THE NEW CULTURE OF INNOVATION

Africa in the Age of Technological Opportunities

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Introduction[1]

Africa, led by the African Union, is rethinking its place in the global economic in an age of unprecedented growth in scientific and technical knowledge. Unlike its predecessors who had to make do with limited technical knowledge, Africa's challenge is how to manage technological opportunities. Its role models will be other nations that have focused their development strategies on advancing technological innovation as a foundation for economic growth. Africa's central challenge therefore is how to foster a new culture of technological innovation in an age of epochal technological opportunities.

But despite the explosive growth in scientific knowledge that can be harnessed for Africa's development, most national science and technology policy still focus on basic research approaches that are founded on the notion of "scarcity" of knowledge. This is illustrated by the preoccupation of national policies on using percentages of the GDP devoted to R&D.

Policy approaches based on the concept of "technological opportunities" available worldwide would leave to different strategies which emphasize technology prospecting and international partnerships. In other words, their quest for discovery would focus on using existing knowledge as a starting point in problem-solving. This approach would be necessity focus on learning and continuous improvement. It is this opportunity-based outlook that this paper seeks to develop.

African countries are as diverse in culture as they are differentiated in their political heritage. Most of them are historically been associated with natural resources and raw materials. Most of the economies have either stagnated or decline. A few have prospered but their lessons are not easy to extend to others. There is growing recognition, however, that Africa can only strengthen its economic performance through considerable investment and use of new knowledge (Commission for Africa, 2005).

A new economic vision for the region–expressed at the highest level of government–should focus on the role of knowledge as a basis for economic transformation (UN Millennium Project, 2005). Doing so will entail placing policy emphasis on emerging opportunities such as renewing infrastructure, building technical capabilities, stimulating business development, and increasing participation in the global economy (Stern et al., 2005). These areas should provide a firm foundation upon which to base development investments and international partnerships.

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[1]. This paper builds on the findings of the Task Force on Science, Technology and Innovation of the UN Millennium Project available as *Innovation: Applying Knowledge in Development*. I have also drawn heavily a collection of essays by the London-based Smith Institute published as *Going for Growth: Science, Technology and Innovation in Africa*. I am grateful to Dr. Ismail Serageldin and members of the High Level African Panel on Modern Biotechnology of the African Union (AU) and the New Partnership for Africa's Development (NEPAD) for many of the ideas outlined in this paper.

1. Economic growth as social learning

1.1 Learn to grow

Contemporary history informs us that the main explanation for the success of the industrialized countries lies in their ability to learn how to improve performance in a variety of fields – including institutional development, technological adaptation, trade, organization and the use of natural resources. In other words, the key to their success is putting a premium on learning by focusing on improving their skills as a way to solve problems (Schwerin and Werker, 2003).

One of the most critical aspects of a learner's strategy is that every generation receives a legacy of knowledge from its predecessors that it can harness for its own advantage. Every generation blends the new and the old and thereby charts its own development path, making debates about potential conflicts between innovation and tradition irrelevant.

At least three key factors contributed to the rapid economic transformation of emerging economies. First, these countries invested heavily in basic infrastructure, including roads, schools, water, sanitation, irrigation, clinics, telecommunications and energy (Ridley and Lee, 2005; Rouach and Saperstein, 2004). The investments served as a foundation for technological learning. Second, they nurtured the development of Small and Medium-sized Enterprises (SMEs) (Oyelaran-Oyeyinka and Lal, 2006).

Building these enterprises requires developing local operational, repair and maintenance expertise, and a pool of local technicians. Third, government supported, funded and nurtured higher education institutions, as well as academies of engineering and technological sciences, professional engineering and technological associations, and industrial and trade associations (Nankani, 2005).

The emphasis on knowledge should be guided by the view that economic transformation is a process of continuous improvement of productive activities, advanced through business enterprises. In other words, government policy should focus on *continuous improvement* aimed at enhancing performance, starting with critical fields such as agriculture for local consumption and extending to international trade (Brown, 2005; Cantner and Pyka, 2001).

This improvement indicates a society's capacity to adapt to change through learning. It is through continuous improvement that nations transform their economies and achieve higher levels of performance. Using this framework, with government functioning as a facilitator for social learning, business enterprises will become the locus of learning, and knowledge will be the currency of change (King, 2005). Most African countries already have in place the key institutional components needed to make the transition towards being a player in the knowledge economy. The emphasis should therefore be on realigning the existing structures and creating new ones where they do not exist.

