengthen national and regional policies on scientific and technical issues through various inter-African expert committees that include the committee on S&T. These activities are in line with the African Union's overall role of providing guidance and direction. Its scientific and technical cooperation efforts mainly coordinate scientific investigations in a number of areas reminiscent of those carried out in the colonial period — human health, animal health, plant protection, education, and earth sciences. STRC has also been engaged in related campaigns, including an anti-rinderpest campaign. Although this does not suggest that these areas are of no relevance to the economic development of African countries, this historical pattern may limit the exploitation of new areas of research that could provide substantial socioeconomic benefits.

The AU has a complementary STI project initiative, the New Partnership for Africa's Development (NEPAD) that was adopted in 2001. NEPAD operates under the AU's Human Resources, Science and Technology portfolio to implement flagship projects outlined in its S&T action plan, which was launched in 2005. The focus of the action plan is on strengthening the science base of Africa through the establishment of centres of excellence for higher education and research in various areas, including water, energy, biotechnology, and biodiversity. In addition, it aims at creating a mechanism for building STI capacity for policy analysis, formulation, monitoring, and implementation. However, the impact of these efforts on STI policy content and management and consequently, on socioeconomic gains, are yet to be observed.

It is noteworthy that little attention seems to be geared toward areas that do not relate to agriculture and health. Although a flagship project has been outlined for manufacturing, it specifically focuses on training for engineers — the supply side component referred to as education and research systems by Arnold and Bell (2001). Such an effort is important, but it only addresses part of the challenge in terms of developing STI dynamism; the promotion of technological learning through innovation within firms appears absent despite its central role in generating technological transformation (Wangwe 1992). This observation is not intended to negate the importance of research in health and agriculture and in particular the need for cutting edge research in areas specific to conditions in Africa. It is a mere observation of the omission of an aspect that provides overwhelming evidence of its importance in attaining technological transformations, particularly in an environment that is dominated by micro and small-scale enterprises.

The general approach of the S&T action plan is inclined toward consolidation of STI infrastructure through the creation of African research centres and technology parks. It emphasizes S&T or knowledge supply through research and development. The sufficient adaptation of knowledge, for generalized application and commercialization to achieve the desired socio-economic benefits of innovation, receives much less elaboration. More specifically, a focus on the development of extension approaches and organizational aspects, which are highly effective in enhancing knowledge sharing and use (e.g., associations and cooperatives partnerships), is absent. Mechanisms for stimulating demand for knowledge by farms and firms are central to knowledge exploitation and application.

The United Nations Economic Commission for African (ECA) is another organization that has made notable efforts on policy issues in Africa since 1958. Although its focus has been on broad economic policy aspects, it is recognised that such implicit STI policies play a large part in influencing the STI activities of an economy. More recently, ECA has made attempts to incorporate STI directly into the development agenda of African countries through collaboration with NEPAD as well as through its Information and Communication Technology (ICT) and Science and Technology programs. Other initiatives in the form of conferences and workshops that took place on both implicit and explicit S&T policy issues in the post-independence period include CASTAFRICA I (1974), Lagos Plan of Action (1980), and CASTAFRICA II (1987). These conferences recognized that a suitable macroeconomic environment was important for promoting S&T, and that development of S&T based almost entirely on importation of “full turn-key” technologies was limited, (UNESCO 1987). The importance of linking STI policy issues and their proposed solutions with the socioeconomic interests of a country is one of the key elements that have emerged from conferences and workshops. However, implementation of the recommendations has remained minimal. This may point to a possible weakness with regard to the design and implementation of STI policy in many African countries.

These initiatives do not provide an exhaustive list of continent-wide efforts that have attempted to offer advice on both implicit and explicit policy measures; they nevertheless present a general context for the emergence of STI policy issues. Arguably, these initiatives contributed to the awareness of the importance of S&T, which particularly in the 1970s, led a number of African countries to formulate S&T policies. However, it is notable that the main emphasis of S&T policies was on consolidation of facilities (S&T infrastructure)

that previously span colonial territories, and therefore no longer fit the ambitions of the newly independent States. In particular, the recognition of the important role of S&T in development, led to the establishment of public research institutes that grew substantially in the first post-independence decade. The resurgence of the importance of STI issues for development in Africa in the last decade, after a major silence during the structural adjustment period in the 1980s and 1990s, appears to proceed with the consolidation efforts of the 1970s — albeit in a different direction. Efforts tend to focus on pooling resources aimed at creating facilities for research at the regional level. On the whole, the initiatives have been instrumental in raising awareness of the importance of STI in socioeconomic development and, therefore, the need to put in place explicit and implicit policies.

### **The emergence of STI policy research**

Effective STI policies depend to some extent on the quality of support they are able to draw from research on STI policies issues. Hence, research on STI policy issues may be considered as one of the components of STI policymaking. Concerns that S&T policy in Africa requires support from S&T policy research for analysis, formulation, implementation, and monitoring of STI policy have led to a number of initiatives specific to the promotion of STI policy research. The International Development Research Centre (IDRC) in collaboration with ECA organized a meeting on the creation of centres for technology policy studies in 1973. A discussion on technology policy and planning in some African countries, including Ethiopia, Tanzania, and Ghana, indicated that they had created scientific councils and institutes within major universities that intended to carryout scientific and technological research. However, there was no indication that S&T policy research was on-going. The meeting recommended that national interdisciplinary groups be established to carryout S&T policy research. The national groups were expected to development tight links with their governments to ensure close consultations and make attempts to create links among the national groups.

The conference on the state of S&T in Africa (in Vienna in 1979) echoed the need to develop technology-policy research capacity. In the early 1980, IDRC supported four technology-policy workshops as a follow-up on developing technology-policy research in Africa. These efforts led to the creation of the Eastern Africa and Southern African Technology Studies Network (EATPS) and the Western Africa Technology Studies Network (WATPS) in the 1980s. There is no indication, however, that the creation of these two networks resulted in the development of national groups with strong STI policy research capacity, as recommended by the IDRC–ECA meeting in 1973 (IDRC–ECA 1973). It may be

reasonable to assume that although a number of studies on technology-policy research were commissioned on interdisciplinary issues of S&T policies, including social, economic, and legal aspects, the development of S&T policy research did not develop to a level that contributed significantly to S&T policies. In fact, S&T policies were for a large part never implemented for reasons related to both policy content (including lack of a clear focus on how they would impact socioeconomic development) and policy management (such as how desirable impacts could be triggered, monitored, and strengthened during implementation).

Although there have been a number of attempts to build STI policy-research capacity in Africa, little impact on the design and implementation of STI policies has been observed. It is argued that despite the existence of National Councils for Science and Technology and Ministries of Science and Technology, *on the whole the S&T policy institutions have not been instrumentally effective in actively informing and guiding scientific and technological change* (Khalil-Timamy 2002). Systematic information on policies to promote STI and their impact on development is generally not available. In some cases, information on STI issues in national policy in many African countries is incorporated within the Poverty Reduction Strategy Papers. However, the focus on STI issues in Poverty Reduction Strategy Papers is generally weak (Warren-Rodriguez 2007).

