

going for growth:

science, technology and
innovation in Africa

The Smith Institute

The Smith Institute is an independent think tank that has been set up to look at issues which flow from the changing relationship between social values and economic imperatives.

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Preface

Wilf Stevenson, Director, Smith Institute

The Smith Institute is an independent think tank, which has been set up to undertake research and education in issues that flow from the changing relationship between social value and economic imperatives. In recent years, the institute has centred its work on the policy implications arising from the interactions of equality, enterprise and equity.

This year has seen an unprecedented determination by the world's richest nations to engage with the development of the poorest. The report of the Commission for Africa, chaired by UK Prime Minister Tony Blair, *Our Common Interest*, set out the themes that dominated the G8's discussions at Gleneagles over the summer, while a mass movement, in the form of the Make Poverty History campaign, affirmed that the political agenda was matched by a widespread public demand for action.

One of the most important messages emerging from these developments has been the necessity for a transition from short-term disaster relief to long-term approaches based on partnership and economic development that allow developing countries to build on their strengths and transform their economies. Central to this transformative agenda will be the role of science, technology and innovation, both as a driver of economic growth within the developing countries and as a core element in nurturing the managerial and governance competencies that will allow a risk-taking, problem-solving approach to development co-operation.

The Smith Institute is pleased to be publishing this collection of essays by leaders in the field, expertly edited for us by Professor Calestous Juma. We hope that their contributions will help to develop the debate around the role of science, technology, innovation and education in the developing world.

The Smith Institute gratefully acknowledges the support of Syngenta AG towards this publication and the associated seminar series.

Foreword

Rt Hon Gordon Brown MP, Chancellor of the Exchequer

This has been a crucial year in our widely shared goal to promote international development. The Commission for Africa's report set out a new agenda for the poorest continent in the world. The G8, under the presidency of the UK, agreed unanimously to drive forward new measures on aid, trade and debt relief. And this year has also seen a new, progressive consensus form under the banner of the Make Poverty History campaign: a coalition that has, arguably, achieved more for the needs of the poor in one short year than have all the isolated acts of individual governments in the last 100 years.

And yet the need could not be greater. When I visited Africa earlier this year, I saw not only the potential and promise of economic and social growth in Africa but also mothers paid only £5 a week begging for free education for their children, supporters of AIDS orphans asking only that they have free healthcare, and men and women everywhere with a yearning that their growing political and constitutional rights now be matched by economic and social opportunities.

We know that despite increased aid, trade and debt relief, coupled with improvements in economic growth and governance in Africa, those opportunities will not be realised unless and until the foundations of economic growth – sustained investment, innovation, education, skills, science and technology – are in place and built on over the long term. This is the central message of *Going for Growth*. Each of the chapters in this excellent pamphlet recognises that long-term development rests on long-term investment in the indigenous sources of economic growth.

The challenges are, of course, great. The World Bank estimates that for traders in 24 of the world's poorest countries there is neither the infrastructure nor the communications to compete fairly, that costs for Africans transporting goods from village to town to port are twice those in Asia, and that telecommunications charges for people calling from the poorest countries to the USA are five times those of a developed country.

Our task now is to equip the poorest, through investment, with the capacity to compete, so companies can take advantage of trade with the rest of the world. But building capacity to trade is about more than investment in infrastructure; it must also be about investment in people and their education, skills and entrepreneurial potential. These ideas are at the heart of this Smith Institute pamphlet, which makes a significant, positive and constructive contribution to the challenge of international development in the years ahead. I warmly welcome its publication

Introduction

Professor Calestous Juma, Professor of the Practice of International Development, Kennedy School of Government, Harvard University

The dawn of the new millennium has offered humanity the opportunity to reflect on major global issues. The adoption of the UN Millennium Declaration in 2000 marked the beginning of a re-examination of international development co-operation, the most elaborate outcome of which is reflected in *Our Common Interest* – the report of the Commission for Africa, chaired by UK Prime Minister Tony Blair.

One of the central messages of the report is its emphasis on building Africa's capacity to solve its own problems. This focus is reflected in the stress placed on economic growth as a critical basis for addressing poverty. This collection of essays seeks to elaborate on this theme by underscoring the role of science, technology and innovation in development in general, and in international co-operation in particular. The different chapters signal the growing interest in making the transition from short-term, relief-based activities to long-term development, based on building competence at all levels of science.

While *Our Common Interest* outlines a strong conceptual framework for integrating technological innovation into sustainable development strategies, the chapters of this pamphlet present a range of practical options for bringing science, technology and innovation to bear on development. They build on the findings contained in *Innovation: Applying Knowledge to Development*, which was prepared under the auspices of the UN Millennium Project and presented to the Secretary-General in early 2005.

They emphasise the importance of building technical competence; modernising infrastructure as a foundation for technological development; renewing agriculture; stimulating business development and partnerships; energising civil society organisations; and improving the policy environment to promote economic growth through systematic science and technology support.

The range of options laid out call for bold actions among donor and recipient countries alike. They emphasise the importance of aligning government structures with development-oriented technological imperatives. But more importantly, they focus on raising Africa's technical competence, in order to facilitate problem solving.

They acknowledge the importance of experimentation, learning and risk taking. But they also call for measures that reduce the uncertainties associated with development, underwrite the risks of venturing into new fields and reinforce the use of lessons learned from development projects. In other words, the chapters in this pamphlet treat economic transformation as a learning process associated with continuous improvement, and make a plea for innovation in both the technological and social fields.

Chapter 1

Reinventing growth

Professor Calestous Juma, Professor of the Practice of International Development, Kennedy School of Government, Harvard University

Reinventing growth

Professor Calestous Juma

Most African economies have historically been associated with natural resources and raw materials. There is growing recognition, however, that a transition into modern economies will involve considerable investment and use of new knowledge.

A new economic vision for the country – articulated at the highest level of government – should focus on the role of knowledge as a basis for economic transformation. Doing so will entail placing policy emphasis on emerging opportunities such as renewing infrastructure, building human capabilities, stimulating business development, and increasing participation in the global economy. These areas should provide a firm foundation upon which to base international partnerships.

Learning to develop

Contemporary history informs us that the main explanation for the success of the industrialised countries lies in their ability to learn how to improve performance in a variety of fields – including institutional development, technological adaptation, trade, organisation and the use of natural resources. In other words, the key to their success was their focus on improving their skills as a way to solve problems. They put a premium on learning.

One of the most elegant aspects of a learner's strategy is that every generation receives a legacy of knowledge 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 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. The investments served as a foundation for technological learning. Second, they nurtured the development of small and medium-sized enterprises. 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.

The emphasis on knowledge should be guided by the view that economic transformation is a process of *continuous improvement* of productive activities, enacted through business enterprises. In other words, government policy should be continuous improvement aimed at enhancing performance, starting with critical fields such as agriculture.

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.

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.

Identifying strategic opportunities

Higher education and research

Higher technical education is increasingly recognised 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.

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. 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.

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 high-tech 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 and government.

Characteristics of the new approach

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. For example, EARTH University in Costa Rica focuses on agricultural sciences, while other universities emphasise information and communications technologies as well as genomics.

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. 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.

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 organisations to universities. The educational institutions would help to nurture new enterprises through providing critical services in the early stages of enterprise development.

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.

Infrastructure as a technological foundation for development

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 reducing poverty in Africa. 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. It is estimated that increasing the stock of infrastructure by 1% could add 1% to the level of GDP. But in some cases the impact has been far greater: the Mozal investment in Mozambique doubled the country's exports and added 7% to GDP, while creating new jobs; and, through its Small & Medium Enterprises Empowerment & Linkages Programme, Mozal has contracted with and trained numerous local companies.

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.

Designing the learning process

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, organisational 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, tele-communications networks, water supply and sanitation systems, and research facilities in ways that promote technological, organisational 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 co-operation between government, industry and academia.

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.

Business development

Economic change is largely a process whereby knowledge is transformed into goods and services. 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 emphasise 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.

Banks and financial institutions also need to play key roles in fostering technological innovation. But their record in this field has been poor in developing 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 small and medium-sized start-ups into multinational institutions. Bringing venture capital into African countries helps to create new businesses and improve their sustainability.

Social entrepreneurship

Civil society has played an important role in promoting a wide range of developmental activities in Africa. Indeed, civil society organisations are key sources of social innovation through their diversity and creativity. In the political arena, for example, civil society organisations have played a key role in promoting democratic change. Similarly, these organisations 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 organisations 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. The growing focus on competence building will require expanded sources of support for development activities. Civil society organisations 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.

International trade and technology development

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.

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.

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 (through licences and patents), and establishing local production facilities (through foreign direct investment).

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 foreign direct investment 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. Foreign direct investment 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.

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.

Harnessing global intellectual resources

One of the concerns raised about investing in technical training in developing countries is the migration of skilled manpower to industrialised 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. Such studies tend to focus on policies that seek to curb the so-called "brain drain". 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.

The most notable case is the Taiwanese diaspora, which played a crucial role in developing the country's electronics industry. 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 serves as a channel and link for entrepreneurs, investors and advisers in the Greater Philadelphia region and Singapore. The organisation seeks to create opportunities for collaboration and partnerships in the area.

India 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 be replaced by a new view of “global knowledge flows”.

Managing change

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 at the highest level possible in government. Advice on science, technology and innovation needs to reach policy makers. For this to happen, an institutional framework needs to be created and commitment needs to be garnered to support it.

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 or jurisdictional 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.

Science, technology, engineering, medicine and agricultural academies can play important roles in providing advice to governments. But they need to be strengthened or reformed in order to play this function. Scientific and technical academies need to co-operate with other institutions – especially judicial academies – whose activities influence scientific

and technological development. Where they do not exist, efforts should be made to create them.

Successful implementation of science, technology and innovation policy requires civil servants with the capacity for policy analysis – capacity that most 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 can also increase their capacity to handle technological issues in international forums.

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 partnership has to be truly open and collaborative. 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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Chapter 2

Knowledge for productivity-led growth

Dr Gobind Nankani, Vice-president (Africa), World Bank

Knowledge for productivity-led growth

Dr Gobind Nankani

Africa needs economic growth. The Commission for Africa has joined the continent's leaders in reminding us that no other element is more important for reaching the UN Millennium Development Goals, as well as national poverty reduction goals. The poverty reduction strategies of individual countries differ in many aspects, but uniformly recognise higher rates of growth over longer stretches of time as the foundation for improved quality of life and a better future.

Where growth comes from and who participates in it matter as well. Growth must be shared, with benefits moving beyond asset owners in capital cities. Rural dwellers, low-wage earners and excluded groups must see new opportunities and new ways to participate in their own economic development. To create such opportunities, growth must be continuous and consolidated over the long term. Boom-and-bust cycles based on fluctuating commodity prices will not be the basis for real change in Africa.

If expansion of productive capacity replaces the vicissitudes of commodity prices as the underlying driver of growth, yearly output increases of 7% or 8% can become the norm. Fifteen countries in Africa have now experienced more than a decade of average annual growth above 5%.¹ Hopes are high that they are beginning a transition to significantly higher levels of productivity capacity. But what should they do to make the transition?

Conditions for success

Continuously expanding productive capacity requires two sets of preconditions. The first is good governance: transparency and accountability in the use of public resources, fairness and the rule of law in social and business transactions, a level playing field for investment and competition, and reward for risk takers and entrepreneurs. Sound provision of public goods and services is the other set of indispensable preconditions: road and rail transport, ports, energy and communications infrastructure, clean water, health and education services raise the productive potential of firms and people. Progress is evident on these two fronts in many countries, and the prospects for continued improvement are promising.

Getting the policies on governance and service delivery right can spark a burst of growth, as previously repressed microeconomic activity flourishes. However, release of pent-up

¹ World Bank "Strengthening the Development Partnership for Achieving the MDGs: An Africa Action Plan" (August 2004), p13.

demand, welcome though it is, may not necessarily lead to sustained productivity growth. In improved investment climates, as people search for more and better ways to organise themselves to make money, access to technology increasingly determines their success. Better business climates should open channels for newer, more sophisticated uses of know-how and physical capital. But in Africa access to technology is limited and knowledge institutions are weak; explicit efforts are needed to increase technology flows.

The continent's knowledge institutions, particularly universities and research institutes, are confronted with this tremendous challenge and opportunity: how to contribute to economic dynamism as investment climates improve? How to become conduits for economically valuable knowledge and skills in nascent national innovation systems? This challenge comes as many African university systems are emerging from the crises of the past two decades. As they grow stronger, they are finding the world a different place, changed by rapid global advancement of technology. These changes cannot help but affect the missions and modus operandi. In deciding how to shape themselves now, aspirations for the future may be a better guide than traditions of the past.

Three trends or facts bear significantly on how African knowledge institutions may want to reposition themselves:

- the need for strong capacity in fundamental disciplines of science, technology and engineering to connect to growing global stocks of knowledge;
- the need for explicit national technology-learning strategies and key partnerships to make knowledge flow to where it is needed in production; and
- the opportunity to take advantage of technological "latecomer" status, and apply or adapt existing technologies to the continent's most pressing problems.

Knowledge institutions, especially universities, face two additional challenges that will shape their ability to respond:

- exploding enrolment growth and demand for tertiary education; and
- limitations of public resources for investment in universities.

Each point poses a particular challenge; how they are confronted may determine the contribution that universities and other knowledge institutions make to development in Africa in the years and decades to come.

Strong science and technology capacity needed to connect to global knowledge

Globally, science and technology are recognised as drivers of increased wealth and continuously improving standards of living. Analyses from a variety of perspectives lead to the same conclusion. Since the beginning of the Industrial Revolution (circa 1870), scientifically and technologically advanced countries have become continuously wealthier, and their rates of growth have not slowed significantly over time.²

These countries have succeeded by reinvesting a growing percentage of their gross domestic product in further advancement of research. Each year the 29 member countries of the Organisation for Economic Co-operation and Development altogether spend about 1.5 times more on research and development than the entire economic output of sub-Saharan Africa.³ Ambitious developing countries have followed suit, increasing research capacity and skills development in a variety of science and technology disciplines. Knowledge creation through research, however, is only one part of the story.

Translation of research into new, more efficient modes of production has brought dramatic benefits. For example, agricultural productivity has grown sharply: world food production doubled between 1961 and 1998 with virtually no increase in land under cultivation.⁴ From 1980 to 1996, trade in high-tech manufactured goods grew at double the rate of resource-based goods.⁵ Some of the East Asian countries that capitalised on these opportunities have transformed themselves into middle- or even high-income economies.

As the rest of the world has advanced technologically, Africa has fallen relatively further behind. From 1988 to 2001, the number of scientific articles published worldwide grew by 40%. Africa not only failed to keep pace with this growth, publication counts actually declined by 12% in absolute terms. In 1988, Africa accounted for 1.26% of all scientific publications; by 2001 its share was only 0.76%.⁶

And as the technological intensity of trade has grown, Africa has seen its share of world trade decline. Africa accounted for 2% of global merchandise exports in 1990, but only

2 Pritchett *Divergence Big Time* (1995).

3 Data from World Bank *African Development Indicators 2003 and OECD Science, Technology & Industry Outlook 2003*.

4 1.5 billion hectares of land were used in 1998 to produce twice the amount of grain and oilseeds that were produced on 1.4 billion hectares of land in 1961. Pardey and Beintema "Slow Magic: Agricultural R&D a century after Mendel" in *IFPRI Food Policy Report* (Washington, DC, 2001).

5 Lall, Sanjaya "Exports of Manufactures by Developing Countries: Emerging Patterns of Trade and Location" in *Oxford Review of Economic Policy* vol 14 (2) (Oxford University Press, 1998).

6 US National Science Foundation *Science & Engineering Indicators* (Virginia, 2002). Of the leading 10 countries, Kenya, Nigeria, Senegal, South Africa and Zimbabwe all published fewer articles in 2001 than in 1988. Of the countries that had increases (Cameroon, Ethiopia, Ghana, Tanzania, Uganda and others), none published more than 100 articles annually at any time from 1988 to 2001.

1% by 2002.⁷ During the four decades in which world food output doubled with almost no increased land use, 60% of increased cereal yields in Africa came from increasing the amount of land under cultivation.

Capacity is insufficient even to stay meaningfully connected to global advances in science and technology. Opportunities to transfer and adapt knowledge – the same knowledge that is producing concrete benefits elsewhere – remain mostly unknown and vastly underexploited in Africa.

Demand for technology and the emergence of national innovation systems

Connections to global knowledge are a starting point for the complex process of intensifying the knowledge content of production. Much of the global success of science and technology-based growth in recent decades has come from the realisation that a linear model for national R&D (sometimes referred to as the “science push” model) is obsolete and incompatible with the rapidly changing demands of the global economy. In its place, more flexible national innovation systems have evolved.

The core of an innovation system is the demand for technology from firms that want to succeed in their markets. Some of these – exporters and domestic producers competing with global imports – face competition from the most technologically advanced producers anywhere. In a well-functioning innovation system, the pressure of competition drives firms to demand ever better skills and knowledge from existing and potential employees, from knowledge institutions such as universities and research institutes, and from intermediary organisations like business associations or clusters and supply chain networks that share information. The resulting “technology deepening” or development comes from the interplay of people, know-how and institutions that are constantly seeking better and more cost-effective technological means of producing goods and services.

Dynamic national innovation systems use knowledge embodied in technology to overcome the constraints posed by geography and natural endowments. African firms must now compete against a growing number of rivals whose competitiveness is anchored in strong technological advantage. The result is that African firms have not only had a hard time breaking into new markets, they have seen foreign competitors beat them in markets where they have natural advantages. A recent study of palm oil production in Malaysia⁸ found that:

⁷ World Bank *World Development Indicators 2004*, p201.

[The palm oil] industry originated in Africa, where cooking oil was first extracted from oil palm cultivation extensively in Western and Central Africa ... The climatic and soil conditions of these economies are ideally suited for oil palm cultivation. ... [Yet p]alm oil remains a major consumption item [in Africa] and Malaysia is the chief source of imports. Malaysia now accounts for 50% of world palm oil production, and its plantations, processors, and downstream product manufacturers are generally regarded as being at the technology frontier in the industry. Malaysia has evolved from simply being a learner in cultivation and crude oil processing activities to become the lead innovator controlling the industry's value chain.

Likewise, Chile has expanded into salmon production, and become a market leader despite having no natural stocks of this fish. As other countries advance technologically, the pressure will increase for African countries to match their technological prowess or cede market share or even whole industries.

Latecomer strategies and starting from today's challenges

Being late developers in the technology game can give firms, industries and whole economies advantages, if they know how to capitalise on them. Kenya showed how to do this with its floriculture industry. By exploiting existing technologies in lower-cost settings, Kenyan businesses generated profit and jobs while providing the opportunity for increased capability through "technology learning". As a result, Kenyan floriculture became a leading export earner, garnering 25% of the European market.