The challenge is building the international partnerships needed to align government policy with the long-term technological needs of Africa. The promotion of science and technology as a way to meet human welfare needs must, however, take into account the additional need to protect Africa's environment for present and future generations. The concept of 'sustainable development' has been advanced specifically to ensure the integration of social, economic and environmental factors in development strategies and associated knowledge systems. Mapping out strategic options for Africa's economic renewal will therefore need to be undertaken in the context of sustainable development strategies and action plans.

1.2 Identify technological opportunities

There is widespread awareness of rapid scientific advancement and the availability of scientific and technical knowledge worldwide. In fact, the spread of scientific knowledge in society is eroding traditional boundaries between scientists and the general public. The growth in knowledge is also making it possible to find low-cost, high-technology solutions to persistent problems.

For example, the development of the XO laptop (popularly known as the $100 laptop) is classic illustration of new solutions provided by expanding technological opportunities. The laptop is a prominent example of emerging initiatives that seek to find technological solutions to development challenges. Similar efforts to develop low-cost, high-technology products are underway in the medical fields. Most of these ideas have been around for a long time but their feasibility was hampered by the lack of technical knowledge.

Life sciences are not the only areas where research could contribute to development. Two additional areas warrant attention. The continent's economic future crucially depends on the fate and state of its infrastructure whose development will depend on the contributions of the engineering, materials and related sciences. It is notable that these fields are particularly underdeveloped in Africa and hence could benefit from specific missions that seek to use local material in activities such as road construction and maintenance.

Other critical pieces involve expanding the energy base through alternative energy development programs, such as geothermal, biofuels, solar and wind energy. This sector is particularly important because of Africa's past investments, availability of human resources and its potential to stimulate complementary industries that provide parts and services to the expansion of the sector. Exploiting these opportunities requires supporting policies.

Advances in science and technology will therefore make it possible for humanity to solve problems that have previously been in the realms of imagination. This is not a deterministic view of society but an observation of the growth global ecology of knowledge and the feasibility of new technical combinations that are elicited by social consciousness. This view would lead to the conclusion that Africa has the potential to have access more scientific and technical knowledge than the more advanced countries had in their early stages of industrialization.

2. Strength in diversity

The facilitation of regional cooperation is emerging as a basis for diversifying economic activities in general, and leveraging international partnerships in particular (Kim, 2005). Many of Africa's individual states are no longer viable economic entities; their future lies in creating trading partnerships with neighbouring countries. Indeed, African countries are starting to take economic integration seriously.

For example, the recreation of the East African Community (covering Kenya, Uganda, Tanzania, Rwanda and Burundi) 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. However, the inherent diversity serves as an incentive for cooperation (Murenzi and Hughes, 2005).

The current malaise in the traditional development community is being challenged by new technology alliances involving the more developed among developing countries. 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. India and China, for example, have created a joint steering committee to promote coordination in their technological development efforts. Such alliances provide examples that could be emulated in new technology and trade partnerships between Africa and its allies in the industrialized countries (Juma et al., 2005).

Africa needs similar agreements that promote the use of regional technological capabilities in international trade. Signing peace agreements is an important step in ending wars and promoting stability. But the real challenge is how to use international trade and technology cooperation as critical tools for enhancing regional stability.

Increases in democratic practices, economic growth and innovation often are associated with the rise in the capacity of a nation to participate in international trading regimes. As these links unfold, the trading nations must establish a wide range of harmonized practices, such as standards, regulations, and tariffs. Trade links usually have positive effects on political relationships between countries. Thus, democratic countries with trade interdependencies are usually less likely to go to direct war with one another.

African countries have adopted numerous regional cooperation and integration arrangements, many of which are purely ornamental. The continent has more than 20 regional agreements that seek to promote cooperation and economic integration at sub-regional and continental levels. They range from limited cooperation among neighbouring states in narrow political and economic areas to the ambitious creation of an African common market. They focus on improving efficiency, expanding the regional market, and supporting the continent's integration into the global economy. Many of them are motivated by factors such as the small-size of the national economy, a landlocked position, and poor infrastructure.

The key gains that Africa hopes to derive from economic integration include the role of larger markets in stimulating technological innovation, fostering economies of scale arising from infrastructure investments, and the diffusion of technical skills into the wider economy. In effect, science and innovation are central elements of the integration agenda and should be made more explicit.

