

Reinventing African Economies
TECHNOLOGICAL INNOVATION AND
THE SUSTAINABILITY TRANSITION

Dr. Calestous Juma

APRIL 6 & 7, 2006



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THE JOHN PESEK COLLOQUIUM
ON SUSTAINABLE AGRICULTURE

THE SPEAKER

CALESTOUS JUMA



alestous Juma (Kenya)

is Professor of the Practice of International Development and Director of the Science, Technology and Globalization Project at Harvard University's Kennedy School of Government. Professor Juma has made outstanding contributions to policy research on the applications of science and technology to sustainable development. His work on the implications of biotechnology for sustainable development in Africa is widely cited and his achievements have been honored by his election to several scientific academies including the US National Academy of Sciences (NAS) and Academy of Sciences for the Developing World (TWAS). He coordinated the Task Force on Science, Technology and Innovation of the UN Millennium Project commissioned by UN Secretary-General Kofi Annan and co-chairs the High-Level African Panel on Modern Biotechnology of the African Union and the New Partnership for Africa's Development. He chairs the NAS Committee on Global Challenges and Directions for Agricultural Biotechnology of the US National Academy of Sciences, where he has served on several committees dealing



with agriculture and natural resources, geographical information sciences, genetic resources and science advice.

Professor Juma is a former Executive Secretary of the UN Convention on Biological Diversity, founding Executive Director of the African Centre for Technology Studies in Nairobi and former Chancellor of the University of Guyana. He has won several international awards, including the Pew Scholars Award in Conservation and the Environment (1991), the UN Global 500 Award (1993) and the Henry Shaw Medal (2001). He has served on numerous boards of international agencies and advises numerous heads of state and government on science, technology and innovation.

His research interests include: co-evolution of technology and social institutions; science and technology policy studies; biotechnology and biological diversity. His major works include *Long-Run Economics* (Pinter, 1987); *The Gene Hunters* (Princeton University Press, 1989); *Science, Technology and Economic Growth* (UN University, 2000) *Innovation: Applying Knowledge in Development* (Earthscan, 2005) and *Going for Growth: Science, Technology and Innovation in Africa* (Smith Institute, 2005). He is founding editor of the *International Journal of Technology and Globalisation* and editor of the *International Journal of Biotechnology*.

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Introduction

African economies historically have been associated with natural resources and raw materials. But contrary to this dominant image, African countries still suffer from chronic food shortages and recurrent famines. Such episodes often have been treated as ephemeral, requiring short-term responses through food aid. However, their intensity and frequency have been rising, suggesting the existence of major challenges to the sustainability transition. These challenges also present major opportunities.

First, there is growing recognition that promoting African agricultural sustainability must be tackled in the wider context of economic modernization programs and not simply through local interventions. Secondly, such modernization will require considerable investment in the continent's capacity to utilize and generate new scientific and technical knowledge. This paper focuses on the dual task of defining agriculture as a central theme in the wider context of economic transformation and the specific role that science and innovation can play in that process.

More fundamentally, the paper stresses the importance of framing agricultural sustainability in the context of "innovation systems" and rejects the classical view of considering agriculture as a separate sector requiring unique policy interventions that are decoupled from the wider process of economic learning. This is not to deny the centrality of agriculture in African economies. To the contrary, it argues that agriculture, as a central locus for economic learning, requires the intensive use of new technical knowledge. This view has far-reaching implications for the structure and functioning of African governments as well as the nature of international development partnerships.



As the UK Chancellor of the Exchequer Gordon Brown has put it, the "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."ⁱ

To address the issues, this paper is divided into five parts. The first part provides a conceptual framework for understanding the sustainability transition as a learning process through which society utilizes and generates technical knowledge. It places agricultural sustainability in the wider context of systemic economic learning. The second part explores the implications of regional diversity and integration on sustainable development. The third part stresses the importance of diversity and interconnectedness in economic learning. It points to the importance of regional integration as a way to facilitate experimentation and benefit from economies of scale. The last two parts address strategic options for action and opportunities for international cooperation.

1. DEVELOPMENT AS LEARNING

Toward a new development vision

A new economic vision for Africa's agricultural transformation—articulated at the highest level of government—should be guided by new conceptual frameworks that define Africa as a learning entity and not a desperate case requiring emergency responses. This shift will entail placing policy emphasis on emerging opportunities such as renewing infrastructure, building human capabilities, stimulating agribusiness development, and increasing participation in the global economy. These areas, which constitute what can be called "the learning economy," should be the foundation upon which to base international development partnerships. In other words, development learning should inform the formulation of Africa's foreign policy."ⁱⁱ

Contemporary history informs us that the main explanation for the success of the industrialized countries lies in their ability to learn how to improve performance in a diversity of social, economic and political fields. The key to their success was their focus on practical knowledge and the associated improvements in skills needed to solve problems. They put a premium on learning."ⁱⁱⁱ

One of the most reassuring aspects of a learner's strategy is that every generation receives a legacy of knowledge that it can harness for its own use. Every generation blends the new and the old and thereby charts its own development path, making debates about innovation and tradition irrelevant. Furthermore, discussions about the impact on intellectual property rights take on a new meaning if one considers the fact that the further away you are from the frontier of research, the larger is your legacy of technical knowledge.^{iv} The challenge, therefore, is for Africa to think of research in adaptive terms, and not simply by focusing on how to reach parity with the technological front-runners. Understanding the factors that help countries to harness available knowledge is critical to economic transformation.

At least three key factors have contributed to the rapid economic transformation of emerging economies. First, the country invested significantly in **basic infrastructure**.^v The investments served as a foundation for local technological learning by acting as the centers of diffusion of skills into the rest of society.^{vi} Infrastructure is broadly defined as the facilities, structures and associated equipment and services that facilitate the flow of goods and services among 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 improving human welfare in Africa.^{vii} In Uganda, for example, transport costs add the equivalent of an 80 percent tax on clothing exports. Infrastructure is also a key component of the investment climate, reducing the costs of doing agribusiness and enabling people to access markets.^{viii}

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 untapped potential for the creation of productive employment. For example, increasing the stock of infrastructure by 1 percent could add 1 percent 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 percent to GDP. It created new jobs and helped to create skilled personnel in local firms. Without adequate infrastructure, further application of technology to development is not possible. For instance, electric power, transportation networks and communications infrastructure are crucial to 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 have happened without basic telecommunications infrastructure. 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. It should also be noted that the poor state of Africa's telecommunications infrastructure has hindered the capacity of the region to make use of advances in fields such as geographical information sciences in sustainable development.^{ix}

Higher technical education is increasingly recognized as a critical aspect of the development process, especially in light of the growing awareness of the role of science and innovation in economic renewal.

Secondly, the nations created and nurtured the development of **small and medium-sized enterprises** (SMEs) through a network of incentives and support systems.^x Building these enterprises requires development of local operational, repair and maintenance expertise, and a pool of local technicians. Economic change is largely a process whereby knowledge is transformed into goods and services. In this respect, creating links between knowledge generation and agribusiness development is the most important challenge facing Africa. For Africa to promote the development of local technology, it needs to review its incentive structures to determine their relevance to innovation.^{xi} A range of structures is suitable for creating and sustaining enterprises—from taxation regimes and market-based instruments to consumption policies and changes in the national system of innovation.

Small and medium-sized enterprises (SMEs) should play leading roles in the development of new opportunities and the use of technology.^{xii} Policy-makers need to develop, apply and emphasize the important role of engineering, technology and SME development in human welfare improvement and sustainable development. They need to support agribusiness and technology incubators, export processing zones and production networks as well as sharpen the associated skills through agribusiness education.

Banks and financial institutions also must play key roles in fostering technological innovation and supporting investment in domestic technologies.^{xiii} Unfortunately, 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. In other words, financial innovations can just be as important as technological innovations to the success of business ventures.^{xiv}

Capital markets have played a critical role in creating SMEs in developed countries. Venture capitalists do not bring only money to the table; they help groom small and medium-sized start-ups into later enterprises.^{xv} Bringing venture capital into African countries helps create new agribusinesses and improves their sustainability. Thirdly, the governments supported, funded and promoted institutions of higher technical learning, as well as academies of engineering and technological sciences, professional engineering and technological associations, and industrial and trade associations. Higher technical education is increasingly recognized as a critical aspect of the development process, especially in light of the growing awareness of the role of science and innovation in economic renewal. While primary education has been the focus of donor community attention for decades, secondary higher education and research are only now beginning to gain policy attention in development circles.^{xvi}

The urgency of investing in higher technical education is compounded by the impact of HIV/AIDS and other infectious diseases on Africa's economic growth in general and agriculture in particular.^{xvii} The challenges include building human capacity and transmitting agricultural skills to succeeding generations, which underscores the urgency to expand women's access to higher technical education. Educating women in science and technology is not simply a matter of meeting legal obligations related to equality and social justice; it has a clear practical purpose of changing social attitudes and preparing the next generation to adapt to changing world conditions.^{xviii}

In addition to providing degree training, a new view is emerging that places universities and research institutions at the center of community development. The application of this concept also extends to other levels of learning, such as colleges, research and

technical institutes and polytechnics. Higher education and research institutions therefore have become a valuable resource for agribusiness, industry and society. In facilitating the development of agribusiness and industrial firms, universities can contribute to economic revival and 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 agribusiness incubator facilities; introduce entrepreneurial training; and encourage students to transform research into enterprises.^{xix} This approach is based on the strong interdependence of academia, industry, government and relevant sections of civil society.

The emphasis on knowledge is guided by the view that economic transformation is a process of continuous improvement in productive activities. In other words, government policy should be aimed at enhancing performance, starting with critical fields such as agriculture, while recognizing inter-disciplinary linkages.

These types of improvements indicate 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 economic learning, agribusiness enterprises will become the locus of learning, and knowledge will be the currency of change.

Most African countries already possess the key institutional components they need to become players in the knowledge economy. The emphasis, therefore, should be on realigning the existing structures, creating necessary new ones where they do not exist, and promoting interactions among key players in the economy. More specifically, the separation between government, industry and academia stands out as one of the main sources of inertia and waste in Africa's knowledge-based institutions.^{xx} The challenge is not simply creating institutions, but creating systems of innovation in which emphasis is placed on economic learning through interactions between key players in the society.