The industry has matured to the point that more technologically sophisticated aspects of the business moved there from Europe:

Increasingly, Northern European breeders are incorporating aspects of their plant selection and testing on-site, in producing countries such as Kenya ... There are nearly 15 rose breeders targeting producers in Kenya. A Dutch company that operates in Kenya has trial centres worldwide: in Holland for the European market; in Kenya for the East African market; and in Ecuador for the Latin American market. Breeders who have no facilities of their own contract with local producers to conduct trials.⁹

8 Rasiash, R "The How-To of Technological Change for Faster Growth in Oil Palm Exports", UNU-INTECH working paper, p2. This study and the two cited below on Kenya and Uganda are part of a series of case studies commissioned by the World Bank on the how-to of technology transfer.

9 Whitaker and Kolavalli "The How-To of Technological Change for Faster Growth in Floriculture in Kenya", pp19-20.

Though a latecomer to floriculture, Kenya continues to seek access to the same technologies that its global competitors use in production. Although the industry is still heavily dependent on foreign consultants for management of production technologies, the number of Kenyan production managers is growing.

In its earlier stages, this technological learning may be led by individual firms or industry associations. As they move up the technological ladder to more sophisticated tasks – in this case, from managing propagation of plants to tissue culture and the creation of new plant varieties – firms need connections to universities and research institutes that are able to work at or near the frontier of their disciplines.

Few African universities have degree or research programmes that can adequately respond to the knowledge needs of these emerging technology-driven businesses. In Kenya, at least one university offers a degree in ornamental floriculture, but those seeking more sophisticated research skills still go abroad for training. Similarly, an analysis of the Ugandan fish export sector found only one zoology programme nationwide. Its curriculum included no significant skills formation or research for capture fisheries or aquaculture. Collaboration among academic programmes in food science, zoology and veterinary science was also completely lacking.¹⁰

Improving education and research

Deficiencies of the past can be the spur to improvement. By matching first-rate academic practice in science and engineering disciplines with the technological demand of firms or national priorities, universities can redefine both quality and relevance. In too many important areas, Africa's productivity is constrained because no one is adapting technologies commonly used elsewhere to solve local problems. African agriculture, for example, uses mechanisation on only 1% of cultivated land (compared with almost 100% in Europe). A study of African agriculture by the Inter-Academy Council¹¹ found that expanding mechanisation:

... is slowed by the fact that most African countries rely on imported technologies ... [as a result] many forms of mechanisation are not yet appropriate to African agriculture simply because they are not known by, or are not of sufficient priority to, American, European, and Asian machinery makers. In addition, most imported agricultural machines are not equipped to handle the mixed cropping systems that are a feature in Africa.

10 Kiggundu, R "The How-To of Technological Change for Faster Growth in Uganda's Fishery's Exports".

11 InterAcademy Council *Realizing the Promise & Potential of African Agriculture* (Amsterdam, 2004), p93.

Qualified university engineering departments worldwide make it their core business to design and adapt appropriate machinery for agriculture. They habitually do so with the best knowledge available in their disciplines. As more African engineering programmes engage in this problem, they stand to create truly appropriate technology for African agriculture: technology that uses the best available knowledge to create cost-effective solutions. Doing so adds directly to productive capacity and growth.

Science and technology in the changing landscape of African tertiary education

Space does not permit an exhaustive discussion of how African knowledge institutions can make the transition outlined above. The recommendation for deepening science and technology infrastructure in Africa is made with a full awareness of the myriad challenges facing tertiary and research institutions. Investment resources are lacking, but this is not the only or even the main problem to be solved.

As the international community renews its commitment to increase aid to Africa, new thinking on how to revitalise its knowledge institutions is in order. Only some categories of suggestions for developing science and technology in knowledge institutions are offered here, with the hope that they will receive detailed consideration in due course. The dialogue should include discussion of:

- refocusing some institutional mandates to include excellence in scientific and technological research and relevance to industry explicitly;
- recognising the costs of maintaining scientific and technological competence;
- diversifying university funding sources and strategic planning for capital investments in science and technology;
- revitalising institutional management and creation of meaningful career incentives for professors to undertake relevant research;
- restructuring science, technology and management curricula, with greater emphasis on problem-solving skills and technology evaluation skills;
- closer connections between natural science studies and valuable social science skills in organisation and management, marketing and business administration; and
- creating mechanisms for collaborative priority setting among business, government and knowledge institutions.

Yet dialogue, or even an agenda for revitalising the contribution of science and technology to African development, cannot succeed as a one-off proposition. In its least successful form, science and technology policy can degenerate into bureaucrats picking perceived

winning market opportunities or providing subsidies and privileges that mask the true costs of production.

On the other hand, science and technology policies succeed when founded on continuous co-operation on setting research priorities and investing in knowledge. Businesses and industry clusters have a role in making their long- and short-term technological needs known. Government's role is to listen to business, assure the soundness and relevance of the science and engineering base, and make it equally available to all firms.

Knowledge institutions perform the research and training to produce the skilled individuals for firms to absorb. A main output of such a system is flexible problem solvers with sound fundamental science and technology skills. Firms use engineers, technologists and researchers to scan the world for existing technology and adapt it for profitable local use, and in doing so move closer to wholly new solutions to perennial problems.

World Bank support for tertiary education in Africa

In order to revitalise science and technology in the directions discussed above, the World Bank intends to intensify its efforts within an overall framework of support for tertiary institutions and research. At present, nine of the 29 World Bank-financed education projects (accounting for about 13% of the £700 million (\$1.3 billion) in total commitments) under implementation in Africa focus exclusively on tertiary education (Ethiopia, Mauritania, Mozambique and Uganda), or contain tertiary education components in sector-wide operations (Cameroon, Ghana, Guinea, Mali and Rwanda).

These operations concentrate on a few key areas: competitive funds to encourage innovation, strategy development to chart the future direction for higher education, staff development to upgrade faculty competence, curriculum design to increase relevance to economic needs, and library and information systems to widen access to global knowledge resources.

In addition, the World Bank supports countries through policy dialogue: 22 African countries have articulated poverty reduction strategies that now treat tertiary education as an explicit development issue.

To promote cross-country learning and exchange, the bank also convenes key events with partners, including the Association of African Universities and the Association for the Development of Education in Africa. The most recent example is the 2003 Ghana

Conference on Improving Tertiary Education in Sub-Saharan Africa: Things that Work!, which brought together some 150 participants from 18 African countries to share lessons learned in Africa on how to carry out innovation, change and transformation in tertiary education.

Looking to the future, the World Bank's commitment to increased support for science and technology in Africa can be found in its Africa Action Plan for 2006-08, a document that was presented to and approved by the board of the World Bank in September 2005. One of the plan's 25 priority actions over the next three years pertains to building skills for growth and competitiveness, and to this end, the bank plans to develop and implement new operations to support tertiary education and research institutions, including agricultural education, in several African countries.

This emphasis grows out of an increasing awareness that African higher education systems suffer from broad and systemic weaknesses that are depriving countries of the managers required for effective government and business administration, and the researchers needed to harvest and apply the world's stock of scientific and technical knowledge. Most African countries also need to nurture nascent national innovations systems that can connect African businesses to repositories of knowledge and skills (for example, in universities, centres of excellence, technical and vocational training institutes and so on) in ways that help them compete successfully in global markets.

To inform the World Bank's engagement in this arena, it plans to expand its analytic work on tertiary institutions, paying careful attention to the role of science and technology in accelerating growth in Africa and drawing on lessons from successful country experiences elsewhere. Bringing about a knowledge- and technology-driven transformation of African economies will require sustained support and strong collaboration with others on country-driven plans. The challenges are enormous, but we cannot fail to meet them if we are to succeed at helping Africans to transform their economies and improving the lives of millions on the continent.

Chapter 3

Higher education in economic transformation

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Higher education in economic transformation

Professor José Zaglul and Professor Daniel Sherrard

Higher education is increasingly being recognised 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 has been viewed as essential to development only in more recent years.

Today's economic circumstances make higher education a more compelling need in developing countries than it has ever been. Key factors in this change include the increased demand for higher education, owing to improved access to schooling; pressing local and national concerns that require advanced knowledge to address; and a global economy that favours participants with high technological expertise.

Higher education and economic growth

Universities and the societies they are embedded in co-evolve, shaping each other in a variety of ways. This co-evolution is an uncertain process, involving continuous dialogue and interaction. Globalisation and the search for sustainability have cast a new spotlight on the role of knowledge institutions in general, and universities in particular. This focus is a product of the view that every society creates the university it needs; and universities in turn help to shape the character of the society in which they are located.

As nations become more integrated, so do universities extend their global influence and amplify their impact. The modern world of innovation is thus a complex network of institutions tied together by flows of knowledge. Universities are key nodes in this global institutional ecology. It is within this institutional context that universities can deliver on their economic growth goals.

Universities and other institutions of higher education, such as technical colleges, have been arguably the most under-utilised institutions in efforts to promote sustainable development. Today, African universities are largely places to train the labour force, but not a locus for productive activities – yet such institutions remain the loci of scientific and technological information, playing a critical role in the leadership of the sustainability transition.

In facilitating the development of business and industrial firms, universities can contribute

to economic revival and growth in their surrounding regions. The university can conduct research and development for industry; create its own spin-off firms; be involved in capital formation projects, such as technology parks and business incubator facilities; and introduce entrepreneurial training into its curricula. It can also ensure that students become acquainted with the problems faced by companies – through internships, for example.

Universities should also ensure that students appreciate the relationships between science, technology, innovation and development, to be sensitive to societal needs. This approach is based on the strong interdependence of academia, industry and government.

The first generation of post-independent African universities focused on nation building, with emphasis on providing functionaries for the civil service. Today, African countries are facing new challenges related to participation in the global economy, meeting basic needs, and contributing to the transition towards sustainability. These require increased investment in generating, adapting and diffusing available technical knowledge to local uses.

The 1980s witnessed the emergence of overt public criticism of universities for being out of touch with the development realities of their countries. Universities were perceived as elitist centres of privilege, far removed from the national endeavour to find solutions to the problems of development. In response to these challenges, a number of African countries are exploring how universities could contribute directly to economic transformation through closer interactions with the private sector and government.

Africa will need to change the way that universities operate. First, countries will need to consider universities as productive entities, not simply producers of a trained workforce. In other words, universities will need to act as incubators of new enterprises. Second, universities and other technical institutes must integrate with their communities.

So far, most major universities are located in capital cities. Their value would greatly improve if they could create branches in rural areas. If universities cannot reinvent themselves to play a leading role in the transition towards sustainability, enlightened governments should charter other categories of institutions to perform this community function.

Entrepreneurial education: Costa Rica's EARTH University

EARTH University, located in the rural Caribbean lowlands of Costa Rica, is a private, non-profit, international university founded in 1990, with the goal of contributing to the

sustainable development of the tropics through education in agriculture and natural resources management.

With approximately 400 students from 20 different countries in Latin America, but also including students from Africa and Asia, EARTH is dedicated to the education and development of professionals committed to sustainable development through the formation of positive values, environmental and social consciousness, an entrepreneurial spirit and a commitment to community service. EARTH is focused on innovation, interaction, analysis, synthesis and dissemination of knowledge for promotion of the development of communities in the tropics.

It is this balance that makes EARTH unique in its mission. A critical element of the mission is providing education to economically disadvantaged young people. Half the students receive a full scholarship, while an additional 30% study thanks to partial scholarships.

Offering a *Licenciatura* degree (roughly between a BSc and MSc) in agricultural sciences, EARTH is focused on the formation of leaders who will help promote sustainable development in their countries of origin. To foster the formation of "agents of change", EARTH University has developed a distinctive and novel curriculum based on experiential learning. Emphasis is placed on agriculture as a human activity; the holistic integration of many academic disciplines, understanding today's changing and globalising world, and the integration of social and environmental concerns with production and resource management.

The curriculum is characterised by student-centred learning, the development of entrepreneurial capabilities, a strong emphasis on ethics and values, teamwork, group problem solving, communication skills, vertical and horizontal integration of the curriculum, and fostering of social sensitivity through the acquisition of community development skills.

The EARTH model is a response to global sustainable development needs. The programmes most divergent to standard university curricula are those based on experiential education. These programmes include community outreach, a unique student entrepreneurship programme in which students form real businesses, an internship programme and work experience. Experiential learning is important because it promotes individual development in areas such as planning, decision making, analysis and synthesis, leadership skills and responsibility, critical and creative thinking, development and application of knowledge, application of skills and evaluation of results.

Learning by doing

Social consciousness and community development are promoted in the community outreach programme. Third-year students spend a full day each week living and working with local rural families involved in agriculture. This programme is designed to promote an understanding of everyday rural family life.

By giving students the opportunity to establish a positive and respectful dialogue with the host family, students develop communication skills that allow them to solve farm and community challenges. Third-year students also must include a community development component in their internships.

During their third year, students also leave campus to undertake a 15-week internship with a host organisation such as a business, non-governmental organisation, or a farm. Using knowledge and skills acquired in their first three years at EARTH University, students obtain real-world practical experience upon which they can reflect during their fourth and final academic year.

Work experience on EARTH's teaching farms focuses on the routine and often labour-intensive activities of crop and animal production. Students not only acquire technical skills that help them work with farmers in the future, they also develop a respect for and appreciation of rural farm labour.

The most distinguishing aspect of EARTH University's curriculum is the entrepreneurial project programme. Reflecting a profound shift in the relative importance of the private and governmental sector in development efforts over recent decades, EARTH places a significant emphasis on providing graduates with the tools needed to become successful, socially responsible entrepreneurs.

This programme includes a series of modules over the course of six semesters designed to provide students with the knowledge and skills necessary to develop a viable enterprise, as well as business acumen and competence. Emphasis is placed on the development of economic and technical skills, as well as the social and environmental concerns of starting or managing an agricultural business.

The centrepiece of the programme is the opportunity for students to create their own business. Provided with a loan from the university, students design a project, carry out feasibility and market studies, and develop and run their own enterprise over the course

of the first three years of study. If the business generates a profit, then two-thirds of the earnings go to the students, and the remaining third is deposited into a fund maintained by the university to cover those enterprises that suffer losses.

Since its inception, EARTH University has incorporated an entrepreneurial focus in all aspects of its operations, from giving students the opportunity to run their own businesses as part of the curriculum to operating its own profitable agribusiness, which has produced strong relationships with the private sector and industry-wide advances.

Putting sustainable principles into practice

When EARTH University acquired its 3,300ha campus in the late 1980s, the management team decided to continue to run and operate the commercial banana farm located on the property – in spite of the fact that the banana industry included many practices that were not consistent with the principles upon which the institution was founded. The university implemented a series of changes designed to promote more environmentally and socially sustainable production.

Innovations have included replacing the pesticide-coated bags that cover the developing bananas with a bag coated with natural insect deterrents, creating a recycling programme for the bags, and manufacturing paper out of the banana residues generated in the packing process. EARTH has made important contributions in transforming banana production into a more sustainable endeavour. These and other changes have been implemented by banana producers in the region and adopted by industry leaders such as Dole and Chiquita.

The commercial farm is also an integral part of the academic programme, giving students an opportunity to experiment with sustainable production methods and pesticide and nematocide reduction on a functioning, large-scale farm.

In addition to fresh fruit production, EARTH has created a market for a wide range of other agricultural innovations and products. EARTH's commercial operations provide the university with a growing and sustainable financial resource. Its business practices have also connected EARTH to the private sector, resulting in worldwide alliances and partnerships that are increasing awareness of the university's mission. Most importantly, EARTH's commercial operations serve as a functioning example of the three components of sustainability: economic, social and environmental.

The model has been able to maximise its commercial opportunities to the benefit of its educational programme and the sustainability project. Through its faculty-run, highly personalised admissions process, EARTH students are selected because of their leadership potential and their demonstrated commitment to return to and use acquired knowledge and skills to contribute to the development and wellbeing of their communities and countries.

With 17% of its nearly 1,000 graduates now running their own businesses, and many more working hard to save capital to follow in their footsteps, the university is making important strides in producing job creators. EARTH graduates are assuming important positions of leadership in their governments, businesses and communities, and their influence is increasingly being felt.

Innovative and creative education based on entrepreneurial spirit and social and environmental commitment around the world is a necessity for the future of sustainable development. Through the leaders they produce, universities do have the potential to make positive global changes. EARTH has taken the lead.

Community development: Ghana's University for Development Studies

The government of Ghana established the University for Development Studies in the northern region in 1992. The legislative instrument expressly mandated the university to blend the academic world with that of the community for constructive interaction to develop northern Ghana. The university's mandate emphasised agricultural sciences, medical and health sciences, and integrated development studies, relying on the resources available in the region.

The University for Development Studies aims to make tertiary education and research directly relevant to communities, especially in the rural areas. It is the only university in Ghana required by law to break from tradition and become innovative in its mission. It is a multi-campus institution, located throughout northern Ghana – a region suffering from serious population pressure and hence vulnerable to natural resource degradation. The region is the poorest in Ghana, with a relatively high child malnutrition rate. The university's philosophy, therefore, is to promote the study of subjects that will help address poverty.

The pedagogical approach emphasises practice-oriented, community-based, problem-solving, gender-sensitive and interactive learning. It aims to address deep-seated socio-

economic imbalances through well-focused education, research and service. The curricula emphasise community entry, community dialogue, extension and practical tools of inquiry.

Students are required to internalise the importance of local knowledge and to find effective ways of combining it with science. The curricula also incorporate participatory rural appraisal, participatory technology development, and behaviour change communication methodologies to involve the poor in development.

An important component of the emphasis on addressing poverty is the third-trimester field practical programme. The university believes that the most feasible and sustainable way of tackling underdevelopment and poverty is to start from what the people know and understand. By doing so it becomes possible to recognise the extent to which indigenous knowledge is scientific. The field programme aims to institutionalise the concept of bringing science to bear on indigenous knowledge from the outset in the training of young scientists and professionals, to ensure changes in perceptions and attitudes to development.

Under this programme, the third trimester of the academic calendar, eight weeks, is devoted exclusively to fieldwork. All students are required to live and work in rural communities. They identify development goals and opportunities with the people and design ways of attaining the goals together. The programme requires the same groups of students to work in the same locality for the four trimesters of the year, formulating action plans and helping in their implementation.

The university liaises with governmental and non-governmental organisations in the communities for shared learning in the development process. The field exposure helps students build up ideas about development and helps them reach beyond theory. The impact of this innovative training approach is already being seen, with the majority of University for Development Studies graduates working in rural communities.

Business incubation: The University of Zambia

In many African countries, the need to reorient universities to play a greater role in the development of their countries has to take centre stage. They can play this role by strengthening their entrepreneurial activities, as well as by supporting national projects, industry and other national centres of excellence.

In 1990 the director of the Computer Centre at the University of Zambia (UNZA) connected a few personal computers to exchange emails within the institution, with Rhodes University in South Africa, and then onwards to the rest of the world. The university network served health institutions, NGOs, governmental and development organisations. In 1994 Zambia became the first sub-Saharan country outside South Africa to get on to the internet.

Zambia benefited from at least three programmes. The ESANET (Eastern and Southern African Network) focused on promoting connectivity among universities in the region; the local project was UNZANET. The lack of human capital forced the University of Zambia to pool all the resources of related projects at the computer centre. This created a culture of mutual understanding, trust and interest. Similarly, in-house training of users by experts served to popularise the email system and provide technical knowledge.