3. Renewing economic growth

3.1 Build infrastructure facilities

Infrastructure is broadly defined as the facilities, structures and associated equipment and services that facilitate the flows of goods and services between individuals, firms and governments. Conventional infrastructure includes: public utilities, such as power, telecommunications, water supply, sanitation and sewerage, and waste disposal; public works, such as irrigation systems, schools, housing and hospitals; transport sectors, such as roads, railways, ports, waterways and airports; and research facilities such as laboratories and related equipment.

Infrastructure services include the provision, operation, and maintenance of the physical facilities of the infrastructure. Poor infrastructure is a critical barrier to accelerating growth and welfare improvement in Africa (Fay et al., 2005; Holloway et al., 2000). In Uganda, for example, transport costs add the equivalent of an 80% tax on clothing exports. Infrastructure is also a key component of the investment climate, reducing the costs of doing business and enabling people's access to markets.

Infrastructure promotes agricultural trade and integration into world markets, and is fundamental to human development, including the delivery of health and education services. Infrastructure investments also represent an enormous untapped potential for the creation of productive employment in Africa. Without adequate infrastructure, further application of technology to development is not possible. For instance, electric power, transportation networks and communications infrastructure are the underlying factors behind any efforts to improve basic science and technological capabilities in Africa.

The advancement of information technology and its rapid diffusion in recent years could not happen without basic telecommunications infrastructure, such as telephone, cable and satellite networks. In addition, electronic information systems, which rely on telecommunications infrastructure, account for a substantial proportion of production and distribution activities in the secondary and tertiary sectors of the economy (Adeoti and Adeoti, 2006).

Because of its fundamental role, the learning process in infrastructure development is a crucial element of a country's overall technological learning process. Development and infrastructure literature often overlooks infrastructure's dynamic nature. Every stage of an infrastructure project, from planning and design through to construction and operation, involves the application of a wide range of technologies and associated institutional and management arrangements.

Because infrastructure facilities and services are complex physical, organizational and institutional systems, they require deep understanding and adequate capabilities among the engineers, managers, government officials and others involved in them. Africa should therefore structure the design and construction of railways, airports, roads, telecommunications networks, water supply and sanitation systems, and research facilities in ways that promote technological, organizational and institutional learning.

Infrastructure development priorities signal the need for long-term capacity for maintenance and technology development. Such projects should provide ideas for curriculum development in universities and other research institutions. This convergence of interest is achievable with continuous interaction and cooperation between government, industry academia and civil society.

The alignment of research and training activities with infrastructure development is a critical element in promoting the development of domestic technological capabilities and should therefore be a critical element in project design. Where research institutions do not exist, infrastructure projects should explicitly propose their creation.

3.2 Reform higher technical education

Higher technical education is increasingly recognized as a critical aspect of the development process, especially with the growing awareness of the role of science, technology and innovation in economic renewal. While primary and secondary education have been at the focus of donor community attention for decades, higher education and research have been viewed as essential to development only in recent years (National Research Council, 2006; House of Commons, Science and Technology Committee,
2004).

The urgency of investing in higher technical education is compounded by the impact of HIV/AIDS and other infectious diseases on Africa's labour force (Corrigan et al., 2005; Misselhorn, 2005). The challenges include building human capacity and transmitting technical skills to succeeding generations, which underscores the urgency to expand women's access to higher technical education (Everts, 1998).

Other than providing education, a new view is emerging that places universities and research institutions at the centre of the development process. The application of this concept also extends to other levels of learning, such as colleges, research and technical institutes and polytechnic schools. Higher education and research institutions have therefore become a valuable resource for business, industry and society. In facilitating the development of business and industrial firms, universities can contribute to economic revival and technology-based growth in their regions.

Higher education and research institutions integrate into the production sector and into society in many ways. They conduct research and development for industry; create their own spin-off firms; are involved in capital formation projects, such as technology parks and business incubator facilities; introduce entrepreneurial training; and encourage students to transform

research into enterprises. This approach is based on the strong interdependence of academia, industry, government and civil society. Considerable efforts are under way to reform existing institutions in Africa. Additional opportunities exist in the design of new higher learning institutions.

