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GOVERNING INNOVATION

African countries are increasingly focusing on promoting regional economic integration as a way to stimulate economic growth and expand local markets. Considerable progress has been made in expanding regional trade through regional bodies such as the Common Market for Eastern and Southern Africa (COMESA) and the East African Community (EAC). There are six other such Regional Economic Communities (RECs) that are recognized by the African Union as building blocks for pan-African economic integration. So far, regional cooperation in agriculture is in its infancy and major challenges lie ahead. This chapter will explore the prospects of using regional bodies as agents of agricultural innovation through measures such as regional specialization. The chapter will examine ways to strengthen the role of the RECs in promoting innovation. It adopts the view that effective regional integration is a learning process that involves continuous institutional adaptation.[1]

Through extensive examples of initiatives at the national or cross-border levels, this chapter provides cases for regional collaboration or scaling up national programs to regional programs. Africa's RECs have convening powers that position them as valuable vehicles. That is, they convene meetings of

political leaders at the highest level, and these leaders take decisions that are binding on the member states; the member states then regularly report on their performance regarding these decisions. Such meetings provide good platforms for sharing information and best practices. Africa's RECs have established and continue to designate centers of excellence in various areas. COMESA, for instance, has established reference laboratories for animal and plant research in Kenya and Zambia. Designation of centers of excellence for specific aspects of agricultural research will greatly assist specialization within the RECs and put to common use the knowledge from the expertise identified in the region.

Regional Innovation Communities

Regional integration is a key component of enabling agricultural innovation because it dismantles three barriers to development: "weak national economies; a dependence on importing high-value or finished goods; and a reliance on a small range of low-value primary exports, mainly agriculture and natural resources."[2]

Physical infrastructure creates a challenge for many African countries but also presents an opportunity for the RECs to collaborate on mutually beneficial projects. In many parts of Africa, poor road conditions prevent farmers from getting to markets where they could sell their excess crops profitably. Poor road conditions include the lack of paved roads, the difficulty of finding transportation into market centers, and the high cost of having to pay unofficial road fees to either customs officials or other agents on the roads. These difficulties become more extreme when farmers have to get their crops across international borders to reach markets where sales are profitable.

The inability to sell crops, or being forced to sell them at a loss because of high transportation costs, prevents farmers

from making investments that would increase the quantity and quality of their production, since any increase will not add to their own well-being, and the excess crops may go to waste. This is a problem where national governments and regional cooperation offer the best solution. Regional bodies, with representation from all of the concerned countries, are placed to address the needs for better subregional infrastructure and standardization of customs fees at only a few locations.

Having countries come together to address problems of regional trade, and particularly including representatives from both the private and public sectors, allows nations to identify and address the barriers to trade. The governments are now working together to address the transportation problem and to standardize a regional system of transport and import taxes that will reduce the cost of transporting goods between nations. This new cooperation will allow the entire region to increase its food security by capitalizing on the different growing seasons in different countries and making products available in all areas for longer periods of time, not just the domestic season. Such cooperation also provides African farmers with access to international markets that they did not have before, since it allows them to send their goods to international ports, where they can then sell them to other nations.

Regional economic bodies provide a crucial mechanism for standardizing transport procedures and giving farmers a chance to earn money selling their products. This cooperation works best when it happens both between countries and between the private and public sectors. Having multiple actors involved allows for better information, more comprehensive policy making, and the inclusion of many stakeholders in the decision-making process. Governments and private actors should strengthen their participation in regional bodies and use those groups to address transportation issues, market integration, and infrastructure problems.

Facilitating regional cooperation is emerging as a basis for diversifying economic activities in general and leveraging international partnerships in particular.[3] Many of Africa's individual states are no longer viable economic entities; their future lies in creating trading partnerships with neighboring countries. Indeed, African countries are starting to take economic integration seriously.[4] For example, the re-creation of the EAC is serving not only as a mechanism for creating larger markets but also is promoting peace in the region. Economic asymmetry among countries often is seen as a source of conflict.[5] However, the inherent diversity serves as an incentive for cooperation.

Emerging Regional Research Cooperation Trends

The original Organisation of African Unity (OAU) was transformed and restructured to form the African Union (AU) with a stronger mandate to ensure the socioeconomic development of the continent. The secretariats of the AU Commission and the New Partnership for Africa's Development (NEPAD) were divided into departments that reflect development priorities of the AU. For example, both have offices of agriculture and science and technology (S&T). The AU Commission takes responsibility for formulating common policies and programs of the AU and presents them for approval by heads of state and government. NEPAD, on the other hand, spearheads the implementation of approved policies and programs.

In 2006, heads of state and government approved the Consolidated Plan for African Science and Technology, which is both a policy and a program document for the promotion of S&T in Africa. Since then the AU Commission's Department of Human Resources, Science, and Technology has mobilized participation of member states in a specialized ministerial structure that advises AU heads of states and government on

matters related to S&T. The NEPAD office of S&T managed the implementation of the research program that consisted of flagship programs covering themes such as biosciences, biodiversity, biotechnology, energy, water, material sciences, information and communication technology, space science, and mathematics.

Of the flagship programs, the biosciences program is the most advanced in that it has five regional programs that were developed bottom-up by scientists in the regions. The program has attracted loyal sponsors and some programs are at a stage of transforming their results into promising products. For example, Southern Africa Network for Biosciences (SANBio), which had identified HIV/AIDS as one of its priorities, has been conducting research into the validation of traditional medicines for affordable treatment of HIV/AIDS and HIV-related opportunistic infections. The study obtained very encouraging results. Two peptides with anti-HIV activity have been isolated and currently the study is focusing on developing this lead into a herbal medicine that could benefit HIV/AIDS patients.

Other regions have equally advanced programs that are derived from regional interests. However valuable as these programs appear, they have not captured the interest of governments and local industry enough to leverage local investment. For example, the SANBio program runs on the basis of Finnish and South African funding. This is a major limitation to growth of the programs. An analysis of the problem seems to reveal that the NEPAD science and technology program is bedeviled by its isolation from the local economy—the biosciences-related industry that has both government and related industry vested interests backed by local investment. At this stage, based on the absence of investment in the program, the NEPAD science and technology effort seems divorced from the African reality even though it is framed around African S&T-related problems.

Various research and development programs are being carried out in each of the networks created under NEPAD, such as Biosciences Eastern and Central Africa Network (BecANet), West African Biosciences Network (WABNet), and North Africa Biosciences Network (NABNet). Research programs at SANBio include technology transfer to local communities, especially women, for producing mushrooms using affordable local resources and research in aquaculture systems involving use of plastic sheeting as covers to improve productivity of pond environments for increased fish growth.