The STI policy environment in Africa has suffered from intermittent support and frequent changes in the institutional organization (discussed in more detail later). This situation may have interfered with the ability to strategically focus on STI activities, which generally require consistent measures based on long-term objectives. It is no wonder that during the 1980s and 1990s structural adjustment programs took priority and confined S&T policy issues to the shelves — despite the overwhelming evidence of the benefits of investing in S&T, for example, in Southeast Asia. It is reported that *While research institutions grew to over 2,000 in the 1970s with a research work force of about 11,000, the pool of skilled human capacity declined sharply in the 1980s and 90s due in part to restrictive structural adjustment programs and greater focus on basic education, despite evidence from South East Asia* (African Development Bank 2007). The extent to which African countries have made progress in developing quality STI policy-research capacity to inform STI policymaking may have a bearing on this situation.

## **STI policy-research initiatives in Africa**

The importance of STI policy research in supporting governments to make well-informed strategic interventions in relation to STI issues has led to the creation of a number of initiatives that span the continent. This review of STI policy-research initiatives attempts to take into account various aspects that affect the effectiveness of STI activities in an economy. Bell (2007) notes that *It is important to bear in mind that the areas of public policy that have the greatest impact on scientific, technological and innovation activities and capacities are not the areas of policy that are explicitly focused on those activities and capacities. Instead, they are aspects of broad economic policy — macro-economic policy, trade policy and so forth — that do not specifically address issues about science, or technology or innovation but nevertheless have a huge influence on the technological behaviour of enterprises across the economy. They also have a pervasive influence on public sector funding for key elements of the scientific and technological infrastructure, in particular, the various levels and types of education and training that contribute to the development of STI capacities.*

This section briefly discusses a number of initiatives related to STI policy research. The initiatives are grouped into: research organizations, centres, and networks; and university-based research networks. The relatively broad coverage of countries by the networks and organizations and centres is taken into account. In addition, the selection considers the importance of both implicit and explicit STI policies and the need to expand the base for STI-related skills owing to their importance in supporting innovation activities within enterprises. Finally, a summary of the STI policy-research activities is provided.

### **STI policy-research organizations and centres**

Five initiatives are reviewed in this section: the African Technology Policy Studies Network (ATPS); the African Centre for Technology Studies (ACTS); the African Economic Research Consortium (AERC); the Council for the Development of Social Science Research in Africa (CODESRIA); and the Education Research Network for West and Central Africa (ERNWACA). ATPS and ACTS are viewed as targeting explicit STI policy; whereas, AERC, CODESRIA, and ERNWACA focus on policies that have an implicit impact on STI policy.

### ***African Technology Policy Studies Network (ATPS)***

The African Technology Policy Studies Network emerged as a fusion of the EATPS and WATPS networks in 1994. With support from IDRC, ATPS operated as a secretariat of IDRC for 7 years. This was a major step toward developing technology-policy research in Africa following the initial idea supported by IDRC in 1973 to create national technology-policy studies centres. However, the time lag is perhaps an indication that gaining a foothold in S&T policy research was a challenge. ATPS became autonomous in 2001 and was recognized as an international organization in 2003. Its main objective is to provide STI policy-research findings to policymakers and other stakeholders. The network carries out multidisciplinary STI policy research geared toward strengthening capacity for policy formulation and implementation. One of the channels used to facilitate this role is working through its 23 national chapters that have direct contact with their STI policy environment.

The network approach seeks to foster collaboration of researchers, policymakers, and other actors and to generate critical mass of research and its dissemination. In addition, the organisation of research through national chapters appears to be important in promoting research on locally determined priority areas, particularly research supported through small grants from 1994 to 2002. These small grants are often based on country case-studies on varying aspects of STI related activities and targeted at training young researchers. About 50% of the research funded through the small grants between 1994 and 1999 has been published between 1994 and 2007 as ATPS *Working Papers* and as externally reviewed *Research Papers*. The output consists of forty four *Working Papers* and three *Research Papers*. In terms of other outputs of ATPS based on the network's publication list, the *Technology Briefs Series* that provides knowledge and advice on policy has a total of fifteen published issues. The briefs are said to be the most popular output of the network, although it is difficult to determine their impact on STI policymaking.

ATPS also carries out collaborative research that brings together a group of national chapters to work on themes related to the programs of the network. These programs are on biotechnology policy, health-technology policy, water and environment sustainability, agriculture, and innovation systems. There is also a program on STI knowledge for development, which appears to cut across all other programs. Finally, there is a youth program that targets sensitization in general. Although the programs appear to be of relevance, the rationale for their selection may not be obvious. Information on how the programs have evolved over time could perhaps provide some guidance, but this would require access to outcomes of collaborative research since 1994 and subsequent

analysis. A review of the ATPS *Working Papers* as well as the *Research Papers* indicates that the main thrust of the research in relation to the program areas is as follows: STI knowledge for development (26), agriculture and innovation systems (17), biotechnology (2), water and environment sustainability (1), and ICTs (1). Nevertheless, this categorization is not based on strict demarcations of the programs — the papers generally touch on issues across program areas.

Other activities carried out by the national chapters include provision of policy support on STI issues through national training and dissemination workshops. One of the aims of ATPS is to extend coverage across the continent. However, some of the existing national chapters are weak — particularly in eastern and southern Africa compared to West Africa (Sida-Sarec 2006). One reason for this may be weak research environments that require specific interventions.

### ***African Centre for Technology Studies (ACTS)***

The African Centre for Technology Studies (ACTS) is a S&T centre that carries out policy research to strengthen the capacity to harness S&T for sustainable development. The research focus areas are agriculture, energy, biological diversity, biotechnology, international trade and intellectual property protection, and natural resources tenure and management.

ACTS was set-up in 1988 and its membership comprises Kenya, Malawi, Malta, Uganda, and Ghana, as well as one international network (Third World Academy of Sciences) and an international research centre (World Agroforestry Centre, ICRAF). It is also linked to a number of networks and organizations. ACTS seeks to have direct impact on policy analysis through its collaborative research projects. Its role as an intermediate organization is particularly important because, in Africa, intermediate organizations that primarily focus on knowledge intermediation are not common. The role is often carried out by public research institutions and universities.

One of the main attributes of ACTS rests within its emphasis on strengthening linkages for information exchange aimed at developing a science, industry, and government interface. Its efforts to enhance knowledge flow involve three specific interventions: the *science and technology literacy promotion program* targets capacity development of practitioners for policy formulation and analysis in its focus areas; the *ACTS institute of science and technology, policy analysis, and training* offers interdisciplinary courses in its focus areas — the courses are aimed at policy analysts and managers in S&T policy and environmental management, and accreditation is offered by collaborating

universities; and the ACTS attempts to develop research potential by engaging young scholars in its research areas for limited durations to allow for a continuous flow and to offer opportunities to a larger number of young scholars. A new initiative is underway to encourage young scholars to undertake doctoral studies in S&T policy.

The focus areas of ACTS fall mainly within the sectors of agriculture, environment and natural resources, and to some extent health. Although the issues addressed may have evolved over the years, it appears that a tight focus has been maintained and the issues are well integrated.

### ***African Economic Research Consortium (AERC)***

AERC is an economic policy research and training network in sub-Saharan Africa established in 1988. It seeks to enhance the technical skills of local researchers to conduct policy-relevant economic inquiry; promote retention of such capacity; and encourage its application in the policy context. AERC's focus on supporting informed macroeconomic management, based on its strong policy and practice framework in economic policy, provides an important platform for explicit STI policies. Its role as an intermediate organization in strengthening economic policy formulation is said to have been visible in many countries. AERC has two main components: economic policy research and training.