First, many of these institutions focus on technical training as a core aspect of their curricula. The technical training could reflect specific needs. Second, the new species of higher learning institutions places particular emphasis on building entrepreneurial skills among students. This additional focus ensures that students develop the capacity to transform ideas into business proposals as well as actual products and services for local and international markets. Students in these institutions will be expected to develop practical skills in enterprise creation as a prerequisite for graduation. This approach requires a reorientation of local banking and financial institutions, including the development of new instruments such as venture capital. Third, most of the universities that exist in Africa were originally designed to support nation building. The challenge today is community development. As a result, the new species of university should integrate into the communities in which they are located and seek specifically to promote economic transformation in their locales (Hansen and Lehmann, 2006; McDowell, 2001). This means not only that their curricula will need to be adapted to local needs, but also that students should be expected to spend part of the time working with local communities (Kaburise, 2003).

One of the most pioneering examples in curriculum reform is EARTH University in Costa Rica, whose curriculum is designed to match the realities of agribusiness. The university dedicates itself to producing a new generation of young people trained specifically to focus on changing the human condition though entrepreneurial activities (Zaglul and Sherrard, 2005). The students are trained to serve as agents of change and seek to improve human welfare by creating and managing new enterprises. A related African example is the University of Development Studies (UDS) in northern that is pioneering a new approach that focuses on experiential learning and direct student participation in community development.

In South Africa, Stellenbosch University was the first teaching institution in the world to design and launch a satellite. The project focused on designing a curriculum intended to help solve specific problems such as developing new products or improving the environment, and not to simply produce graduates. This approach illustrated the importance of relating curriculum development to local needs. Such reorientation of higher educational activities could be extended to fields such medicine, public health and environmental management.

Even more critical are pressures to bring medical research and training together in a new generation of teaching hospitals and health centres across Africa. In Uganda, Makerere University has developed a new approach to teaching that enables students to contribute significantly to the solution of public health problems in their communities. Several other African universities are involved in similar social outreach activities.

Africa’s reconstruction challenges require creating the technical competence needed to design and manage infrastructure projects. The Kigali Institute of Science, Technology and Management (KIST) in Rwanda shows how higher education institutions can help transform

the communities in which they are located. KIST is located in what used to be the military barracks of the country before the genocide. This is in itself an important lesson on the potential conversion of Africa's current institutional infrastructure to serve development. The National University of Namibia is symbolically located in what used to the military base of the pre-independent army. There are many military bases in Africa waiting to be converted into institutions of higher learning and military engineers ready to help build and maintain the infrastructure for human security.

In another pioneering example of business incubation is the University of Zambia. This was the midwife of Zamnet, the country's largest Internet provider. Zambia's experience demonstrates that universities have great potential for creativity and innovation, even under the most difficult financial conditions. Numerous Brazilian universities, led by the pioneering work of the Genesis Centre at the Pontifical Catholic University of Rio de Janeiro, have been pursuing similar models which becoming a permanent feature of university activities (Konde, 2004).

Universities and other institutions of higher learning could also contribute to community development by using technologies such as community radio as is currently done by the University of Education, Winneba in Ghana. Radio Windy Bay is used to broadcast lectures and serve as a communications link for the various halls of residence at the campuses of the university.

In addition, it serves as a medium for broadcasting university functions as well as for advertising. This technology allows students to listen to lectures in their rooms, Junior Common Room or any appropriate location and interact with the lecturer through the telephone system (Anamuah-Mensah, 2005).

Such radio stations focus on development and use principles of fairness and respect for diverse views and interests. They are usually very open, participatory and accountable to communities they serve. They are valued for the power of information and education. The stations develop civic responsibility to demand good governance and enable grassroots feedback on government policy and service delivery. Initiatives aimed at assisting in their development, especially through training in content development, programming and management, and the development of self-help networks could therefore contribute to better human development.

The focus of the new species of university will be to produce graduates who are trained to create enterprises and therefore generate jobs while adding to the growth of the economy. This would be a departure from the present system, which focuses on providing technical skills to people who would not go on to create employment.

In addition to training, universities would need to function as incubators for businesses and social enterprises. This function would be in addition to the traditional practices of linking enterprises and civil society organizations to universities. They would help to nurture new enterprises through providing critical services in the early stages of enterprise development (Etzkowitz, 2003).