BecANet has implemented three flagship and five competitive grant projects in the areas of banana, sorghum, bovine and human tuberculosis, teff, cassava, sweet potatoes, and tsetse and trypanosomiasis. The BecANet hub hosted at least 24 research projects on crops and livestock. The research on trypanosomiasis led to the discovery of a compound that could be used to produce a drug for treating sleeping sickness. This compound was subsequently patented. The results from the work on tracking bush meat in Kenya using DNA techniques at the BecANet hub suggest that bush meat, as whole meat, is not sold within Nairobi, but outside the city. This type of study has wider implications for food recall and traceability in Africa.

WABNet has implemented a flagship project on the inventory and characterization of West African sorghum genetic resources. This project conducted a germplasm collection expedition during which 45 new sorghum accessions were collected from 15 districts including (Upper West Region), Bawku (Upper East Region), and Tamale (Northern Region) of Ghana by November 2009. In Ghana, for example, 245 accessions of sorghum were at a risk of being lost as a result of deteriorating storage conditions in the gene banks. This project was instrumental in recovering about 100 of these accessions. This project had to therefore refocus its objectives on the new collections and on those that had been recovered from the banks. Sorghum nutritional enhancement through mutagenesis and

genomics is inducing mutagenesis through irradiation, with the aim of producing new varieties of sorghum that could be higher yielding and more nutritionally enhanced. Trials on this aspect of the project are still ongoing.

NABNet carried out a flagship project on production of elite biofortified North African barley genotypes tolerant to biotic and abiotic stresses. In addition, the network is implementing the following research projects: multidisciplinary investigation of the genetic risk factors of type II diabetes and its complications in North Africa; biotechnological approaches to protect date palm against major plagues in North Africa; and production of *Bt* bioinsecticides useful for biological control of the phytopathogenic insects and human disease vectors.

Within SANBio, through support from the governments of Finland and South Africa, NEPAD African Biosciences Initiative (NEPAD/ABI) is establishing a bioinformatics center at the University of Mauritius and an indigenous knowledge systems center at the University of North West in South Africa. These centers will enhance capacity building in these domains in southern Africa.

Through the support of the government of Canada and International Livestock Research Institute (ILRI), laboratories at ILRI have been upgraded offering opportunities to African scientists to carry out cutting-edge biosciences research at the BecANet hub. As the facilities became fully operational by the end of 2009, it is expected that there will be an increase in the number of projects being carried out in 2010 onward. The infrastructure upgraded at the BecANet hub can support research in bioinformatics, diagnostics, sequencing, genotyping, molecular breeding, and genetic engineering of crops, livestock, and wild animals and plants.

Within WABNet, NEPAD/ABI has established and furnished offices in Dakar and Senegal and a biotechnology laboratory at the University of Ouagadougou in Burkina Faso. These facilities will enhance coordination, research, and development in the region.

Networking is viewed as an essential component for accelerating capacity building and collaborative research efforts among institutions involved in biosciences in Africa. More endowed biosciences institutions are being linked to less endowed ones in all the regions of the continent. Over the years, thematic research teams have been established, such as ones for improving banana production; for validation of herbal remedies, bioinformatics, fisheries, and aquaculture; and for cereal improvement, just to mention a few. A more important development is that thematic networks are now running across regional and international boundaries and broadening the scope for participating international research programs.[6]

For example, the trypanosomiasis and tsetse fly research network consists of institutions and researchers in the SANBio and BecANet countries. Networking has provided opportunities for young men and women to access training facilities in several countries and subregions. A total of 20 students from post-conflict countries of the Democratic Republic of the Congo, Sudan, Congo Brazzaville, and Burundi are now training for postgraduate qualifications in Kenya and Uganda.

The COMESA region is home to some of Africa's most important fisheries resources. These include, among others, marine systems in the western Indian Ocean, the southeastern Atlantic, the Mediterranean, and the vast freshwater systems of the Nile, Congo, and Zambezi Basins and the Great Lakes found within them. Taken together, COMESA member states have access to a coastline of some 14,418 kilometers, a continental shelf of about 558,550 square kilometers, and a total Exclusive Economic Zone area of about 3.01 million square kilometers, as well as inland waters of about 394,274 square kilometers.

COMESA has identified aquaculture as a priority growth area for achieving the objectives and targets of the Comprehensive Africa Agriculture Development Programme (CAADP) to significantly contribute to food and nutrition security in the

region. In September 2008, member states agreed on the outline of a COMESA Fisheries and Aquaculture Strategy to enable COMESA to scale up their coordinating and facilitative role.

COMESA in partnership with Lake Victoria Fisheries Organization is implementing a program that seeks to maximize economic benefits and financial returns on processed Nile perch through innovation and development of sophisticated value-added products. Currently, with decreasing levels of Nile perch, fish processing establishments are operating well below capacity, sometimes as low as 20% capacity. To remain competitive, companies are seeking to transform by-products or fish fillet waste into high-value products for export through use of innovative processes and production methods.

Three companies are supported by COMESA to achieve this. Interventions have focused on two areas. First, they support companies to develop new products through piloting of new recipes, processes, and production methods while utilizing new or improved technologies. Second, they help fish processing companies to assess food safety aspects of new products developed from fish wastes and the application of appropriate quality assurance and food safety systems based on the Hazard Analysis and Critical Control Point (HACCP) system to address the associated risks. The HACCP is a food and pharmaceutical safety approach that addresses physical, chemical, and biological hazards as a preventive measure rather than inspection of finished products.[7]

The results are encouraging. One company successfully launched frozen fish burgers and established HACCP-based food safety systems that are compliant with EU requirements. As a result, the company has accessed high-value markets in the European Community (EC).

Another product development innovation in the fisheries sector is using Nile perch skin as a raw material for exotic leather products. This has been picked up by COMESA, which has developed a value chain sector strategy for leather and

leather products, part of which is now being implemented under a Canadian-funded Programme for Building African Capacity for Trade. A key issue for the region's competitiveness is innovation in new products and markets for leather products rather than continuing to export raw hides and skins. The fish skin niche market that was identified started in Uganda, at the Crane Shoes factory in Kampala. The use of fish skin began as the factory sought new markets and alternatives to leather to compete with Chinese imports. The key question, however, is how to support the industry to achieve long-term sustainability, which may require a rare form of aquaculture for the Nile perch, which is becoming a rare species in Lake Victoria.