The connectivity project at the University of Zambia was successful and highly supported by the government and donors. However, despite high-level interest, it failed to attract any direct support from donors. Early in 1994, the university decided to establish a campus-based company called Zamnet Communication Systems to link the institution to the internet and provide service to commercial customers. At this point the World Bank expressed an interest in covering 80% of the cost of the first year's operation. It lent Zamnet the start-up capital, with the condition that the university offer some shareholding in the unit to the public.

The administration worked with customers and other interest groups and intensified marketing. The university provided most of the manpower and the operational space for four years. The number of commercial accounts grew from five to 165 between January and June 1995, and seven months before the lapse of the World Bank loan, Zamnet was generating enough income to buy new equipment.

The commercial lesson

The commercialisation of Zamnet demonstrated that provision of internet services could be good business even in poor countries. The demand for email and internet services was high. Soon after its launch, the link to South Africa became saturated. Zamnet installed a VSAT by late 1996, which was upgraded to 265Kbps by January 1998. Other institutions soon followed. With the experience gained from Zamnet, the national regulator, Zambia Telecommunication Corporation, developed a new unit that specialised in internet service provision.

The economic impact of Zamnet is yet to be fully assessed. However, Zamnet's market share is estimated at between 70% and 80% of internet users. Therefore many of the country's businesses, government departments and learning institutions, and most of the internet cafés and telecentres are connecting through Zamnet. The impact of Zamnet in encouraging enterprise development, and thereby creating employment opportunities and livelihood, is immense.

The case demonstrates how countries could utilise international resources through universities to achieve national objectives. It also shows the importance of local management of projects through an accessible and transparent implementing institution, where different players feel comfortable, and the important role of the policy environment and government support.

Enterprises as incubators of universities: Korea's Pohang University of Science & Technology

Pohang University of Science & Technology (POSTECH) was established in 1986. It is a product of two outstanding visionaries: Professor Hogil Kim, the founding president of POSTECH, and Tae-Joon Park, the chair of the Pohang Iron & Steel Company (POSCO), who had the singular goal of building an excellent research university in Korea. This is an outstanding example of how business enterprises can serve as incubators of institutions of higher learning.

Combining the scientific and educational expertise of Professor Kim with Park's financial and enterprising abilities, they followed a simple formula of selecting a small number of outstanding students, supporting them fully, and recruiting the finest staff available. In March 1987 POSTECH admitted 249 freshman students into nine departments – mathematics, physics, chemistry, material science and engineering, mechanical engineering, industrial engineering, electronic and electrical engineering, and chemical engineering. In 1987 the Ministry of Education allowed it to offer graduate programmes, with the first graduate students admitted in 1988.

In 1989 the Department of Life Sciences was approved, followed by the Graduate School of Information Technology in 1991 and the Graduate School of Iron & Steel Technology in 1994. In 1995 the Ministry of Education selected POSTECH's environmental engineering programme for its graduate school support programme, enabling it to admit 18 students in 1996.

By 2002, POSTECH had awarded 2,464 bachelor's degrees, 3412 master's degrees and 570 doctoral degrees in science and engineering. It had 2,677 students, with 210 full-time and 49 visiting professors. POSTECH also pursues academic exchanges and collaborations with world-acclaimed institutions of higher learning, and has formed academic agreements with 49 universities in 13 countries, where its students attend six-month exchange programmes.

POSTECH places heavy emphasis on research. In addition to the Pohang Light Source, it houses the Pohang Accelerator Laboratory, the only synchrotron light accelerator in Korea and one of the largest of its kind in the world. The university also hosts eight research centres of excellence and more than 21 affiliated laboratories.

In January 1999 the Pohang Technopark Foundation was established – jointly with the Pohang city government, POSCO and POSTECH – to provide the infrastructure for the transfer of technology between academia and industry. In 2003 the POSTECH Biotech Centre opened, one of the largest in Korea. It is pursuing large-scale collaborations between academia and industry in biotechnology.

Through the collaborative initiative and vision of its founders, POSTECH defied all odds to become an excellent internationally renowned university. In 1998 *AsiaWeek Magazine*, in its survey of Asian universities and institutions of higher learning, selected it as the top university in science and technology. In addition, the Ministry of Education has recognised it as the most outstanding university in educational reform every year since 1996.

The one sterling lesson is the role of POSCO in developing POSTECH. POSCO's initial goal was to train top-class engineers for its steel industry. It shows that private companies in the developing world can get into higher education for not only their own benefit but also that of their economies. Africa already has several well-established profitable industries that rely heavily on innovations in science and technology that could emulate this model.

Implications and conclusions

African universities and other institutions of higher learning represent a major foundation for promoting economic growth. But their contributions to economic development can be implemented only through a wider focus on long-term technological programmes. Donor agencies can play an important role in leveraging change through support for a range of activities, which include:

University infrastructure rehabilitation and development

Government support will be needed to rehabilitate and develop university infrastructure – especially universities' information and communications facilities – to integrate them into the global knowledge community. The R&D infrastructure needs major revamping to put universities at the cutting edge of knowledge. There is potential for governments to consolidate and locate their scientific and technological infrastructure in higher education institutions.

Institutional design

Institutional design should emphasise bringing research, teaching and community outreach together. For example, medical schools should be more integrated into hospitals, just as agricultural research stations should have a strong teaching role. This process may involve reforms in existing universities, creation of new ones, or upgrading existing institutions. There is an urgent need to take stock of the full scope of research and training facilities in Africa, especially those falling outside the formal rubric of "universities", and explore how they could be harnessed to supplement the contributions of existing universities.

Curriculum reform

There is a need to reform curricula to introduce creativity, enquiry and entrepreneurship. For example, it is vital to focus attention on technical subjects as prerequisites for technological innovation; nevertheless, it would be necessary to balance this with other fields such as entrepreneurial education, the social sciences and humanities.

Also related to the curriculum are changes in pedagogy to emphasise experiential learning. These reforms should also include close co-operation with the private sector and local communities. Universities that seek to contribute to local economic transformation should integrate more with their communities; students should have greater familiarity with the needs of their communities, and hence need closer extended contacts with their wider environment

Innovations in management

For universities and technical institutes to adopt their new role as development partners, a new set of management procedures is necessary. The recommended changes require drastic revisions in student and faculty selection procedures, new incentives and transparency mechanisms, and revised curricula and teaching methods.

Universities should enjoy greater autonomy to allow timely adaptation to a rapidly changing world. The granting of autonomy should, however, be guided by the delivery of community development, rather than being done purely for governance purposes.

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Chapter 4

Africa in the global knowledge economy

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Chapter 4: Africa in the global knowledge economy

Professor Romain Murenzi and Mike Hughes

New strategies for international co-operation in Africa will need to consider major trends such as globalisation and regional integration initiatives. Major reforms in political governance and democracy are taking root in most parts of Africa, but challenges – such as war and low levels of economic growth – remain.

One of the most important forces of change and improvement in Africa is the emerging commitment to regional and subregional integration, accompanied by renewed interest in promoting territories that can serve as engines of growth in specific localities. These efforts will help to expand the domestic markets, enable pooling of development resources, and offer opportunities for peaceful coexistence among members. They will also create the economies of scale necessary for rapid diffusion of technological innovation and management skills. This chapter examines these trends, and offers suggestions on how to stimulate technological innovation and economic growth through regional integration. It focuses on Rwanda as a case study in knowledge growth and regional impact.

The Commission for Africa's report *Our Common Interest* stresses that Africa will not achieve sustainable growth and poverty reduction, and will fail to meet the UN's Millennium Development Goals, unless it increases its diminishing share of world trade. The report highlights the decline in Africa's share of world trade – from 6% in 1980 to 2% in 2002. These problems have further been compounded by growth in other developing regions such as China and India.

Africa's poor trade performance has been partly due to supply-side bottlenecks, with its low capacity competitively to produce and trade in commodities, manufactured goods and services. Demand-side constraints, through capacity constraints and protectionism in developed world markets, have played a role too. The report recommends interventions from the developed nations, in order to: increase Africa's capacity to trade; remove trade barriers in developed and other developing country markets; and provide transitional support to Africa as global trade barriers are removed.

Increasing capacity for trade would require the development of manufacturing centres in Africa, which is dependent on the development of knowledge and skills. The Commission for Africa report calls for prioritising trade in development strategies, with proper integration with other economic reforms. Although developed countries have an important

role to play in building Africa's trade capacity, Africa itself has to take the initiative to increase its domestic production capabilities, especially in sectors with regional market potential. It has to reduce its own economic barriers and develop regional integration to support sustainable growth.

Technology and regional integration

Several regional co-operation and integration schemes have been adopted by most African countries. At present, there are more than 20 regional agreements to promote co-operation and economic integration at subregional and continental level. Their aims range from limited co-operation among neighbouring countries in specific areas of political and economic development to the creation of an African common market. These integration initiatives aim to improve efficiency, increase the regional market and support integration into the global economy.

Attempts at regional integration have reflected the desire to deal with the perceived growth-inhibiting problems associated with the structure of African countries. These include the small size of the economies, their often landlocked positions (entailing the need to access ports of coastal neighbours in order to enter the global economy), and poor infrastructure services (especially transportation and communication). Regional integration therefore remains important in the quest for high and sustainable economic growth in Africa.

While it is prudent for Africa to emphasise international trade, doing so requires greater investment in developing trade capabilities, including technological innovation, the development of business and human resources, and institutional strengthening. The impact of bigger markets on technological innovation, the economies of scale arising from building infrastructure, and the diffusion of technical skills from infrastructure development into the economy are some of the most important gains Africa could make from regional integration.

A common feature of African regional integration agreements is their recognition of the importance of science and technology in national and regional economic development. Competitive advantage is partly based on an uneven endowment of resources around the globe, and partly on specialisation, skilled labour, and the accumulated capital equipment that can be used to add value to natural resources. In the case of small African economies such as Rwanda, there is a shortage of natural mineral resources as well as land. Such economies have little alternative but to commit themselves to building their science and

technology infrastructure and knowledge base as a foundation for their competitive advantage.

The integration of science and technology is based on the recognition that individual African economies are small, and poorly endowed with the human, physical and financial resources necessary to develop and harness technology. There is, however, momentum in African regional efforts to design and implement plans for the application of technology to development. Co-operation in science and technology can take various forms, including joint science projects, sharing of information, conferences, building and sharing joint laboratories, setting common standards for research and development, and exchange of expertise.

The cost of building a science and technology infrastructure often overwhelms national economies, especially the small states. Some African countries are already endowed with vast technology infrastructure, which could easily be exploited by less equipped countries. New initiatives such as the East African Community will need to play greater roles in using science, technology and innovation and motive forces in regional integration.

Regional integration: Africa's experience

The experience and empirical evidence, however, show that Africa's traditional trade-focused model of regional integration has failed, not only in promoting African trade but also in encouraging economic growth. Furthermore, despite the recognition of the importance of regional co-operation in technological development, provisions have largely remained statements of intent. The absence of appropriate regional science and technology institutions, and the failure to adjust regional organisations, have made it difficult to implement the agreements.

Overall, previous efforts at regionalism have not contributed to the economic transformation of the African continent. This has provided an explanation for the lack of success of regional integration. Traditionally, the effectiveness of any economic integration is seen in terms of its relative gains from trade creation and losses from trade diversion. Although their main objective is to promote economic integration, regional economic communities have spent the last four decades resolving political and social conflicts in some of its member countries.

The overriding feature of most regional initiatives is the misconception that merely expanding markets for existing products would lead to economic growth. Countries

thought that merely opening borders would increase their trade. Since gains from trade have been minimal, at best, enthusiasm for regionalism has dissipated. African countries largely ignored the importance of developing and strengthening domestic capabilities to trade, and overlooked the importance of trade facilitation initiatives such as the development of infrastructure and institutions. Consequently, the bigger markets created by regional integration have neither encouraged innovation nor nurtured the potential economies of scale created by the development of infrastructure.

The ability of infrastructure development to diffuse technical skills into the economy has been overlooked. Instead, infrastructure development is considered only for its direct benefits, not the indirect role in facilitating learning. Furthermore, by overly emphasising trade, African countries have neglected another important area for co-operation: building (joint) production capacity to supply regional markets. There are common sectors in the regions that are greatly hindered by thin markets, inadequate resources and poor infrastructure.

The focus on integration for trade's sake has therefore stifled Africa's innovation in domestic development strategies. African countries have paid dearly for this error. Dani Rodrik, for example, laments that economic integration has become a cliché, with global integration seen as a substitute for development strategy.¹² He sums his argument thus:

World markets are a source of technology and capital; it would be silly for developing countries not to exploit these opportunities. But globalisation is not a shortcut to development. Successful development strategies have always required a judicious blend of imported practices with domestic institutional innovation. Policy makers need to forge a domestic growth strategy, relying on domestic investors and domestic institutions. The most costly downside of the integrationist faith is that it is crowding out serious thinking and efforts along such lines.

The role of innovation in the reconstruction of Rwanda

Given its recent history, which culminated in the genocide of 1994, Rwanda is a very special case. The genocide devastated the Rwandan economy and destroyed much of the infrastructure. The loss of up to 1 million people and the emigration of many more obliterated the human resource base, especially trained personnel. Ten years on, the new

¹² Rodrik, Dani "Trading in Illusions: Developing Countries' Hazardous Obsession with Global Integration" in *Foreign Policy* (Mar/Apr 2001).

government has succeeded in rehabilitating infrastructure, restoring public services, and re-establishing credibility.

Rwanda, however, remains one of the poorest countries in the world. In 2000, more than 64% of the population lived in absolute poverty. Its economy is mainly rural agriculture, which supports over 90% of the population. The industrial sector is underdeveloped, consisting mainly of factories transforming imported semi-manufactured products. The country has no appreciable natural resource base.

Rwanda faces many challenges on its road to development, such as:

- agriculture – the inability to meet the food and nutrition needs of the population;
- human resources – specifically science and technology education and research capacity, which are almost nonexistent at all levels of education;
- infrastructure – the need to improve access to infrastructure and basic services such as housing, energy, water, sanitation;
- health – improving nutrition and hygiene, and fighting malaria and HIV/AIDS; and
- environment – the need to combat deforestation and soil erosion.

These challenges, together with its weak industrial base, weak purchasing power and land-locked nature, hinder development. Consequently, the Rwandan government recognised that it needed to develop the human resource base, particularly in science and technology, which has historically been marginalised.

However, Rwanda also boasts many advantages. These include: the strength of its leadership; its small size, which means that development of infrastructure and interconnectivity is achievable more rapidly; a favourable climate; and increasing international visibility.

In 1997-98, Vision 2020 was promulgated to guide Rwanda's future development. This strategy aims to build "a modern and prosperous nation, strong and united, worthy and proud of its fundamental principles". Achieving this vision will require the development of extensive scientific, technological and research capacity at all levels. The Rwandan cabinet recently adopted a national policy on science, technology and innovation, with four major objectives: knowledge acquisition, knowledge creation, knowledge transfer and building a culture of innovation.

The development of science and technology capacity in Rwanda is designed to support

the development of the population in a prosperous knowledge-based, technology-led economy. In particular, a developed science and technology sector will:

- stimulate a steady growth in GDP;
- advance the quality of life for all citizens;
- improve skills and knowledge among the population; and
- integrate technical education with commerce, industry and the private sector in general.

What is being done

The Rwandan government has realised that it needs to create conditions for economic growth and sustainable development, with its people as the main agents. To do this, domestic capacity to identify the potential benefits of technology, and to adapt it to meet Rwanda's needs and constraints, is needed.

Before the war, Rwanda had one university, the National University of Rwanda. Total enrolment was around 2,000 students, with an annual intake of less than 500. The genocide greatly affected the university, because many teachers either were killed or killed their colleagues. In fact, the ideology of the genocide was mooted at the university.

The last seven years have seen major efforts at bringing science and technology to the forefront. In addition to the Kigali Institute of Science, Technology & Management (KIST), other top-class institutions have been established, such as the Kigali Health Institute, the Kigali Institute of Education and the Institute of Agriculture & Animal Husbandry. As a result, enrolment in higher education now numbers more than 25,000 students in a total of 14 institutions (according to MINEDUC statistics for 2004).

Since its inception in November 1997 as a project of the UN Development Programme, KIST has grown in strength with many international supporters. It has introduced courses in computer and information technology; automotive, mechanical and electronics technology; electrical, civil and environmental engineering. KIST has forged collaboration with numerous institutions of higher learning throughout the world – in particular the Kaiserslautern University of Technology in Germany – to develop it into a world-class centre of excellence.

In 2001 KIST received the Ashden Award for sustainable energy, for developing an energy-efficient oven that uses 25% of the fuel required by traditional ovens. KIST

subsequently established the Centre for Innovation & Technology Transfer to develop appropriate technology solutions for rural areas, including renewable energy. One area of focus for the centre is the development of biogas digesters, which are being installed in prisons and schools. For example, at the Cyangugu prison in south-west Rwanda, the use of biogas has reduced fuel wood consumption from the surrounding forests by 75%. This was internationally recognised when KIST was again awarded the Ashden Award in 2005.

Kigali Institute of Science, Technology & Management

Reconstruction efforts following the genocide in Rwanda have been associated with an emphasis on the role of science, technology and engineering in economic transformation. This is illustrated by the decision by the Rwandan government to convert military barracks into a home for a new university, the Kigali Institute of Science, Technology & Management (KIST), the first public technological institute of higher learning in Rwanda.

KIST aims to contribute to Rwanda's economic renewal through the creation of highly skilled manpower. It seeks to become a regional centre offering courses in science, technology and management; carrying out extensive research activities and knowledge dissemination; and providing technical assistance and services to all sections of the community.

KIST was created as a project of the UN Development Programme in 1997. It was established with the help of the government of Rwanda as the main stakeholder, UNDP (Rwanda) as the executor of the project, and the German Agency for Technical Co-operation (GTZ) as the implementing agency. Initial funding came from UN Development Programme core funding and a UN Development Programme trust fund obtained from generous contributions by the governments of Japan and the Netherlands.

KIST was officially inaugurated in April 1998. In July 2002 it held its first graduation, awarding 403 diplomas and 62 degrees to its 465 proud pioneers in management and computer science disciplines.

Despite many challenges, KIST today boasts a highly motivated and trilingual student population of 3,247, enrolled in both regular and part-time undergraduate programmes. Students choose from a wide variety of engineering and management courses. KIST recently introduced a postgraduate diploma in demography and statistics.

Source: <http://www.kist.ac.rw/>

Building ICT infrastructure

The government of Rwanda recognised the role of information and communication technologies in accelerating development. An integrated ICT-led socioeconomic development policy was designed to transform Rwanda into a knowledge-based economy in 20 years. To implement the policy, a national information and communication infrastructure plan was developed to provide infrastructure, equipment and support, and to teach and integrate ICT skills in all sectors.

To date, the plan has facilitated the development of a cellular telephone network with an active subscriber base of around 167,000, and a passive optical fibre network (under construction) to connect government, businesses and residential schools.