Its economic policy research component comprises a network of local researchers who carry out research on priority areas that are regionally determined. It is based on collaborative research that aims to strengthen national economic policymaking. The policy research targets priority issues and is carried out in close coordination with policymakers. Promotion of links between researchers and policymakers contributes to: research relevance to policy; its ability to influence policymaking; and strengthening of economic policymaking capacity. Mechanisms for strengthening economic policymaking include: national policy workshops and senior policymaker seminars.

The training component is based on a partnership with 21 universities in 16 countries. The collaborative Master's program in Economics is taught at seven of the accredited universities. Enrolment levels have more than doubled over the last 15 years (58 students in 1993 to 140 in 2004). A collaborative doctoral program was commenced in 2003 and now supports a total of 71 students. The program is taught in 8 universities in four regions — Southern Africa, Eastern Africa, Anglophone West Africa, and Francophone Africa. Efforts to create local

research capacity through training involve thematic research, which also serves as a tool to link researchers and strengthen the network. Various mechanisms are put in place to ensure quality research — including thematic workshops, methodological workshops, and close interaction of researchers.

The policy research and training components appear to have remained focused and closely integrated. Although AERC's headquarters are in Nairobi, its approach to tapping and developing local research capacity around a set of strong node points across the continent appears to have been cost-effective and efficient in developing strong economic research capacity spread across the continent. AERC is reported to have been instrumental in the production of high-quality poverty-reduction strategy papers in many African countries through its collaborative research project on poverty. Its peer-review mechanism for research is reported to yield quality research, and the involvement of senior policy researchers in advisory roles is said to have grown considerably.

***Council for the Development of Social Science Research in Africa (CODESRIA)***

CODESRIA is a social science research organization established in 1973 to develop intellectual thought in Africa. The council's multidisciplinary research covers broad issues of development that include sociology, history, culture, politics, higher education, and international affairs. Social science research is important with regard to STI policy research insofar as it informs implicit policies, which influence STI policy interventions.

The research is organized into three categories: core research activities; policy-oriented research projects; and collaborative research projects. Core research is the council's main instrument of intervention and comprises various groups: multinational working groups of senior researchers with a record of quality research who are expected to mentor young researchers; national working groups that target national priorities on aspects of social processes; and comparative working groups that seek to strengthen comparative research.

Policy-oriented research refocuses research findings to directly address policy issues and inform policymaking. The *Policy Dialogue Series* — that involves researchers, government officials, professional associations, and international organisations — supports this policy-oriented research project. CODESRIA also undertakes collaborative research with other research institutions, organizations, and agencies, which is an attempt to ensure that the African research community participates in major debates with a bearing on Africa.

With regard to training, the council has a training program that supports masters, doctoral, and post-doctoral research by students in African universities, organizes methodological training sessions, and has various other initiatives targeting research-capacity development. One important characteristic of the Council in its training efforts is that over the last decade it has launched four institutes: the Governance Institute, the Humanities Institute (located at the University of Ghana), the Gender Institute, and the Child and Youth Studies Institute. CODESRIA's efforts to strengthen research capacity appear to have been successful, particularly with regard to its training program.

### ***Educational Research Network for West and Central Africa (ERNWACA)***

ERNWACA is an educational research network that was created in 1989 to promote policy and practice. It is comprised of 14 francophone and anglophone member countries in West and Central Africa — Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Gambia, Ghana, Guinea, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, and Togo. ERNWACA has a secretariat and national networks. Its researchers are drawn from universities, research centres, training institutes, and government. Its research targets issues related to the weaknesses of educational systems in Africa, with an emphasis on research for capacity building and policy development.

In its training efforts, ERNWACA offers small grants to young researchers based on themes that are determined by the national and regional scientific committees. The initial selection is done at the national level through the national scientific committees, and selected proposals are forwarded to the regional scientific committees for final selection. A total of 55 small grants have been awarded in the three programs that have been held since 2001. The small-grants research is carried out over a period of 9 months and the research is submitted to the secretariat. In the most recent small-grants program, 21 grants were offered to address the theme *Role of the University in Shaping Society in Africa: Values in Higher Education*. ERNWACA will launch the *Journal of Educational Research in Africa* next year, and one of its objectives is to promote the publication of research articles derived from the small-grants research reports.

Other research and training activities of ERNWACA include national and transnational studies that have been instrumental in designing and implementing changes in the quality of education in a number of the member

countries. The network also offers training workshops for researchers and education professionals, and it is currently running a Pan-African program, the *Panafrican Research Agenda on the Pedagogical Integration of ICT*, which seeks to promote pedagogical integration of ICTs to improve the quality of teaching and learning in Africa. The current member countries are Cameroon, Central African Republic, Congo, Kenya, Mali, Morocco, Mozambique, the Republic of South Africa, Senegal, and Uganda.

### **University-based networks for STI-related training and policy research**

This section reviews two university-based networks engaged in STI-related training and research. The Regional Universities Forum (RUFORUM) focuses on agriculture, which is a major concern of most sub-Saharan African countries. The University Science, Humanities and Engineering Partnerships in AFRICA (USHEPiA) focuses on the development of science and engineering capacity as well as capacities in the humanities. The selection of these networks is based on the observation that many sub-Saharan countries do not have sufficient knowledge and skills in STI-related areas. The impact of STI policy-research capacity invariably depends on the extent to which these human capacities are available, in particular, for use and further development within enterprises.

#### ***Regional Universities Forum (RUFORUM)***

RUFORUM is an East and Southern Africa university-based initiative for strengthening human-resource capacity in agriculture through interdisciplinary training and research. The consortium of 12 universities in Kenya, Malawi, Mozambique, Uganda, and Zimbabwe was established in 2004. In addition to providing solutions for strengthening agricultural productivity, it targets value-addition and commercialization of the produce of small-scale farmers.

The consortium's two pronged approach — addressing technology and market access challenges faced by farmers — is a novel attempt in Africa to provide comprehensive and integrated solutions to development. This important attribute is encapsulated in its stated roles of *innovator, information and knowledge broker, co-ordinator of partnerships and collaborations as well as an advocate*. As an intermediate organization within our framework for analysis, the consortium appears to attempt to develop well-entrenched linkages with both the business system and the education and research systems in addition to providing a platform for supporting policymaking. Its integration of the business system within its training and research efforts is of particular interest

in generating demand-driven solutions and ensuring their adoption by farms through substantial involvement with farmers. Within the education and research systems, there is an attempt to strengthen institutional capacity through *Nurturing Grants* that target specific institutional gaps and a staff exchange and skill enhancement program.

RUFORUM supports training at the Masters and PhD level through its *Competitive Grant System*. There were 14 recipients of the first competitive grants in 2004, and 18 in 2005. The training program is open to students outside member countries. It is currently training students from Rwanda and the Democratic Republic of Congo. There are on-going efforts to develop programs for Central and West Africa. The thematic research areas are:

- Understanding farmer organizations and expanding their capacities for service provision;
- Strengthening breeding, biotechnology, and seed and breed systems;
- Revitalizing African traditional crops and exploring their roles in contemporary diets;
- Strengthening natural resources management through improved agroforestry and soil and water management;
- Sustainable management and conservation of fragile rangelands and cultivated drylands through focused research and community-based interventions to enhance quality of life of the rural poor;
- Harnessing opportunities for postharvest management, value addition, and commercialization;
- Strengthening local government planning and decision-making through Geographical Information Systems (GIS) and other planning tools;
- Strengthening agricultural policies and markets;
- Strengthening capacity of communities and institutions to respond to the HIV/AIDS pandemic; and
- Improving the capacities of national universities for upstream research and outreach.