Agriculture and innovation systems

Discussions about agricultural development in Africa often are carried out in the context of food security, which has worsened substantially since the early 1970s. Food availability has failed to keep up with the growing population, as reflected in the rise

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of the absolute number of malnourished people from about 88 million in 1970 to more than 200 million in 1999–2001. The situation is projected to worsen if current policies continue. But these trends could be reversed through a variety of measures that increase “investments in education, HIV/AIDS prevention and treatment, water-harvesting technologies and agricultural extension, female schooling, and clean water access.”^{xxi} These measures must address rural development concerns in general, and agriculture in particular.^{xxii}

Agriculture is considered central to African economies. But it is treated like other sectors, which are considered separate fields with their own distinctive institutions, and with little regard to their relationship with the rest of the economy.^{xxiii} This view is reinforced by traditional approaches, which argue that economic transition occurs in stages that involve the transfer of capital from the agricultural to the industrial sector. Both the sector and stage approaches conceal important linkages between agriculture and other sectors of the economy.

A more realistic view is to treat economies as “systems of innovation.” The process of technological innovation involves interactions among a wide range of actors in society, who form a system of mutually reinforcing learning activities. These interactions and the associated components constitute dynamic “innovation systems.”^{xxiv} Innovation systems can be understood by determining what within the institutional mixture is local and what is external. Open systems are needed, in which new actors and institutions constantly are being created, changed, and adapted to suit the dynamics of scientific and technological creation.^{xxv} The concept of a system offers a suitable framework for conveying the notion of parts, their interconnectedness, and their interaction and changes over time. Within countries, the innovation system can vary across regions. Regional variations in innovation levels, technology adoption and diffusion, and the institutional mix are significant even in the most developed countries.

Government, the private sector, universities, and research institutions are important parts of a larger system of knowledge and interactions which allows diverse actors with varied strengths to come together to pursue broad common goals in agricultural innovation. In many African countries, the state still plays a key role in directing production activities. But the private sector is an increasingly important player in adapting existing knowledge and applying it to new areas.

2. REGIONAL INTEGRATION AND ECONOMIC DIVERSITY

Technology and regional integration

The facilitation of regional cooperation is emerging as a basis for diversifying economic activities in general, and leveraging international partnerships in particular.^{xxvi} Many of Africa's individual states are no longer viable economic entities; their future lies in creating trading partnerships with neighboring countries. Indeed, African countries are starting to take economic integration seriously.^{xxvii} For example, the recreation of the East African Community (covering Kenya, Uganda, Tanzania and Rwanda) is serving not only as a mechanism for creating larger markets, but also is promoting peace in the region. Economic asymmetry among countries often is seen as a source of conflict.^{xxviii} However, the inherent diversity serves as an incentive for cooperation.

The current malaise in the traditional development community is being challenged by new technology alliances involving the more developed among developing countries. For example, India, Brazil and South Africa have launched a technology alliance that will focus on finding solutions to agricultural, health and environmental challenges. In addition, more developing countries are entering into bilateral partnerships to develop new technologies. India and China, for example, have created a joint steering committee to promote coordination in their technological development efforts.^{xxxx} Such alliances provide examples that could be emulated in new technology and trade partnerships between Africa and its allies in the industrialized countries.

Africa needs similar agreements that promote the use of regional technological capabilities in international trade. Signing peace agreements is an important step in ending wars and promoting stability. But the real challenge is how to use international trade and technology cooperation as critical tools for enhancing regional stability. Increases in democratic practices, economic growth and innovation often are associated with the rise in the capacity of a nation to participate in international trading regimes. As these links unfold, the trading nations must establish a wide range of harmonized practices, such as standards, regulations, and tariffs. Trade links usually have positive effects on political relationships between countries. Thus, democratic countries with trade interdependencies are usually less likely to go to direct war with one another.

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

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

Using part of Africa's military budgets to support higher technical education and related infrastructure activities would constitute a key investment in human security

3. UNIVERSITIES AND ECONOMIC LEARNING

Higher education and economic growth

Universities and the societies in which they are embedded co-evolve, shaping each other in a variety of ways. This co-evolution is an uncertain process, involving continuous dialogue and interaction. Globalization 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 that universities in turn help to shape the character of the society in which they exist.

In many developing countries, universities suffer from unclear mandates and limited funds. The urgent need to invest in higher education is illustrated by the case of Togo. The country's 5 million people have a per capita income of \$270. Support to higher education is negligible and unpredictable. In 2004, students at the University of Lomé went on strike for the non-payment of the annual \$1.6 million owed to them by the government. They reportedly had not been paid their stipend since 2001. Payment of the accumulated stipend is not the only problem. The university remains overcrowded. It was designed to accommodate 6,000 students, but today enrolls 14,000. A second university at Kara is not yet fully functional. In contrast, the country spends nearly 2 percent of its GDP on the military, amounting to nearly \$32 million a year. Using part of Africa's military budgets to support higher technical education and related infrastructure activities would constitute a key investment in human security.^{xxxx}

African universities lack the flexibility to meet basic needs (often dealt with by public research centers in "mission mode") or to promote competitiveness (dealt with by the private sector or government training institutes). Universities often lack the resources and the demand from a sound productive economic sector eager to benefit from the knowledge they and their students could provide. They often are isolated from the rest of society and have acquired the reputation of being irrelevant to immediate social needs.

Reversing this scenario is one of the challenges for development—one that cannot be fulfilled by pushing universities to change while everything else remains the same. A better approach is to channel energies within the university environment to carry out a combined research, teaching, and application mandate, with different types of universities taking on different challenges and government and industries engaging in effective interaction with them.

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-utilized institutions in Africa's efforts to promote sustainable development. Today, African universities are largely places to train the labor force; they also serve as loci of scientific and technological information, playing a critical role in the leadership of the sustainability transition. Yet they do not have strong connections with production sectors.

In facilitating the development of agribusiness and industrial firms, universities can contribute to economic revival and growth in their surrounding regions. A 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 agribusiness incubator facilities; and introduce entrepreneurial training into its curricula.^{xxxiii} It also can ensure that students become acquainted with real-life problems faced by firms through arrangements such as internships.

Universities also should ensure that students appreciate the relationships between science and development, encouraging them to be sensitive to societal needs. The success of this approach is based on the strong interdependence of academia, industry, government and civil society.

The first generation of post-independence 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 centers of privilege, far removed from national efforts 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 must change the way in which universities operate. First, countries will need to consider universities as productive entities, not simply producers of a trained workforce.^{xxxiiii} In other words, universities will need to act as incubators of new enterprises.^{xxxv} Secondly, universities and other technical institutes must integrate with their communities.

So far, most major universities are located in capital cities. Their value would greatly increase 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.

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Universities as agents of sustainable development

The preeminent role of universities as vehicles of community development is exemplified in the US land-grant system.^{xxxvi} The system not only played a key role in transforming rural America, but also offered the world a new model for bringing knowledge to support community development. This model has found expression in a diversity of institutional innovations around the world. While the land grant model largely is associated with agriculture, its adaptation to industry is less recognized. Universities such as the Massachusetts Institute of Technology (MIT) and parts of Stanford University owe their heritage to the land grant system.^{xxxvii} The drift of the land grant model into other sectors is not limited to the US. Their central mission of bringing higher education to stimulate community development is practiced around the world in a variety of forms. African countries must look critically at these variants and adapt them to their conditions.^{xxxviii}

Entrepreneurial education: Costa Rica's EARTH University

In 1948, Costa Rica abolished its army and applied part of the saved revenue to health and higher education. This courageous act helped the country prosper and become an economic force in Central America. The nation has a lot to show for its focus on higher education reform. Costa Rica's EARTH University, for example, has pioneered a new educational model that trains young people to create enterprises and become employers rather than employees.

EARTH University is a private, non-profit, international university founded in 1990 with support from the US International Development Agency (USAID) and the Kellogg Foundation. The university has nearly 400 students from 20 Latin American, African and Asian countries. It is devoted to educating professionals committed to sustainable development through positive values, environmental and social awareness, an entrepreneurial spirit, and strong interest in community service. EARTH University focuses on innovation, interactive learning, critical analysis, interdisciplinary synthesis and wider dissemination of knowledge. The overall goal is community development in the tropics through agricultural education and natural resources management.^{xxxix} A central mission of the university is to offer education to economically disadvantaged young people. Nearly half of the students receive a full scholarship, while another 30 percent get partial support from the university.

EARTH University offers a four-year Licenciatura degree in agricultural sciences. It focuses on training leaders who will help advance sustainable development in their countries. By training "agents of change," EARTH University has developed a unique curriculum based on experiential learning. It focuses on agriculture as a human activity, the integration of many academic disciplines, understanding the changing and globalizing world, and the linkages among economic, social and environmental concerns.^{xxxix}

In their first year, the students focus on doing practical work related to crop and animal production. This equips them with work experience and a deeper understanding of rural economies. During the next 18 months, students are required to create and run their own micro-enterprises using a \$3,000 loan from the university. Groups of five students undertake project design, feasibility assessment, market study and business management. If the business generates a profit, two-thirds of the earnings go to the students and the remainder is paid into a fund maintained by the university to

cover enterprises that suffer losses. At the end of the study period, the enterprises are dissolved to create space for the next generation of students. During their last year, students prepare business plans, write papers or do internships.^{xi}

Community development: Ghana's University for Development Studies

The government of Ghana established the University for Development Studies (UDS) in the northern region in 1992. The aim of the university is to bring academic work to support community development in northern Ghana (Brong-Ahafo, Northern, Upper East and Upper West Regions). The university includes agricultural sciences; medicine and health sciences; applied sciences; integrated development studies; and inter-disciplinary research. It relies on the resources available in the region.

UDS seeks to make tertiary education and research directly relevant to communities, especially in 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 affected by serious population pressure and hence vulnerable to ecological 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 improve human welfare.^{xii}

The pedagogical approach emphasizes practice-oriented, community-based, problem-solving, gender-sensitive and interactive learning. It aims to address local socioeconomic imbalances through focused education, research and service. The curricula stress community involvement and community dialogue, extension and practical tools of inquiry.

Students are required to internalize the importance of local knowledge and to find effective ways of combining it with science. The curricula also include participatory rural appraisal, participatory technology development, and communication methodologies that seek to strengthen the involvement of the poor in development efforts.

An important component of the emphasis on addressing sustainable development is the field practical program. The university believes that the most feasible and sustainable way of tackling under-development is to start with what the people already know and understand. This acknowledges the value of indigenous knowledge. The field program brings science to bear on indigenous knowledge from the outset.

Under this program, the third trimester of the academic calendar, eight weeks, is exclusively for fieldwork. Students live and work in rural communities. Along with the local people, they identify development goals and opportunities and design ways of attaining them.