The Rwandan government is also a founding member of the Development Gateway Foundation, which has enabled it to establish:

- the Regional ICT Training & Research Centre;
- the Centre for Geographical Information & Remote Sensing; and
- the Rwanda Development Gateway, which aims to set up a national web portal.

To equip young people with the knowledge and skills necessary in the global economy, every secondary school is being provided with computers. Over 4,000 computers have been purchased and a contract has been signed to provide broadband internet access, connecting about 250,000 students to the world of knowledge. Since the schools are dispersed throughout the country, the project will also connect rural areas.

When complete in December 2006, internet connectivity in Rwanda will be the highest in sub-Saharan Africa, outside South Africa. It is a fulfilment of the pledge given by President Paul Kagame at the World Summit on the Information Society, in Geneva, on 10 December 2003:

We plan to provide broadband connectivity to all secondary schools within three years, using optic fibre and wireless communication technology. These will serve as telecentres for the benefit of rural communities in catchment areas, with the ultimate aim of providing universal access.

From 2006, Rwanda will roll out a project to equip all of the country's 2,200 primary schools with a science corner, to provide information relevant to the school's surroundings.

In addition, Rwanda aims to build a high-level technical school in every province. A model technical school, supported by the African Development Bank, is already in operation at Gitarama. The ministry plans to equip all schools with bio-digesters – saving thousands of trees, solving sanitation problems in schools, giving technical and scientific skills to students and teachers involved in the project, and demonstrating the importance of science, technology and innovation in solving real-life problems.

Driving growth

Landlocked, small and densely populated, with a population density of 345/km² in 2000, Rwanda's most important asset is its people. Despite the tremendous strides made towards the goals of Vision 2020, new initiatives are necessary to develop export-processing zones, in order to stem the net capital outflow and to use knowledge to create real wealth. One of the key ideas is for Rwanda to serve as a regional hub in various fields, such as ICT, high-tech manufacturing, and small-scale high-value processing applications.

Other potential areas for growth include:

- increased agricultural production and transformation through value-adding before export;
- the development of the tourism industry; and
- the export of knowledge, following on Vision 2020, to become a knowledge-based economy.

Despite progress, Rwanda alone cannot fully realise its goals. With an integrated science policy and the key institutions already in place, what remains to be achieved are strong links with the global knowledge economy. Rwanda faces considerable difficulties in transportation, where inadequate infrastructure escalates the cost of economic activity and hinders service provision in rural areas, thereby reinforcing poverty.

The high transport costs also increase the cost of international trade. To a considerable extent, Rwanda relies on its neighbours' infrastructure to conduct its international trade, which makes integration into the region the best economic strategy. Regional integration could open larger markets and economies of scale for the country.

Rwanda is pursuing regional co-operation in infrastructure development through the northern, eastern and southern corridors. A combination of projects to improve roads,

extend the rail network and oil pipeline, and develop water transport are being either implemented or explored. In particular, an on-going study is exploring the possible construction of a railway line between Tanzania and Kigali, which would give Rwanda a direct rail connection to the port of Dar-es-Salaam. There are also plans to extend the fibre-optic backbone network nationally and internationally, through the East African Submarine Cable System, which will provide the last loop to encircle Africa with a high-capacity telecommunications network.

Rwanda is set to join the East African Community, which promises to be an important economic engine. Rwanda will then not only be able to draw from the vast human capacity in the region, but will also vastly expand its market potential with greater purchasing power.

Policy implications

If African countries are competitive in their production of goods and services, there will be many opportunities for the substitution of the commodities of one country for another, leading to more trade creation than diversion.

Technological innovation could stimulate and sustain economic diversity and trade creation, and thus should underpin regional integration. Trade creation is unlikely to occur in Africa without technological and organisational innovation.

Most importantly, innovation is more than the development of science capability – it has a lot to do with entrepreneurship too. Scientists invent, but entrepreneurs innovate in production and organisation processes to actualise the inventions. It is in enterprises that learning occurs through continuous experimentation. But successful entrepreneurs require open economies and larger markets, to mitigate the risks of innovating. Access to regional markets would reduce uncertainty, and hence spur innovation in sectors that might not have been viable with only domestic markets.

Technological progress and business development require a firm infrastructural base. Without Africans significantly investing in the development of hard and soft infrastructure, the twin desires for economic growth and increased trade will remain a pipe dream. The case of Rwanda shows that regional infrastructure projects are important; even more important, infrastructure development should be tailored to the transfer of skills and facilitation of the learning process in domestic economies.

For Africa to utilise and benefit from scientific discoveries and facilities located elsewhere, it needs skilled researchers who maintain constant communication and work frequently in collaboration with scientists around the world. The challenge therefore is for the continent to invest in creating a cadre of scientists that will be able to peer with other scientists on specific regional and international projects.

Regionalism requires that science and technology diplomacy becomes an important tool in shaping a regional agenda to the benefits of partner countries. Besides, national innovation systems and policies need to conform to regional programmes. African countries should therefore learn to discard narrow national policies and instead leverage regional resources through skilled diplomacy.

Conclusion

Poor countries often cannot afford to back basic science development, and the scientists do not stay. The result is that the inequality of innovative activity magnifies the inequality of global incomes. In response, the Rwandan government is focusing on the development of science, technology and innovation to lift the capability of its people and spur economic growth.

It has also been demonstrated that Rwanda, despite its visionary leaders, cannot do this alone. As stated in *Our Common Interest* (p262), "much more could be done by regional economic communities to encourage intra-regional industrial linkages and improved co-operation to address infrastructure and production constraints".

It is clear that regional integration can help alleviate most of the barriers to economic growth faced by African countries. While the onus is on these countries to drive their development agenda, the role of the international community in supporting regional initiatives in trade and technological innovation will be important. With proper development strategies, African countries are capable of developing to take their place in the global knowledge economy.

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Chapter 5

Infrastructure, innovation and development

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Infrastructure, innovation and development

Professor Tony Ridley and Dato' Ir Yee-Cheong Lee

The absence of adequate infrastructure services is one of the main problems that hinder efforts to develop Africa. Technology and innovation are the engines of economic growth. With the globalisation of trade and investment, technological capabilities are a source of competitive advantage.

While infrastructure development and technological development are two of the most important areas of development policy, practitioners and academics alike tend to consider them as separate issues. The focus of infrastructure development in recent years has shifted from merely construction of physical facilities to appropriate provision of services. Environmental and social factors have become part of infrastructure development and planning. Yet most infrastructure projects are not explicitly linked to technological development efforts.

The aim of this chapter is to show that infrastructure development can contribute greatly to technological development. It stresses that adequate infrastructure is a necessary requirement for enhancing the creation and application of science and technology in development. Infrastructure development also serves as a technological learning process, which provides individuals, firms and governments with opportunities to acquire and diffuse new knowledge and skills.

The scope of infrastructure development as a technological foundation includes both conventional, tangible infrastructure, such as transportation and communications, and less tangible technological infrastructure, such as product-testing facilities, sectoral technology centres and standards organisations.

Infrastructure and technological innovation

The poor state of infrastructure in most African countries is one of the most critical challenges facing development planners. Indeed, efforts such as regional integration are affected by the poor state of infrastructure.

History has not served African infrastructure well. The initial design of transportation networks focused on moving raw materials to the ports for export, and was not necessarily intended to stimulate local industrial development. Recent efforts to promote infrastructure projects have been riddled with failure and concerns about environmental

impacts, prompting major donors such as the World Bank to scale back their lending operations in this sector.

Time to rethink infrastructure

Recent interest in integrating Africa into the global economy has rekindled interest in infrastructure. In addition, addressing basic concerns such as local food production and distribution of medical supplies has refocused attention on the linkages between infrastructure and overall human welfare.

It is therefore critical that this renewed interest is accompanied by a rethinking of the overall role of infrastructure in economic development. The potential for integrating technological considerations into infrastructure projects in Africa is illustrated by the growing investment in this sector.

For example, the Maputo Corridor is a joint initiative of South Africa and Mozambique, aimed at addressing the poor state of transport infrastructure between the Indian Ocean port of Maputo in Mozambique and the industrial interior of South Africa. The initiative represents a new opportunity to create linkages with other sectors.

The plan's focus has included upgrading and constructing road links from Witbank to Maputo; improving rail facilities from Maputo to Johannesburg, together with lines connecting Maputo to Zimbabwe and Swaziland; updating Maputo's port and harbour operations; and setting up a new, integrated border post to facilitate movement between Mozambique and South Africa.

It also included improving telecommunications facilities, as well as related non-transportation investment such as the Maputo iron and steel plant, which will use natural gas from Mozambique's Pande fields. The diversity of the technology-based activities within the parameters of the Maputo Corridor project illustrate its scope.

Deeper benefits of infrastructure projects

More critically, a country like Mozambique could use the design of such a project to create strong linkages between the facilities and local technological institutions. This would not only help to utilise local expertise, but also help in upgrading technological capacity in the country over time. But such outcomes cannot be guaranteed without deliberate efforts to design infrastructure projects and foundations for technological development.

Infrastructure development provides a foundation for technological learning, because infrastructure uses a wide range of technologies and complex institutional arrangements. Governments traditionally view infrastructure projects from a static perspective. Although they recognise the fundamental role of infrastructure, they seldom consider such projects as part of a technological learning process.

Governments need to recognise the dynamic role of infrastructure development and take a more active role in acquiring relevant knowledge, through collaboration between indigenous and foreign construction and engineering firms. Building railways, airports, roads and telecommunications networks, for example, could be structured to promote technological, organisational and institutional learning.

Infrastructure contributes to technological development in almost all sectors of the economy. It serves as the foundation of technological development; its establishment represents, in effect, technological and institutional investment. The infrastructure development process also provides an opportunity for technological learning.

The creation and diffusion of technology relies on the availability of infrastructure. Without adequate infrastructure, technology cannot be harnessed. The advancement of information technology, and its rapid diffusion in recent years, could not have happened without basic telecommunications infrastructure.

Many high-tech firms, such as those in the semiconductor industry, require reliable electric power and efficient logistical networks. In the manufacturing and retail sectors, efficient transportation and logistical networks allow firms to adopt process and organisational innovations, such as the just-in-time approach to supply chain management.

The concepts of innovation systems and interactive relationships stress the links between firms, educational and research institutes and governments. These concepts cannot be implemented without the infrastructure that supports and facilitates the connections. Particularly in the era of globalisation and knowledge-based economies, the quality and functionality of information and communications technology infrastructure – as well as logistical infrastructure – are essential for the development of academic and research institutions.

Using infrastructure to attract high-tech businesses

As part of its efforts to enhance its technological base in the information and communications technology sector, the Malaysian government initiated the Multimedia Super-Corridor Project in 1995. Located in the corridor between Kuala Lumpur and Putrajaya, the new administrative capital of Malaysia, the Multimedia Super-Corridor accommodated a cluster of information technology firms.

The key element of the project is the provision of high-quality infrastructure. To attract high-tech multinational corporations – from small and medium-sized high-tech firms to large corporations such as Microsoft and Oracle – the government invested heavily in developing physical and communications infrastructure in Cyberjaya and other “cybercities” within the corridor. This infrastructure includes a fibre-optic backbone, with an estimated capacity of 2.5-10 gigabits per second, which has links to international centres, open standards, high-speed switching and multiple protocols.

The project is complemented by other large infrastructure projects, such as transportation routes that link it with Kuala Lumpur and the new international airport. Recognising that human resources are key to technological development, the project provides other infrastructure services and amenities that aim to improve the quality of life. It is clear that the Malaysian government considers infrastructure development to be a key component of its science, technology, and innovation policy.

While efforts to expand the use of technology in development depend on the existence of infrastructure, the development of new innovations and technology also contribute to infrastructure development. For example, advancement in communications and data-processing technologies has fostered the development of intelligent transportation systems for more efficient traffic management. And the use of geographic information systems and remote-sensing technologies enables engineers to identify groundwater resources in urban and rural areas.

Infrastructure and technological innovation for development thus reinforce each other. For these reasons, the construction and maintenance of infrastructure represents a technological and institutional investment. Infrastructure is a fundamental element of a comprehensive and effective science, technology and innovation policy.

Infrastructure and technological learning processes

Infrastructure contributes to technological development by providing opportunities for

learning associated with the acquisition of technology. Because of the fundamental role of infrastructure in the economy, the learning process of developing infrastructure is a crucial element of a country's overall technological learning process. This dynamic aspect is often overlooked in the development and infrastructure literature.

Learning from foreign consortia

In 1993 the Korea High-Speed Rail Construction Authority announced that it had selected a French consortium to build a high-speed train network linking Seoul with Pusan and Mokpo. Its experience with the French consortium has already helped Korea to develop its own bullet train system.

The Korean experience shows that in many respects an infrastructure project is a technological and institutional investment. It shows that a government can structure an infrastructure project in a way that allows domestic industries to benefit from technology transfer and organisational and institutional arrangements.

Korea expects the industrial and technological effects of the project to be enormous, because high-speed rail spurs the development of advanced aerodynamics, civil engineering, and mechanical and electronics technologies. Such technologies can also be applied to materials, automation, information, aerodynamics and other industries.

The project enhanced Korea's overall design capability for mass transportation, and the automatic computer control and self-diagnosis technologies it mastered can be applied to the automation of industrial robots.

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 institutional and management arrangements. Because infrastructure facilities and services are complex physical, organisational, and institutional systems, deep understanding and adequate capabilities are required on the part of engineers, managers, government officials and others involved in these projects.

Infrastructure plays another crucial role in science, technology and innovation efforts in African countries: it is one of the most important factors in attracting foreign direct investment, in addition to being itself an investment target whose future economic sustainability is expected to stabilise. Infrastructure is one of the key factors that multinational corporations consider in determining the location, scope and scale of their investments.

Foreign direct investment in infrastructure increased substantially in the 1990s – for several reasons, including favourable foreign direct investment policies, the reduced risk of expropriation in African countries and the development of innovative financing strategies.

Increased foreign participation in infrastructure projects, particularly in the form of foreign direct investment, means that there are now more opportunities for African countries to use infrastructure development as part of their technological and institutional learning process.

Governments need to design and implement rules and regulations to govern private networks that are no longer under public control. They also have the option of building up the infrastructure that replaces private networks. Given that the global economy relies increasingly on information and knowledge flows, governments are faced with strategic options that could have significant implications for their science, technology and innovation policies.

Research facilities as infrastructure

Defining infrastructure to include technological innovation requires rethinking the strategic importance of research facilities. Indeed, infrastructure projects can serve as research facilities themselves, while maintaining strong links with other research institutions.

The management of geothermal energy facilities, for example, requires continuous in situ research as well as linkages with external research facilities. But much of the research associated with infrastructure projects in African countries is usually implicit.

Support to strategic technology development should be considered part of the national infrastructure, in the same category as energy, transportation networks and water and sanitation. A number of African countries, such as South Africa, are starting to work towards creating networked research facilities that are accessed in a managed way. Other countries have consolidated research entities to create single research institutions designed to maximise synergies in human resources.

The best-known research facility of this kind is the Industrial Technology Research Institute in Taiwan. It was created in 1973 by the Ministry of Economic Affairs as a non-profit research and development organisation focused on applied research and technical service. Its original aim was to address the technological needs of Taiwan's industrial development.

By 2003 the institute had more than 6,000 people in 11 laboratories. It acts as a locus of technical support to industry and as an unofficial arm of the government's industrial policies. Industrial Technology Research Institute operations have become global.

The institute's main task has been identifying the latest technology available globally, adapting it to local needs, and then diffusing it into Taiwan's industrial sector. Most of the major semiconductor foundries in Taiwan have their roots in the institute. The Industrial Technology Research Institute also undertakes contract research for the private sector, provides technical training, carries out long-term research projects for the state and provides incubation facilities to help entrepreneurs establish high-tech firms.

Planning for infrastructure development

An essential aspect of economic planning in African countries is fostering the development and maintenance of infrastructure in a way that is appropriate to local conditions and consistent with ecological and other principles. Planning for infrastructure development should be placed on a par with other planning processes.

Infrastructure serves as a strategic foundation for the application of technology to development. As an essential element of a country's long-term development efforts, it should include direct links to human resource development, enterprise creation and R&D.

African countries need to prioritise infrastructure investment according to the degree of need as well as the potential impact of particular investments on the economy and the society as a whole. Doing so does not mean that they should focus only on basic infrastructure, however, and forgo investment in infrastructure that is of strategic importance.

On the contrary, African countries need to upgrade strategically important infrastructure in order to tap into the opportunities that may arise from rapid technological change and the increasingly integrated global economy.

African countries also need to enhance their own ability to develop, operate and maintain infrastructure services. Foreign construction and engineering firms will continue to be the main sources of technological, organisational and institutional knowledge for infrastructure development. But governments in African countries should devise policies to encourage technology transfer and build local capabilities in infrastructure projects.

Research and development activities for the development, operation and maintenance of

infrastructure should also be promoted, and linkages should be established with both domestic and overseas research networks.

Taking local responsibility for infrastructure development

Since the 1970s Algerian policy makers have considered the construction industry one of the "industrialising industries" that generates a large share of employment and GDP. To spur the industry, the government encouraged the purchase of complex, advanced and costly technologies from foreign firms.

Sophisticated and highly integrated contracts, such as turnkey and product-in-hand contracts, were used to assemble and co-ordinate all project operations – from conception through implementation and installation – into one package. The aim was to transfer all responsibility to the foreign technology supplier.

These types of contracts did not lead to as much technology transfer as the Algerian government had hoped. The turnkey contracts required that the foreign supplier take full responsibility for the project, but they did not include the sourcing or training of local people. This meant continuous reliance on external assistance, inefficient operation by local management owing to a lack of understanding and skill, or both.

Having learned from its failures, the government later encouraged "decomposed" or "design and installation supervised" contracts, under which infrastructure projects are more fragmented and involve more local firms. Local firms now take charge of the pre-installation phases (exploration and planning). With the technical assistance and supervision of foreign suppliers, local managers carry out the projects.

This new approach not only reduces uncertainty in implementation, it also facilitates the process of learning by doing in local firms, enhancing their technological capability. The approach has also contributed to the development of investment and managerial capabilities of local managers.

Infrastructure services may be provided through combinations of public and private enterprises, while taking into account the needs of the poor. Governments may reduce their role as producers of infrastructure but retain their roles as regulators, financiers, suppliers and even competitors of private providers. Whatever roles they play, governments need to recognise that different types of infrastructure require different policies and approaches.

Although infrastructure services have several common characteristics, they also have important differences. Telecommunications is less essential than water, energy and transportation. Its pricing is therefore less politically sensitive and reflects its true financial, if not economic costs. This could mean that the payback periods for investments in telecommunications are shorter than for other types of infrastructure.

Different types of infrastructure have different technologies and organisational arrangements. Governments may need to assume a direct role in certain infrastructure projects if they see strategic importance in fostering the transfer and building up of local capability in the required technologies.

In-country studies need to be carried out to identify the essential infrastructure services necessary to support development goals. The location of the poor and their critical infrastructure service needs should be pinpointed, and the cost and cost-effectiveness of infrastructure interventions to meet these needs should be calculated. Another fundamental task will be to highlight and address the problems of implementation.