#### ***University Science, Humanities and Engineering Partnerships in AFRICA (USHEPiA)***

USHEPiA is a university-based network that was set up in 1994 to promote collaboration among African researchers in the generation and dissemination of knowledge, and to build institutional and human capacity. Its initial emphasis was on the development of science and engineering capacity, but it later developed a program in humanities. The overall aim is to produce capabilities for addressing development-related issues in sub-Saharan Africa. The network

currently comprises 8 universities in the seven member countries: Botswana (University of Botswana); Kenya (University of Nairobi and Jomo Kenyatta University of Agriculture and Technology); South Africa (University of Cape Town); Tanzania (University of Dar es Salaam); Uganda (Makerere University); Zambia (University of Zambia); and Zimbabwe (University of Zimbabwe).

USHEPiA concentrates research in fields of particular relevance to Africa's developmental needs. So far, it has offered a total of 56 degree fellowships and developed a peer-reviewed research publication network that targets research on socioeconomic development by young academics. It focuses on training in engineering with a particular interest in promoting engagement of African countries in innovation activities. In its institutional development efforts, it also promotes lecture exchange programs, short courses, collaborative research projects, and exchange of external examiners. USHEPiA aims to transform centres of excellence into networks of excellence.

### **Summary of African-based networks for research and training**

This section discusses the networks that are reviewed earlier. The networks are engaged in both policy research and training, although the degree to which these activities are carried out varies across the networks. The section presents other networks that undertake similar activities, although most of them are inclined toward training with little or no emphasis on policy research. It also presents research institute-based networks for STI policy research, which play an important role in policy advocacy, particularly in agriculture. Other international networks that support STI policy research and advocacy are mentioned.

#### ***Reviewed networks***

Three of the seven reviewed networks carry out research that directly targets STI policy — ACTS, ATPS, and RUFORUM. The role of AERC, CODESRIA and ERNWACA on implicit STI policy cannot be undermined. Although USHEPiA focuses on training, its role is critical in addressing the challenge of strengthening indigenous research and innovative capabilities for direct engagement in the exploitation and generation of technology. The role played by USHEPiA is no doubt relevant to the African context. A report commissioned by IDRC and other partners concluded that *without sufficient knowledge and skills in many areas, including science and technology, developing countries could find it increasingly difficult to meet their needs effectively* (Farley 2005). Knowledge and skills, particularly in the area of design and engineering,

require critical attention to enable African countries to engage effectively in innovative activities — in spite of the relatively weak attention given to this area in terms of the requirements of the continent. There are a few other initiatives that attempt to deal with this lacuna in Africa. For example, the African Network of Scientific and Technological Institutions, coordinated by UNESCO, supports research and training in basic and engineering sciences. It has made important contributions particularly with regard to strengthening S&T training institutions in Africa. Nonetheless, greater efforts across the continent are necessary to ensure that adequate production of design and engineering skills are available, not only for strengthening training institutions, but also for providing support to innovation activities within the industrial and infrastructure sectors.

Another important initiative aimed at creating skills in STI-related areas is currently being undertaken at the continent-wide level. The African Institute of Science and Technology (AIST) will open its doors in September 2008 to offer training in science and engineering, as well as humanities and business. The aim is to produce science, engineering, and entrepreneurship skills for the application and exploitation of knowledge. The training and research activities will be strongly linked to the private sector to ensure the relevance of its teaching and research activities. An important attribute of AIST is that it will also have interdisciplinary centres that will be carrying out research and training at the post-graduate level in new and emerging fields. In addition, there will be an interdisciplinary centre for S&T management. The Sub-Saharan African Learning Network (SSALN) for promoting education and training across the continent will also be established.

To the extent that STI issues permeate a wide array of aspects that influence human development, STI policy research attempts to draw insight from a range of disciplines — including economics, sociology, history, law, science, and engineering. This interdisciplinary approach generally sets the background for one or two themes around which policy research is developed. The main focus of ACTS is on agriculture and environment; whereas, RUFORUM focuses on agriculture. This is perhaps a reflection of the complex relationships that characterize STI issues and may create difficulties of measurement, quantification, and even conceptualization because of intimate feedback loops (Rath 1990). Isolation of focus areas could therefore be an attempt to disentangle some of the difficulties.

The multidisciplinary approach of ATPS does not *a priori* suggest a blurred approach to STI research. Rather, it may be a deliberate attempt to provide

space for engagement of STI research from varied perspectives. It could be viewed as an alternative approach that pursues a transversal approach to STI issues that run across various fields of activity. An example of a transversal issue that runs through different areas (agriculture, health, manufacturing, and infrastructure) is the development of technological capabilities through technological learning across sectors, although approaches may vary depending on specific sectors. Other transversal STI issues related to technological capability building could include quality improvement (value addition) in processes, products, and services and the diversification (expansion of range) of processes, products, and services. Indeed, such an approach could be instrumental in providing complementary knowledge on the impacts of STI on social, environmental, and economic development. However, the review on ATPS does not indicate that this transversal approach is clearly present.

RUFORUM, AERC, CODESRIA, and ERNWACA appear to promote capacity building based on structures that are much more strongly embedded than ACTS and ATPS. The direct emphasis of ACTS and ATPS on STI policy research is of particular importance, although the ability of both organizations to strengthen capacity building in STI policymaking appears to be limited by the inherent structures of the STI environment. Put differently, the ability to support STI policymaking and policy-research capacity invariably depends on the extent to which human capabilities in other STI-related activities exist, including technology and innovation-management capacities in enterprises. In the African context, it would be difficult to conclude that such human capabilities exist in abundance.

Table 2 provides a list of some of the existing STI policy and research networks, and provides information on their areas of focus. The reviewed networks generally aim to provide both training and evidence-based policy research. Most of the other networks that are presented in the table mainly carry out training activities. Their role cannot be undermined in a sub-Saharan African context that suffers from shortages in human knowledge and skill in STI-related areas. It is important to note that the Union Economique et Monétaire Ouest Africaine (UEMOA) supports a large number of networks (networks and centres of excellence) such as R.A.BIOTECH in the francophone West African region, that focus on training along disciplinary lines. The University of Ouagadougou hosts a number of the UEMOA networks, including the International Institute for Water and Environmental Engineering, which is poised to become an affiliate centre of excellence with the African Institute of Science and Technology in water and environment.

**Table 2.** Existing STI policy and research networks in Africa and their areas of focus.

<b>Reviewed Networks</b>	<b>Area of Focus</b>
African Centre for Technology Studies (ACTS)	Agricultural and Environmental Sciences
African Economic Research Consortium (AERC)	Economics
African Technology Policy Studies Network (ATPS)	Multidisciplinary
Council for the Development of Social Science Research in Africa (CODESRIA)	Social Sciences
Education Research Network for West and Central Africa (ERNWACA)	Education
Regional Universities Forum for Capacity Building in Agriculture (RURAFORM)	Agriculture
University Science Humanities and Engineering Partnerships in Africa (USHEPiA)	Science, Engineering and Humanities
<b>Other Networks</b>	<b>Area of Focus</b>
Africa Array	Geosciences
Africa Earth Observatory Network (AEON)	Earth Sciences
African Centre for Crop Improvement (ACCI)	Agriculture (Plant Breeding)
African Clothing and Footwear Research Network	Industrial innovation
African Mathematics Millennium Science Initiative (AMMSI)	Mathematics
African Network of Scientific and Technological Institutions (ANSTI)	Basic and Engineering Sciences
Biosciences Eastern and Southern Africa (BECA)	Biotechnology
Centre d'Etude Regional pour l'Amélioration de l'Adaptation à la Secheresse (CERAAS)	Agriculture and Biosciences
Collaboration Masters Programme in Agriculture and Applied Economic in Eastern, Central and Southern Africa (CMAAE)	Agriculture and Economics
Ecole Inter-Etats d'Ingénieurs de l'Equipeement Rural (EIER)	Science and Engineering
In-Depth Network	Demography, statistics (in health)
Internation Centre of Insect Pyisiology and Ecology (ICIPE)	Crop and Insect Science
Natural Products Research Network for Eastern and Central Africa (NAPRECA)	Chemistry
Research ICT Africa	ICT (regulation and applications)
Réseau Ouest Africain de Biotechnologies (R.A.BIOTECH)	Biological and Biochemical Sciences
Southern and Eastern Africa Network of Analytical Chemists (SEANAC)	Analytical Chemistry