An investment study on Uganda's fish and fish farming industry identified a number of policy measures that are being put in place in order to benefit from the fisheries sector. These include a tripartite Lake Victoria Environment Management Project established to ensure improved productivity of Lake Victoria; support for the Aquaculture Research and Development Institute at Kajjansi; provision of resources to upgrade landing sites and quality control laboratories to meet international standards; and provision of resources to strengthen the Uganda National Bureau of Standards and Inspectorate section of the Fisheries Department.

Fostering the Culture of Innovation

Improving the Governance of Innovation

Promoting a growth-oriented agenda will require adjustments in the structure and functions of government at the regional, national, and local levels. Issues related to science, technology, and innovation must be addressed in an integrated way at the highest possible levels in government. There is therefore a need to strengthen the capacity of presidential offices to integrate

science, technology, and innovation in all aspects of government. In 2010 no African head of state or government had a chief scientific adviser.

The intensity and scope of coordination needed to advance agricultural innovation exceeds the mandate of any one ministry or department. As noted elsewhere, Malawi addressed the challenge of coordination failure by presidential control of agricultural responsibilities. The need for high-level or executive coordination of agricultural functions is evident when one takes into account the diverse entities that have direct relevance to any viable programs. Roads are important for agriculture, yet they fall under different ministries that may be more concerned with connecting cities than rural areas. Similarly, ministries responsible for business development may be focusing on urban areas where there is a perception of short-term returns to investment. The point here is not to enter the debate on the so-called urban bias.[8]

The main point is to highlight the importance of strategic coordination and alignment of the functions of government to reflect contemporary economic needs. Aligning the various organs of government to focus on the strategic areas of economic efforts requires the use of political capital. In nearly all systems of government such political capital is vested in the chief executive of a country, either the president or the prime minister depending on the prevailing constitutional order. It would follow from this reasoning that presidents or prime ministers should have a critical agricultural coordination role to perform. They can do so by assuming the position of minister or by heading a body charged with agricultural innovation. The same logic also applies for the RECs.

The dominant thinking is to create "science and innovation desks" in the RECs. Such desks will mirror the functions of the science and technology ministries at the national level. It is notable that currently no African leaders are supported by effective mechanisms that provide high-level

science, technology, and engineering advice. The absence of such offices (with proper terms of reference, procedures, legislative mandates, and financial resources) hampers the leaders' ability to keep abreast of emerging technological trends and to make effective decisions. Rapid scientific advancement and constant changes in the global knowledge ecology require African leaders at all levels (heads of RECs, presidents, or prime ministers and heads of key local authorities such as states or cities) to start creating institutions for science advice. In 2010 COMESA led the way by adopting decisions on science, technology, and innovation along these lines (see Appendix II). Agricultural innovation could be the first beneficiary of informed advice from such bodies.

Bringing science, technology, and engineering to the center of Africa's economic renewal will require more than just political commitment; it will take executive leadership. This challenge requires concept champions, who in this case will be heads of state spearheading the task of shaping their economic policies around science, technology, and innovation. So far, most African countries have failed to develop national policies that demonstrate a sense of focus to help channel emerging technologies into solving developmental problems. They still rely on generic strategies dealing with "poverty alleviation" without serious consideration of the sources of economic growth.

One of the central features of executive guidance is the degree to which political leaders are informed about the role of science, technology, and engineering in development. Advice on science, technology, and innovation must be included routinely in policy making. An appropriate institutional framework must be created for this to happen. Many African cabinet structures are merely a continuation of the colonial model, structured to facilitate the control of local populations rather than to promote economic transformation.

Advisory structures differ across countries. In many countries, science advisers report to the president or prime minister,

and national scientific and engineering academies provide political leaders with advice. Whatever structure is adopted, the advising function should have some statutory mandate to advise the highest levels of government. It should have its own operating budget and a budget for funding policy research. The adviser should have access to good and credible scientific or technical information from the government, national academies, and international networks. The advisory processes should be accountable to the public and be able to gauge public opinion about science, technology, and innovation.

Successful implementation of science, technology, and innovation policy requires civil servants with the capacity for policy analysis—capacity that most current civil servants lack. Providing civil servants with training in technology management, science policy, and foresight techniques can help integrate science, technology, and innovation advice into decision making. Training diplomats and negotiators in science, technology, and engineering also can increase their ability to discuss technological issues in international forums.

African countries have many opportunities to identify and implement strategic missions or programs that promote growth through investments in infrastructure, technical training, business incubation, and international trade. For example, regional administrators and mayors of cities can work with government, academia, industry, and civil society to design missions aimed at improving the lives of their residents. Universities located in such regions and cities could play key roles as centers of expertise, incubators of businesses, and overall sources of operational outreach to support private and public sector activities. They could play key roles in transferring technology to private firms.[9]

Similar missions could be established in rural areas. These missions would become the organizing framework for fostering institutional interactions that involve technological learning and promote economies of scale. In this context, missions that

involve regional integration and interaction should be given priority, especially where they build on local competencies.

This approach can help the international community isolate some critical elements that are necessary when dealing with such a diverse set of problems as conservation of forests, provision of clean drinking water, and improving the conditions of slum dwellers. In all these cases, the first major step is the integration of environmental considerations into development activities.

Reforming the Structures of Innovation Governance

The RECs offer a unique opportunity for Africa to start rethinking the governance of innovation so that the region can propel itself to new frontiers and run its development programs in an enlightened manner that reflects contemporary challenges and opportunities. The focus of improvements in governance structures should be at least in four initial areas: a high-level committee on science, innovation, technology, and engineering; regional science, technology, and engineering academies; an office of science, technology, and innovation; and a graduate school of innovation and regional integration.

Committee on science, innovation, technology, and engineering: The committee will be a high-level organ of each REC that will report directly to the councils of ministers and presidential summits. Its main functions should be to advise the respective REC on all matters pertaining to science, technology, engineering, and innovation. The functions should include, but not be limited to, regional policies that affect science, technology, engineering, and innovation. It shall also provide scientific and technical information needed to inform and support public policy on regional matters in areas of the competence of the RECs (including economy, infrastructure, health, education, environment, security, and other topics).

For such a body to be effective, it will need to draw its membership from a diversity of sectors including government, industry, academia, and civil society. The members shall serve for a fixed term specified at the time of appointment. Within these sectors, representation should reflect the fact that science, technology, engineering, and innovation are not limited to a few ministries or departments but cover the full scope of the proper functioning of society.

The committee should meet as needed to respond to information requests by chief executive, councils of ministers, or the summits. To meet this challenge, the committee should solicit information from a broad spectrum of stakeholders in the research community, private sector, academia, national research institutes, government departments, local government, development partners, and civil society organizations. The committee's work can be facilitated through working groups or task forces set up to address specific issues.