In planning and implementing infrastructure projects, efforts should be made to harness the enthusiasm and drive of young professionals, many of whom are looking for an opportunity to serve the African world.

Establishing standards

The design, manufacture, supply and delivery of infrastructure hardware, software and systems are now global. This globalisation would not have been possible without internationally agreed standards. In order for infrastructure services in African countries to become more effective and extensible, countries need to create and enforce national standards that conform to international benchmarks.

Efforts should be made to facilitate co-ordination, skills development and use of standards to promote the interoperability of infrastructure systems from the early design stages. Interoperability challenges are often associated with heterogeneity in legislation, which can hamper technological innovation.

Conclusion

Without adequate infrastructure, African countries will not be able to harness the power of science, technology and innovation to meet development objectives. Because infrastructure uses a wide range of technologies and complex institutional arrangements, its

development provides a foundation for technological learning.

Infrastructure is also critical in attracting foreign direct investment. African countries need to strengthen their infrastructure and enhance their ability to develop, operate and maintain infrastructure facilities and services.

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Chapter 6

Innovation, agricultural growth and poverty reduction

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Innovation, agricultural growth and poverty reduction¹³

Gareth Thomas MP

Agriculture's weak performance in many of the poorest countries in Africa over the past 30 years has led some to doubt its relevance to growth and poverty reduction strategies. However, there is increasing evidence of the importance of growth in agriculture, and in related natural resource systems such as fisheries and forestry, for overall development and poverty reduction.

As a result, thinking is changing and African leaders themselves have developed a framework for boosting agricultural growth. This framework – the Comprehensive Africa Agriculture Development Programme of the African Union/New Partnership for Africa's Development – is expected to galvanise action and build a consensus that agricultural growth matters, particularly for Africa.

The international community also recognises – for example, in the work of the Commission for Africa and the UN Millennium Project – that without a major improvement in agriculture's performance we are unlikely to meet our commitment to halve the number of people living on less than a dollar a day by 2015. Similarly, international consensus on the key role of science and innovation in international development is building.

African-led initiatives, such as the science and technology action plan of the New Partnership for Africa's Development, and a renewed focus by the donor community will help to ensure that science and innovation are integrated into the development policy of countries as well as international organisations.

Agriculture and science will therefore remain a key part of efforts to reduce global poverty and achieve the UN Millennium Development Goals. This chapter lays out the important role that agricultural science and innovation can play in these efforts, and how we might overcome some of the particular challenges associated with innovation in Africa.

The role of agriculture in growth and poverty reduction

Agriculture's contribution to poverty reduction is sometimes thought to be small, because

¹³ This paper draws on work by the Department for International Development's policy team on renewable natural resources and agriculture, including the forthcoming policy paper "Productivity Growth for Poverty Reduction: An Approach to Agriculture", as well as the team's work on technology in collaboration with Rob Tripp of the Overseas Development Institute, and on the DfID central research department's Renewable Natural Resources Research Strategy.

its relative economic importance usually falls when low-income countries successfully develop. This view is misleading. Strong agricultural growth, particularly through increased productivity, has been a feature of countries that have successfully reduced poverty.¹⁴

Evidence consistently shows that agricultural growth is highly effective in reducing poverty. It has been reported¹⁵ that every 1% increase in per capita agricultural output led to a 1.6% increase in the incomes of the poorest 20% of the population. Another study¹⁶ concluded from a major cross-country analysis that, on average, every 1% increase in agricultural yields reduced the number of people living on less than a dollar a day by 0.83%.

The importance of agriculture and other natural resource-based livelihoods for poverty reduction goes far beyond its direct impact on poor people's incomes. Evidence shows that increasing agricultural productivity benefits millions across the world, through higher incomes and cheaper food.

Furthermore, there are strong linkages or multipliers between growth in agriculture and growth in the wider economy,¹⁷ which historically allowed poor countries to diversify their economies to sectors where growth is generally faster and labour productivity and wages are higher. Where agricultural productivity has grown slowly, particularly in sub-Saharan Africa, non-farm activities have also tended to grow slowly and to offer low wages.¹⁸

While making the transition to a more diversified and faster-growing economy is the key to sustained poverty reduction for the poorest countries in Africa, it is increasing agricultural productivity that has allowed poor countries to get on to trajectories of development that lead to growth and improved well-being. This is especially true in labour-intensive, small-scale agriculture, with its strong links to growth in other areas. No country has ever successfully reduced poverty through agriculture alone, but almost

14 Agricultural productivity is a measure of how efficiently resources are used in producing agricultural products. When productivity increases, there is an increase in the amount of output for any given amount of inputs in its production. Productivity gains can be realised through increases in the efficiency with which labour, capital and land are used. In combination, these increases contribute to "total factor productivity", a measure that takes into account all inputs used in production.

15 Gallup et al (1997).

16 Thirtle et al (2001).

17 These growth linkages were first recognised in the 1960s (Johnston and Mellor, 1961).

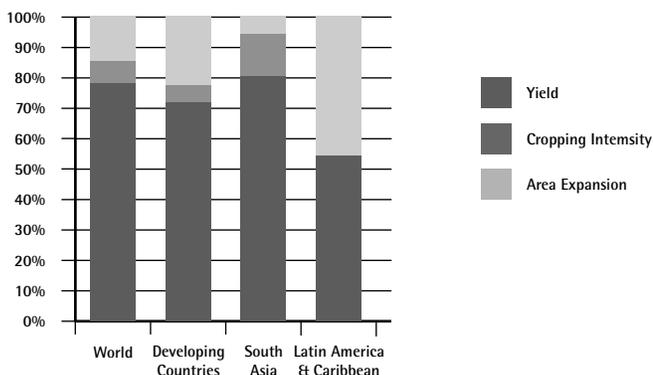
18 Haggblade et al (2002).

none have achieved it without first increasing agricultural productivity. In Africa there are few exceptions to this rule.¹⁹

Across most of Africa, however, increases in agricultural output have barely kept pace with population growth over the past five decades, and most gains have been from expansion of land rather than an increase in cropping intensity or improvements in yield (figure 1).

Where agricultural productivity has stagnated, it has slowed wider economic growth and exacerbated poverty. Reversing recent disappointing trends in agriculture's performance is critical if poor people in Africa are to escape the trap of low-risk, low-input and low-output agriculture.

Figure 1: Sources of growth in agricultural production 1961-99



Source: Food & Agriculture Organisation of the UN (2002)

The role of technology in agricultural growth and poverty reduction

New science and ideas are crucial for achieving agricultural growth and poverty reduction. Agricultural research has had proven impact through its contribution to improved farmer incomes, greater farmer resilience against shocks and vulnerability, cheaper food prices across rural and urban areas, mitigation of hunger, generation of wealth in the non-farm sector and stimulating economic transition.

¹⁹ Only in Botswana have rich mineral endowments been a pathway to growth and poverty reduction without significant growth in agriculture. Elsewhere, countries well endowed with minerals, such as Zambia and Nigeria, have not been able to convert this wealth into long-term poverty reduction and stable incomes.

Recent case studies by the International Food Policy Research Institute on India, China, Vietnam and Uganda suggest that additional investments in agricultural research and development reduce poverty more than any other form of investment in rural areas, including roads, education and health.

The institute's work confirms that the adoption of new technologies and methods, generated from well-communicated agricultural research, produces major multiplier effects in other sectors: during the green revolution in Asia, on average every pound of additional farm income generated a further 80 pence in non-farm income.

We know that agricultural technology has been a primary factor contributing to increases in farm productivity in developing countries over the past 50 years. In Africa, although there is still widespread food insecurity and poverty, the situation without existing technology would have been unimaginable.

These are some examples of successes in which the UK Department for International Development has been involved:

- Improved cassava varieties, developed for their resistance to the mosaic virus carried by tropical whitefly, have prevented widespread famine in central and eastern Africa among poor people who depend on cassava as their staple food.²⁰
- Improved cotton crop management techniques in Uganda have brought about a doubling of national production levels. Farmer incomes have also risen by up to 47% through better integrated pest management.
- On-farm seed priming, developed by DfID's plant sciences programme, has been adopted by thousands of resource-poor farmers in Africa and Asia. It brought an average increase in yields of 30% and can be used to further increase yield by as much as 90% through overcoming soil deficiencies and improving disease resistance.
- Research in South Africa and Zimbabwe under DfID's livestock programme showed that tsetse flies (transmitters of animal tripanosomosis, which affects around 3 million cattle each year in sub-Saharan Africa) feed on only specific parts of animals – enabling farmers to restrict insecticide applications to those areas and reduce per capita treatment to around 60p (\$1) a year.

Other promising examples from DfID-funded research include new options for rainwater

²⁰ Nweke et al (2002), Otim-Nape et al (2000).

harvesting in Tanzania, the development of rust fungi to prevent the spread of invasive weeds, and increasing yields and incomes while reducing labour inputs through zero-tillage (sowing wheat after rice) practices.

Limitations of research

However, the link between research investment and poverty reduction is complex, and research should not be seen as a silver bullet. Agricultural research does not target individual users, but produces technologies.

Poor people chiefly benefit from agricultural technology through three main mechanisms: first, where it directly produces more food for poor small landholders; second, where adoption of high-yielding varieties, or other technologies, increases the demand for labour – owing to higher harvesting and threshing requirements – and provides income opportunities for poor farmers; and third, where increased productivity leads to lower food prices, particularly for staples, allowing the poor to eat more and possibly better food with a positive impact on nutrition, health and food security.

But the extent to which poor people actually benefit from technological innovation in agriculture also depends on whether the technologies are taken up, and by who. This depends on what incentives exist for poor people to adopt new technology, and an effective and efficient **institutional structure** to deliver technology. Thus, technological innovation in agriculture must be seen as part of a bigger picture – part of the development continuum – if it is to have large-scale impact on poverty reduction.

Innovation elsewhere in the agriculture sector

Technology to increase the efficiency and output of agricultural production is not the only place where innovation is required in the agricultural sector. A wider range of factors are critical determinants of the rate at which farmers adopt and adapt to new ideas that enable them to raise productivity for growth and poverty reduction. These include stable output markets, stronger supply systems for inputs, supporting infrastructure and reducing levels of risk and vulnerability in poor farming households.

It is difficult to overestimate the importance of reliable **output markets** as an incentive to new technology adoption. Farmers will innovate to increase subsistence production, but as innovation generally implies some type of investment (in labour, cash or learning) the chances of farmers investing and innovating are greatly enhanced by the existence of secure markets (see box on Fruits of the Nile).

Sustainable markets for dried fruit – Fruits of the Nile (Uganda)

Many small-scale farmers in Uganda lack storage facilities for the abundance of fresh fruit available at certain times of the year. Research carried out by the Uganda's Kwana Agricultural Research Institute, in collaboration with the UK's Natural Resources Institute and supported by DfID, identified solar drying as a sustainable method of reducing losses of these fruits after they were harvested.

In 1992, Fruits of the Nile was formed specifically to provide a stable and sustainable market for the dried fruits. It provides market access to over 200 groups of farmers and so improves their buying power. The farmers also receive cash on delivery of their fruit (important in Uganda, where banks are so unreliable) and receive 55% of the wholesale price.

If output prices are volatile, then investments in technology are too risky for poor farmers. Thus, green revolution successes in Asia are characterised by stabilisation of output prices – a function that has been progressively dismantled in Africa, where innovation has been limited.

Virtually every one of the few African success stories is associated with well-functioning output markets.²¹ Unreliable grain markets lock many farmers into inefficiently producing as much of their own grain needs as possible, rather than innovating with new crops.²²

Effective input supply systems are essential, particularly when technological change or advance depends on purchased inputs. Establishing the systems to provide those inputs is, however, one of the major challenges for many technologies. The box on clean potato seed in East Africa gives an example of new approaches.

Clean potato seed for improved crop yields in East Africa

Access to clean, quality seed by smallholder farmers in Uganda is a major constraint. A joint partnership between CABI and a local NGO, AT-Uganda, looked at the effects of clean potato seed and its impacts on improving crop productivity. The research, funded by DfID's crop protection programme, focused on the implementation of locally driven and monitored quality-assured production methods that allow for potato tubers to be traced as they move through cycles from multiplication through to delivery to the small-scale farmer.

²¹ Wiggins (2000).

²² Orr & Orr (2002).

The research trained more than 20 local private-sector seed potato multipliers in seed potato production and disease monitoring and management. More than 1,000 farmers have accessed clean seed under the programme, and have been trained in multiplication and storage of healthy seed. Before the research, potato was being grown on a very minimal size of land, but land area allocation for potatoes after the project was relatively high.

A major impact has been seen in the increase in household incomes from potato. Prior to the research, potato accounted for between 7% and 34% of household income. In 2004 it accounted for between 14% and 74% of household income, and potato has gained preference as a staple food crop in the area. Through the research, the farmers who produce potato seed have established a Seed Potato Producers Association to maintain quality assurance in seed health.

The presence of supporting infrastructure is often fundamental to uptake of effective innovation and was a major factor in Asia's successful green revolution. Roads are critical to supporting input and output marketing,²³ but the expansion of irrigation probably constituted the most important element of supportive investment.

This presents a particular challenge in Africa, where the levels of irrigation are much lower than in Asia (see table 1). By 2030, it is projected that about 80% of future production gains will be made from intensification (which is in part dependent on irrigation), with a much smaller proportion through land expansion.²⁴

Table 1: Irrigation in Africa and Asia 1961/63 to 1997/99

| | Irrigated land in use (million hectares) | | |
|--------------------|--|-----------|-----------|
| | 1961/1963 | 1979/1981 | 1997/1999 |
| East Asia | 40 | 59 | 70 |
| South Asia | 37 | 56 | 81 |
| Sub-Saharan Africa | 3 | 4 | 5 |

Source: Food & Agriculture Organisation of the UN (2002)

23 Dorward et al (2004).

24 de Haen et al (2003).

The relationship between risk and technology use is also critical. On the one hand, the adoption of agricultural technology can reduce the vulnerability of the poorest. Examples include the adoption of drought-resistant varieties that reduce the risk of crop failure because of drought.

On the other hand, taking up new agricultural technology is, in itself, risky. Adoption is often associated with capital and transaction costs that poor people may not be able to afford. On the whole, because poor people are risk-averse, they tend to benefit less than others from new agricultural technologies

Institutions and policy

The challenge for Africa is to create the appropriate institutional and policy environment for innovation in the agricultural sector. What can donors like DfID do to support this? The key is engaging at a number of different levels – internationally, regionally, nationally and locally – and with different kinds of stakeholders – government, civil society and the private sector.

Examples of how DfID is working include the following:

- **National growth and poverty reduction strategies** are increasingly highlighting the role of agriculture in establishing the link between growth and poor people. DfID is focusing on 16 countries in Africa, to respond to their strategies and help deliver growth for the poor – including the many farmers, herders and fishermen, though not forgetting poor consumers who need cheap and nutritious food.
- The **African Union and New Partnership for Africa's Development** are beginning to play an important role in transforming an understanding of the importance of boosting Africa's agriculture sector. DfID, with other development partners, is supporting the African Union/New Partnership for Africa's Development Comprehensive Africa Agriculture Development Programme framework. Technology development is seen as a key strand of the framework, and DfID is working with others to support subregional research organisations in delivering improved technologies.
- **International public research** remains centred principally on the Consultative Group on International Agricultural Research. Recently, the group has emerged with a strong science council, active and productive standing panels and an effective secretariat. There is renewed conviction to work better with national agricultural research systems and farmers' groups.

- **Public extension** is also undergoing major change and pressures. The traditional notion of extension as a hierarchical organisation responsible for transferring technology to farmers is increasingly downplayed, and various proposals for revitalising extension – often involving greater decentralisation, more accountability and diversified service provision – have been considered. Uganda and Benin, within national agricultural research systems, are developing forms of demand-led extension with increased involvement of the private sector in delivery of services.

Beyond public-sector roles, one of the most notable changes in the structure of agricultural technology research and delivery in recent years is the growing importance of the private sector and recognition of the need to build partnerships between different stakeholders (see box on increasing maize yields in East Africa).

There is increasing use of purchased inputs whose characteristics, combined with the increasing scope of intellectual property protection, make them "appropriable" and subject to private investment. The private sector has significantly greater resources for investment than the public sector, suggesting that public investment should be directed to those research areas not covered by the private sector, and should guide private investment towards poverty reduction goals.

Increasing maize yields of smallholder farmers in East Africa

Maize is the most important food crop in Kenya, providing on average 44% of calorie intake. However, farmers are unable to increase their productivity unless the problems of plant diseases, reducing soil fertility and increasing soil acidity are overcome. DfID research under the renewable natural resources research strategy has benefited not just poor maize farmers, who are able to produce more maize, beans and vegetables for less work, but also village and small town level agricultural input suppliers – providing important insights into building relationships between different stakeholders.

Conventionally, fertiliser is retailed in large bags, which are too expensive for the risk-averse farmer. A Kenyan organisation, Farm Input Promotions Africa, packages fertiliser in small bags and provides a small pack of disease-resistant certified seed free of charge. Since the research began in January 2003, over 200,000 1kg bags of fertiliser have been sold in the project area, and more than 60,000 free small packs of maize seed have been provided by the seed companies. Yield increases of up to 150% have been achieved through the use of fertiliser and improved maize seed. A reduction in the use of herbicides has also reduced the cost of production by 50%.

Through the research, people who supply farm inputs such as seed and fertiliser have been trained in the identification and control of maize streak virus. Private firm Western Seed Company has vastly expanded its operation in the districts covered by the project, and thousands of farmers are benefiting from improved crop yields, even when the rain is below average.

The research provided solutions to technical production problems, but more importantly, it helped to bring together public- and private-sector organisations with farming communities to increase the supply of fertiliser and virus-resistant seed and ensure sustainability.

Recognising the importance of accessing technologies developed by the private sector, DfID is increasingly exploring support to public-private partnerships. Differences in incentives, concerns about transactions costs and lack of information can limit immediate development of public-private partnerships²⁵ but there are success stories (see box on public and private sector working together).

The public and private sectors working together

The African Agricultural Technology Foundation, based in Nairobi and supported by DfID, Rockefeller Foundation and USAID, helps farmers – and African researchers – to access productivity-enhancing technologies held by the private sector that would otherwise not be available, owing to intellectual property rights.

Similarly, the Global Alliance for Livestock Vaccines – a partnership between large pharmaceutical companies and donors – is making new livestock disease technology available to developing countries. Some three to four new vaccines, to tackle the deaths of one in five animals each year, will be developed within the next 10 years. This will help to transform the lives of the 600 million people who depend on livestock for their livelihoods.

Finally, a growing amount of internationally funded agricultural research and extension is channelled through **non-governmental organisations** of various types. A recent review of research impact found that, variation in competence, integrity and procedures notwithstanding, NGOs tended to have a better reputation among farmers than government agencies, and were better at targeting the poor.²⁶

25 Spielman Et von Grebmer (2004).

26 Meinzen-Dick et al (2003).

However, NGOs can and do fill in where the public and private sectors fail, and long-term solutions are required to address weaknesses in public and private sectors.