### ***Research institute-based networks for STI policy research***

Public policymaking in sub-Saharan Africa also draws support from other forms of networks. In particular, networks based on public research institutes have an important role in policy advocacy and research activities. Public research institute-based networks that are progressively moving away from humanitarian interventions toward more sustainable research and policy activities are mainly in the area of agriculture. Some of these networks include: the Forum for Agricultural Research in Africa (FARA); the Association for

Strengthening Agricultural Research in Eastern and Central Africa (ASARECA); and the Food, Agriculture and Natural Resources Policy Analysis Network (FANPRAN). A brief profile of each of these networks is provided in Table 3.

**Table 3.** Research institute-based networks for STI policy research.

The **Forum for Agricultural Research in Africa**, is an umbrella organization bringing together and forming coalitions of major stakeholders in agricultural research and development in Africa. FARA complements the innovative activities of national, international, and subregional research institutions to deliver more responsive and effective services to its stakeholders. It plays advocacy and coordination roles for agricultural research for development; whereas, the national agricultural research systems (NARSs), advanced research institutions (ARIs), and international agricultural research centres (IARCs) develop improved technologies along the research-to-development continuum in their respective countries and coverage areas (source: <http://www.fara-africa.org/>)

The **Association for Strengthening Agricultural Research in Eastern and Central Africa** (ASARECA) is a non-political organization of the national agricultural research institutes (NARIs) of ten countries: Burundi, Democratic Republic of Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania, and Uganda. ASARECA seeks to enhance productivity, value addition, and competitiveness of the regional agricultural research system by sponsoring creative, innovative, and high-quality regionally coordinated research projects. These projects must promise results and outcomes that are demonstrably communicable to end-users and enhance communication between researchers and end-users in the region. ASARECA aims to increase the efficiency of agricultural research in the region so as to facilitate economic growth, food security, and export competitiveness through productive and sustainable agriculture (source: <http://www.asareca.org/>)

The **Food, Agriculture and Natural Resources Policy Analysis Network** (FANPRAN) is a Southern Africa Development Community (SADC) initiative that focuses on: improving policy research, analysis, and formulation on key themes in the southern Africa region; developing human and institutional capacity for coordinated policy dialogue; and improving policy decision-making through the generation, exchange, and use of policy-related information. In recent years, FANPRAN has placed increased emphasis on managing policy dialogues and knowledge management to complement its research and analysis roles. It works through nodes in the member countries that comprise stakeholders from government, private sector, farming unions, policy-research institutions, and nongovernmental organisations. The nodes convene in-country stakeholder consultations to define policy agendas, undertake policy research, and conduct policy advocacy (source: <http://www.fanrpan.org/>)

The STI policy and research environment also benefits from international research initiatives. A notable example of such an initiative is the Consultative Group on International Agricultural Research (CGIAR), which operates fifteen research centres. Four of which are located in sub-Saharan Africa: the International Institute of Tropical Agriculture (IITA); the International Centre for Research on Agro-Forestry (ICRAF); the International Livestock Research Institute (ILRI); and the African Rice Centre (WARDA). The centres have had considerable success with a number of improved technologies, and they are increasingly focusing their interventions on more sustainable agricultural development activities. Other international networks that carry out STI policy

research and advocacy for developing countries include the Academy of Sciences for the Developing World (TWAS) and the United Nations Commission for Science and Technology Development (UNCSTD).

The relevance of STI policy research rests within its ability to influence STI policies for the enhancement of sustainable development. This requires that linkages between STI policy researchers and STI policymakers go beyond interaction and communication between the two groups. Although such interactions may be useful in developing the STI awareness of policymakers, which is a necessary condition for providing prominence to STI issues, it is not sufficient to ensure that STI policies will be successful in facilitating the creation of desirable impacts on society. The work of the STI policy researchers must adequately inform the tasks of policymakers in promoting the utilization and generation of knowledge. The efficiency with which policymakers promote knowledge utilization and generation is closely related to organizational and institutional arrangements. An important role of STI policy research, therefore, relates to its ability to provide practical solutions for creating and strengthening mechanisms for knowledge flow and exploitation to achieve desired outcomes.

## **STI policy environments of selected countries**

The exploitation, generation, and generalized use of knowledge involve complex interrelationships that influence knowledge flow through interactive learning. These complex interrelationships occur within particular social, political, policy, economic, and institutional contexts. This section provides an overview of institutional context of STI policymaking in a selected number of African countries. An overview of STI governance structures in four sub-Saharan African countries is followed by a brief analysis of the STI policy environments in Africa.

### **Governance structures for STI activities**

#### ***Senegal***

S&T activities in Senegal focus largely on agriculture and health, and continue to reflect the system that was inherited at independence. The creation of the Directorate for Scientific and Technical Affairs in 1968 was the first attempt to organize S&T activities. The Ministry of Scientific and Technical Research was created in 1983 then abolished in 1986. The coordination of S&T research resumed within the *département ministériel de plein exercice* in 1995. S&T research coordination activities were later attached to the Ministry of Higher Education, which became the Ministry of Higher Education and Scientific Research in 2000. A full ministry to oversee S&T activities was reinstated in 2002 — the Ministry of Science and Technology Research. The ministry has three main research directorates: scientific research; technology research; and biotechnology research. The ministry has formulated a new strategic plan for 2006–2010. The Senegalese Academy of Science and Technology plays an advisory role on national S&T development.

Research activities are mainly conducted by the public-sector research institutes such as the Senegalese Institute of Agricultural Research (ISRA), and the universities such as Université Cheikh Anta Diop de Dakar (UCAD) and Université Gaston Berger (UGB). Most public research facilities in Senegal deal with agriculture and health. Nevertheless, the new strategic plan for S&T prioritizes information and communication technologies (ICTs), biotechnologies, textile manufacturing, aquaculture, nuclear science, and laser technologies despite the fact that the private sector performs little research. Senegal recognizes the importance of S&T in socioeconomic development, but the creation of a well coordinated system to achieve the intended benefits has been a challenge.

## **Ghana**

Ghana's attempts to integrate S&T in its socioeconomic development can be traced back to 1957 when it became the first black African Member State of the then colonial sub-Saharan network for S&T, the Commission for Technical Cooperation in Africa South of the Saharan (CCTA). The Research Act (No. 21) was enacted in 1958, and the National Research Council (NRC) was established in 1959. Efforts to strengthen the coordination of S&T activities led to the creation of the Ministry of Industries, Science and Technology (MIST) in 1979. MIST was renamed the Ministry of Environment and Science (MES) in 2001 and finally dissolved in 2006. The S&T docket now falls within the Ministry of Education and Sports.