The committee's work will be supported by the Office of Science, Innovation, Technology, and Engineering headed by a director who also serves as the Chief Science, Innovation, Technology and Engineering Adviser to the chief executive. A national analogue of such a committee is India's National Innovation Council that was established in 2010 by the Prime Minister to prepare a roadmap for the country's Decade of Innovation (2010–2020). The aim of the council is to develop an Indian innovation model that focuses on inclusive growth and the creation of institutional networks that can foster inclusive innovation. The council will promote the creation of similar bodies at the sectoral and state levels.[10]

Regional academies of science, innovation, technology, and engineering: African countries have in recent years been focusing on creating or strengthening their national academies of science and technology. So far 16 African countries (Cameroon, Egypt, Ethiopia, Ghana, Kenya, Madagascar, Mauritius, Morocco, Mozambique, Nigeria, Senegal, South Africa, Sudan, Tanzania,

Uganda, and Zimbabwe) have national academies. There is also the nongovernmental African Academy of Sciences (AAS).

It is notable that despite Africa's growing emphasis on investing in infrastructure, only one African country (South Africa) has an academy devoted to promoting engineering. Most of the others seek to recognize engineers through regular scientific academies, but their criteria for selection tend to focus on publications and not practical achievements. A case can be made on the need to expand the role of academies in providing advice on engineering-related investments.

The creation of regional academies of science, innovation, technology, and engineering will go a long way in fostering the integration of the various fields and disciplines so that they can help to foster regional integration and development.[11] The main objectives of such academies would be to bring together leaders of the various regions in science, innovation, technology, and engineering to promote excellence in those fields. Their priorities would be to strengthen capabilities, inspire future generations, inform public debates, and contribute to policy advice.

The fellows of the academies will be elected through a rigorous process following international standards adopted by other academies. Their work and outputs should also follow the same standards used by other academies. The academies should operate on the basis of clear procedures and should operate independently. They may from time to time be asked to conduct studies by the RECs but they should also initiate their own activities, especially in areas such as monitoring scientific, technological, and engineering trends worldwide and keeping the RECs informed about their implications for regional integration and development. Unlike the committee, the academies will operate independently and their advisory functions are only a part of a larger agenda of advancing excellence in science, innovation, technology, and engineering.

As part of their public education mission, the academies could collaborate with groups such as the Forum for Agricultural Research in Africa, an umbrella organization that brings together and forges coalitions of leading stakeholders in agricultural research and development in Africa. If needed, specialized regional academies of agriculture could be created to serve the sector. Such agricultural academies could benefit from partnerships with similar organizations in countries such as China, India, Sweden, and Vietnam. The proposed academies will need to work closely with existing national academies and AAS.

Office of science, innovation, technology, and engineering: The RECs will need to create strong offices within their secretariats to address issues related to science, innovation, technology, and engineering. The bulk of the work of such offices will be too coordinate advisory input as well as serve as a link between the various organs of the RECs and the rest of the world. The head of the office will have two main functions. First, the person will serve as the chief adviser to the various organs of the RECs (through the chief executive). In effect, the person will be the assistant to the chief executive on science, innovation, technology, and engineering. Second, the person will serve as director of the office and be its representative when dealing with other organizations. In this role the director will be a promoter of science, innovation, technology, and engineering whereas in the first role the person will serve as an internal adviser.

For such an office to be effective, it will need to be adequately funded and staffed. It can draw from the personnel of other departments, academies, or organizations to perform certain duties. In addition to having adequate resources, the office will need to develop transparent procedures on how it functions and how it relates to other bodies. It is imperative that the functions of the office be restricted to the domain of advice and it should not have operational responsibilities, which belong to the national level.

School of regional integration: The need to integrate science and innovation in regional development will require the creation of

human capacity needed to manage regional affairs. So far, the RECs rely heavily on personnel originally trained to manage national affairs. There are very few opportunities for training people in regional integration. Ideally, there should be a graduate African School of Regional Integration to undertake research, professional training, and outreach on how to facilitate regional integration. Such a school could function either as a stand-alone institution or in conjunction with existing universities. A combination of the two where an independent school serves as a node in a network of graduate education in regional integration is also an option.

The school could focus on providing training on emerging issues such as science and innovation. It can do so through short executive courses, graduate diplomas, and degree programs. There is considerable scope for fostering cooperation between such a school and well-established schools of government and public policy around the world. The theme of regional integration is a nascent field with considerable prospects for growth. For this reason it would not be difficult to promote international partnerships that bring together regional and international expertise.

The school could also serve as depository of knowledge gained in the implementation of regional programs. Staff from the RECs could serve as adjunct faculty and so could join it as full-time professors of the practice of regional integration. The school could also work with universities in the region to transfer knowledge, curricula, and teaching methods to the next generation of development practitioners. The area of agricultural innovation would be ideal for the work of such a school and a network of universities that are part of the regional innovation system.

Funding Innovation

One of the key aspects of technological development is funding. Financing technological innovation should be considered in the wider context of development financing. Lack of political

will is often cited as a reason for the low level of financial support for science, technology, and innovation in Africa. But a large part of the problem can be attributed to tax and revenue issues that fall outside the scope of science and technology ministries.[12] For example, instruments such tax credits that have been shown to increase intensity of research and development activities are unlikely to work in policy environments without a well-functioning tax regime.[13] Other instruments such as public procurement can play a key role in stimulating innovation, especially among small and medium-sized enterprises (SMEs).[14]

Currently, Africa does not have adequate and effective mechanisms for providing support to research. Many countries have used a variety of models, including independent funds such as the National Science Foundation in the United States and the National Research Fund of South Africa. Others have focused on ensuring that development needs guide research funding and, as such, have created specific funding mechanisms under development planning ministries. While this approach is not a substitute for funding to other activities, it distinguishes between measures designed to link technology to the economy from those aimed at creating new knowledge for general learning. What is critical, however, is to design appropriate institutional arrangements and to support funding mechanisms that bring knowledge to bear on development.

Creating incentives for domestic mobilization of financial resources as a basis for leveraging external support would be essential. Other innovations in taxation, already widespread around the world, involve industry-wide levies to fund research, similar to the Malaysian tax mechanism to fund research. Malaysia imposed cesses on rubber, palm oil, and timber to fund the Rubber Research Institute, the Palm Oil Research Institute, and the Forestry Research Institute. A tax on tea helps fund research on and marketing of tea in Sri Lanka. Kenya levies a tax on its tea, coffee, and sugar industries, for

example, to support the Tea Research Foundation, the Coffee Research Foundation, and the Kenya Sugar Board.