Efforts should be made to create a strong technical foundation through polytechnics, which can be turned into community colleges to serve local populations. This would require higher education regulators to be proactive and flexible in seeking to link curriculum development to local needs, promoting experiential learning, strengthening university management and expanding opportunities for women students.

Research, teaching and community outreach must merge in new institutional designs. For example, medical schools should be more integrated into hospitals, just as agricultural research stations should have a strong teaching role. Similarly, strong links must be forged between universities and the business community. This process may involve reforms or upgrades within existing universities and the creation of new institutions.

Research and training facilities in Africa need to be examined, especially those that fall outside the formal rubric of 'universities', to explore how they could supplement the contributions of existing universities. All government ministries are involved in one or another aspect of research and training and therein hold the seed for populating the economic arena with new species of higher learning institutions adapted to specific needs.

Collective efforts will be needed to reform curricula by replacing outmoded sections with new approaches that encourage creativity, enquiry and entrepreneurship. These reforms also should include close cooperation with the private sector and the communities in which universities are located. In turn, government at all levels (central, urban and regional) should be at the forefront of creating space and opportunities for the contribution of universities to development.

But reform in curricula will not be sufficient unless accompanied by adjustments in pedagogy to emphasize experiential learning. The need to provide students with access to practical experience and learning from direct engagement is particularly critical in rapidly changing technological fields. Experiential learning can be promoted more readily in universities that have direct linkages with the production sector. This makes community linkages even more critical to the effective functioning of universities.

Universities should enjoy greater autonomy in management so that they can adapt in a timely manner to a rapidly changing world. But this autonomy should be guided by the need to deliver community development and not be seen simply as an artifact of good governance. If African universities do not make these changes and make themselves relevant to local needs, they will become increasingly marginal and their status in society will decline (Oyelaran-Oyeyinka and Barclay, 2004). Governments, on the other hand, will do no better if they do not move to make knowledge the driving force for improvement.

3.3 Spur business entrepreneurship

Economic change is largely a process whereby knowledge is transformed into goods and services through business enterprises (Grimaldi. and Grandi, 2005). In this respect, creating links between knowledge generation and business development is the most important

challenge facing Africa. For Africa to promote the development of local technology, it needs to review the incentive structures already in place. There is a range of structures suitable for creating and sustaining enterprises, from taxation regimes and market-based instruments to consumption policies and sources of change in the national system of innovation.

SMEs should play leading roles in the development of new opportunities and the use of technology. Policy makers need to develop, apply and emphasize the important role of engineering, technology and SME development in poverty reduction and sustainable social and economic development. They need to support business and technology incubators, export processing zones and production networks as well as sharpening the associated skills through business education (Lalkaka, 2003).

Banks and financial institutions also need to play key roles in fostering technological innovation. But their record in this field has been poor in African countries. Reforming some banking and financial institutions would allow them to help promote technological innovation. Capital markets have played a critical role in creating SMEs in developed countries. Venture capitalists do not just bring money to the table; they help groom SME start-ups into multinational institutions.

Bringing venture capital into civil society has played an important role in promoting a wide range of developmental activities in Africa. Indeed, civil society organizations are key sources of social innovation through their diversity and creativity. In the political arena, for example, civil society organizations have played a key role in promoting democratic change. Similarly, these organizations have been vital in other fields, such as environmental conservation, where their contributions have ranged from awareness-raising to field-based practical activities.

Civil society organizations are often adapted to local needs and guided by specific mandates. This gives them the capacity to respond quickly to challenges. But as result, their operations tend to focus on short-term responses. Emerging evidence, however, suggests that visionary leaders are starting to focus on long-term competence-building. For example, the Uganda Rural Development and Training Programme (URDT) created in the Kibaale District in Uganda in 1987 recently created the African Rural University for Women which focuses on integrated rural development.

The growing focus on competence building will require expanded sources of support for development activities. Civil society organizations could therefore be an important platform for social entrepreneurship that will complement the work of the private sector. These entities can support innovation in a variety of ways.

First, they can help to bring social justice to the application of science and technology in development, and redress some of the inequities associated with the use of new technology. Second, they can serve as an important mechanism for bringing civic engagement in technological innovation. This is an important aspect of democratic decision making and practice. Finally, they can help define demand-oriented strategies for technological development.