A number of public and private research institutions have been established. The Ghana Atomic Energy Commission (GAEC) and the Council for Scientific and Industrial Research (CSIR) are the main public research bodies, established soon after independence in 1957, and comprise various institutes. Research is also carried out in higher education and in private-sector research institutes. Private research institutes include the Centre for Economic Policy Analysis (CEPA) and the Kumasi Institute of Technology and Environment (KITE), which is involved in energy research.

Ghana is one of the few African countries with a dedicated focus on STI research for policymaking. STI policy research is conducted by a CSIR institute, the Science and Technology Policy Research Institute (STEPRI). STEPRI has five STI policy programs: biotechnology policy studies; policy studies and waste management; technology assessment studies; technology-transfer management studies; and S&T policy-management studies. STEPRI also carries out a human resource development program in a number of STI policy areas. STEPRI assisted in the development of the Ghana Science and Technology Policy document (2000) and the set up of the framework for the implementation of a new structure for the management of S&T in Ghana.

Ghana has established a relatively considerable S&T infrastructure. However, the achievement of substantial impact on socioeconomic developed appears to face various challenges including the coordination of S&T activities and the absence of clear policies on S&T.

## **Kenya**

Kenya's post independence S&T research activities were initially carried out under the framework of the East African Community (Kenya, Uganda, and Tanzania) based on structures created in the colonial period. A national framework was developed with the enactment of the Science and Technology Act, Chapter 250 of the Laws of Kenya in 1977. The National Council for Science and Technology was established to coordinate research and guide S&T policy and strategies.

The Ministry of Regional Development, Science and Technology was set up in 1982 to oversee S&T activities. It was later replaced by the Ministry of Research and Technical Training in 1987, which became the Ministry of Technical Training and Applied Technology in 1990, was renamed the Ministry of Technical Training and Technology in 1992, and then merged with the Ministry of Education in 1999 to become the Ministry of Education, Science and Technology. In all these changes, the docket of S&T was a department within the various ministries with limited room for articulation. The Ministry of Science and Technology was created in 2005 and is made up the Directorate of Technical Education, the Department for Research and Development, and the semi-autonomous National Council for Science and Technology.

Research is mainly conducted by public research institutes, most of which were set up in the early 1980s and include: the Kenya Medical Research Institute (KEMRI); the Kenya Agricultural Research Institute (KARI); and the Kenya Industrial Research Development Institute (KIRDI). Research is also carried out by universities, the private sector, and public-private research bodies such as the Tea Board of Kenya. Most of the research is concentrated in agriculture and health.

Kenya has made a number of notable advances in research, particularly in agriculture and health. However, strategic coordination of STI activities to ensure widespread benefits has been lacking. There has been scant effort geared toward the assessment of the impact on socioeconomic development of investment in the research institutes. The Strategic Plan 2007–2012 emphasizes evidence-based policymaking, technical education, and private-sector participation in STI.

## **Zambia**

The Department of Science and Technology in the Ministry of Science, Technology and Vocational Training (MSTVT) is responsible for the coordination

of all aspects of S&T in the country. The Department of Science and Technology produced the National Policy on Science and Technology in 1996 and facilitated the enactment of the Science and Technology Act No. 26 of 1997. The department was also responsible for transforming the National Institute for Scientific and Industrial Research (NISIR) to the National Council for Scientific Research in 1998, establishing the National Science and Technology Council in 2000, and creating the National Technology Business Centre (NTBC) in 2001.

Zambia's research activities are mainly carried out by the National Council for Scientific Research in the areas of livestock production and disease, food technology, textiles, industrial and building minerals, forestry and underutilized plants, safe use of nuclear energy, water, and energy. The University of Zambia (UNZA) and research departments within ministries (Agriculture, Food and Fisheries; Environment and Natural Resources; Mines and Mineral Development; and Health) also engage in significant research activities within the public sector. Private-sector research is also active in Zambia. ZamSeed and the Maize Research Institute (MRI), which conduct maize research, and Dunavant, which focuses on cotton research, accounted for 14% of agricultural research spending in 2000.

### **Analysis of the STI policy environments in Africa**

S&T research activities in Africa are generally reminiscent of pre-independence research that focused on agriculture and health. However, although national documents that define research priority areas often refer to a range of other sectors such as industry, energy, education, environment, natural resources, and information and communication technology. However, in health and agriculture, there is a clear shift in the main objectives of research in the two sectors, which is now targeted at the improvement of the socioeconomic welfare of the local communities. It may be argued that the emphasis on the two sectors is an attempt to address the most critical aspects of many African economies, although the continent continues to face major challenges with regard to food security and preventable diseases. Research in agriculture and health is for the most part carried out within public research institutes that often also play the role of intermediate organizations. However, their research efforts tend to be disconnected from the demand of the sectors, and in particular, they have not been successful in stimulating demand for their research from the private sector. To some extent, the weak articulation of demand for research output impinges on the innovation activities of firms.

With regard to industrial and infrastructure sectors, approaches for generating knowledge for socioeconomic development differ from those that are relevant for the health and agriculture sectors: *the key STI-related actors, interactions, knowledge bases and learning process in industry/infrastructure sectors are very different from those in other sectors — e.g., in agriculture and health* (Bell 2007). Nevertheless, the attention given to industry and infrastructure, which rarely goes beyond an allusion to their importance in policy document, is not reflective of the potential opportunities for the development that can be derived from these sectors.

STI activities in Africa have generally suffered from intermittent support and frequent changes in the institutional organizations. This situation may have interfered with the ability to strategically focus on STI activities over sufficient periods of time to ensure that they progressively become demand-driven — based on emerging opportunities for the private sector to engage in the innovation process. Within such policy environments, modalities vary randomly, priorities may be divergent, and conflicting policies may exist. It is difficult to expect statements within policy documents resolving to promote STI in all sectors of the economy to result in much progress in terms of creating a dynamic STI environment.

In many African countries, the STI systems may be viewed as nascent. Nurturing and transforming them into dynamic systems for economic growth will entail tremendous efforts to create arrangements that promote strategic engagement in STI activities, and in particular, strengthen linkages to enhance knowledge generation and application by industry. The STI focus on public research institutes to trigger dynamic innovation processes is perhaps overly ambitious. Firms play a major role in developing a dynamic innovation system and therefore, require significant attention in STI policies. Effective ST&I policy research is important in providing evidence-based research for designing and implementing coherent innovation policies that provide a direction for developing dynamic systems of innovation.

## **Discussion**

Undeniably, STI activities in agriculture and health occupy an important place in addressing development challenges in many African countries. Nevertheless, substantial benefits could emanate from providing dedicated attention to the industrial and infrastructure sectors. Some of the key factors that have been found to contribute significantly to the rapid economic transformation of emerging economies relate to major efforts in these sectors:

- massive investments directed toward basic infrastructure, including roads, energy, telecommunication, schools, water, and sanitation, and investments strategically targeted to serve as a basis for technological learning;
- targeted development of technological capabilities within firms, including in countries characterized by small- and medium-sized enterprises; and
- government support to higher education institutions, particularly in engineering and technological sciences, as well as to professional engineering and technological associations.

These three elements are distinctly important, but complement each other to the extent that they attempt to deal with both demand and supply for technological knowledge.