These initiatives could be restructured to create a funding pool to cover common areas. Reforming tax laws is an essential element in the proposed strategy. Private individuals and corporations need targeted tax incentives to contribute to research funds and other technology-related charitable activities. This instrument for supporting public welfare activities is now widely used in developing countries. It arises partly because of the lack of experience in managing charitable organizations and partly because of the reluctance of finance ministries to grant tax exemptions, fearing erosion of their revenue base.

The enactment of a foundation law that provides tax and other incentives to contributions to public interest activities, such as research, education, health, and cultural development, would promote social welfare in general and economic growth in particular. Other countries are looking into using national lotteries as a source of funding for technological development. Taxes on imports could also be levied to finance innovation activities, although the World Trade Organization may object to them. Another possibility is to impose a tax of 0.05% or 0.1% of the turnover of African capital markets to establish a global research and development fund, as an incentive for them to contribute to sustainable development.

Other initiatives could simply involve restructuring and redefining public expenditure. By integrating research and development activities into infrastructure development, for example, African governments could relax the public expenditure constraints imposed by sectoral budgetary caps. Such a strategy has the potential to unlock substantial funds for research and development in priority areas. But this strategy requires a shift in the budgetary philosophy of the international financial institutions to recognize public expenditures on research and development as key to building capabilities for economic growth.

Financing is probably one of the most contentious issues in the history of higher education. The perceived high cost of running institutions of higher learning has contributed to the dominant focus on primary education in African countries. But this policy has prevented leaders from exploring avenues for supporting higher technical education.

Indeed, African countries such as Uganda and Nigeria have considered new funding measures including directed government scholarships and lowering tuition for students going into the sciences. Other long-term measures include providing tax incentives to private individuals and firms that create and run technical institutes on the basis of agreed government policy. Africa has barely begun to utilize this method as a way to extend higher technical education to a wider section of society. Mining companies, for example, could support training in the geosciences. Similarly, agricultural enterprises could help create capacity in business.

Institutions created by private enterprises can also benefit from resident expertise. Governments, on the other hand, will need to formulate policies that allow private sector staff to serve as faculty and instructors in these institutions. Such programs also would provide opportunities for students to interact with practitioners in addition to the regular faculty.

Much of the socially responsible investment made by private enterprises in Africa could be better used to strengthen the continent's technical skill base. Additional sources of support could include the conversion of the philanthropic arms of various private enterprises into technical colleges located in Africa.

Governmental and other support will be needed to rehabilitate and develop university infrastructures, especially information and communications facilities, to help them join the global knowledge community and network with others around the world. Such links will also help universities tap into their experts outside the country. Higher technical education should

also be expanded by creating universities under line ministries as pioneered by telecom universities such as the Nile University (Egypt), the Kenya Multimedia University, and the Ghana Telecoms University College. Other line ministry institutions such as the Digital Bridge Institute in Nigeria are also considering becoming experiential universities with strong links with the private sector.

Governments and philanthropic donors could drive innovation through a new kind of technology contest.[15] One approach is to offer proportional "prize rewards" that would modify the traditional winner-take-all approach by dividing available funds among multiple winners in proportion to measured achievement.[16] This approach would provide a royalty-like payment for incremental success.[17]

Promoting innovation for African farmers has proven especially challenging, due to a wide variety of technological and institutional obstacles. A proportional-prize approach is particularly suited to help meet the needs of African farmers. For that purpose a specific way should be devised to implement prize rewards, to recognize and reward value creation from new technologies after their adoption by African farmers.

In summary, the effectiveness of innovation funding depends on choosing the right instrument for each situation—and perhaps, in some situations, developing a new instrument that is specifically suited to the task. Prizes are distinctive in that they are additional and temporary sources of funding, they are used when needed to elicit additional effort, and they can reveal the most successful approaches for reaching a particular goal. For this reason, a relatively small amount of funding in a well-designed prize program can help guide a much larger flow of other funds, complementing rather than replacing other institutional arrangements.

Available evidence suggests that investments in agricultural research require long-term sustained commitment. This is mainly because of the long time lags associated with such

investments, ranging from 15 to 30 years taking into account the early phases of research.[18] Part of the time lag, especially in areas such as biotechnology, is accounted for by delays in regulatory approvals or the high cost of regulation. This is true even in cases where products have already been approved and are in use in technology pioneering countries.[19] These long time lags are also an expression of the fact that the economic systems co-evolve with technology and the process involves adjustments in existing institutions.[20]

Joining the Global Knowledge Ecology

Leveraging Africa's Diasporas

Much of the technological foundation needed to stimulate African development is based on ideas in the public domain (where property rights have expired). The challenge lies in finding ways to forge viable technology alliances.[21] In this regard, intellectual property offices are viewed as important sources of information needed for laying the basis for technological innovation.[22] While intellectual property protection is perceived as a barrier to innovation, the challenges facing Africa lie more in the need to build the requisite human and institutional capability to use existing technologies. Much of this can be achieved though collaboration with leading research firms and product development.[23] This argument may not hold in regard to emerging fields such as genomics and nanotechnology.

One of the concerns raised about investing in technical training in African countries is the migration of skilled manpower to industrialized countries.[24] The World Bank has estimated that although skilled workers account for just 4% of the sub-Saharan labor force, they represent some 40% of its migrants.[25] Such studies tend to focus on policies that seek to curb the so-called brain drain.[26] But they miss the point. The real policy challenge for African countries is figuring out how

to tap the expertise of those who migrate and upgrade their skills while out of the country, not engage in futile efforts to stall international migration.[27] The most notable case is the Taiwanese diaspora, which played a crucial role in developing the country's electronics industry.[28] This was a genuine partnership involving the mobility of skills and capital.

Countries such as India have understudied this model and come to the conclusion that one way to harness the expertise is to create a new generation of "universities for innovation" that will seek to foster the translation of research into commercial products. In 2010 India unveiled a draft law that will provide for the establishment of such universities. The law grew out India's National Knowledge Commission, a high-level advisory body to the Prime Minister aimed at transforming the country into a knowledge economy.[29]

A number of countries have adopted policy measures aimed at attracting expatriates to participate in the economies of their countries of origin. They are relying on the forces of globalization such as connectivity, mobility, and interdependence to promote the use of the diaspora as a source of input into national technological and business programs. These measures include investment conferences, the creation of rosters of experts, and direct appeals by national leaders. It is notable that expatriates are like any other professionals and are unlikely to be engaged in their countries of origin without the appropriate incentives. Policies or practices that assume that these individuals owe something to their countries of origin are unlikely to work.