The preeminent role of universities as vehicles of community development is exemplified in the UDS land-grant system

The university liaises with governmental and non-governmental organizations (NGOs) 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 apparent, with the majority of UDS graduates continuing to work 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 center stage. They can play this role by strengthening their entrepreneurial activities, as well as by supporting national projects, industry and other national centers 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 outward to the rest of the world. The university network served health institutions, NGOs, governmental and development organizations. In 1994, Zambia became the first sub-Saharan country outside South Africa to access the internet.

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

The connectivity project at the University of Zambia was successful and highly supported in principle by the government and donors. However, despite this high-level interest, it failed to attract any direct financial 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 percent of the cost of the first year's operation. It lent Zamnet start-up capital, under the condition that the university would offer some shareholding in the unit to the public.

The administration worked with customers and other interest groups and intensified its marketing. The university provided most of the manpower and the operational space for four years. The number of commercial accounts grew from 5 to 165 between January and June 1995; seven months before the World Bank loan ended, Zamnet was generating enough income to buy new equipment.

The commercialization 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 265 Kbps by January 1998. Other institutions soon followed. With the experience gained from Zamnet, the national regulator, Zambia Telecommunication Corporation, developed a new unit that specialized in internet service provision.

The economic impact of Zamnet has yet to be fully assessed. However, Zamnet's market share is estimated at between 70 percent and 80 percent of Zambia's internet

users. Therefore, many of the country's businesses, government departments and learning institutions and most of the internet cafés and tele-centers are connecting through Zamnet. The impact of Zamnet in encouraging enterprise development, and thereby creating employment opportunities and livelihood, is immense.

This case demonstrates how countries can utilize 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 in which different players feel comfortable, and the important role of the policy environment and government support.⁴¹¹

Enterprises as university incubators: Pohang University of Science & Technology

Pohang University of Science and 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 and Steel Company (POSCO). The two had the goal of building an excellent research university in South 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 best 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). It admitted its first graduate students 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 and Steel Technology in 1994. In 1995, the Ministry of Education selected POSTECH's environmental engineering program for its graduate school support, allowing it to admit 18 students in 1996. In addition to training, POSTECH also pursues academic exchanges and collaborations with international institutions of higher learning, and has formed academic agreements with nearly 50 universities in 13 countries, where its students participate in six-month exchange programs.

POSTECH places a 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 centers of excellence and more than 21 affiliated laboratories. In January 1999, the Pohang Technopark Foundation was established as a joint venture with Pohang City, POSCO and POSTECH. It provides the infrastructure for the transfer of technology between academia and industry. In 2003, POSTECH opened the Biotech Centre, one of the largest in South 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 recognized it as the most outstanding university in educational reform every year since 1996.

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

There is no reason, for example, why telecommunications firms that have benefited from the cell phone revolution cannot create leading information and communications schools. Similarly, mining, oil, tourism and agriculture firms can be the sources of new innovations in their respective fields. Banks can be pioneers in creating schools of management. The only limiting factor is imagination on the part of government and business leaders.

Reconstruction: Kigali Institute of Science, Technology and 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 of 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 center, 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 (UNDP) 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 UNDP core funding and a UNDP trust fund obtained through generous contributions from 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 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 programs. Students choose from a wide variety of engineering and management courses. KIST recently introduced a postgraduate diploma in demography and statistics.

The success of KIST is due to a combination of enlightened state guidance, supportive international agencies and autonomous management. These factors, when coupled with entrepreneurial executive leadership, can deliver results in a relatively short time. KIST has put to rest the myth that institutions of higher learning, especially universities, take too long to deliver results. It also has shown that entrepreneurial capabilities can be more effective than the pedantic appeal of extensive consultative processes that have become a key attribute of good governance. Those working to solve Africa's problems must be guided by governance systems that reflect the attendant sense of urgency.

Higher education and wider development lessons

The rising interest in Africa's future has coincided with a new awakening of interest within international development agencies in the role of technological innovation in economic growth. But much of the discussion on Africa's development only marginally addresses the need to harness the world's existing fund of knowledge for development. The Commission for Africa has, for example, played an important role in placing the issue on the international policy agenda. But the commission also has pointed out that using existing knowledge for economic development will require governments and other players to focus on strengthening the role of the academic community as well as business in the service of development.

Universities and other institutions of higher learning are key players in domesticating knowledge and diffusing it into the economy. But they can only accomplish this through close linkages with the private sector. This will require major adjustments in the way universities function in Africa (as well as the rest of the developing world). Many of these universities will need to transform themselves from conventional sources of graduates into engines of community development. In other words, they will need to become "developmental universities," working directly within the communities in which they are located.

*Enterprises particularly
new ones are the basis of
economic transformation*

The main role of the first generation of African universities was to create civil servants. Unfortunately, this classical model has become the template within which new universities are created, even though social and economic needs have changed radically. The continent needs a new generation of universities that can serve as engines of both community development and social renewal.

The task ahead is not simply one of raising more funds. It will require deliberate efforts by governments, academia, agribusiness and civil society to reinvent higher education and put it to the service of the African people. To achieve this, a qualitative change in the goals, functions and structure of the university is needed. As part of this process, fundamental reforms will be needed in curriculum design, teaching, location, selection of students and the management of the continent's universities. Such an effort will push African leaders to the frontiers of institutional innovation; nothing less will meet the challenges.

Brazil is another rich source of lessons. For example, the Pontifical Catholic University of Rio de Janeiro produces both graduates and enterprises nurtured in the university's Genesis Institute. It helps society by training students and producing new business and social enterprises. Indeed, the "incubator movement" represents one of the key sources of innovation from Brazilian systems of higher learning.

Curriculum reform is needed to create an adaptive generation of professionals. South Africa's Stellenbosch University offers a shining example of how to adjust curricula to the needs of research and development (R&D) organizations. It was the first university in the world to design and launch a micro-satellite as part of its training. In Uganda, Makerere University has developed new teaching approaches that allow students to solve public health problems in their communities as part of their training. Similar approaches should be adopted by students in other technical fields. For example, engineering students should spend part of their time solving local problems in fields such as infrastructure development and maintenance.

Universities also can play a key role as social entrepreneurs. For example, students at Ghana's University of Education, Winneba, tune into Radio Windy Bay to listen to lectures. The university could use radio and other tools such as "pod-casting" to extend its social mission, becoming a community radio station.⁴¹¹¹

Universities should be at the center of using new telecommunications technologies and should serve as loci for diffusing knowledge into society. In addition, the education of the students would include designing radio programs that would prepare them for participation in the emerging creative industries.

Many of these examples are the result of isolated initiatives—some resulting from government foresight, others from occasional academic entrepreneurship, or just serendipity. The challenge facing Africa is to move away from relying on luck and tenacity to create an environment that helps to realize the developmental role of universities across the continent. This must start with government policy. Little will happen unless governments realize the strategic role that universities can play in harnessing the world's fund of scientific and technological knowledge for development.

The issue is not simply about more funding, but involves redefining higher education as a developmental force. This will require efforts to align university activities with development missions. This in turn will influence the location of universities. East African countries depend heavily on tourism to earn foreign exchange. Given this, there is a strong case for creating institutions of higher learning that are devoted to wildlife management and are located appropriately. The sustainable management of freshwater resources—such as those of Lake Victoria and Lake Chad—requires similarly dedicated institutions of higher learning.

The way ahead involves at least three types of strategic decisions. The first is to promote reform in existing universities, in order to bring research, training and outreach activities into the service of their regions. Most of the universities located in urban areas, for example, should forge close links with municipal authorities to help solve the economic, social and environmental challenges they face.

Existing universities also can play an important role in promoting infrastructure development. Road construction, for example, can benefit from local research results. Countries such as Malaysia have experimented with linking road construction to the creation of civil engineering programs at local universities.

The second type of decision involves upgrading the level of academic competence at technical institutions that already have contributed to community development, while preserving their traditional role. This, however, is only possible if existing university policies and regulations are sufficiently flexible to accommodate developmental functions. Many are not; as a result, such upgrades often have been carried out at the expense of community service.

Finally, African governments are currently reviewing an increasing number of applications to set up new universities. This gives them a unique opportunity to shape the curricula, pedagogies and locations of these institutions so they can perform developmental tasks.

Putting universities at the service of community development also will require extensive international partnerships. Development agencies such as the World Bank and their bilateral partners will need to complement their current focus on primary education with a new vision for higher education. African countries, in turn, will need to demonstrate their commitment to long-term development by providing incentives and formulating policies that bring higher education into the service of development. Today, Africa's poor flock to the cities—many in search of the higher education that they see as the passport to their children's personal success. The time has come for

*The people cannot
demand that presidents
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to practice*

higher education to show results through novel technological development and commercialization alliances that contribute to economic development.

4. GOVERNING ECONOMIC LEARNING^{xiv}

Governing economic learning is a complex process that involves interactions among government, industry, academia and civil society. These interactions, however, are based on specific functions performed by these actors. More specifically, governments play key roles as facilitators of industrial learning, while institutions of higher technical learning add the expertise needed for improving performance. Enterprises—particularly new ones—are the basis of economic transformation. Technological and managerial competence accumulates at enterprise levels. In addition, civil society organizations serve a variety of functions, and the role of social enterprises is emerging as a critical element in Africa's development.^{xiv}

Strategic considerations

Government as a learning facilitator

Government plays an important role as a facilitator of technological learning. However, most governments do so in an implicit way. Facilitating technological change will require governments to become active promoters of technological learning. Government action represents a key element in the domestic ownership and control of the development agenda.^{xv} An emphasis on entrepreneurial leadership will alter the role of the state from being a provider of services to being an enabler and promoter of business development. Developing countries should become **entrepreneurial states** whose main function is to promote human welfare through emphasis on the role of the private sector, especially small and medium-sized enterprises.^{xvi} This is not to diminish the role of the public sector in development, but to argue that the main function of an entrepreneurial state is to create a viable environment and offer the support needed to empower the people to meet their own needs by finding creative solutions to local problems.^{xvii}

There are at least three ways to think about the government's involvement in promoting technological learning. The first, **market systems**, deals with the generation and selection of technological innovation. Although science, technology, and innovation policy often is thought of as a manifestation of the selection environment, it has a significant effect on policies that promote the generation of new technologies.

Even if indigenous capabilities exist, they may remain un-commercialized. Those who envision and design innovative products and processes need to commercialize them. It is often insufficient for inventors to hand over their findings to the private sector, because the proof of a concept itself is not easily transferred. The people who commercialize innovations must not be cut off from research personnel once a project is past the prototype stage. The web of capabilities must remain enmeshed. Effective innovation systems make use of a variety of skills from many sources at every stage.