From a broad perspective, challenges and opportunities for STI policy research are linked to the central element of a dynamic innovation process, and more specifically technological learning. However, in the context of many African countries, various capacities that critically contribute to the creation of a dynamic innovation systems are absent or weak at four distinct levels: government policymaking; education and training within the formal education system; technological capability building within firms; and research institutes and knowledge intermediate organizations. These four aspects are discussed in the following sections.

### **Designing coherent STI policies**

The importance of formulating and implementing both implicit and explicit policies for the promotion of STI activities cannot be overemphasized. The capacity of governments to formulate coherent policies based on distinct development strategies remains a major challenge. This not only affects the ability to implement, monitor, and adapt the policies adequately, but is also in part responsible for the apparent lack of prioritization of STI activities. For

example, although the concentration of research in agriculture and health is to some extent motivated by the desire to address specific challenges of major importance to the development of many countries, it may also be related to the apparent ease of following a chartered path. Structures for STI research in agriculture and health, although they may have had to undergo adaptations, existed in the colonial era. In addition, even within agriculture and health, governments rarely provide more than maintenance resources to the public research institutes. Research funding is provided by donors — perhaps understandably, due to the resource constraints in many African countries. However, the definition of research priorities also tends to be inclined toward donor priorities. Although it is difficult to dismiss the possibility of donor interest to promote their own research agendas, it can also be argued that the capacity to design locally defined priorities is weak. Despite the bias of research toward agriculture and health over decades, major challenges related to food security and preventable diseases abound.

Other effects of the inability to define coherent policies that adequately prioritize STI activities may be related to:

- the observed random changes in institutional arrangements in the past decades;
- the inability to step out of the chartered waters and integrate STI activities in the industrial and infrastructure sectors, despite their large potential for technological capability building that could create substantial resources and perhaps provide an opportunity to better support health and agricultural STI activities;
- the broad allusions to the importance of STI activities for socioeconomic development within policy documents and generally vague definitions of priority areas; and
- attempts to align national policies to international laws without sufficient exploration of their merits and demerits. For example, it is common to find statements in policy documents that advocate the strengthening of intellectual property rights as a strategy for promoting a dynamic system of innovation.

Developing capacities to design coherent explicit, as well as implicit, STI policies is critical to creating opportunities for strengthening STI activities. Even in countries that have managed to develop fairly strong S&T infrastructure, suitable policies are required to ensure that the technological capacities are translated into knowledge-intensive, value-added goods and services. Most countries need to focus their attention on policies for promoting

technological capability building and, in particular, technological learning in their local enterprises, which takes place through the performance of complex tasks that involve engagement in innovation-related activities. In general, development of capacities to design coherent policies that clearly identify weaknesses and provide adequate strategies could go a long way to providing opportunities for deriving STI benefits.

### **Education and training within the formal system**

Firms tend to adjust the technology they employ to the level of skills capacity produced by the formal education system (Lall 1992). However, the production of labour with a capacity to engage in knowledge-intensive activities entails more than churning out high-level scientists and engineers from universities. For many countries in Africa, developing technical and vocational skills is of higher priority, particularly in engineering and technical skills. Effective performance of technology-development tasks by high cadre scientists and engineers generally requires the support of an adequate number of medium cadre staff with requisite technical skills. Inadequate availability of technical skills to support high-cadre skills cannot only result in the inability to effectively engage in innovation activities, but also in massive brain drain of the scientists and engineers.

For the supply of skills by the education and training system to be effectively absorbed into industry, the skills must also match the requirements of industry. Technical and vocational training provide the flexibility required to rapidly respond to market signals required by the private sector. However, the supply of adequate skills must be met by a demand that offers opportunities to further develop these skills within productive employment and by performing innovation development-related tasks. This aspect is highly complemented by high-cadre skill, particularly in design and engineering. In an economy with an adequate supply of both high- and medium-cadre technical skills, the ability to attract foreign investment is enhanced. But, more importantly, the country is able to develop the capabilities required to access, exploit, and apply new knowledge that comes with foreign investment. The existence of skilled workers at both levels (high and middle cadre) is important in attracting new knowledge into the economy. It also increases the demand for technical skills and for skills in design and engineering. This means that investments in education and training do not result in a situation of brain drain with hardly any chance of drawing the benefits of brain circulation. The large supply of technical skills in engineering, and the strong demand for them within enterprises, have been

critical in helping countries, particularly in Southeast Asia, to make structural changes.

### **Technological learning within enterprises**

Even in the presence of substantial levels of technical skills, the demand for them by the private sector and their subsequent development through technological learning may be limited by the ability of firms to develop technological capabilities. The acquisition and generation of knowledge within an economy takes place effectively if enterprises develop the capacity to exploit knowledge for the production of higher value goods and services. This technological capability is the element of the technology-acquisition process that is responsible for creating an interface between the existing knowledge within a firm and knowledge that is new to the firm. It facilitates knowledge generation within the firm as well as the ability of the firm to acquire and exploit new knowledge for the production of higher value-added goods and services. This involves a structured process that is managed by the enterprise and requires strategic investment in technological learning that is supported by engaging skills in innovative technology-developing tasks. This form of learning within firms does not occur automatically; substantial investments are required to ensure that opportunities are created for generating new knowledge that adds to the technological capabilities of the firm.

The importance of technological learning within firms in many African countries attracts little attention despite its critical role in providing the ability to harness STI benefits for socioeconomic development. It develops the innovation dynamism within the firm and creates a competitive advantage that is characteristic of a well-functioning innovation system. In many African countries, efforts to promote STI activities generally target public research institutes and expansion of higher education. These supply-side measures are based on the assumption that demand for the output of research institutes and higher education institutions already exists. However, such measures are not likely to lead to more robust innovation activities within firms unless they are complemented by efforts to increase the private sector's capacity to innovate and increase its demand for knowledge.

The challenge of promoting the development of technological capabilities of firms lies in the non-appropriability and externalities associated with knowledge. In many African countries, the problems of building technological capabilities within enterprises are compounded by the high risk associated with developing human technological capabilities through technological learning. This process involves substantial investments, but where the

technological learning process is not well entrenched, the risk of poaching tends to constrain investment in technological learning. Loss of technological competencies through poaching generally implies loss of investment and the need to reinvestment in technological learning due to the relatively small pool of such competencies. The possibilities for “counter-poaching” are limited, and this may have far-reaching adverse effects on the expansion and deepening of technological learning. Learning within enterprises may be restricted to specific in-house requirements that offer minimum diversity for technological creativity in an attempt to limit the loss of investment associated with the loss of technological competencies. This situation may in part explain why many African countries face a significant loss of science and engineering skills through brain drain despite the fairly modest quantities produced by the formal education and training system. In addition, the situation may also be attributed to the view by local entrepreneurs that there is no shortage of science and engineering skills. These challenges could be mitigated by reorganizing structures in the public sector to promote private-sector innovation. Specific mechanisms could be identified through STI policy research targeted at technological learning. In particular, the research could take account of the variations that exist across sectors in assisting in the definition of suitable arrangements.