Conclusion

Africa is a difficult environment in which to achieve productivity gains in agriculture, but nevertheless it remains critical to growth and poverty reduction. Technological innovation is important and has helped to avoid significantly higher levels of poverty and hunger than those hitherto experienced.

Despite the challenges, there are many opportunities and much promising technology. These will, however, require a broader, more coherent and joined-up approach to policy, one that also recognises the importance of innovation to provide incentives for farmers to adopt new ideas and to ensure that institutional structures provide effective delivery of new technologies.

DfID is committed to supporting innovation in African agriculture, both through its 10-year research programme and support for partner countries, and by getting behind an African-led agenda for agricultural growth.

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Chapter 7

Agriculture, business and development

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Agriculture, business and development

Michael Pragnell

Political reforms in Africa have coincided with the growing realisation that economic growth is largely a result of the transformation of knowledge (expressed in the form of education, science and technology and the associated institutions) into goods and services. To reduce poverty in Africa, economies must grow and Africans must become agents of their own development.

Historically, public-sector interventions have dominated Africa's development strategy. While these approaches have helped to address issues relating to public goods, the role of entrepreneurship and business in economic transformation has received less attention.

A vicious circle of low investment and low growth have deprived the private sector of the capital needed for innovation and increased productivity. At the same time, weak legal and regulatory structures have undermined the confidence in a long-term, predictable investment climate that is critical to both local and international private-sector growth. The public sector's role has instead often proved more of a barrier than an encouragement to economic development.

Economic history shows that the development process requires several universally recognised ingredients. Beyond education and public health, one such ingredient is technology. Another is a flourishing small and medium-sized enterprise sector, which is critical to socioeconomic development, and a successful agricultural sector is yet another.

This chapter examines the importance of business enterprise – in particular with reference to agriculture – as the central agent that transforms knowledge into value, and the challenges facing Africa in linking knowledge with business development. It explores strategies that promote the growth of SMEs, looks at the role of multinational corporations and suggests a more dynamic engagement of business in initiatives promoting African development.

Key sectors for business development

It is clear that most of Africa's productive sectors are in stagnation. Agricultural and manufacturing sectors continue to perform poorly despite some policy reforms. Twenty-three sub-Saharan countries are experiencing food emergencies because their agricultural sectors are not performing as they should. Yet these sectors are the most important to

economic growth. They are in need of urgent technological upgrading to play their full role in economic development.

Agriculture

Agriculture's central role in development and in poverty alleviation is increasingly recognised. The plan of action from the 2002 Johannesburg World Summit on Sustainable Development acknowledged that: "Agriculture plays a crucial role in addressing the needs of a growing global population, and is inextricably linked to poverty eradication, especially in developing countries."

Agricultural productivity is a crucial stepping stone to prosperity. A number of factors contribute to low agricultural productivity in many of the poorest countries in sub-Saharan Africa. Farming is all too often as labour-intensive as it has been for centuries – producing just enough food to survive. Markets are often weak or poorly developed.

A large proportion of the population is thus trapped in a vicious circle of low income and low assets. This persists from generation to generation, rendering a low GDP per capita inevitable. The situation is exacerbated by a physical infrastructure that impedes the effective distribution and marketing of agricultural goods, by degraded soil fertility, by uncertain land tenure, by lack of access to credit, and by limited irrigation possibilities, worsened still further by growing competition for scarce water and the threat of climate change. These are compounded by the disastrous effect of HIV/AIDS on the adult community in rural populations.

Agricultural investment provides the catalyst for the development of essential infrastructure, including transport, communication, education and health services. Agriculture and food production is a high-volume, low-cost enterprise that demands transport and a functioning infrastructure. Raising agricultural productivity beyond subsistence levels is therefore key to initiating a broader economic momentum.

In addition, with food supply secure, produce can be traded locally – thus increasing incomes. As nutrition improves, health improves, and with it the population's productivity grows. Increased productivity releases people from being tied to the land and, with better education and infrastructure support, this starts the process of rural development.

Technology

Technology is critical in all sectors of the economy, perhaps above all to agricultural

productivity. The importance of technology in agriculture and of the private sector's role in its provision has been increasingly acknowledged in recent years. As *The Economist* noted approvingly last year in citing the findings of the Copenhagen Consensus – a project organised by Denmark's Environmental Assessment Institute, with the co-operation of *The Economist* – "investments in technology [are] the most effective means of increasing the incomes of hungry people. Teaching a man to farm better, it seems, can yield far more than simply giving food or medicines away." The UN Millennium Development Goals similarly call for the availability of technology as a key objective, specifically in co-operation with the private sector.

The agribusiness industry is certainly aware of its role as a key contributor to global agricultural productivity, above all through the provision of technology. It invests some 10-11% of its gross turnover in research and development, and has considerable know-how in delivery of goods and services to farmers. Indeed, it is actively engaged in the International Assessment of Agricultural Science and Technology for Development, a three-year project initiated by the World Bank, which is bringing together a wide range of public- and private-sector stakeholders to see how agricultural science and technology can best improve nutrition, health and rural livelihoods.

This innovative multiple stakeholder approach is a promising indicator of how the debate over development, growth and the respective contributions of private and public sectors has progressed in recent years.

Manufacturing

Industrial manufacturing remains a core component of long-term enterprise learning. Historically, industry has been a critical source and diffuser of technological progress and associated skills. Manufacturing is a driver of innovation because it affords opportunity for experimentation in engineering, production, quality and the management of organisations. Enterprises with manufacturing capability diffuse new processes, organisational practices and learning opportunities for the labour force.

The existing constraints on private-sector investment in Africa affect the manufacturing sector particularly harshly. Opaque tax and regulatory regimes undermine investor confidence. Manufacturing, production and distribution processes attract an unfortunate degree of state attention and bureaucracy, with the concomitant possibility of corruption deadening efficiency at all levels.

Education and training

The provision of education as a public good is largely within the remit of the public sector. Education forms part of the social and human infrastructure upon which the private sector depends. Educated communities are clearly a prerequisite for successful private investment. The private not-for-profit-sector has also played a considerable role in the provision of education in Africa, with some successful examples even at the level of higher education.

As a company investing in agriculture worldwide, Syngenta recognises our responsibility to the broader community – through partnership schemes across the developing world, for example, in the education of schoolchildren. Not only do we share best practice on product use, but we support local growers with advice on optimising the impact of their farming practices. In southern Africa, we initiated a project whereby we trained graduates, agronomists among them, so that they could establish their own small enterprises and provide services to small farmers who could not afford or maintain their own equipment.

Education is key to the rise of emerging markets, a phenomenon that is transforming the global economy. Entrepreneurial skills and training are an equally important component of the dynamism driving these regions. If success is to be replicated in Africa, we need a similar focus on education and business training, as well as exposure to global experience for those sectors looking beyond the domestic market.

This is why Syngenta has created a scholarship endowment for emerging leaders from the developing world at INSEAD, the French-based international business school renowned for its cultural diversity. The foundation will fund some four scholarships each year for students from developing countries to study for a master's degree in business administration. A commitment to contribute to the future development of their countries is a condition of award.

The role of business in development

Business is the most important engine of economic change. Creating links between knowledge, investment and business development is the most important economic challenge facing Africa.

Contribution of the private sector

Employment: Job creation is clearly a central way in which businesses can be of direct benefit to society. In addition to jobs, business commitment to core labour standards can

contribute to poverty reduction by promoting broad-based economic and social development. In technology-intensive sectors, employees often become entrepreneurs themselves. The technical and managerial skills, the networks, and market information acquired spawn competing downstream enterprises.

Goods: Developing economies need access to quality goods and services at affordable prices. Adequate access to affordable healthy food, healthcare and transport has contributed immensely to economic growth in many parts of the world, by lowering the cost of production. Businesses in Africa have performed poorly in this respect by offering expensive but poor-quality goods and services, especially in the poorer market segments. Helping business provide quality goods at lower cost benefits the poor as well as Africa's growth as a whole.

Social services: In addition to government provision of public services, business can directly benefit employees through support for education, housing and health services; it can add an important voice in lobbying for public expenditure to benefit the poor. Moreover, the overall mindset and business skills imparted to employees enhance the quality of human capital.

Small and medium-sized enterprises

Much of the discussion of business development in Africa continues to focus on the role of multinational corporations, with only limited policy interest in the importance of domestic businesses as sources of economic dynamism. However, SMEs account for over 90% of the private sector worldwide. The critical nature of technological progress offers a significant role for small-scale technology entrepreneurship in employment generation, facilitating structural change and stimulating growth.

SMEs have an essential role to play, but investments and incentives to build SMEs have been generally lacking in Africa, with public and foreign investments still focused on large infrastructure and industrial projects. Consequently, the barriers to the development of this sector are numerous:

- limited local demand, with limited market development;
- financial constraints due to low income and savings, and the absence of long-term credit;
- lack of support, knowledge and experience in business and management;
- shortage of skilled and experienced manpower;

- lack of business and market information;
- insufficient intellectual property rights protection; and
- regulatory barriers and inconsistent government policies.

Much of the above is due to market failures and imperfect information. Governments can help by instituting measures that lead to the creation and expansion of enterprise, including incentives that promote the use of intellectual capital in economic transformation. Such measures include:

- promoting the establishment of business and technology incubators, business development services and technology parks;
- fostering the development of the micro-credit sector;
- building exclusive economic zones, permitting participating firms to acquire their imported inputs duty-free in exchange for an obligation to export; and
- forging production networks, giving SMEs access to skills, educated labour, and pooled business services.

The public sector and multinational corporations

Most observers agree that the prospects of complex global production systems spreading to Africa are remote. Industrialisation in Africa continues to face many of the same constraints it did before the spread of integrated production systems. Fostering the development of local capabilities and building capacity remains the essential prerequisite. Public policy initiatives and regulatory reform, as well as financial and capacity-building initiatives, are all needed. Continuing instability remains a threat to business development.

Public policy initiatives

Effective strategies are required for science and technology and capacity building. We have seen in our own sector, agricultural research, a dramatic decline in public-sector funding, which has now been overtaken by the private sector. My own company, Syngenta, invests around £450 million (\$800 million) annually in such R&D, making us the largest investor in agricultural research globally. Yet such research is inevitably targeted towards the major existing markets. We need both a greater degree of public support for agricultural research and a more consistent and determined exploration of the mutual benefits to be derived from successful public-private partnerships, much as the pharmaceutical sector has recently been developing.

Strengthening national innovation systems would require various policy measures, including:

- better co-ordination of educational systems and institutions;
- creation and/or reform of R&D institutions and increase in public funding for R&D;
- development of effective public-private co-operation;
- development of technology diffusion programmes and mechanisms; and
- encouragement of private investment in and financing of technology and innovation.

Legislative and regulatory environments

A consistent and balanced legislative and regulatory framework is critical to securing sound and long-term private-sector investment. This is essential in all sectors, but of cardinal importance where the introduction of new technology requires a fair, transparent and predictable regulatory and legislative environment.

This sphere of governmental action is an essential contribution towards establishing a general business environment that is innovation- and entrepreneur-friendly. Well-functioning legal, judicial and regulatory systems help create a stable macroeconomic environment, remove bureaucratic barriers to investment and foster support for business infrastructure and robust markets.

Among the key requirements are:

- alignment of the legal and regulatory frameworks with global standards;
- laws to underpin and guarantee intellectual property rights;
- fair and transparent judicial systems;
- laws facilitating partnerships;
- legislation creating more attractive environments for innovative international firms; and
- clear anti-corruption laws and standards.

Needless to say, legislation and regulations only work if there is strict promulgation and implementation. In this respect the African experience is discouraging. The scourge of corruption is of course anchored in the foundations of the economy and the weakness of the public sector. So long as public officials do not receive an income upon which they can raise their families with dignity, the temptation of corruption will be hard to resist.

As long as courts have no faith in the commitment of foreign companies to the long-term well-being of the countries where they are investing, and foreign companies have no faith

in their ability to get a fair hearing at the hands of domestic courts, there will be little trust between them and no basis for long-term investment. Public aid flows under these circumstances have brought little value.

Therefore, the legislative agenda cannot be divorced from the wider economic, social and political picture. Nevertheless, it is a critical agenda, and it must be supported by strong implementation capability and regulatory oversight.

The private sector can lend its expertise in regulatory matters and in the development of sound regulatory structures. Syngenta has been able to work successfully with the authorities in Burkina Faso in supporting their development of regulatory expertise in new technologies. The appropriate research institutes have been strengthened and research personnel supported and trained, with the result that they are well equipped to put in place and maintain the necessary legislative framework and monitor the required field trials.

Financial initiatives

Financial support is important for investment in SMEs and for business incubation. Governments need to play a role in indirect financial support through:

- drafting and adopting investment laws, enabling both the development of a dynamic microfinance sector and financial institutions to set up venture capital support;
- providing tax incentives for incubators, participating private enterprises and research institutions, and public/private partnerships;
- enacting clear land tenure laws that allow land to be used as collateral for credit; and
- supporting entrepreneurial projects based on research outputs from public institutions.

Capacity-building initiatives

Governments need to invest in capacity-building initiatives, to directly and indirectly support business development. Such initiatives could include:

- support for transport and telecommunications infrastructure;
- tax-free zone initiatives; and
- further investment in education, training and public health.

Multinational corporations

Multinational corporations have long been prepared to transfer the missing elements of technology, skills and capital needed to complement local capabilities if they see a

competitive product, an attractive market or a component for global sourcing. In the process, they develop new capabilities, promoting efficient production and enabling technology transfer.

The relationship between the multinational and the local, between multinational corporations and SMEs, is key to sustained growth in Africa – developing long-term relationships with SMEs is one of the most important contributions of larger companies. Establishing linkages with SMEs enhances productivity, learning and quality, and improves managerial skills.

For example, new telecommunications companies in Africa have invested in supporting downstream service providers and have catalysed growth in the sector's SMEs. In Kenya, agribusiness companies, collaborating with farmers and entrepreneurs, have been instrumental in creating a thriving horticultural industry.

The interaction between multinational corporations and SMEs is particularly important in agriculture and food production, from the provision of inputs to small farmers – the smallest of SMEs – on up the value chain to food production and marketing. These connections can be made formally, through various forms of joint venture, or through more informal networks.

Syngenta formed a seeds joint venture in southern Africa, where Syngenta brought the technology and offered our partner, a Zimbabwean seed company, the scope to widen the market for its products. It in turn brought to Syngenta additional market access, as well as local knowledge, seed production capacity and access to seed varieties that we lacked – a synergistic collaboration to develop, produce and market maize seeds.

Successful partnerships are rare, however: there is a vicious circle where lack of capacity prevents domestic SMEs from becoming valid partners for multinational corporations. Funding or lending agencies supporting private-sector development, such as the World Bank's International Finance Corporation, are constrained from making the investments they would wish by a lack of suitable domestic partners.

Syngenta faces the same challenges, and has been experimenting with complex partnership arrangements, bringing together the distributors of our products with traders and financiers of the commodities produced. This in effect integrates the production chain and allows the farmers to receive pre-payment for their goods, which allows them to pay for

the inputs to achieve increased productivity.

Conclusion: Enterprise for Africa

The Commission for Africa calls for a "a sea change in the way the business community, both domestic and international, engages in the development process in Africa". It urges businesses "to sign up to leading codes of good social and environmental conduct, including on corruption and transparency, and focus their efforts on co-ordinated action to tackle poverty – working in partnership with each other, with donors, with national governments, and with civil society ...". This is a call for corporate engagement and responsibility that the private sector can and should accept.

Yet the challenge is immense. Building productive and purposeful partnerships between multinational corporations and local SMEs is an essential ingredient in stimulating African economies. Policies that provide incentives for multinational corporations to build domestic capacity are of paramount importance. African economies must be friendly to business, both domestic and foreign, and bridge the knowledge gap that hinders business operation. The potential of entrepreneurship has to be nurtured and unleashed – an outcome that the domestic public sector in Africa has conspicuously failed to encourage.

As for the international public sector, official development assistance has not determined how to introduce aid and financing into the economy in a sustainable manner. The imagination of international companies has identified few long-term growth opportunities in Africa. Too often returns for private-sector investment in Africa are not competitive with other regions. For the short term, we may have to view the opportunity through the prism of what might be called an extended corporate social responsibility. But sustainability for a company, as for a country, means taking the long-term view.

These failures have a shared ownership and illustrate the difficulties ahead. But there are actions that the respective sectors can take, some of which I have outlined, to engender a cycle of increasing confidence for investment and growth. We have to build on a sound strategy of economic development that recognises the key role of agriculture as a stepping stone for wider progress. We will have to work together to match risk with reward and ensure that our roles are truly complementary. A much more dynamic engagement of business in present activities, and business forums for Africa, could help meet these goals.

The multinational corporation and SME relationship has to be deepened and mentoring possibilities explored. We need to bring the stakeholders together – whether these are

governments, both African and committed supporters of the continent; private industry from the major sectors; international financial and development agencies; or NGOs. The participants in an innovative and action-oriented Enterprise for Africa initiative, focusing on food and agricultural production and bringing African and international companies together, would take the policy achievements of the Commission for Africa and implement practical outcomes that only investment, principally from the private sector, can accomplish.

The private sector must set standards in manufacturing, environmental management, quality control and employee training. By the same token, the public sector must provide a balanced and consistent legislative framework. It must provide what the Commission for Africa terms the framework "within which the private sector can create the economic growth without which the lives of poor people can never be substantially improved".

The roles are clearly mutually supportive, each bringing its strengths and capabilities. Governments need investment, know-how and the economic catalyst brought by the private sector, while business needs the enabling environment of the public sector.

The present political focus is encouraging: business is back at the table. From the halls of the UN general assembly to the enlightened leadership of countries and companies alike, the focus is on Africa, on the critical role of the private sector and on science and technology. There is also a heartening and realistic emphasis on agriculture.

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Chapter 8

Civil society and economic growth

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Civil society and economic growth

Dr Robert Tripp and Dr Dirk Willem te Velde

Scientific skills and knowledge enable countries to find their own solutions to their own problems, and bring about step changes in areas from health, water supply, sanitation and energy to the new challenges of urbanisation and climate change, and, critically, they unlock the potential of innovation and technology to accelerate economic growth and enter the global economy. Commission for Africa report, p138

The Commission for Africa is right that scientific skills and knowledge will play an important part in Africa's future development. The emphasis on skills and knowledge rather than science for its own sake is also important: it is not the existence of knowledge that transforms societies, but rather what people do with knowledge. Policy makers need to be concerned not just with research, but with the wider realm of innovation. That process can be encouraged by government, but essentially takes place in the private sector, whether on farms, in firms or in communities – in fact, in civil society. Civil society is thus central to any discussion of science, technology and innovation in Africa.

Within civil society, organised interest groups play a key role. Such groups may have economic objectives, but they are not commercial entities; they may be legally protected, but they are independent of the state. They include organisations representing African producers and consumers, entities promoting African (and international) science and technology, and non-governmental organisations that are concerned with development assistance in Africa.