Science, technology, and innovation policies must become a core of industrial, agricultural, and service policies. They must create explicit links between market

and non-market institutions—linking universities and state R&D laboratories to workers' associations, community development organizations, and firms, for example. Technology licensing offices may be one form of link between universities and firms; agricultural extension services may link farmers and companies producing seeds or animal vaccines. The extension approach has worked in developed countries in both the agricultural and the manufacturing sectors. It should be encouraged in developing countries.

Successes and failures, particularly in agriculture and industry, must be documented. These “good” learning practices must be institutionalized into structured relationships between market and non-market organizations.

The second aspect of government facilitation of technological learning is the creation of *technology flows*—transfers of foreign technologies, domestic diffusion of foreign technologies, or indigenous R&D efforts to innovate. While industrial policy usually covers these, science, technology, and innovation (STI) policy often does not, leaving critical elements of acquisition, absorption, and generation of technologies with no immediate link to the marketplace. Countries in which science, technology, and innovation policies form the basis for industrial and agricultural policies, or in which the technological frontiers of the sector are moving rapidly, can adapt better to global economic fluctuations.

The third way in which government can enhance learning is by strengthening a *diversity of learning institutions*. The mix of firms, universities, and government can play a significant role in development. Community development organizations are important sources of innovation and diffusion. They also articulate future directions of governmental science, technology, and innovation policies. Particularly important is government procurement of technology.

Discussing governance in Africa would be incomplete without addressing the continent's pandemic corruption. The fight against corruption has become an important standard against which public leadership is judged in the developing world. But victory will remain elusive unless these efforts are accompanied by deeper institutional reforms that involve aligning public expectations with the make-up of the legislature and the use of executive authority by presidents.

Parliamentarians elected on a platform of new ethical standards will be in a stronger position to regulate corruption, vet public appointments and keep executive excesses in check. The people cannot demand that presidents conform to higher ethical standards than they themselves are willing to practice.

International organizations should play a leading role in promoting science, technology, and engineering education in developing countries.

A victory on this ticket will give the government a chance to align popular demands for improved governance with the composition of the legislature as well as the make-up of the executive branch. Executive powers alone are not a sufficient instrument for uprooting deep-seated corruption. The public must be directly involved, not just in calling for change, but starting with changing their own behavior and reflecting it in their electoral decisions.

This does not mean that presidents cannot use their executive authority without a fresh mandate. On the contrary, reaching out to the people and calling for their support to fight corruption should be part of their efforts to reinvent the management of public affairs. Their moral authority in doing so depends largely on public perception, not on whether allegations of corruption are true or false. Moreover, leaders often are judged by what remains to be done; not by what they have achieved.

African countries in general must take deliberate steps to reconstruct their public image and show strong leadership in reinventing public institutions. Many leaders spend more time lamenting the bad press they get internationally than using their country's positive attributes to project their own outlook to the rest of the world. The first step in this process involves adhering to international standards related to corruption. They can do so by starting to implement the provisions contained in the United Nations Convention to Combat Corruption adopted in 2003.

Pursuing reinvention efforts guided by an international instrument would put them in charge of the reform process, rather than the general practice of responding to external pressure. International legal instruments also can protect donors from the perception of using anti-corruption campaigns to promote their own economic interests.

The reinvention of public service should involve leadership training at all levels—in the governance of public affairs in general and innovation in particular. Jamaica, for example, is setting up the Patterson Institute for Science, Technology and Innovation to undertake research, training and outreach on how to enhance the application of knowledge to economic transformation. The institute honors the country's long-serving prime minister, P.J. Patterson, who pioneered institutional innovations in the country's governance system aimed at harnessing technology for development.

Every new crop of leaders should attend specially designed leadership training courses before taking office. Dedicated schools of governance are needed to focus on this important task. By extension, civil education institutions should begin to focus on providing the ethical foundations needed to raise good citizens. The media and civil society organizations could play a key role in such educational campaigns. They will, however, need to start with their own housekeeping.

Corruption also is rampant in the private sector. In fact, many cases of grand corruption result from interactions between public and private institutions. Entrenching professional standards in private enterprises is critical to the fight against corruption. Institutions such as banks—many of which are implicated in corruption scandals—could play a key role in promoting the use of sustainable agribusiness practices in society. Banks can do more than just educate the public; they can promote and enforce anti-corruption standards encoded in law or advanced through voluntary codes of conduct.

Anti-corruption measures must be accompanied by the creation of specialized offices (for example in the banking, industrial, public service and other sectors) of the ombudsperson with whom individuals can file a corruption complaint. These offices would make available information on general trends in corruption, but also would alert appropriate authorities in cases that warrant further investigation.

The offices should focus on collating information and recommending action, but they should lead investigation and prosecution of legitimate government agencies. In fact, the media and many NGOs already are acting as ombudspersons. But none of these measures will have real impact without deliberate efforts to align public interest with legislative mandates and executive leadership. Only in this way can countries re-brand themselves as respected members of the international community.

The United Nations estimates that about \$11 billion was looted from Nigeria and Kenya by corrupt government officials in the 1990s. The estimate puts the plunder of Nigerian assets at \$7.7 billion, of which some \$2.2 billion was exported to other countries. Kenya's looting is put at more than \$3 billion. Corruption and the transfer of illicit funds have been major factors in the flight of capital from Africa, with more than \$400 billion stolen and hidden in foreign countries. Around \$100 billion of the total is estimated to have come from Nigeria alone, according to the UN Office of Drugs and Crime. Mobutu Sese-Seko of the former nation of Zaire is reported to have embezzled nearly \$5 billion.

These funds could be used to support development activities that are usually difficult to fund from state budgets. For example, higher technical education is emerging as a critical element in long-term development. But funding higher technical education will require increased support from domestic and foreign sources. One possible source is repatriated funds channeled through a new generation of private foundations. Foreign and local banks also should be encouraged to make charitable contributions to these foundations.

Pursuing such a strategy would require a number of institutional reforms. Strict measures should be adopted to make it unattractive for government officials to engage in such looting. The risk of further corruption should be minimized. Transparency in global banking systems will make such crimes more noticeable.

Governments should formulate laws that allow nationals to create and manage private foundations for disbursing the funds for public interest activities. Institutions such

as the Ford Foundation could play an important role in guiding the creation of such laws. In addition, managers of such foundations should receive training in foundation management. Creating foundation laws requiring looted funds to be used in social programs should be part of longer-term strategies to generate local revenue for development; they should be written to accommodate others who want to contribute to the common good.

Ministries of finance in developing countries have always been reluctant to provide tax exemptions for charitable activities. Their main argument has been the potential loss of revenue. This concern is misplaced, considering that they have not been very helpful in preventing the funds from leaving the country in the first place. Given the pressure to attract foreign investment, government officials should see the investment of such revenue as one of the first steps in strengthening the base for local development. Such laws not only would give the government a new vehicle for contributing to development, they also would create new opportunities for improving competence in new areas of governance.

African governments will need to work closely with the industrialized countries where the loot is stashed away. They also will need to work closely with financial intelligence agencies. Information obtained through such means should help governments strengthen their capacity to negotiate with suspected looters. Exploring new avenues for funding long-term development is just as important as freezing repayment of foreign debt. The time has come to debate this option in the open.

Higher technical training as a source of economic renewal

Developing countries must increase indigenous capacity by training scientists, technologists, and engineers in relevant fields. Such a strategy would help address local concerns such as health, food security, infrastructure and manufacturing. Universities can play a vital role in development by nurturing their countries' innovation systems and human resources. It is therefore imperative for universities in developing countries to focus on engineering as well as other advanced technological fields. They must focus on key national priority areas and design an action plan accordingly. International organizations should play a leading role in promoting science, technology, and engineering education in developing countries.

The growing presence of multinationals and foreign firms in developing countries provides an additional impetus for these countries to focus on technical education, because these organizations require increasingly skilled and educated workers. Participation in the global economy—through trade, foreign direct investment, and firm location—requires that developing countries hire and train more educated workers in local firms as well, so that new technologies can be adopted and adapted.^{xix}

With the notable exception of some East Asian countries, most developing countries have placed a low priority on education in science and technology. Many developing countries view science and technology as luxuries that are irrelevant to their immediate needs. Another misconception is that technology destroys jobs. Technology merely has changed employment patterns, reducing the number of jobs in production of goods relative to services, increasing the relative importance of high-skill occupations within sectors, and broadening skills within occupations.

Many developing countries view science and technology as luxuries that are irrelevant to their immediate needs.

Enterprises as centers of economic learning

While learning occurs in a variety of institutions, agribusiness and industrial enterprises are the most critical points at which learning of economic significance takes place. Government acts as a facilitator of institutionalizing knowledge acquisition, but the locus of that learning rests in enterprises, both public and private. The structure of industrial organization and the nature of the production process provide returns of varying amounts based on input factors of skilled labor, robust management practices, and other elements of production. The returns to investment that build innovative capacity vary, depending on the resource base, the institutional environment, and other factors.

Enterprises, particularly those involved in manufacturing, show great promise as centers of upgrading technology and organizational practices. Enterprises that develop capabilities in design, research, and product development establish themselves along a global value chain that allows for more opportunities and increased profit margins through innovation and product differentiation. Yet manufacturing remains a core skill important to long-term enterprise learning. Historically, industry has been a critical source, user, and diffuser of technological progress and associated skills and attitudes. Industry is therefore not just an input, but also a critical node in the development process. The fact that the manufacturing sector can experiment with endless permutations of inputs in the production process and benefit from increasing returns to scale of many industrial technologies gives it a special role in economic development.

Manufacturing is also an engine of innovation because, relative to formal R&D processes, it affords much greater opportunity for experimentation in engineering and production, as well as innovation in procurement, quality control, and other management aspects of the organization. Enterprises with manufacturing capability have been critically important historically, not only for creating new products but also for diffusing new processes, organizational practices, and learning opportunities into the labor force. Manufacturing enterprises act as a nucleus for spreading innovation outward into the wider economy.

At the outset, the scope of an enterprise is to master imported technologies and gradually improve upon them in ways that benefit local production. This process is not simply one of replication. It involves complex learning activities and interactions with other players in the economy, including the original source of innovation.

Perhaps most important from an institutional and learning standpoint is the historical role played by manufacturing enterprises in spearheading institutional changes,

particularly financial and legal changes, to support production processes worldwide. The extent to which these national institutions conform with or diverge from global practice defines the extent of convergence of learning speeds and economic development across countries.