### **Research institutes and intermediate organizations**

Efforts to support STI research activities tend to focus on public research institutes. They often have the dual role of carrying out research and acting as intermediate organizations. At least three constraints can be observed with regard to this structure:

- government funding to public research institutes is generally for maintenance. Research funding is provided by donors and they often determine research priorities. These two aspects offer little flexibility for the research institutions to determine and respond to research priorities of the private sector — research is generally targeted at dealing with public threats. In their role as intermediate organizations that are expected to promote knowledge exploitation and application by the private sector, their impact is dismal;
- public research institutes generally focus on agriculture and health. Public research in the industrial and infrastructure sectors is either limited or absent, although it is not likely to contribute much to the innovation dynamism of an economy. New structures and arrangements that directly target innovation within the private sector may be more

useful in terms of creating opportunities for drawing STI benefits from knowledge exploitation in these sectors; and

- the research institutes generally do not link research to teaching — their ability to contribute to the creation of new researchers is limited. The process of knowledge generation ideally involves training the next generation of scientists. In addition, research is carried out along specific disciplines. Multi-disciplinary problem-solving research is not common, despite the changing nature of STI activities that increasingly draw knowledge from different fields.

In many African countries, enhancing the performance of research institutes may require a change in the way in which the research activities are organized — including in the main sectors of agriculture and health. In addition, greater attention is required for knowledge generation in industrial and infrastructure sectors, which may involve creating new structures attuned to the sectors. For example, a major constraint facing many African countries is the difficulty of creating technological competencies through technological learning because of the high risk of losing them to competing firms. New arrangements targeting clearly defined gaps could play an important role by assisting in the development of technological competencies.

## **Concluding remarks**

### **Summary of findings**

The bulk of STI policy research and advocacy in Africa takes place in agriculture. Other areas that benefit from relatively significant policy research include health and education. Although the relevance of these areas is evident, their emphasis could in part be attributed to the existence of structures, particularly for health and agriculture, set up during the colonial period and hence the possibility of some ease in following a charted path.

Policy research in education has mainly focused on curricula development and access, particularly at the primary level. Although increasing efforts are now being directed to tertiary education, the emphasis is mainly on expansion of universities, despite the soaring rates of unemployment for graduates. Formally, university education targeted the provision of an administrative cadre in the public administration, and that objective has been achieved in many countries. A shift in the education policy for tertiary education is required. Greater attention is required to boost the production of technical skills in technical training colleges and polytechnics, enhance the production of design and engineering skills for employment and further development in the private sector, and reorient university education toward the needs of the private sector.

Economic-policy research has also attracted significant attention on the continent over the last two decades. With the economic crises in many African countries during the 1980s and 1990s, as well as increased globalization impacts, major efforts were directed to the development of economic-policy research capacity. The African Economic Research Consortium is a notable effort in this direction, and it has been associated with the improved capacity to produce high-quality economic policy documents in many African countries.

Efforts to promote science, technology, and innovation for socioeconomic development in Africa have so far led to sporadic results. This is evident in structural inertia of STI policymaking bodies in many African countries, characterized by random changes in STI governance coupled with the inherent view of STI as strictly the supply of S&T. Admittedly, the complex relationships that characterize STI issues may have contributed to the lack of clear articulation and consistent prioritization of STI issues in African countries. However, the potential gains from STI continue to draw attention to the need to

understand the complex relationships. Based on the main objective of ATPS, to provide STI policy-research findings to policymakers and other stakeholders, it is worth noting that it is one of the few networks that attempts to address these complex STI issues. Nevertheless, what appears more important, over and above the existence of STI policy-research networks, is the match between the focus in their activities and the latent STI issues that are generally difficult to address, but are key to promoting or undermining the ability to benefit from science, technology, and innovation. Put differently, the existence of the few STI policy-research networks in Africa is of relevance particularly with regard to policy advocacy on the technicalities of international laws affecting STI activities. However, their efforts are likely to have little impact on the creation of dynamic STI environments unless inherent structural aspects are addressed.

### **Implication for STI policy research**

A notable effort to support STI policy research in Africa is that provided by the International Development Research Centre (IDRC). The inception report of IDRC's Innovation Policy and Society (IPS) program area states that: *IPS-supported research will improve knowledge of the social, environmental and economic impacts of science, technology and innovation policies from a Southern and also a marginalized perspective.* Although the scope for intervention appears to be fairly broad, and could engender blurriness in the specification of critical STI-related issue for Africa, it is nonetheless one of the major efforts that provides room to address development challenges in Africa through STI. Strengthening the development impact of STI policy research in Africa appears to require strong support at two levels:

#### ***STI policy-research themes***

Due to the nature of STI issues, which could be viewed as somewhat amorphous, it is increasingly common to accept broad definitions of STI issues. They cut across a wide spectrum and it is now recognized that implicit STI policies influence the effectiveness of explicit STI policies. Therefore, there is an increased interest in a multidisciplinary approach to STI policy research. That notwithstanding, it appears that STI policy-research themes are generally inclined toward an approach based on specifically defined areas (e.g., water, environment, agriculture, and energy). Although the rationale behind this approach can be justified, it appears that research along transversal lines could provide a significant contribution in the African context.

One such transversal aspect is related to the limited ability of many African countries to access, exploit, generate, and apply knowledge. From a broad perspective, research in such aspects would be useful in providing specific information on underlying structural aspects that are major drawbacks in efforts to harness benefits for STI. For example, it would be useful to provide information on existing gaps and structural inertia across sectors. This information should be expressed in terms of the ability to engage in technological learning, which is linked to important aspects of quality improvement and diversification of products and services. It would not only assist in providing clarity on how technological learning, which can vary widely across sectors, need to be strengthened, but also on how production of technical skills in tertiary education could be improved to meet the requirements for innovation within enterprises. This involves providing clear guidance for the production of design and engineering skills as well as technical operating skills by universities, technical training colleges, and polytechnics.

### ***STI-related human capacities***

Two critical gaps exist with regard to the STI-related human capacities. To ensure that STI issues become strongly embedded in public policymaking in African countries, the governance structures must have the requisite knowledge for STI policymaking. Although many countries continue to rely on ephemeral support (including from international organizations), particularly during the drafting of STI policy documents, the creation of inherent long-term capacities does not attract much attention. It is not surprising that many policy documents are generally not implemented, often out-dated, and tend to lack focus. In addition, STI governance structures tend to undergo random changes. These problems could in part be attributed to limited knowledge on the articulation and implementation of STI policies. Efforts to strengthen the STI policymaking process through policy research and advocacy by STI policy-research networks can only, at best, be partial. They can also only be expected to be effective to the extent that long-term human capacities exist for STI policymaking, implementation, and monitoring within the STI governance bodies.

There is a strong case to support training across the continent on public policy for S&T. To achieve a reasonable outcome, well-entrenched training structures and cost-effective approaches, such as those employed by AERC in producing capacity for economic policymaking are necessary. Although workshops for practitioners and policymakers have their role, training at the Masters level to

provide a firm understanding of the dynamics of innovation processes cannot be undermined. The amorphous nature of STI is in part related to the increasingly rapid pace with which global transformations occur. Therefore, a strong understanding of the dynamics of STI-related aspects is critical within the STI governance machinery. This long-term view of strengthening STI policymaking, implementation, and monitoring may be less attractive than the other complementary approaches, such as policy advocacy or policy research by networks. However, it is likely to lead to more tangible progress in terms guiding countries in accessing socioeconomic development.

Another major gap that needs to be address is with regard to training in technology and innovation management. Important as it may be, designing and implementing coherent STI policies is not in itself a sufficient condition for stimulating innovation activities. As pointed out previously, firms lie at the heart of a dynamic innovation process within an economy. The ability to access, exploit, generate, and apply knowledge does not occur more or less automatically with the provision of coherent policies. Training that supports the capacities of entrepreneurs in technology and innovation management would also be instrumental in achieving the desired STI-related outcomes.

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