3.4 Foster international trade

The process of technological innovation is intricately linked to the global economic system. The shift from largely domestic activities to complex international relationships demands a review of policies that integrate science, technology and innovation into economic development strategies (Redding and Schott, 2003). The involvement of developing countries in producing new technologies and innovations is almost negligible. Africa, in particular, lags far behind the rest of the developing world. The challenge facing the global community is to create conditions that will enable developing countries to make full use of the global fund of knowledge to address development challenges.

Much of the international debate over technology has focused on new technologies and ignored the global context in which such inventions are applied. Globalisation of technology falls into three categories: the international exploitation of nationally produced technology, the global generation of innovation and global technological collaborations (Archibugi and Pietrobelli, 2003).

The first category, international exploitation, includes innovators' attempts to gain economic advantages by exploiting their technological assets in foreign markets. Multinational corporations, as the main agents of this type, often maintain their national identity even as they spread their technologies to other countries. They exploit their technological assets by selling innovative products and technological knowledge using licences and patents, and establishing local production facilities through foreign direct investment (FDI). The second category, global generation, refers to the production of technologies by single proprietors (largely multinational corporations) on a global scale. The third category, global technological collaborations, has grown in importance in recent years. Technological collaborations occur when two companies establish joint ventures or formally agree to develop technical knowledge and products, while maintaining their respective ownership. Many partnerships are between firms located in different countries, thus contributing to technological globalisation.

The global rules for FDI have changed, as have the modes in which they are most useful. Global production systems have changed the ways in which investment flows and how funds can be made available in certain parts of the world for long-term growth instead of rapid flight to new, cheaper locales. FDI needs to be used as a vehicle for carrying tacit knowledge as well as assisting enterprises at the frontiers of world technological learning. Under the right conditions, foreign companies can contribute to local industrial development by providing capital, markets and technological and business skills. They can also increase the local content of their products through subcontracts with local SMEs (Kohpaiboon, 2006).

To enhance technological competence, local firms in African countries had to first enter the chain and then gradually move up it to engage in higher value-added activities. An analysis of value chain linkages provides insights into how these linkages facilitate or impede technological and industrial upgrading. Policy makers in Africa need to understand the structure and function of the existing global value chains and how they are likely to change over time.

3.5 Join the global knowledge ecology

Much of the technological foundation needed to stimulate African development are based on public domain ideas (whose property rights have protection has expired). In this regard, intellectual property offices are viewed as important sources of information needed for laying the basis for technological innovation (Chen and Puttitanum, 2005). While intellectual property protection can serve as barrier to innovation, the challenges facing Africa lie more in the need to build the requisite human capability to use existing technologies and less in restrictive intellectual property systems. 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. The World Bank has estimated that although skilled workers account for just 4% of the sub-Saharan labour force, they represent some 40% of its migrants (Özden and Schiff, 2005). Such studies tend to focus on policies that seek to curb the so-called 'brain drain' (Carr et al., 2005). 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 in the diaspora, not engage in futile efforts to stall international migration (Stark, 2004; Séguin et al., 2006). The most notable case is the Taiwanese diaspora, which played a crucial role in developing the country's electronics industry (Saxenian, 2001). This was a genuine partnership involving the mobility of skills and capital. Countries such as India are now understudying this model.

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 globalisation such as connectivity, mobility and interdependence to promote the use of the diaspora as a source of input into national technological and business programmes. These measures include investment conferences, the creation of rosters of experts and direct appeals by national leaders.

Significant experiments are under way around the world to make effective use of the diaspora. The Swiss government has converted part of its consulate in Cambridge (Massachusetts, USA) into a focal point for interactions between Swiss experts in the USA and their counterparts at home. The Swiss House was created in recognition of the importance of the area as the world's leading knowledge centre, especially in the life sciences. In addition to Harvard University and Massachusetts Institute of Technology (MIT), the Boston area is home to more than 50 other colleges and universities and a cluster of biotechnology activities.

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, is introducing a number of policy measures– including granting dual citizenship to Indians in countries of strategic interest–aimed at strengthening the role of the diaspora in national development. Such approaches can be

adopted by other developing countries, where the need to forge international technology partnerships may be even higher. The old-fashioned metaphor of the 'brain drain' should to be replaced by a new view of 'global knowledge flows'.