This is not to say that institutions should be homogeneous. The more national institutions are compatible with or open to other external institutional changes, such as regulatory changes or trading rules, the more governments and local enterprises will be able to make decisions that quickly transform local conditions to reflect the external economic and geopolitical climate. The modernizing environment that was created by governments and firms in East Asia accelerated the investments made and the type of learning that took place across manufacturing enterprises.

The extent to which enterprises, particularly small and medium-sized ones, can play a role in innovation and social well-being, depends largely on the internal skills they have at their disposal. One of the biggest challenges for developing countries is the lack of participation of researchers in enterprises. Programs to help SMEs hire young engineers and other professionals—similar to programs implemented in many European countries—can help redress this weakness.

Participation in the global knowledge economy

One of the key features of the globalizing world is the rise in knowledge networks and partnering activities. These networks are a result of complex inter-linkages among a wide variety of enterprises. The links are designed to reduce the risks associated with the development of new products and facilitate the exchange of information. These partnering arrangements help provide sources of financing through licensing and upfront fees for R&D expenses, reimbursement of expenses for partnered products and services, royalties, profits, and other “fees” associated with the achievement of certain goals.

Such arrangements are particularly important in areas with limited access to other forms of financing, such as venture capital. Even where venture capital is available, these arrangements still serve an important risk-reducing function. Partnering activities are naturally more concentrated in the industrial countries, but these arrangements are being extended to developing countries, especially in agricultural biotechnology. Similar arrangements could be considered in industrial biotechnology.

In addition to reducing risk, partnering arrangements also can play a key role in developing the technological capabilities of firms and institutions in developing countries. Such capacity would be specialized and related to particular products and services. Such partnering also would be useful in promoting the adoption of good management practices as standards of industrial production in developing countries. Partnering models that are relevant to developing countries must be identified and promoted as part of the expansion of the new economy.

One important goal of strengthening the scientific and technological base and improving science and technology policy in African countries is the generation of new goods and services that can improve health in developing countries. Stimulating the biotechnology industry in Africa is one way to achieve commercialization of R&D.¹¹ Forward-looking economic policies have tended to improve conditions for private enterprise in general in recent years, allowing countries with large market potential like China and India

One of the biggest challenges for developing countries is the lack of participation of researchers in enterprises.

to enjoy rapid growth in the private sector. These countries took steps to liberalize their economies and strengthen protection of intellectual property rights in order to create incentives for foreign direct investment. International collaboration between companies also may help foster private-sector growth in African countries.

South-South collaboration between companies in developing countries also can create new opportunities for entrepreneurs. Cuba's Heber Biotech, a semi-private company, has helped commercialize Cuba's biotechnology products. By 1998, Heber Biotech was recording about \$290 million annually in sales of hepatitis B vaccines and pharmaceuticals in 34 countries. Now the company is entering into partnerships with other developing countries. In 2001 it established a joint marketing venture with Kee Pharmaceuticals of India. The company's new division, Kee Biogenetics, has launched India's first recombinant DNA product, streptokinase, capable of dissolving coronary clots and preventing heart attacks. The resulting drug, Cardiotrep™, is owned by Heber Biotech. The company aims to use special pricing to access the \$11 million Indian market.

The linkage between research activities and commercial enterprises remains weak in most African countries. Strengthening this link could help provide fresh stimulus to academic research and re-energize universities. It also could be instrumental in translating basic research into important commercial products for local use, such as molecular diagnostic tools.

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 contribution 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 in addressing developmental challenges.

Much of the international debate over technology has focused on new technologies and has ignored the global context in which such inventions are applied. Globalization of technology falls into three categories: the international utilization of nationally produced technology, the global generation of innovation, and global technological collaborations.ⁱⁱⁱ



The first category, *international utilization*, includes innovators' attempts to gain economic advantages by utilizing 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 licenses and patents), and establishing local production facilities (through direct foreign 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 such partnerships are between firms located in different countries, thus contributing to technological globalization.

The global rules for direct foreign 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 must 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 agribusiness skills. They also can increase the local content of their products through subcontracts with local SMEs.

To enhance technological competence, local firms in African countries first had to 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 they can 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.

Managing innovation

Aligning governance structures and providing executive leadership

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

So far, most African countries have failed to develop national policies that demonstrate a sense of focus to help channel emerging technologies into solving developmental

problems. They still rely on ill-guided strategies dealing with “poverty alleviation,” without serious consideration of the sources of economic growth. There are signs of hope, however. The New Partnership for Africa’s Development (NEPAD)’s Ministerial Forum on Science and Technology has played a key role in raising awareness among African leaders on the role science and technology in economic growth.

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

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

Advisory structures differ across countries. In many countries, science advisers report to the president or prime minister, and national scientific and engineering academies provide political leaders with advice. Whatever structure is adopted, the advising function should have some statutory, legislative 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.

Successful implementation of science, technology and innovation policy requires civil servants with the capacity for policy analysis—capacity that

Bringing science and technology to the center of Africa’s economic renewal will require more than just political commitment; it will take executive leadership.

most current civil servants lack. Providing civil servants with training in technology management, science policy and foresight techniques can help integrate science, technology and innovation advice into decision-making.ⁱⁱⁱⁱ Training diplomats and negotiators in science and technology also can increase their ability to discuss technological issues in international forums.

Universities are starting to respond to this need by offering specialized courses for policy-makers. The Science, Technology and Innovation Policy executive training program, which runs annually at Harvard University’s John F. Kennedy School of Government, provides high-level leaders from government, academia, industry, and civil society with a unique opportunity to integrate science and technology into a national development policy. The program will focus on the role of STI in meeting human needs, participating in the global economy and making the sustainability transition.

Identifying sustainable development missions

African countries have many opportunities to identify and implement sustainable development missions. For example, mayors of cities can work with government, academia, industry and civil society to design missions aimed at improving the lives of specified slum dwellers. Universities located in such cities could be play key roles as centers of expertise, incubators of agribusinesses and overall sources of operational outreach to support private and public sector activities. Similar missions could be established in the natural resources and water resources fields. These missions would become the organizing framework for fostering institutional interactions.

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

Bringing higher education to the service of sustainable development

Addressing the sustainability challenge require greater investment in the generation and utilization of scientific and technical knowledge. This goal can be achieved by aligning the missions of universities and other institutions of higher learning with sustainability goals.

Most universities in developing countries are located in urban areas. Most of these institutions, however, do not play significant roles in helping to solve local problems. Much can be gained by adjusting the curricula, pedagogy and management of urban universities to address challenges such as sanitation and improvement of the conditions of slum dwellers. Similarly, universities and research institutions located in rural areas could serve as loci for research, training and outreach on the management of natural resources.

Universities should work more closely with the private sector in sustainable development activities. Promoting enterprise development, especially in urban areas, is one of the most effective ways to improve human welfare. Programs must be established to promote enterprise creation and development, especially among the urban poor. Similar efforts need to be adopted in rural areas. Institutions of higher learning and other mechanisms could serve as agribusiness incubators as well as sources of ideas and support for upgrading urban and rural economic activities.

Governmental and other support will be needed to rehabilitate and develop **university infrastructures**, especially information and communications facilities, to help them join the global knowledge community and network with others around the world. Such links will also help them tap into their experts in diaspora.

Research, teaching and community outreach must merge in **new institutional designs**. For example, medical schools should be more integrated into hospitals, just as agricultural research stations should have a strong teaching role. Similarly, strong links must be forged between universities and the agribusiness community. This process may involve reforms or upgrades within existing universities and the creation of new institutions. All research and training facilities in East Africa must be examined, especially those that fall outside the formal rubric of “universities,” to explore how they could supplement the contributions of existing universities. All government ministries are involved in one or another aspect of research and training and therein hold the seed for populating the economic arena with new species of higher learning institutions adapted to specific needs.

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

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

Many African cabinet structures are merely a continuation of the colonial model, structured to facilitate the control of local populations rather than to promote economic transformation

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

Financing higher education is probably one of the most contentious issues in the history of higher education.^{iv} The perceived high costs of running institutions of higher learning have contributed to the dominant focus on primary education in African countries. But this policy has prevented leaders from exploring avenues for supporting higher technical education. Indeed, African countries such as Uganda and Nigeria are experimenting with measures including directed government scholarships and lowering tuition for those going into the sciences. Other long-term measures include providing tax incentives to private individuals and firms that create and run technical institutes on the basis of agreed government policy. Africa has barely begun to utilize this method as a way to extend higher technical education to a wider section of society.

Mining companies, for example, could support training in the geosciences. Similarly, agricultural enterprises could help create capacity in agribusiness. Institutions created by private enterprises also can benefit from resident expertise. Governments, on the other hand, will need to formulate policies that allow private sector staff to serve as faculty and instructors in these institutions. Such programs also would provide opportunities for students to interact with practitioners in addition to the regular faculty. Much of the socially responsible investment made by private enterprises in Africa could be better used to strengthen the continent’s technical skill base.^{iv} Additional sources of support could include the conversion of the philanthropic arms of various private enterprises into technical colleges located in Africa.

The establishment of the Chalker Foundation for Africa as a UK-based charity is a good example of the growing interest in finding innovative ways to support Africa’s future. Its mission is to empower people in Africa to lead healthy and self-sustaining lives. The CFA was created by Baroness Lynda Chalker of Wallasey, who served as UK Minister of Overseas Cooperation from 1989 to 1997. The aim of the foundation is to support and foster the advancement of medical, scientific and educational knowledge in Africa. It will rely on funds transferred from Africa Matters, Limited, a consulting firm created by Baroness Chalker. In addition, it will seek contributions from other sources. The Chalker Foundation is an innovative response to Africa’s challenges that has already begun providing fellowships for outstanding students admitted for medical training.^{iv}

5. OPPORTUNITIES FOR INTERNATIONAL COOPERATION

Innovation and international cooperation

Science and technology increasingly are recognised as key forces in shaping international relations. While the role of science and technology in international security and energy is widely acknowledged, it is only now that its pervasive role in international relations is being recognised. But this understanding is explicit in the character and content of a number of major international agreements adopted by governments in the last decade, especially in the environmental field. Advances in a number of fields such as genetics have resulted in the call for new international regulatory instruments. Technological developments in other fields such as satellite imagery are starting to shape prospects for monitoring compliance with international agreements. In still other fields, advances in the sciences are opening up new opportunities for solving persistent problems in health, agriculture and environmental management, thereby raising new questions about access to new knowledge for development.