Considerable effort needs to be put in fostering atmosphere of trust between the ex-patriates and local communities. In addition, working from a common objective is critical, as illustrated in the case of the reconstruction of Somaliland. In this inspirational example, those involved in the Somaliland diaspora were able to invoke their competence, networks, and access to capital to establish the University of Hargeisa that has

already played a critical role in building the human resource base needed for economic development. The achievement is even more illustrative when one considers the fact that the university was built after the collapse of Somalia.[30] Similar efforts involving the Somali diaspora in collaboration with King's College Hospital in London have contributed significantly to the health care sector in Somaliland.[31] There are important lessons in this case that can inform the rest of Africa. The initial departure of nations to acquire knowledge and skills in other countries represents a process of upgrading their skills and knowledge through further training. But returning home without adequate opportunities to deploy the knowledge earned may represent the ultimate brain drain. A study of Sri Lankan scientists in diaspora has shown that further studies "was the major reason for emigration, followed by better career prospects. Engineering was the most common specialization, followed by chemistry, agricultural sciences and microbiology/biotechnology/molecular biology. If their demands are adequately met, the majority of the expatriates were willing to return to Sri Lanka."[32]

Strengthening Science, Technology, and Engineering Diplomacy

The area of science, technology, and engineering diplomacy has become a critical aspect of international relations.[33] Science is gaining in prominence as a tool fostering cooperation and resolving disputes among nations.[34] Much of the leadership is provided by industrialized countries. For example, the United States has launched a program of science envoys which is adding a new dimension to U.S. foreign policy.[35] This diplomatic innovation is likely to raise awareness of the importance of science, technology, and engineering in African countries.

Ministries of foreign affairs have a responsibility in promoting international technology cooperation and forging strategic alliances. To effectively carry out this mandate, these

ministries need to strengthen their internal capability in science, technology, and innovation. To this end, they will need to create offices dealing specifically with science, technology, and engineering, working in close cooperation with other relevant ministries, industry, academia, and civil society. Such offices could also be responsible for engaging and coordinating expatriates in Africa's technology development programs.

There has been growing uncertainty over the viability of traditional development cooperation models. This has inspired the emergence of new technology alliances involving the more advanced developing countries.[36] For example, India, Brazil, and South Africa have launched a technology alliance that will focus on finding solutions to agricultural, health, and environmental challenges. In addition, more developing countries are entering into bilateral partnerships to develop new technologies. Individual countries such as China and Brazil are also starting to forge separate technology-related alliances with African countries. Brazil, for example, is increasing its cooperation with African countries in agriculture and other fields.[37] In addition to establishing a branch of the Brazilian Agricultural Research Corporation (EMBRAPA) in Ghana, the country has also created a tropical agricultural research institute at home to foster cooperation with African countries.

Significant experiments are under way around the world to make effective use of citizens with scientific expertise who are working abroad. The UK consulate in Boston is engaged in a truly pioneering effort to advance science, technology, and engineering diplomacy. Unlike other consulates dealing with regular visa and citizenship issues, the consulate is devoted to promoting science, technology, and engineering cooperation between the UK and the United States while also addressing major global challenges such as climate change and international conflict.

In addition to Harvard University and MIT, the Boston area is home to more than 60 other universities and colleges, making it the de facto intellectual capital of the world. Switzerland has also converted part of its consulate in Boston into a focal point for interactions between Swiss experts in the United States and their counterparts at home. Swissnex was created in recognition of the importance of having liaisons in the area, which many consider the world's leading knowledge center, especially in the life sciences. These developments are changing the way governments envision the traditional role of science attachés, with many giving them more strategic roles.[38]

In another innovative example, the National University of Singapore has established a college at the University of Pennsylvania to focus on biotechnology and entrepreneurship. The complementary Singapore-Philadelphia Innovators' Network (SPIN) serves as a channel and link for entrepreneurs, investors, and advisers in the Greater Philadelphia region and Singapore. The organization seeks to create opportunities for international collaboration and partnerships in the area.

India, on the other hand, has introduced changes in its immigration policy, targeting its citizens working abroad in scientific fields to strengthen their participation in development at home. Such approaches can be adopted by other developing countries, where the need to forge international technology partnerships may be even higher, provided there are institutional mechanisms to facilitate such engagements.[39] The old-fashioned metaphor of the "brain drain" should to be replaced by a new view of "global knowledge flows."[40]

But even more important is the emerging interest among industrialized countries to reshape their development cooperation strategies to reflect the role of science, technology, and innovation in development. The UK Department for International Development (DFID) took the lead in appointing a chief scientist to help provide advice to the government on the role of innovation in international development, a decision that was

later emulated by USAID.[41] Japan has launched a program on science and technology diplomacy that seeks to foster cooperation with developing countries on the basis of its scientific and technological capabilities.[42] Similarly, the United States has initiated efforts to place science, technology, and innovation at the center of its development cooperation activities.[43] The initiative will be implemented through USAID as part of the larger science and technology diplomacy agenda of the U.S. government.[44]

South Korea is another industrialized country that is considering adopting a science and innovation approach to development cooperation. These trends might inspire previous champions of development such as Sweden to consider revamping their cooperation programs. These efforts are going to be reinforced by the rise of new development cooperation models in emerging economies such India, Brazil, and China. India is already using its strength in space science to partner with African countries. Brazil, on the other hand, positioning itself as a leading player in agricultural cooperation with African countries, is seeking to expand the activities of the Brazilian Development Cooperation Agency.

China's cooperation with Africa is increasingly placing emphasis on science, technology, and engineering. It is a partner in 100 joint demonstration projects and postdoctoral fellowships, which include donations of nearly US$22,000 worth of scientific equipment. China has offered to build 50 schools train 1,500 teachers and principals as well as train 20,000 professionals by 2012. The country will increase its demonstration centers in Africa to 20, send 50 technical teams to the continent, and train 2,000 African agricultural personnel. Admittedly, these numbers are modest given the magnitude of the challenge, but they show a shift toward using science, technology, and engineering as tools for development cooperation.[45]

Harmonization of Regional Integration Efforts

When the heads of state and government of the Common Market for Eastern and Southern Africa (COMESA), the East African Community (EAC), and the Southern African Development Community (SADC) met in Kampala on October 22, 2008, they conveyed in their communiqué a palpable sense of urgency in calling for the establishment of a single free trade area covering the 26 countries of COMESA, EAC, and SADC. These are 26 of the 54 countries that make up the continent of Africa. The political leaders requested the secretariats of the three organizations to prepare all the legal documents necessary for establishing the single free trade area (FTA) and to clearly identify the steps required—paragraph 14 of the communiqué. In November 2009 the chief executives of the three secretariats cleared the documents for transmission to the member states for consideration in preparing for the next meeting of the Tripartite Summit. The main document is the draft agreement establishing the Tripartite Free Trade, with its 14 annexes covering various complementary areas that are necessary for effective functioning of a regional market. There is a report explaining the approach and the modalities. The main proposal is to establish the FTA on a tariff-free, quota-free, exemption-free basis by simply combining the existing FTAs of COMESA, EAC, and SADC. It is expected that by 2012, none of these FTAs will have any exemptions or sensitive lists. However, there is a possibility that a few countries might wish to consider maintaining a few sensitive products in trading with some big partners, and for this reason, provision has been made for the possibility of a country requesting permission to maintain some sensitive products for a specified period of time.