4. Creating a new culture of innovation

Government plays an important role as a facilitator of technological learning. However, most governments do so in an implicit way. Facilitating technological change will require governments to act as active promoters of technological learning. Government action represents a key element in the domestic ownership and control of the development agenda (King, 2005). The emphasis on entrepreneurial leadership will alter the role of the state from being a provider of services to being an enabler and promoter of business development. In other words, African countries should become *entrepreneurial states* whose main function is to promote human welfare through emphasis on the role of the private sector, especially SMEs (Juma, 2006). This is not to rule out the role of the public sector in development, but to argue that the main function of an entrepreneurial state is to create a viable environment and offer the support needed to empower the people to meet their own needs by finding creative solutions to local problems
(Ebner, 2006).

4.1 Improve technology governance

Promoting a growth-oriented agenda will entail adjustments in the structure and functions of government. More fundamentally, 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.

By extension, an African president's council on science, technology and innovation could be created to champion the role of technological innovation in development. Such a body can either take a formal character under the AU or can be created as an informal community of leaders interested in the subject.

Bringing science and technology to the centre 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. There are signs of hope, however. The African Ministerial Council on Science and Technology has played a key role in raising awareness among African leaders on the role science and technology in economic growth.

An illustration of this effort is the decision of the African Union (AU) and the New Partnership for Africa's Development (NEPAD) to set up a High Level African Panel on Modern Biotechnology (APB) to advise the AU, its member states as well as 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.

One of the central features of executive guidance is the degree to which political leaders are informed about the role of science and technology in development. Advice on science, technology and innovation must be included routinely in policy-making. An appropriate institutional framework must be created in order 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, legislative 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 and technology also can increase their ability to discuss technological issues in international forums (Jain, 2001).

Science and technology diplomacy has become a critical aspect of international relations. Ministries of foreign affairs have a responsibility in promoting international technology cooperation and forging strategic alliances. To effectively carry out this mandate, foreign 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 and technology, working in close cooperation with other relevant ministries, industry, academia and civil society. Such offices could also be responsible for engaging and coordinating diasporas in Africa's technology development programmes.

4.2 Identify strategic technology missions

African countries have many opportunities to identify and implement strategic missions or programmes that promote growth through investments in infrastructure, technical training,

business incubation and international trade. For example, mayors of cities can work with government, academia, industry and civil society to design missions aimed at improving the lives of their residents (Njoh, 2006). Universities located in such cities could be play key roles as centres of expertise, incubators of businesses and overall sources of operational outreach to support private and public sector activities.

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 of 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.

An example of the mission-oriented approach was the 2005 decision of the African Council of Ministers of science and technology to adopt a decision to develop a 20-year strategy on biotechnology. The strategy will have specific regional technology goals to be implemented through Regional Economic Communities (RECs). To carry out this task, the ministers called for urgent efforts to strengthen the capacity of the secretariats of the RECs, especially in the area of regulatory expertise.

4.3 Diversify funding sources

One of the key aspects of technological development is funding. 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 USA 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 (UN Millennium Project, 2005).

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 supporting 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, in similar lines as the Malaysian cess 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 cess on tea helps fund research on and marketing of tea in Sri Lanka. Kenya levies

cess 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.

Cess 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 cess 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 their public expenditure constraints imposed by sectoral budgetary caps. (Scientists in Brazil proposed a similar approach to their government as a framework for negotiations with the International Monetary Fund.) Such a strategy, if pursued, 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 higher education is probably one of the most contentious issues in the history of higher education. The perceived high costs of running institutions of higher learning have 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 are experimenting with measures including directed government scholarships and lowering tuition for those 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 (Linklaters, 2006). 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. An illustration of such a venture is the recent decision by Indian businessman Anil Agarwal, head of the London-based Vedanta Resources, to donate US$1 billion for the creation of a world-class university in

Orissa, India. The gift to Vedanta University is the largest private donation to any educational institution in the world.

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 (Juma, 2006). 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 them tap into their experts in diaspora.

Conclusion

Charting a new development path will require creative thinking and risk taking. A large part of the cautious approach inherent in international development projects is a result of rigidities in existing systems of accountability. All learning processes–of which development is a part–entail a large degree of experimentation and risk taking. What is critical is therefore not simply assessing the final impact of specific projects, but creating environments that promote trust through continuous feedback. In other words, development cooperation has to be truly open and collaborative guided by collective learning. Conventional judgments about project 'failure' and 'success' will need to be replaced with a greater emphasis on lessons learned. As Einstein put it: "Anyone who has never made a mistake has never tried anything new".

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