These trends are placing new demands on the functioning of ministries of foreign affairs and other government organs that deal with international development issues. Recent international negotiations surrounding the role of biotechnology in the international economy have highlighted the growing impact of science and technology in international diplomacy.^{lviii} Relations between countries are based largely on existing patterns of industrial and agricultural production, as well as the associated trade. Technologies that change the patterns of production have the potential to create new trade relations and affect the nature of international cooperation.^{lviii}

Aid agencies and their counterparts in African countries increasingly are dealing with scientific and technical issues involving knowledge of advances in fields such as molecular biology and ecology. For example, participating effectively in the global debate on genetically modified (GM) foods requires an appreciation of the biological sciences as well as related fields, such as law, economics, ethics and sociology. The technical nature of many international negotiations favors countries that use scientific knowledge to inform their positions. In addition, technical knowledge also is shaping the way governments interact with industry and NGOs.

The formation of a science advice capacity in the US Department of State is an example of the importance that governments are placing on science and technology in international diplomacy.^{lix} This development not only serves as a source of inspiration for African countries, but also provides new opportunities for capacity

Universities and research institutions located in rural areas could serve as loci for research, training and outreach on the management of natural resources.

building in African countries on science diplomacy. The existence of such capacity in African foreign ministries will help to create a basis for a common vocabulary on key international issues, in areas such as bio-safety, intellectual property protection and overall scientific and technological cooperation. Working with African countries to bring science and technology to their diplomatic activities will improve cooperation and dialogue between the US and Africa.

African countries have been active participants in the international arena and have played a prominent role in keeping the development agenda alive in various forums. Africa's role in this field goes back to the early 1960s, when the emergent nations sought to articulate their sovereignty on an international plane and worked closely with their counterparts in other regions of the world. They added considerably to the formulation of concepts such as the "new international economic order" and promoted them through the United Nations system. The positions taken by African countries were driven largely by the search for global equity.

International forums became the means through which Africa pressed for reforms in the global system. Not only did Africa use its numerical strength in these forums to argue its case, but also many leading Africans became champions of the international call for global equity. In addition, a number of African countries came to symbolize this persistent quest and a number of ideas that reflect African cultural values. They also have promoted the establishment of new international regimes such as the United Nations Convention to Combat Desertification (CCD).

But as the nature of international discourse shifts toward greater consideration of scientific and technological issues, African countries also will need to re-examine the composition of their foreign ministries to bring them into line with contemporary demands.

New technology alliances and international trade

One of the most widely accepted approaches to technological development is to promote South-South cooperation. Technological development can be promoted through solidarity among developing countries. Numerous such efforts have been made, especially through the United Nations. There are considerable opportunities for promoting technology cooperation among developing countries. These opportunities include regional cooperation arrangements. But additional opportunities now exist in the emergence of countries such as China, Brazil, Mexico, India, Malaysia and others that could play an important role as technology mentors to their less-developed counterparts. Such alliances, however, should be based on technological needs and capabilities, and not on ideological grounds similar to those that characterized the Cold War era.

Indeed, science ministers from India, Brazil and South Africa have been working together to identify areas for trilateral cooperation that include nanotechnology and efforts to prevent and treat HIV/AIDS. Their first meeting was held in October 2004 as part of the India-Brazil-South Africa (IBSA) trilateral commission. The meeting followed a 2003 meeting of the three nations' foreign ministers in Brasilia, Brazil. The session identified science and technology as key areas for trilateral cooperation. This partnership was inspired by the low level of investment in research into tropical

challenges. For example, western countries spend US \$300 billion annually on agricultural subsidies, while only US \$3.6 billion was allocated to HIV/AIDS research worldwide. This is the first major effort to promote such cooperation with a focus on emerging technologies. The IBSA model could inspire other countries to want to join the group or benefit from the results of the alliance. It is possible that industrialized countries will seek to be party—at least indirectly—to this important initiative.

International partnerships can be promoted in other ways. For example, the movement to forgive foreign debt—so-called debt relief—may have seemed an ideal way to help developing countries. However, simplistic arguments about debt relief may have overlooked other creative uses of foreign debt. Many African countries have accumulated large foreign debts because the value of their raw material exports has been falling over time in relation to the value of manufactured goods. Instead of negotiating for debt relief, they could negotiate for access to foreign markets using manufactured goods and use the revenue to repay the debt.

Such a strategy could result in technology cooperation arrangements that not only add value to natural resources, but create new export opportunities. Ethiopia, for example, could have used such a strategy to add value to their animal skins and hides and move into high-end leather products. This strategy also would entail building modern technical institutes in the leather industry that could help create local scientific capacity in related material sciences. Indeed, advances in leather technology appear to be opening up new avenues for entering the field of industrial biotechnology. Countries such as Ethiopia could leapfrog into this arena and assert their competitiveness through the use of environmentally sound technologies.^{ix}

Diasporas in the global knowledge economy

So far much of the attention among poor countries has focused on benefiting from remittances. The global flow of remittances to developing countries now stands at \$150 billion, exceeding foreign aid and becoming the main source of foreign earning for a number of countries.

But the focus on remittances misses the point. We are no longer in the traditional labor economy in which one's value is determined by wage earning. This is a carry-over from olden days when a lad fleeing the village was a real loss of labor power. Today we are in a knowledge economy governed by connectivity, mobility and interdependence.

*Research, teaching
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The most notable case is the Taiwanese diaspora, which played a crucial role in developing the country's electronics industry.^{xi} This was a genuine partnership involving the mobility of skills and capital. Countries such as India are now studying 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 globalization such as connectivity, mobility, and interdependence among national to promote the use of diaspora as a source of input into national technological and agribusiness programs. These measures include investment conferences, the creation of rosters of experts, and direct appeals from national leaders.

Efforts to encourage expatriates to return home often occur after countries emerge from periods of civil unrest or economic decline. Like other professionals, expatriates respond to incentives and a sense of purpose. The most important starting point therefore is to establish a clear mission around which the diaspora can rally. The onus is on the governments of developing nations to design programs and offer incentives that encourage expatriates to contribute to national efforts.^{lxii}

Significant experiments are underway in countries around the world to make effective use of their diaspora. The Swiss government has converted part of its consulate in Cambridge (Massachusetts, US) into a focal point for interactions between Swiss experts in the US and their counterparts at home. The Swiss House was created in recognition of the importance of the area as the world's leading knowledge center, 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 colleges and universities and a cluster of biotechnology activities.

In another innovative example, the National University of Singapore has established a college at the University of Pennsylvania to focus on biotechnology and entrepreneurship. The complementary Singapore-Philadelphia Innovators' Network (SPIN) serves as a channel and link for entrepreneurs, investors, and advisors in the Greater Philadelphia region and Singapore. SPIN 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 diaspora in national development. This is a major change of policy, based on the study of how countries such as Taiwan have benefited from their diaspora. These approaches can be adopted by other developing countries, where the need to forge international technology partnerships may be even higher.

But opportunities remain to be tapped. Guyana has an estimated population of about 700,000 at home. But nearly 210,000 people of Guyanese origin live in the US, of whom about 65 percent are in New York. About 44 percent of the Guyanese immigrants are US citizens, forming a strong bond between the two countries. Guyanese immigrants in the US contribute significantly to the economy through

remittances amounting to \$150 million a year. But their impact could be greater if the focus included greater knowledge flows and technological cooperation. The Dominican Republic, on the other hand, is actively designing a program that would help the country benefit from its nationals living in the US. African countries could launch similar programs. Ghana, for example, is working on strategies to tap into the African diaspora by offering dual citizenship. This model can be extended to building stronger relations with traditionally black colleges in the United States and other institutions of higher learning interested in contributing to the search for solutions to Africa's problems.

These examples illustrate the need to complement concern over "brain drain" with new approaches that make effective use of the opportunities provided by the existence of large pools of expertise in diaspora. Such efforts will require countries to look at globalization in a new light and identify the opportunities it offers. The old-fashioned metaphor of "brain drain" needs to be replaced by a new view of "global knowledge flows."^{lviii}

Rethinking development cooperation

Donor agencies are under pressure to increase their budgets to meet development challenges, while African countries continue to be criticized for corruption and lack of capacity to use available finances. Most of the rules, procedures and routines used by most donor agencies were designed to reflect the public sector model. They are therefore ill-equipped to deal with the dynamic, uncertain, risky and experimental world of agribusiness evolution. The world needs a new generation of development cooperation instruments that reward creativity rather than bureaucratic routine; encourage risk-taking rather than glorify complacency; manage uncertainty instead of making false appeals to predictability; appreciate the value of learning through trial-and-error instead of looking for mythical blueprints. Finally, development is a long-term process and therefore new aid instruments will need to accommodate time as a critical element.

These criteria could lead to a new generation of aid instruments such as endowments and trust funds as well as innovations in the way agribusinesses function. Some of the most innovative educational institutions in Latin America were established as endowments with donor support. EARTH University in Costa Rica, for example, is funded through an endowment with initial funding from USAID and Kellogg Foundation. But such funds will need not only local matching assets; they will also

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require incentives and laws that promote the emergence of new social enterprises. The question of scale often is taken for granted. It is common practice for donors and their partners to argue for "starting small" and then scaling up. This commonly held view ignores the fact that often the act of scaling up is a new beginning, and lessons valid at one scale may not be transferable to other levels. It is therefore critical to encourage donor investments at the right scale. For example, infrastructure projects might yield maximum impact at regional rather than national levels. Donor agencies could focus on such projects rather than small-scale activities that could be undertaken easily by local actors.

Not only do international aid agencies rely on outmoded management procedures, they have generally failed to recognize the important role played by technological innovation and entrepreneurship in economic renewal.

Classical development cooperation must be replaced by partnerships that focus on bringing the latest scientific and technological innovations into the service of development. In other words, traditional charity should give way to the enhancement of creativity.

There are hopeful signs that the UK can play an equally important role in bringing science and technology to bear in solving development challenges. The decision by the UK government to appoint a Chief Scientific Advisor of its Department of International Development (DFID) is major step forward in reforming the aid system.^{lviv} The office is part of a system of advisory activities led by the Chief Scientist in the Office of the Prime Minister. A recent review of USAID stresses the importance of science and technology in development cooperation and proposes measures that would enable the agency to strengthen its competence in this arena.^{lvv}

A narrow understanding of the role of technology in development, especially in the environmental community, has fueled controversies over the role of new technologies in development. These controversies, for example, have compromised efforts in developing countries to critically examine the opportunities and risks associated with emerging biotechnologies.