To have an effective tripartite FTA, various complementary areas have been included. The FTA will cover promotion of customs cooperation and trade facilitation; harmonization and coordination of industrial and health standards; combating of

unfair trade practices and import surges; use of peaceful and agreed dispute settlement mechanisms; application of simple and straightforward rules of origin that recognize inland transport costs as part of the value added in production; and relaxation of restrictions on movement of businesspersons, taking into account certain sensitivities.

It will also seek to liberalize certain priority service sectors on the basis of existing programs; promote value addition and transformation of the region into a knowledge-based economy through a balanced use of intellectual property rights and information and communications technology; and develop the cultural industries. The tripartite FTA will be underpinned by robust infrastructure programs designed to consolidate the regional market through interconnectivity (facilitated, for instance, by all modes of transport and telecommunications) and to promote competitiveness (for instance, through adequate supplies of energy).

Regarding the steps required, or the road map, the proposal is that there should be a preparatory period for consultations at the national, regional, and tripartite level from early 2010 to June 2011. Member states will use this period to carefully work out the legal and institutional framework for the single FTA using the draft documents as a basis. It is expected that each organization will discuss the tripartite documents, and, through the tripartite meetings at various levels, will deliberate and reach concrete recommendations. By June 2011, there should be a finalized agreement establishing the Tripartite FTA, ready for signature in July 2011. When signed, member states will have about six months (up to December 2011) to finalize their domestic processes for approving the agreement (for instance, ratification) and for establishing the required institutions and adopting the relevant customs and other documentation and instruments. It is proposed that once this process ends, the Tripartite FTA should be launched in January 2012. Throughout the preparatory period, strong sensitization

programs will be mounted for the public and private sectors and all stakeholders including parliamentarians, business community, teaching institutions, civil society, and development partners.

The main benefit of the Tripartite FTA is that it will be a much larger market, with a single economic space, than any one of the three regional economic communities and as such will be more attractive to investment and large-scale production. Estimates are that exports among the 26 tripartite countries increased from US$7 billion in 2000 to US$27 billion in 2008, and imports grew from US$9 billion in 2000 to US$32 billion in 2008. This phenomenal increase was in large measure spurred by the free trade area initiatives of the three organizations. Strong trade performance, when well designed—for instance, by promoting small and medium-scale enterprises that produce goods or services—can assist the achievement of the core objectives of eradicating poverty and hunger, promoting social justice and public health, and supporting all-round human development. Besides, the tripartite economic space will help to address some current challenges resulting from multiple membership by advancing the ongoing harmonization and coordination initiatives of the three organizations to achieve convergence of programs and activities, and in this way will greatly contribute to the continental integration process. And as they say, the more we trade with each other, the less likely we are to engage in war, for our swords will be plowshares.

Harmonization of Regulations

The need to enhance the use of science, technology, and engineering in development comes with new risks. Africa has not had a favorable history with new technologies. Much of its history has been associated with the use of technology as tools of domination or extraction.[46] The general mood of skepticism toward technology and the long history of exclusion created a political atmosphere that focused excessively on the risks of

new technologies. This outlook has been changing quite radically as Africa enters a new era in which the benefits of new technologies to society are widely evident. These trends are reinforced by political shifts that encourage great social inclusion.[47] It is therefore important to examine the management of technological risks in the wider social context even if the risk assessment tools that are applied are technical.

The risks associated with new technologies need to be reviewed on a case-by-case basis and should be compared with base scenarios, many of which would include risks of their own. In other words, deciding not to adopt new technologies may only compound the risks associated with the status quo. Such an approach would make risk management a knowledge-based process. This would in turn limit the impact of popular tendencies that prejudge the risks of technologies based on their ownership or newness.

Ownership and newness may have implications for technological risks but they are not the only factors that need to be considered. Fundamentally, decisions on technological risks should take into account the impacts of incumbent technologies or the absence of any technological solutions to problems.

One of the challenges facing African countries is the burden of managing technological risks through highly fragmented systems in contiguous countries. The growing integration of African countries through the RECs offers opportunities to rationalize and harmonize their regulatory activities related to agricultural innovation.[48]

This is already happening in the medical sector. The African Medicines Regulatory Harmonization (AMRH) initiative was established to assist African countries and regions to respond to the challenges posed by medicine registration, as an important but neglected area of medicine access. It seeks to support African Regional Economic Communities and countries in harmonizing medicine registration.

COMESA, in collaboration with the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and other implementing partners, has engaged in the development of regionally harmonized policies and guidelines through the Regional Agricultural Biotechnology and Biosafety Policy in Eastern and Southern Africa (RABESA) initiative since 2003. The COMESA harmonization agenda—now implemented through its specialized agency the Alliance for Commodity Trade in Eastern and Central Africa (ACTESA)—was initiated to provide mechanisms for wise and responsible use of genetically modified organisms (GMOs) in commercial planting, trade, and emergency food assistance.

The draft policies and guidelines are expected to be endorsed soon by its policy organ. The guidelines seek the establishment of a COMESA biosafety and centralized GMO risk assessment desk, with standard operating procedures. ACTESA has established a biotechnology program to coordinate biotechnology- and biosafety-related activities and provide guidance in the region. The COMESA panel of experts on biotechnology has been established to provide technical assistance in policy formulation and GMO risk assessment.

The establishment of the World Trade Organization (WTO) in 1995 and the coming into force of a multilateral trading system backed by legally binding trade agreements placed fresh challenges on WTO member states, particularly African countries that were already struggling with trade liberalization and globalization that encouraged the free movement of humans, animals, food, and agricultural products across borders.