These bodies have multiple roles in innovation. First, new technologies often engender significant economic change, and it is important to ensure that benefits are equitably distributed; second, the increasing complexity of science and technology demands greater citizen involvement and understanding; and third, recent advances in the understanding of innovation emphasise the role of demand-led technology development and the importance of involving a wide range of stakeholders in technology generation.

We should not be naive, however. There are four potential pitfalls.

Limits of civil society

First, the term "civil society" is sometimes used to describe an undifferentiated and benign force that merits promotion in all circumstances. In fact, it reflects the exceptionally

complicated circumstances of political life, and its contribution to equitable development depends on the context in which it operates. As Robinson and White remark: "Actual civil societies are complex associational universes encompassing a wide diversity of organisational forms and institutional motivations. They contain repression as well as democracy, conflict as well as co-operation, vice as well as virtue; they can be motivated by sectional greed as much as by social interest. Thus any attempt to compress the idea of civil society into a homogeneous and virtuous stereotype is doomed to failure."²⁷

Second, the relationship between technological development and civil society is also far from straightforward. There are many examples where civil society has opposed advances in science and innovation. During the Industrial Revolution, associations of craftsmen often tried to obstruct technological advance that threatened their industries. In the South, the technology policies of repressive regimes have led to backlash, such as the opposition of African farmers to soil conservation measures promoted by colonial administrations, or NGO opposition to Green Revolution technology in some Asian countries as part of their struggle against unrepresentative governments. Consumer-based civil society may also oppose new technology, as the widespread concern about genetically modified organisms illustrates.

Third, even when civil society is favourably disposed to technology, it is unlikely to exert strong pressure unless it sees clear advantages. Support from farmers' organisations and other elements of rural civil society would be a great benefit to agricultural technology development in Africa, but it is often difficult to demonstrate the immediate advantages. In many countries, only a minority of farmers are net grain sellers, and rural households' interests in access to more efficient production technology may take second place to their concerns as consumers seeking affordable food prices.

Liberalisation may come with a decline in the political voice of small-scale producers who no longer benefit from subsidised technology, and support for local community development may increasingly come from income generated by migrant labour. Rural civil society is most likely to support technological innovation when there are good returns to farming. The rapid growth of local farmers' associations in mid-19th-century England and of the farm bureaus in the early 20th-century USA took place when the respective agricultural economies were thriving.

²⁷ Robinson, M and White, G "Civil Society and Social Provision: The Role of Civic Organizations", in Minogue, M, Polidano, C and Hulme, D (eds) *Beyond the New Public Management* (Edward Elgar, 1998).

Fourth, organising civil society to represent the supply side of science and technology may also be problematic. Although the image of the lone scientist in her laboratory may be overdrawn, there are relatively few examples of civil society representing the interests of science and technology in political processes. In the USA, professions such as medicine raise funds for political action, but most "pure" science secures access to public research funds through lobbying (for example, by universities) rather than by overt political action. The major instance of organised political activity representing the concerns of the scientific community in the USA has been that related to nuclear disarmament.

The example of environmental issues illustrates how scientific participation in (highly technical) political debates is often overwhelmed by other members of civil society. At the international level, NGOs such as the International Council for Science and the World Federation of Engineering Organisations are focusing increasing attention on development-related issues, and it may be possible to enlist additional support from such bodies.

So, although African technological innovation will benefit from a strong civil society, we must be realistic about the immediate prospects and limitations. Civil society is most likely to support the process of technology generation when it sees clear economic interests. In Africa's present economic climate, many farmers and manufacturers have few incentives to invest in new technologies. Civil society's demands for science and technology will be found where competitive markets reward innovation, rather than where political regimes favour protectionism and privilege.

Strategies for development assistance

How can donors support civil society's role in innovation? Take three examples.

Support producer organisations

With respect to agricultural technology generation in Africa, the most common attempts of development projects to support local associations include endeavours such as: participatory research; the formation of farmer groups for extension or marketing; farmer field schools; and various efforts to link political decentralisation to demand-led research and extension. Many of these efforts can make useful contributions, but they rarely result in associational forms that are sustained beyond the life of the particular project.

Similar concerns may be expressed about the fashionable concept of social capital. A widely cited study in Tanzania found that villages with higher social capital (measured by numbers and types of local groups) had a greater use of recommended agricultural

technology, but the report admits that it had "not empirically identified any policy levers available to expand social capital or estimated the costs of creating social capital".²⁸

A more viable rural civil society will probably be based on broader producer organisations, unions or peasant movements. These are more difficult for donors or governments to support, may be unlikely to embrace technology development as one of their immediate goals, and will often represent the interests of wealthier strata. Nevertheless, if we are interested in the long-term development of a healthy civil society that demands and participates in the generation of useful technology, then such organisations should be a part of development strategies.

Many of these organisations will necessarily be based on commercial crops. There are several examples from West Africa where cotton producer organisations have evolved into significant political forces that promote their members' economic interests (and play a role in ensuring they have access to the most productive technology). It is important to note that these movements are based on cash crop, and not subsistence cultivation.

Small-scale African farmers need better access to domestic and export markets. Current debates about the effects on small farmers of strict grades and standards for horticultural exports, and the growing international and domestic power of supermarkets, underline the potential role for civil society organisations to help farmers compete effectively in local and export markets. But this requires commercial and technical experience that only a handful of NGOs possess.

Support qualified NGOs

There is little doubt that many NGOs are more effective than state agencies in carrying out local projects, but questions must be asked about impact and scale. In order to achieve impact in technology generation, an NGO's organisational skills must be backed up by technical competence. In many African countries, a number of NGO projects promote the same technologies with little co-ordination (in part because they are competing for the same donor funds) and little technical experience. In addition, many NGO projects serve as brokers between state agricultural services and farming communities, rather than organising farmer capacity to interact directly with extension and research.

28 Narayan, D and Pritchett, L *Cents & Sociability: Household Income & Social Capital in Rural Tanzania*, policy research working paper 1796, Social Development & Development Research Group (World Bank, 1997)

Donors that sponsor NGO activity in agricultural technology should invest in identifying those NGOs with adequate technical skills and long-term commitment. This implies more careful oversight of donor projects and investment in skills development, some of which might take place through closer interaction between African universities and technologically oriented NGOs. In addition, donors should insist that the NGOs they support help develop farmer organisations that can make their own demands on state services.

More generally, donors need to recognise that innovation is a political process. Several of the more successful civil society developments in Africa (such as Kenya's Green Belt Movement) began by addressing environmental concerns. Their ability to confront problems of environmental degradation elicited widespread participation and was a basis for the organisation of activities that went on to address issues related to local livelihoods and national politics. The success of this movement also indicates that there should be possibilities for enlisting the interests of the growing African urban middle class in issues such as environmental protection, to help provide pressure for the development of efficient and appropriate technology.

Invest in institutions

A number of other areas are relevant to supporting the emergence of a strong civil society that can promote science, technology and innovation. These include strengthening market institutions, promoting professional associations, developing consumer protection and education, and providing better information: in general, investing in institutions.

Africa's ability to take increasing advantage of science and technology will depend on strengthening local market institutions. Although businesses worldwide depend on personal contacts and experience to a greater extent than generally acknowledged, it may be argued that African enterprise relies too heavily on informal social capital; networks of kinship, ethnicity and locality play an overwhelming role in shaping business decisions. African businesses need more formal mechanisms (such as trade associations) to establish reputations and help enforce contracts.

Global value chains have helped Asian firms upgrade their technology and control of markets, but the capacity of African firms to take advantage of such links has often been less positive. There is a growing appreciation of the importance of clusters that involve networks of firms at a local level and on global value chains that involve networks of firms across countries. Technological upgrading often occurs within such networks. Joint action among firms through business associations can enhance firm performance.

There are a number of examples from Asia (such as the textile and garment industries) where interactions with buyers in the North have led to the acquisition of new production technology. However, most African countries are locked into the upstream part of the production chain, with few incentives and few skills to upgrade to technologies that capture a larger proportion of the value chain.

Clusters of firms need knowledge that can be acquired through establishing technology centres and business associations. Joint action among the firms can lead to co-ordinated marketing efforts and investment in human capital and thus technological upgrading. There is some evidence that clusters and industry associations in Africa are beginning to make a difference in sharing technical information or developing special programmes to assist small firms, such as in the garment industry in South Africa.²⁹

Technical and manufacturing associations can also play an important role. These range from accountants' and lawyers' associations to tourism and engineering associations, and can function within countries or across countries – for instance, regionally. The development of such associations goes hand in hand with the development of the services sectors. Often, the professional services associations can be helpful in co-ordinating the activities of small service providers, or formulating common responses to new government initiatives such as trade policy statements.

Effective partnering

Effective policies are also important. A review of Tanzania's policy shows a high commitment to science and technology in development, but it has been unsuccessful at eliciting effective public-private partnerships.³⁰ By contrast, a public institute in South Africa has been successful in channelling the requirements of the automotive industry to support more relevant human resource development.

The automotive industry in that country consists of seven multinational enterprises, and has gone from a protected industry under the apartheid system to becoming a producer and exporter of top-quality cars. Skills development has been important in making this industry internationally competitive, and the car producers have taken an active role in the formulation of human resource policies.

29 McCormick, D "African Enterprise Clusters and Industrialization: Theory and Reality" in *World Development* 27 (1999).
30 Lall, S and Pietrobelli, C "Failing to Compete" in *Technology Development & Technology Systems in Africa* (Edward Elgar, 2002); te Velde, DW and Morrissey, O "Supporting Industrial Development: Overcoming Market Failures and Providing Public Goods", report in the UNIDO COMPID programme (2005).

Key institutions include the public Automotive Industry Development Centre, which sees itself as a facilitator between the supply-side (public further and higher education and training institutions) and the demand side (the automotive sector). It has signed agreements with a number of higher education providers to develop programmes for which there is a clear industry demand.³¹ While the industry is not representative of the rest of Africa, the account shows that it is possible to build up a competitive industry in the presence of appropriate mechanisms to co-ordinate human resource development.

Discussions of best practice in co-ordination between the public and private sectors often point to East Asian examples. The Malaysian Penang Skills Development Centre was set up in 1989 in response to a growing shortage of skilled labour in the skill-intensive operations (such as electronics and IT) of multinational corporations in the free trade zones and industrial estates. Financed initially through a pooling of public (grants, training materials, equipment and trainers) and private (donations, loan of equipment, furniture, private training facilities) resources, it is now self-financing and offers technical and managerial skill training and higher education.

Another example is Taiwan's Industrial Technology Research Institute, a large, non-profit umbrella organisation established by the government that sponsors a wide range of research and service activities in support of local industries. African governments could draw lessons from some of these examples of intermediate organisations that support technological development.

Organisational innovation is also important to strengthen ineffective regulatory mechanisms for technology in Africa. Regulation of agricultural inputs concentrates on the policing of producers and merchants, rather than empowering farmers to recognise good-quality products and to punish inadequate service. Citizens' organisations can also play an important role in complementing regulatory responsibilities for ensuring access to legitimate pharmaceuticals, safe transportation and a healthy environment.

Finally, the emergence of effective civil society organisations requires good access to information. Support for more effective mass media, such as FM radio and newspapers, is important for allowing technology users and consumers to understand and access innovations. (In terms of the daily rural wage, a newspaper costs a Kenyan farmer 10 times

31McGrath, S "Globalisation, Education and Training: Insights from the South African Automotive Sector", HSRC draft paper for ODI-HSRC project on globalisation and education (2005).

what it costs an Indian farmer.) The quality of mass media is also an issue. In many instances, media responsible for reporting scientific and technical developments merely paraphrase technical journals or the pronouncements of scientists rather than encouraging citizen engagement and participation.

Conclusion

The importance of a strong civil society for supporting national systems of technological innovation has been overlooked. Donors and governments should give more attention to fostering the growth of civil society, although they have very little experience in this area. National governments are at best ambivalent about fostering the growth of civil society, which may be seen as a threat to established regimes.

In addition, the growth of civil society may reinforce existing distributions of power and privilege, rather than furthering democratic objectives. Even representative civil society is not necessarily drawn to interact with processes of technology generation unless there are strong economic incentives. The problem is exacerbated by the fact that civil society organisations are more likely to appear in strong economies. Thus assistance to fostering the type of civil society that can demand better science and technology will require a long-term, co-ordinated approach that includes attention to strengthening markets and building viable public and private institutions.

Despite these significant challenges and limitations, there are several things that donors and governments can do in support of the development of civil society. They can look more carefully for opportunities to support genuine grassroots efforts related to agriculture, manufacturing, or other areas that draw on science and technology. These are likely to be found among relatively better-off groups (such as commercial farmers) and may not necessarily have immediate connections to technology development. But donor support for such efforts will help contribute to the evolution of a strong civil society – if governments and donors ensure that the organisations do not exclude poorer members of society, and if they are sensitive to the dangers of "loving to death" such emerging organisations.

As a corollary, donors should recognise that the conventional assistance strategies of forming small groups for activities in areas such as technology generation or marketing may make useful short-term contributions, but require very careful thought if such social capital is to contribute to the growth of a viable civil society independent of donor assistance or government protection.

More thought is also required regarding the type of NGOs that can effectively contribute to supporting the growth of a civil society that helps foster technological innovation. The requisite skills include technical competence, an ability to develop user capacities to interact with relevant public- and private-sector technology generation, and strong commercial experience to link technology users to markets.

There are also several areas of institutional support that can contribute to the growth of civil society in Africa, including the development of market institutions, trade and industry associations, consumer education, and access to information. Government support for independent, flexible organisations that can foster public-private partnerships in industry, identify and support skills development, and target resources to appropriate research deserves particular attention.

Most of these areas demand new strategies and skills from donors. They imply long-term commitments, sensitivity to national political contexts, technical competence, and a capacity to learn from and adjust to the evolution of local institutions. Whether donors are able to respond to these challenges remains to be seen.

Chapter 9

Governing technology and growth

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Governing technology and growth

Professor Sir David King

The case for science and technology in good governance

While it is possible to govern today without a basis of science and technology, it is not possible to govern well. Not only are governments in constant need of technical advice on issues ranging from energy policy to disease control; a sound economy that supports growth and development must draw on science and technology.

This is true for any nation, but African countries are faced with a set of specific problems, ranging from agricultural production to health, for which scientific, engineering, agricultural, medical and social skills are needed particularly urgently. Yet at present they are all but absent.

This chapter looks at how that gap might be filled. We recognise, however, that the connection between good governance and science and technology is not always seen as self-evident, even by governments and agencies in the developed world. I hope therefore that this chapter will make it apparent that, on the contrary, scientific and technological competence are essential to sustainable development anywhere, but particularly across Africa.

The need for sound scientific advice

It is not hard to find examples in which governments have needed (even if they have not always responded to) good scientific advice. In the UK, the spread of foot-and-mouth disease among livestock in 2001 was limited by measures that were shown by epidemiological modelling to be essential for containment. Scientific advice was also pivotal to governmental healthcare decisions in the wake of public fears about the safety of the MMR vaccination in 2004.

On a global scale, the science of climate change has become central to debates about energy policy. All of these examples have highlighted the tensions that exist between different governmental priorities, as well as the widespread public ambivalence and confusion about the role of scientific advice and the nature of scientific evidence. But they do show that, whatever governments decide in the end, they cannot neglect scientific and technological expertise as a component of their deliberations.

In Africa, faced with the immense importance of, say, predictions about the spread of disease or the effects of climate on agriculture and water resources, this dependency is even clearer.

But these cases are all largely about the management of crises. The importance of science and technology in governance goes deeper than that, because it bears on the very existence of a basis for economic growth. That is why the focus here is on the need for a social and educational infrastructure in Africa that can produce the technically qualified population needed for sustained development.

The tremendous advances in human welfare and life expectancy in developed countries over the past hundred years have resulted largely from technological innovations, particularly in healthcare and the provision of clean water, sanitation, energy, communication networks and efficient agriculture.

The fact that life expectancy has not increased nearly as much in African countries, and indeed is falling in some, can be very clearly linked to deficiencies in these areas. At the root is poverty; but it is acknowledged now that money will not buy a long-term solution unless it is used to set in place the capacities for these countries to become self-reliant. A technically skilled population is a prerequisite.

Whether technology determines or responds to socioeconomic change is still debated, but without arguing over cause and effect, it does seem clear that the two co-evolve. In consequence, governance cannot afford to neglect either the importance of technology for economic growth today or the implications of technological change in the future.

In short, a healthy economy and a stable government must be dynamic, knowledge-based and linked into the global scientific and technological community.

The existing challenges for Africa

Poor governance is recognised as one of the major obstacles to development in Africa. But "good" governments cannot be created by fiat, nor by demands and conditions imposed by aid bodies in developed countries.

Corruption, lack of democratic representation and a tendency to resolve disputes by conflict are in principle easy to condemn (if not to prevent) from the outside, but the obstacles to strong governance in Africa stem also from complex factors that bear on the

technological capacity of the nations concerned: for example, the ability to create a well-educated workforce, the degree of engagement on a technical level with developed nations, the destabilising influences of disease (particularly HIV/AIDS, malaria and tuberculosis) and of climate, the reliability of agricultural resources and the availability of clean water and sanitation.

The key to sustainable development in Africa – that is, development that does not rely indefinitely on foreign aid – is the creation of infrastructure. Part of this is a purely physical matter: a question of civil engineering. The business and finance communities in African nations identify the lack of good roads, railways, air and water transport facilities, energy and water supplies, and telecommunications networks as one of the main obstacles to economic growth.

It is estimated that, to sustain a growth rate of 7% (which only three of the 16 sub-Saharan African countries achieve today), Africa needs to spend £11 billion (\$20 billion) more on this kind of infrastructure each year until 2015.

A healthy infrastructure is vital for the success of new businesses, bearing critically on their profitability and competitiveness and therefore determining the climate for entrepreneurship. Such an infrastructure might be planned and built with foreign aid and expertise but it can only be maintained and renewed, and therefore make a long-term difference, by a skilled African workforce.

But for Africa, developing a reliable and effective infrastructure is not just a matter of engineering. The issue has much more to do with building a physical, cultural and political framework within which science, engineering, medicine, technology and innovation can be nurtured, taught and practised.

Science and technology have too often been viewed as elitist luxuries for Africa, necessary only once poverty has been eradicated. They are essential priorities.

This should be apparent from some of the major problems afflicting the continent today. In sub-Saharan Africa, the incidence of HIV in 2003 was over 7% of the adult population. Up to 90% of those with HIV are aged 15-49 – the most productive section of the workforce – which means that in some countries, projections indicate that 20-40% of this workforce could be lost to AIDS.

Quite aside from its enormous social cost, this depletion has strong economic impacts too. Agricultural yields are reduced when there are insufficient farm workers to collect the harvest, and it is estimated that the economies of countries with a high incidence of AIDS may in 20 years' time have grown by only a third of what they would have otherwise. And producing a well-educated cadre of engineers and technologists is constrained by such a high mortality rate and low life expectancy (typically 40-55 in sub-Saharan Africa).

Food and water are the most basic challenges

Water will become an increasingly scarce resource in the continent, even though parts of equatorial Africa have a relatively high rainfall. Agriculture presents the biggest demand on available water sources – up to 80% in some developing countries – while industrialisation creates new demands, and also new sources of pollution.