Furthermore, a large body of the technical knowledge needed to address development problems lies in the private sector. Yet development NGOs remain skeptical about the role of the private sector in development. Addressing this problem will therefore demand a certain measure of intellectual courage to move aid agencies from their current preoccupation with relief programs toward building long-term scientific, technological and entrepreneurial capacity in developing countries. This process will require greater engagement of institutions of higher learning and the private sector in the UK and its partner countries. But engaging such diverse institutions will require a management model built on the principle of networking and not centralized diplomatic control.

Development is a process of continuous experimentation and cannot be guided by rigid administrative procedures adopted by government bureaucracies. Flexible arrangements that involve institutions such national academies of science and

agribusiness associations will need to be put in place. Much of what is done today by NGOs should be undertaken in partnership with universities, research institutions and other knowledge-based institutions. Civil society organizations 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 emphasized relief-oriented activities.^{lxvi}

New approaches that emphasize competence-building will require not only adjustments in the structure and operations of existing institutions, but will lead new players to enter the field. For example, emerging interest in higher technical education and infrastructure development will call for greater cooperation of engineering associations in development. Similarly, the work of development studies institutions must be complemented by technology-based institutions. More fundamentally, civil society organizations will need to strengthen their technical competence and build stronger linkages with other knowledge-based institutions, such as enterprises and universities.

The current malaise in the traditional development community is being challenged by new technology alliances involving the more developed developing countries. For example, India, Brazil and South Africa have launched a technology alliance that will focus on finding solutions to agricultural, health and environmental challenges facing developing countries.

These emerging partnerships illustrate the growing interest among developing countries in technological innovation as a source of development solutions. If the industrialized countries do not follow this lead and reinvent their development cooperation programs, they will increasingly become less relevant to Africa's needs.

The private sector and development cooperation

Donors can adopt two approaches to improve the contributions of the private sector to human welfare. The first is to work directly with governments and other actors to create space for the development of private enterprises and their alignment with human welfare goals. This would include encouraging the private sector to undertake research relevant to development needs.^{lxvii} This of course presupposes considerable knowledge of these matters on the part of the donor community. A large part of the donor community needs to upgrade its knowledge on the role of agribusiness in development.

A complementary approach would involve mutual learning about the role of agribusiness in human welfare improvement. One way to promote this is to support



reforms in higher education and to create new institutions that train leaders in good governance and entrepreneurship. Donors can facilitate this process by supporting international collaboration among developed countries and African universities on these issues.

Equally critical is the creation of mentoring programs that would enable entrepreneurs in developing nations to learn from role models and benefit from practical advice.^{lxviii}

There is no shortage of corporate leaders willing to share their experiences directly or electronically with young entrepreneurs in developing countries. The US, for example, has used the Digital Freedom Initiative (DFI) to help mentor information and communication technology (ICT) entrepreneurs and small businesses in Senegal, Peru, Indonesia and Jordan.

Donor agencies themselves must improve staff knowledge of agribusiness and human welfare improvement. Most donor agencies are led by people with extensive backgrounds in relief and humanitarian activities. The time has come to increase the level of knowledge and experience of agribusiness activities at the highest levels in donor agencies. Canada has brought corporate executives into leadership positions in development cooperation agencies. This is not to argue the superiority of one model over the other; it is to provide additional expertise that will make donor agencies more adaptive to the tasks at hand and therefore more effective in their missions.

CONCLUSIONS AND THE WAY AHEAD

The task of improving human welfare in Africa and promoting the sustainability transition will require major commitments to institutional innovations that bring scientific and technological knowledge to bear in community development. But it must be more than an effort to improve the functioning of the agricultural sector. It will demand an integrated approach that places agriculture in the context of a wider innovation system. Furthermore, it will require greater economic integration in the region, taking advantage of regional diversity to promote intra-African trade as a foundation for participation in the global economy. The good news is that African countries, especially under the political guidance of the African Union (AU), already are moving in this direction.

In 2007, the AU will hold a presidential summit devoted to science, technology and innovation that will help consolidate current thinking on the subject. Additional impetus can be provided by strengthening the role of institutions such as the African Development Bank (ADB) in aligning their operational activities with technological missions. In addition, the continent needs to develop indigenous capacity for policy analysis; the New Partnership for Africa's Development (NEPAD) is emerging as a key source of ideas on the role of technological innovation in development.

The emerging institutional landscape in Africa and rising awareness of the role of innovation in development present unique opportunities for redirecting international cooperation from its current focus on short-term relief activities toward new approaches that emphasize competence-building (especially through institutions of higher learning, the private sector and relevant parts of civil society). The modernization of Africa will need to go hand in hand with fundamental revisions in our views about Africa.

Endnotes

ⁱ Brown, G.. "Foreword," in *Going for Growth: Science, Technology and Innovation in Africa*, ed C. Juma, 5 (London: The Smith Institute, 2005).

ⁱⁱ Only a small number of developing countries, notably Brazil, use national development as systematic sources of guidance for their foreign policy. Other developing countries such as Jamaica, however, are starting to think along these lines.

ⁱⁱⁱ Mokyr, J. *The Gifts of Athena: Historical Origins of the Knowledge Economy*. (New Haven: Princeton University Press, 2002).

^{iv} Fulvio Castellacci, F. "Innovation, Diffusion and Catching up in the Fifth Long Wave." *Futures* (forthcoming).

^v Fan, S. and Zhang, X. "Infrastructure and Regional Economic Development in Rural China," *China Economic Review*, 15 (2004): 203-214.

^{vi} For details on this approach, see Ridley, T. and Y.-C. Lee. "Infrastructure, Innovation and Development" in Juma, *Going for Growth*, 62-71; Rouach, D. and D. Saperstein. "Alstom Technology Transfer Experience: The Case of the Korean Train Express (KTX)," *International Journal of Technology Transfer and Commercialisation*, 3, no. 3 (2004): 308-323.

^{vii} Studies have shown that "apart from traditional variables (income, assets, education, and direct health interventions), better access to basic infrastructure services has an important role to play in improving child-health outcomes," Fay, M., M. Leipziger, Q. Wodon, and T. Yepes. "Achieving Child-Health-Related Millennium Development Goals: The Role of Infrastructure," *World Development*, 33, no. 8 (2005): 1267.

^{viii} See, for example, Holloway, G., C. Nicholson, C. Delgado, S. Staal and S. Ehui. "Agroindustrialization through Institutional Innovation: Transaction Costs, Cooperatives and Milk-Market Development in the East-African Highlands," *Agricultural Economics*, 23, no. 3 (2000): 279-288.

^{ix} See, for example, National Research Council. *Down to Earth: Geographic Information for Sustainable Development in Africa*. (Washington, DC: National Academies Press, 2002).

^x UN Millennium Project. *Innovation: Applying Knowledge in Development*. Task Force on Science, Technology and Innovation. (London: Earthscan, 2005), 100-118.

^{xi} Stern, N., J.J. Dethier, and H.F. Rogers. *Growth & Empowerment: Making Development Happen*. (Cambridge: MIT Press, 2005).

^{xii} Oyelaran-Oyeyinka, B. and K. Lal. "Learning New Technologies by Small and Medium Enterprises in Developing Countries," *Technovation*, 26 (2006): 220-231.

^{xiii} Mani, S. "Institutional Support for Investment in Domestic Technologies: An Analysis of the Role of Government in India," *Technological Forecasting & Social Change*, 71 (2004): 855-863.

^{xiv} Lethbridge, D. "Innovation in Technology Versus Innovation in Financing: Two Case Studies," *Technovation*, 23 (2004): 869-878.

^{xv} Grimaldi, R. and A. Grandi. "Business Incubators and New Venture Creation: An Assessment of Incubation Models," *Technovation*, 25 (2005): 111-121.

^{xvi} Nankani, G. "Knowledge for Productivity-led Growth" in Juma, *Going for Growth*, 24-32.

^{xvii} Corrigan, P., G. Glomm and F. Mendez. "AIDS Crisis and Growth," *Journal of Development Economics*, 77 (2005): 107- 124; Misselhorn, A. "What Drives Food Insecurity in Southern Africa? A Meta-Analysis of Household Economy Studies," *Global Environmental Change*, 15 (2005): 33-43.

^{xviii} Everts, S. *Gender and Technology: Empowering Women, Engendering Development*. (London: Zed Books, 1998).

^{xix} Markman, G., P. Gianiodis, P. Phan and D. Balkin. "Innovation Speed: Transferring University Technology to Market," *Research Policy*, 34, no. 7 (2005): 1058-1075.

^{xx} Oyelaran-Oyeyinka, B. and L. Barclay. "Human Capital and Systems of Innovation in African Development," *African Development Review*, 16, no. 1 (2004): 115-138.

^{xxi} Rosegrant, M., S. Cline, W. Li, T. Sulser and R. Valmonte-Santos. *Looking Ahead: Long-Term Prospects for Africa's Agricultural Development and Food Security*. (Washington, DC: International Food Policy Research Institute, 2005).

^{xxii} Thomas, G. "Innovation, Agricultural Growth and Poverty Reduction" in Juma, *Going for Growth*, 74-85.

^{xxiii} Omamo, S. and J. Lynam. "Agricultural Science and Technology Policy in Africa," *Research Policy*, 32 (2003): 1681-1694.

^{xxiv} Fagerberg, J. in "Introduction: A Guide to the Literature" in *The Oxford Handbook of Innovation*, ed. Fagerberg, J., D. Mowery and R. Nelson. (Oxford: Oxford University Press, 2005), 1-26.

^{xxv} Sumberg, J. "Systems of Innovation Theory and the Changing Architecture of Agricultural Research in Africa," *Food Policy*, 30 (2004): 21-41.

^{xxvi} Juma, C., C. Gitta, A. DiSenso, and A. Bruce. "Forging New Technological Alliances: The Role of South-South Cooperation," *The Cooperation South Journal* (2005): 59-71.

^{xxvii} Commission for Africa. *Our Common Interest: Report of the Commission for Africa*. (London: Commission for Africa, 2005).

^{xxviii} Kim, Y.-H. "The Optimal Path of Regional Economic Integration between Asymmetric Countries in the North East Asia," *Journal of Policy Modeling*, 27 (2005): 673-687.

^{xxix} Juma, C. "The New Age of Biodiplomacy," *Georgetown Journal of International Affairs*, 6, no. 1 (2005): 105-114.

^{xxx} Murenzi, R. and M. Hughes. "Africa in the Global Knowledge Economy," in Juma. *Going for Growth*, 48-59.