Specifically, the agreement on sanitary and phytosanitary measures (SPS) required governments to apply international standards and establish science-based legal and regulatory systems to manage health and environmental risks associated with food and agricultural products. International standards to derive legislation and regulations for SPS management

include risk analysis and use of the HACCP) system. The production of food products involves complex production and processing methods. For many African governments, this required new skills to conduct scientific risk analysis along the food chain as food products interact with plant and animal diseases, pests, biological hazards such as pathogenic microorganisms, and naturally occurring hazards such as aflatoxins. Risk analysis requires scientific skills and innovation that go beyond conventional training; if not done properly, this risk analysis will result in weak SPS systems, which in turn may result in nontariff barriers in regional and global markets.

COMESA, within its mandate of regional economic integration, recognizes the need to support member states in resolving non-tariff barriers that constrain markets and stifle the integration of food products into regional and global value chains, as an innovative strategy to promote market access to regional and international trade.

In 2005, COMESA commissioned a project to support member states in their efforts to address SPS barriers by improving and harmonizing SPS measures and food safety systems among member states. Country-level focal points were provided to facilitate and initiate the harmonization process and training was provided on how to establish national and regional surveillance systems. A second step involved the establishment of regional reference laboratories for food safety and animal and plant health. Initial training was provided for key laboratory personnel, and guidelines for regional harmonization of SPS measures and the use of reference laboratories were developed. COMESA will now present the harmonization guidelines to its Technical Committee on Agriculture for regional approval and adoption.

The primary aim of harmonizing medicine registration is to improve public health, by increasing timely access to safe and efficacious medicines of good quality for the treatment

of priority diseases. Access will be improved by reducing the time it takes for priority essential medicines to be registered in-country (including the time needed for industry to prepare their registration application or dossier) and so potentially the time taken for essential therapies to reach patients in need (depending on funding and distribution mechanisms). This will include capacity building to ensure transparent, efficient, and competent regulatory activities (assessment of registration dossiers and related inspections) that are able to assure the quality, safety, and efficacy of registered medicines. The AMRH initiative approach seeks to support the RECs and countries to harmonize medicine registration using existing political structures and building on existing plans and commitments.

The AMRH initiative was the outcome of NEPAD) and the Pan-African Parliament, which was hosted in collaboration with consortium partners and attracted representation from nine of the continent's Regional Economic Communities (RECs) and over 40 national medicine regulatory authorities (NMRA). This provided a strong endorsement for the consensus plan that emerged and hence the approach that RECs and NMRAs are now adopting.

The AU Summit approved the Pharmaceutical Manufacturing Plan for Africa in 2007, which specifically recognizes the need for African countries to strengthen their medicine regulatory systems by pooling their resources to achieve public health policy priorities.

Such systems are vital to assuring the quality, safety, and efficacy of locally manufactured products and their positive contribution to public health. Moreover, the success of domestic production will partly depend on intra-regional and intra-continental trade to create viable market sizes. Currently, trade in pharmaceuticals is hampered by disparate regulatory systems, which create technical barriers to the free movement of products manufactured in Africa (and beyond)—and has

negative consequences for timely patient access to high-quality essential medicines.

Several RECs have already supported harmonization of medicine registration by developing common pharmaceutical policies and operational plans—backed by high-level political commitments and mandates. For example, in east Africa under the provisions of Chapter 21 (Article 118) of the EAC treaty, medicine registration harmonization is an explicit policy priority. Likewise, in southern Africa, ministers of health have approved the SADC Pharmaceuticals Business Plan, with explicit goals to harmonize medicine registration.

However, implementation of these policies and plans has suffered from a lack of financial and technical resources and has not progressed significantly. Moreover, RECs continue to work largely in isolation. Coordination is needed to avoid duplication of effort and ensure consistent approaches, especially given that more than three-quarters of African countries belong to two or more RECs. Following commencement of the AMRH initiative, several RECs submitted summary project proposals describing their high-level plans for harmonization of medicine registration.

Following their review, the consortium actively partnered with four REC groupings (EAC, Economic Community of Central African States, ECOWAS, the West African Monetary Union and SADC) to support them in strengthening and moderately expanding their proposals. In the first instance, this involved written feedback from the consortium followed by a visit from a NEPAD delegation to explain the consortium's feedback and agree on a timeline for next steps. Given the importance of NMRA consultations and ownership, NEPAD has also made some funding available for RECs and their constituent NMRAs to jointly ensure that their proposals reflect their shared vision for harmonized medicine registration.

Conclusion

Promoting a growth-oriented agenda will entail adjustments in the structure and functions of government. More fundamentally, issues related to science, technology, and innovation will need to be addressed in an integrated way at the highest level possible in government. Bringing science, technology, and engineering to the center of Africa's economic renewal will require more than just political commitment; it will take executive leadership. This challenge requires concept champions who in this case will be heads of state spearheading the task of shaping their economic policies around science, technology, and innovation.

So far, most African countries have not developed national policies that demonstrate a sense of focus to help channel emerging technologies into solving developmental problems. They still rely on generic strategies dealing with "poverty alleviation," without serious consideration of the sources of economic growth. There are signs of hope though. NEPAD's Ministerial Forum on Science and Technology played a key role in raising awareness among African's leaders of the role of science, technology, and engineering in economic growth.

An illustration of this effort is the decision of the African Union (AU) and NEPAD to set up a high level African Panel on Modern Biotechnology to advise the AU, its member states, and its various organs on current and emerging issues associated with the development and use of biotechnology. The panel's goal is to provide the AU and NEPAD with independent and strategic advice on biotechnology and its implications for agriculture, health, and the environment. It focuses on intra-regional and international regulation of the development and application of genetic modification and its products.

Regarding food security in particular, Africa's RECs have tried to develop regional policies and programs to allow member states to work collectively. ECOWAS and COMESA,

for instance, building on CAADP, have elaborated regional compacts to guide member states in formulating their national CAADP compacts. This comes at a time when experience from the six COMESA national CAADP compacts so far concluded show that there are key cross-border challenges that need a regional approach. Twenty-six African nations had signed CAADP compacts by June 2010, compounding the need for regional strategies.

Thus, there is a need for a larger regional market to support investment in agricultural products and harmonization of standards across the region. This will help address challenges such sanitary and phytosanitary measures that affect the quality and marketability of agricultural products; management of transboundary resources such as water bodies and forests; building of regional infrastructure; promotion of collaborative research; monitoring of key commitments of member states, particularly the one on earmarking 10% of the national budget for the agriculture sector. A key pillar of CAADP relates to agricultural research and innovation. Africa's RECs have a critical role to play under this pillar, through supporting regional research networks and prioritizing agricultural research in regional policies. Experience sharing at the regional level, and the resulting research communities, will greatly enrich individual research.