Efficient irrigation methods can be relatively costly and labour-intensive to install and maintain. It is estimated that the rising per capita demand for water globally will exceed available sources around 2050; in Africa, water shortages and contamination are already a major problem. Around 80% of all diseases, and a third of all deaths, in developing countries are the result of contaminated water.

Between a quarter and a half of the population of African countries is undernourished, and food crises are recurrent in half of these countries. Food imports cost Africa around £12 billion (\$22 billion), even while a considerable part of agricultural activity is devoted to export crops.

Ideally crops would be grown not just for either subsistence or export but to create stocks for African countries that have regular shortages. Part of this relies on better infrastructure, but part depends also on research and innovation. The Commission for Africa stresses that here (as elsewhere) "Africa must choose its own research priorities", and that this should be enabled by international support "channelled through African research organisations and universities".

Africa does not need cutting-edge science in order to address many of the social and technological problems it faces. Most of these stem not from a lack of technical solutions (HIV/AIDS and malaria are exceptions; waterborne diseases are in principle readily preventable, for the most part), but from lack of resources to implement them.

Sound civil engineering, good sewage treatment and watershed management, quality hospital care, reliable energy sources – all these requirements are routinely met in developed countries, but they require a technically able workforce for both implementation and maintenance, which will not exist without investment in basic education. Africa most needs general practitioners, although high-level experts are certainly needed at the level of policy formulation and implementation.

The need to catch up with the developed world

Some of the technological advances of the past several decades, such as cleaner manufacturing methods and waste recycling, solar power and energy-efficient machinery and devices, might be valuable in helping Africa to leapfrog the eras of environmental degradation that Western countries have passed through, and which rapidly developing countries such as China now seem to have entered.

These new technologies might also sometimes better address the particular needs of African communities – for example, by providing power supplies to remote villages that cannot be connected to a national grid, or by using information technology (tailored to particular cultural requirements) to put local users in direct contact with experts who can answer their questions.

But development agencies have found that even relatively simple technologies cannot be introduced in a sustainable way without the infrastructure needed to support them. It is now recognised that the lack of trained people and suitable infrastructures (such as the supply of spare parts) obstructs the dream of technology transfer from developed to developing nations.

Many of the problems besetting Africa are symptoms of the deeper problem of a vicious circle, in which underinvestment in science and technology causes indigenous research to suffer from a brain drain (there are more African scientists and engineers working in the USA than in Africa), leading to continuous weakening of the secondary and tertiary education system. This then does not produce a population able to understand or exploit, let alone produce, new ideas and technologies.

Able researchers in Africa need to be given the opportunity and motivation to work at a high level, in collaboration with the rest of the international community, to address problems that are relevant to Africa.

The recent adoption of the Consolidated Plan of Action for Africa's Science & Technology, by the African Union/New Partnership for Africa's Development, is an important milestone in the effort to address this because it sets out a clear framework for co-ordinated, long-term partnerships between African and donor countries and agencies. This initiative should mobilise the funds to support institutional capacity building to the levels recommended in the Commission for Africa report

Challenges for rich nations in fostering change

The developed world has no clear policy on the development of science and technology capacity in Africa, and thinking can be muddled. On the one hand, there is a tendency to see science and technology as having nothing to do with Africa, because we have to find a solution to poverty first.

On the other hand, both governments and the public have concerns about the effect of science and technology imposed on Africa from outside, particularly as a tool for exploitation by wealthy multinational companies – a fear fuelled, for example, by the mining of genetic information from indigenous crops by agricultural companies, or the development of genetically engineered crop strains that enforce allegiance to a particular supplier for seeds and herbicides.

Alternatively, there is a fear that science and technology will be used to implement "technofixes" to existing problems that fail to address root causes, and simply foster dependence on outside expertise. Incidents such as the mass poisoning at a chemicals plant at Bhopal in India, run by a subsidiary of Union Carbide, have understandably fed the belief that science and technology is all about the exploitation of cheap labour, with low standards of safety and accountability.

This is a potentially dangerous misconception. It is widely acknowledged by African leaders, as it is by leaders in the developed world, that science and technology are essential for national growth and development. A coherent, co-ordinated response to this is needed by donor countries and agencies, to focus on African self-reliance and self-determination.

African science should not be shaped by the preconceptions or demands of northern agendas, whether those be, on the one hand, a blanket and unconsidered rejection of genetically modified crops, or on the other, a desire to turn Africa into a cheap factory for products bound for wealthier places.

Escaping the ties of aid

Much of the aid provided to Africa in previous years has been assigned for particular purposes or projects, carrying with it particular restrictions and obligations. In part this has been motivated by a commendable desire to ensure that it is used responsibly and effectively, or to act as a lever for broader political and social change.

But it can also be self-serving to the donors: almost 30% of aid from G7 donors carries the obligation for the recipient to buy goods and services from the donor countries; this is described as "tied aid". Tanzania's donors, meanwhile, require that it carries out 78 reforms a year.

It is now recognised that tied and/or pre-assigned aid weakens decision making and bypasses accountability systems. The Organisation for Economic Co-operation and Development estimates that in 2002, tied aid reduced the actual value to Africa by between £400 million (\$700 million) and £700 million (\$1.3 billion). So untying of aid is needed; but we must be careful in ensuring that aid goes to the right places.

Aid should be unconditional, co-ordinated with other donors and the recipient governments, and where feasible, it should also be unassigned and predictable. The ability to deliver this does depend on good governance. The UK government has untied all of its aid and is therefore a world leader in this respect

Developed countries are sometimes complicit in the abuses of aid that have limited its effectiveness. It is estimated that foreign bank accounts hold money diverted from aid programmes that is equivalent to half of Africa's external debt. Until rich nations take steps to counter such abuses – for example by making their banking facilities more transparent – it is hard to see how they can be prevented.

The trade in arms and weapons systems to African countries not only has had a destabilising effect but also acts to discredit the role of science and technology in fostering positive change.

The international rules and standards applied to trade and industry sometimes set developing countries at a disadvantage. For example, European and US agricultural subsidies hinder competitiveness, while the constraints on scientific and technological capabilities imposed by the World Trade Organisation and other bodies do not necessarily meet the needs of developing countries.

Educational and institutional requirements for a sound scientific base

Much of the focus on improving educational standards in Africa has been directed at primary education, and with good reason. But that will not produce the doctors, nurses and engineers desperately needed to address Africa's most serious problems, nor indeed the teachers, lawyers, administrators, economists, business people and government workers needed to create a healthy social fabric.

The building of an educational system must be holistic, addressing all stages through primary to degree level. It may seem perverse to be worrying about how many physicists a country produces when adult literacy is so low (40 million children in Africa have no schooling).

But the kind of infrastructural changes that need to happen for general education to be significantly improved are enabled only if the tertiary education system can provide suitably qualified people. Trying to boost primary education alone is like trying to engineer an ecosystem with only one species: it simply cannot sustain itself.

Among the objectives for improving educational standards in Africa are: to increase the number of teachers available (there is a significant shortage in some countries – Ghana has only a quarter the number needed to educate all its children), to increase the number of girls being educated, and to construct a syllabus suited to the particular needs of Africa.

Measures of success for educational institutions

What is required of an effective university system? It must attract and hold on to good scholars, of course: reliable and transparent schemes for assessing output and determining tenure are essential.

Universities are not just a breeding ground for skilled personnel; they can have a direct impact on development in other ways. For example, they can foster entrepreneurial activities such as spin-off companies, particularly if the relevant business skills are taught in the academic curriculum.

According to the UN Millennium Project's Task Force on Science, Technology & Innovation, "technological innovation is one of the least studied but most critical sources of productivity growth".

Universities can act both at the level of the local community, collecting information about local problems and needs and seeking solutions, and at the level of the global community, widening the base of knowledge and contacts on which problem solving and opportunity seeking can draw.

Links between academia and industry can be vital to a region's economic performance. Universities and other academies can themselves be important sources of advice to governments – although at present this rarely happens in Africa.

This latter point perhaps highlights one of the potential hurdles to expanding higher education in Africa: dictatorships do not like intellectual freedom. Not just universities, but a well-educated general population poses a potential threat to non-democratic governments.

For this reason, it may be that some form of supra-national management structure is needed for higher education in Africa, like the peer review system that is being implemented by the African Union to encourage better governance, reform and responsible use of aid.

What needs to happen?

The case of Botswana illustrates that it is possible for impoverished African nations to escape from dependence on aid. Forty years ago it was one of the poorest African countries, and foreign aid constituted over 30% of GDP. Today that figure is less than 1%, while per capita GDP has risen from somewhere over £200 (about \$400) to well over £2,000 (over \$4,000) (normalised to 1995 values). This has come about partly through the Botswanan government's insistence on accepting only unassigned aid.

While short-term investment in peace, stability and good governance in Africa remains important for rich nations, this must be designed to support the long-term goal of sustainable economic development.

The G8 nations have agreed to invest more in better education, extra teaching and new schools, and to help develop skilled professionals for Africa's private and public sectors by supporting networks of excellence between Africa's and other countries' institutions of higher education and centres of excellence in science and technology.

The G8 decision was founded on the increasing understanding of the role of science and technology in the sustainable development of Africa, as set out in the report of the Commission for Africa. The UN Millennium Project has also demonstrated, through its taskforce on science, technology and innovation, the critical role that these play in meeting the Millennium Development Goals.

These reports and the G8 deliberations reflect the changing emphasis in global approaches to the question of development in Africa. In the late 1990s the focus was on "relief"; in 2000 it was "aid", in 2001 "development" and, between 2002 and 2004, on "partnership", with the recognition that capacity building in African countries is all about skills development.

The emphasis has now shifted once again, to African-led development. The task of the developed countries needs to be to support Africa in developing its own visions for skills development, bearing in mind the level of ambition set out in the Commission for Africa report:

- £280 million (\$500 million) a year over 10 years for revitalising higher education; and
- £1.7 billion (\$3 billion) to 2010 to develop centres of excellence in science and technology, including African institutes of technology.

The recently adopted African Union/New Partnership for Africa's Development plan for science and technology development sets out a vision for Africa to develop its own skills to address a set of science and technology priorities, agreed through a two-year consultation process in Africa.

The initial funding requirements are small in developed world terms, but significant in terms of most African national budgets. If the plan is to work it will need to be underpinned by significant amounts of institutional capacity building, to the levels set out above. But it is a hugely positive start, and one that deserves best practice from donors on mobilising funding and technical aid if it is to make progress to implementation.

Creating African centres of excellence

Over time, the networks of centres of excellence proposed by the African Union/New Partnership for Africa's Development plan could be supplemented by pan-African centres of excellence, each located at one of the geographic poles of the continent.

This idea is inspired by the example set by the Indian institutes of technology. The first Prime Minister of independent India, Pandit Jawaharlal Nehru, had a deep respect for science and technology, and as well as investing in training in these areas in schools and higher education establishments, after independence in 1947 he asked for the UK, the USA, Russia and Germany each to fund the creation of one of the Indian institutes.

Just as these centres attract the brightest of India's students and energise the entire Indian education system, so the African institutes would raise standards generally. Of course, one of the key features of this example is that the aid given by each country was long-term, predictable and in response to a clear request from the country itself.

At present, only a few of the Southern African universities have reputations that might hope to compete with those in Western countries, and this might seem to pose a problem if it is assumed that any new African technological institutes are likely initially to draw much of their teaching staff from abroad, particularly from the African diaspora.

But it may be that posts at these institutes should be made attractive to foreign scholars on short-term residencies (such as sabbaticals) as well as permanent employees.

Some higher education establishments are already flourishing in Africa. Rwanda acquired its first public technological institute of higher learning in 1998 (see box on science and technology in Rwanda). The UK Medical Research Council, together with the UK Department for International Development, runs a laboratory in Gambia, with eight programmes of research on diseases including HIV/AIDS, tuberculosis, malaria, reproductive health, viral diseases and respiratory infections.

Science and technology in Rwanda

There is a powerful symbolism in the decision of the Rwandan government to convert a former military barracks into the Kigali Institute of Science, Technology & Management (KIST), inaugurated in 1998. Funding was provided partly by the UN, and also by Japan and the Netherlands, while the German Agency for Technical Co-operation assisted in the development. KIST is now training more than 3,000 students.

The African Institute for Mathematical Science is a recently established educational centre in Cape Town, South Africa, which aims to promote mathematics and science in Africa and to build capacity for African initiatives in education, research and technology. South Africa is also engaged with Brazil and India in discussions over co-operation on

research into HIV/AIDS and nanotechnology.

Africa's richness in natural resources has in the past been something of a curse: those countries most abundant in resources have often been those that have suffered the most from foreign exploitation. Today it is recognised that the best protection against such abuses is to enable countries to become politically stable, self-reliant and economically healthy.

For success stories like Botswana's, the Commission for Africa concludes that "governance is at the core". A technically literate community, engaged with that in the wider world and capable of producing, identifying and capitalising on local opportunities for growth (see box on flex-fuel and sugar cane), supplies the backbone for such a society.

Flex-fuel and sugar cane

Nearly 20% of cars sold in Brazil in 2004 were models capable of switching between ordinary gasoline and ethanol. Not only does this cut dependence on oil imports, it also reduces pollution: ethanol can be made by fermenting sugar cane, a renewable resource.

The carbon released during ethanol combustion is equivalent to that taken up from the atmosphere in growing the crop, making the cars carbon-neutral in this mode. Sugar cane can also be grown in many African countries, offering an indigenous and "green" fuel source that might even become an important export commodity.

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Conclusions: forging ahead

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Conclusions: forging ahead

Professor Calestous Juma

The report of the Commission for Africa chaired by Prime Minister Tony Blair, *Our Common Interest*, has helped to redirect international attention to how it addresses Africa's economic challenges. One of the most important outcomes of the report is the growing focus on the need for Africa and its development partners to make the transition from short-term relief activities to long-term growth-oriented strategies.

This transition involves charting a new path for development co-operation that stresses the importance of technological and institutional innovation. Correspondingly, development co-operation strategies will need to be aligned with this emerging vision.

Charting a new path

By emphasising the importance of economic growth as a basis for solving many of Africa's challenges, *Our Common Interest* lays a strong conceptual foundation for integrating technological innovation into development strategies. This will require a shift from the present approach, which stresses "development diplomacy", toward a transformative approach that emphasises building technical and managerial competence.

Building competence will need to be part of emerging proposals for strengthening development co-operation – including the Chancellor's "Marshall Plan" approach, which could play an important role in creating linkages between technological innovation, entrepreneurship and growth.

New strategies for international co-operation in Africa will need to take into account major trends such as globalisation, as well as new developments in the region. The past decade has been marked by major reforms in political governance, and democracy is taking root in major parts of the region. But challenges, such as war and low economic productivity, remain.

One of the most important forces of change and improvement in Africa is the emerging commitment to regional and subregional integration. This is accompanied by renewed interest in promoting territories that can serve as engines of growth in specific localities. These efforts will help to create larger regional markets and offer opportunities for peaceful coexistence among member states. They will also create the economies of scale needed to diffuse technological innovation and management skills.

Strengthening human competence

Since independence, Africa's institutions of higher learning have played a critical role in creating the capacity needed to run government institutions. These state-building functions are now being replaced by new demands that emphasise economic renewal.

Meeting this challenge will require reorienting institutions of higher learning, especially universities and research institutions, so they can serve as engines of economic transformation. This will involve adjustments in the curricula, pedagogy, location of universities and selection of students (with emphasis on expanding opportunities for women).

Additional efforts will be needed to forge close linkages between research, training and outreach (including the commercialisation of research results). Additional measures will be needed to promote the emergence of centres of excellence which focus on relevant world-class research. New partnerships should focus on the role of universities as engines of community development, and will outline strategies for strengthening linkages between government, university and business.

Modernising infrastructure

Infrastructure development is increasingly being recognised as a critical foundation for economic transformation in general, and technological innovation in particular. Infrastructure forms critical networks for the movement of goods and services. But it also serves as a basis for the generation and diffusion of technological capabilities in the economy, especially if linked to technical training institutions.

It is therefore unlikely that Africa will improve its economic performance without major investment in infrastructure and the associated scientific and technological capabilities. Emerging partnerships should stress the urgent need to review infrastructure projects in an integrated way, with the emphasis on developing technical capabilities among development partners.

Renewing agriculture

Africa's agricultural production has become symbolic of the state of the economy. It is characterised by low levels of productivity, declining farm incomes and ecological degradation. A systemic approach to improve the technical competence of African farmers and enlarge their export opportunities is urgently needed.

Partnerships should focus on promoting the transition toward agricultural sustainability through technological innovation. The partnerships should frame agriculture in a broader context that will include food processing, marketing and other technology-based activities. Supporting such measures will require greater investment through international partnerships in research and development activities.

Spurring entrepreneurship

Africa's development strategies have historically been dominated by public-sector intervention. While these approaches have helped to address major issues relating to public goods, little attention has been given to the role of entrepreneurship and business development in economic transformation.

There is an urgent need to strengthen on-going activities that aim to improve the policy environment for business activities. More specifically, creating strong partnerships between foreign and local enterprises will expand opportunities for economic growth.

International development agencies can play a key role in helping to foster such partnerships and reducing the risks associated with doing business in emerging markets. Additional measures include business education and mentorship aimed at sharpening Africa's entrepreneurial skills.

Energising social entrepreneurship

Civil society organisations have played a significant role in shaping and implementing international development policy. Their character and dynamics have been influenced by the dominant development approaches, which have emphasised relief-oriented activities.

New approaches that emphasise competence building will not only require adjustments in the structure and operations of existing institutions, but will also lead to the entry of new players in the field. For example, emerging interest in higher technical education and infrastructure development will call for greater co-operation of engineering associations in development. Similarly, the work of development studies institutions will be complemented by technology-based institutions.

More fundamentally, civil society organisations will need to strengthen their technical competence and build stronger linkages with other knowledge-based institutions, such as enterprises and universities.

Benefiting from the globalisation of knowledge

There is growing concern over the migration of skilled personnel from Africa to developing countries. Much of the concern is used to justify policies that seek to slow down international migration of skilled personnel – from which Africa itself benefits. The most urgent policy challenge is designing strategies that help African countries to benefit from their nationals in diaspora and not reduce their potential to upgrade their expertise by being part of the global knowledge economy. Such measures will entail closer co-operation between African countries and their industrialised country partners and can form a strong foundation for close scientific, technological and business partnerships. The old-fashioned metaphor of the "brain drain" should be replaced by a new view of "global knowledge flows".

Governing innovation

The transition toward competence-based development assistance will have major implications for development governance among development partners. For example, the need to mobilise scientific and technical expertise from a wide range of sectors will require high-level co-ordination and convening authority.

Scientific and technical advice in the offices of presidents and prime ministers of development partners will become a critical element in the implementation of emerging strategies. These should be complemented by strengthening independent advisory organs, such as scientific and technical academies.

Governing economic renewal will therefore involve a complex ecology of scientific and technical advice at different governance levels. There is an urgent need to align the structures and functions of national governments and international development agencies with growth-oriented strategies.