^{xxxi} Such budgetary reallocations should be part of a program to give the African armies more constructive roles.

^{xxxii} Lofsten, H. and P. Lindelof. "R&D Networks and Product Innovation Patterns—Academic and Non-academic New Technology-based Firms on Science Parks," *Technovation*, 25 (2005): 1025-1037.

^{xxxiii} Hansen, J. and M. Lehmann, "Agents of Change: Universities as Development Hubs," *Journal of Cleaner Production*, in press (2006).

^{xxxiv} Lalkaka, R. "Business Incubators in Developing Countries: Characteristics and Performance," *International Journal of Entrepreneurship and Innovation Management*, 3, nos. 1 - 2 (2003): 31-55.

^{xxxv} McDowell, G. *Land-Grant Universities and Extension into the 21st Century: Renegotiating or Abandoning a Social Contract* (Ames: Iowa State University Press, 2001).

^{xxxvi} Etzkowitz, H. "The Evolution of the Entrepreneurial University," *International Journal of Technology and Globalisation*, 1, no. 1, (2003): 64-77.

^{xxxvii} These institutional adaptations are often faced with opposition from advocates of incumbent university models. Arguments against the model tend to focus on the claim that universities that devote their time to practical work are not academic enough. As a result a hierarchy exists that places such institutions either at the lower end of the academic ladder or simply dismiss them as vocational colleges.

^{xxxviii} Zaglul, J. EARTH University, Costa Rica. 2004, personal communication.

^{xxxix} Aylward, L. EARTH University, Costa Rica. 2004, personal communication.

^{xl} For more details on the model, see L. Aylward, *Higher Education and Sustainable Development: A Model Towards Change*. Harvard University, Undergraduate Honors Thesis (2004).

^{xli} Kaburise, J. "New Variations on the African Development University: The UDS Experience with Developing and Alternative Approach to Tertiary Education. Regional Training Conference on Improving Tertiary Education in Sub-Saharan Africa: Things That Work!" Paper delivered in Accra, Ghana, September 23-25, 2003.

^{xlii} For more details on the case, see V. Konde, “Internet Development in Zambia: A Triple Helix of Government-University-Partners,” *International Journal of Technology Management*, 27, No. 5 (2004): 440-451.

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

^{xliv} This section draws heavily on UN Millennium Project. *Innovation: Applying Knowledge in Development*. Task Force on Science, Technology and Innovation. (London: Earthscan, 2003).

^{xlv} For a review of legal incentives needed to foster social enterprises, see Linklaters, *Fostering Social Entrepreneurship: A Comparative Studies of the Legal, Regulatory and Tax Issues in Brazil, Germany, India, Poland, UK and USA*. Presented at the World Economic Forum, Davos, January 2006.

^{xlvi} King, D. “Governing Technology and Growth,” in Juma, *Going for Growth*, 112-124.

^{xlvii} Juma, C. “Entrepreneurship and Development: Opportunities for Private Sector Participation.” Submission to the International Development Select Committee, United Kingdom Parliament, London (2006).

^{xlviii} “The evolution of the modern state mirrors the emergence of a distinct sphere of self-interested economic activity in the private sector. While the state is concerned with the provision of common goods, its economic impact needs to be assessed with regard to the social interests that mark its relationship with the private sector. This holds for the evolution of fiscal systems as well as for other domains of government activity, involving the temporary carrying out of the entrepreneurial function.” A. Ebner, “Institutions, Entrepreneurship, and the Rationale of Government: An Outline of the Schumpeterian Theory of the State,” *Journal of Economic Behavior & Organization*, 59, no. 4 (2006): 497.

^{xlix} Liu, X. and C. Wang. “Does Foreign Direct Investment Facilitate Technological Progress? Evidence from Chinese Industries,” *Research Policy*, 32 (2003): 945-953.

^l Macpherson, A. “Learning How to Grow: Resolving the Crisis of Knowing,” *Technovation*, 25, no. 10 (2005): 1129-1140.

^{li} Juma, C. and Y.C. Lee. “Reinventing Global Health: The Role of Science, Technology, and Innovation,” *The Lancet*, 365 (2005): 1105-1107.

^{lii} Archibugi, D. and C. Pietrobelli. “The Globalisation of Technology and Its Implications for Developing Countries,” *Technological Forecasting and Social Change*, 70, no. 9 (2003): 861-883.

^{liii} Neugarten, M. “Foresight—Are we Looking in the Right Direction?” *Futures* (forthcoming).

^{liiii} Oketch, M.O. “Determinants of Human Capital Formation and Economic Growth of African Countries,” *Economics of Education Review* (forthcoming).

^{liv} For a survey of corporate social responsibilities approaches, see J.E. Mackie, A.D. Taylor, A.S. Daar and P.A. Singer, “Corporate Social Responsibility Strategies Aimed at the Developing World: Perspectives from Bioscience Companies in the Industrialised World,” *International Journal of Biotechnology*, 8, nos. 1 - 2 (2006): 103-118.

^{lv} Chalker, L., *The Chalker Foundation for Africa*, London. 2006, personal communication.

^{lvi} Weiss, C. “Science, Technology and International Relations,” *Technology in Society*, 27 (2005): 295-313.

^{lvii} Juma, C. “Biotechnology and International Relations: Forging New Strategic Partnerships,” *International Journal of Biotechnology*, 2, Nos. 1- 2 (2002): 115-128.

^{lviii} Neureiter, N. “Science and Technology in the Department of State,” *Technology in Society*, 26 (2004): 303-320.

^{lix} Chakrabarti, S., S. Amba and T. Ramasami. “Study of Landscape of Global Leather Patents and Analysis of Technology Linkages to Trade,” *World Patent Information* (forthcoming).

^{lx} Saxenian, A. 2001. “The Silicon Valley-Hsinchu Connection: Technical Communities and Industrial Upgrading.” *Industrial and Corporate Change*. Vol. 10, No. 4, pp. 893-920.

^{lxi} Séguin, B., L. State, P.A. Singer and A.S. Daar. “Scientific Diasporas as an Option for Brain Drain: Re-circulating Knowledge for Development,” *International Journal of Biotechnology*, 8, nos. 1-2 (2006): 78-90.

^{lxii} Sagasti, F. *Knowledge and Innovation for Development: The Sisyphus Challenge of the 21st Century* (Chiltenham, UK: Edward Elgar Publishers, 2004).

^{lxiii} United Kingdom, House of Commons, Science and Technology Committee. *The Use of Science in UK International Development Policy* (London: The Stationery Office, 2004).

^{lxiv} National Research Council. *The Fundamental Role of Science and Technology in International Development: An Imperative for the US Agency for International Development* (Washington, DC: National Academies Press, 2006).

^{lxv} Tripp, R. and D. te Velde. “Civil Society and Economic Growth,” in Juma, *Going for Growth*.

^{lxvi} Kremer, M. and P. Zwane. “Encouraging Private Sector Research for Tropical Agriculture,” *World Development*, 33, no. 1 (2005): 87-105.

^{lxvii} Gibson, D.E. “Role Models in Career Development: New Directions for Theory and Research,” *Journal of Vocational Behavior*, 65, no. 1 (2004): 134-156.

Selected References

Juma, C., ed. *Going for Growth: Science, Technology and Innovation in Africa*. London: The Smith Institute, 2005.

Mokyr, J. *The Gifts of Athena: Historical Origins of the Knowledge Economy*. New Haven: Princeton University Press, 2002.

National Research Council. *The Fundamental Role of Science and Technology in International Development: An Imperative for the US Agency for International Development*. Washington, DC: National Academies Press, 2006.

Our Common Interest: Report of the Commission for Africa. London: Commission for Africa, 2005.

Rosegrant, M., S. Cline, W. Li, T. Sulser and R. Valmonte-Santos. *Looking Ahead: Long-Term Prospects for Africa's Agricultural Development and Food Security*. Washington, DC: International Food Policy Research Institute, 2005.

Sagasti, F. *Knowledge and Innovation for Development: The Sisyphus Challenge of the 21st Century* Chiltenham, UK: Edward Elgar Publishers, 2004.

Stern, N., J.J. Dethier, and H.F. Rogers. *Growth & Empowerment: Making Development Happen*. Cambridge: MIT Press, 2005.

UN Millennium Project. *Innovation: Applying Knowledge in Development*. (Task Force on Science, Technology and Innovation.) London: Earthscan, 2005.

THE INSPIRATION

DR. JOHN PESEK, IOWA STATE UNIVERSITY EMERITUS PROFESSOR OF AGRONOMY



r. John Pesek, Iowa

State University Emeritus Professor of Agronomy, has had a long and distinguished professional career. He has made nationally recognized research contributions in agronomy in the areas of soil fertility, crop production, and the economics of soil fertilizer use. His work has led scientists to a better understanding of the effects of management practices on the environment and their combined influence on yields.

In the 1980s, Dr. Pesek chaired a National Research Council committee under the National Academy of Sciences Board of Agriculture that was directed to study alternative methods of soil management. The book resulting from their case studies, *Alternative Agriculture*, was a groundbreaking report that documented how farming systems that used lesser amounts of pesticides, fertilizers, antibiotics, and fuel can be productive and

profitable. Its publication generated worldwide attention and brought Dr. Pesek to Washington, D.C., to testify before the Joint Economic Committee of the House and Senate.

Dr. Pesek has been named a fellow of the American Society of Agronomy, the Soil Science Society of America, Crop Science Society of America, the Iowa Academy of Science, and the American Association for the Advancement of Science. He has served as president of both the American Society of Agronomy and the Soil Science Society of America and he helped establish the nation's first National Soil Tilth Center. Dr. Pesek has authored or co-authored more than 75 publications and has been active in international programs in Brazil, Mexico, Egypt, Morocco, Uruguay, Tunisia, and Russia. He was named a Charles F. Curtiss Distinguished Professor of Agriculture in 1981 and received the Agronomic Service Award in 1989.



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The Agronomy Department at Iowa State University has been serving Iowans, inspiring future agronomists, and making innovative discoveries since its inception in 1902. The ISU Agronomy Department offers undergraduate programs that lead to degrees ranging in emphasis from agroecology to business to biotechnology. M.S. and Ph.D. programs are offered in agricultural meteorology, agronomy, crop production and physiology, plant breeding, and six areas of specialization within soil science. Continuing a legacy of pioneering research, faculty and staff are currently involved in research that builds the body of scientific knowledge ranging from very basic molecular-level projects to applied, field-oriented projects. Agronomy Extension provides research-based educational programs in a variety of agronomic areas to support producers and agri-business professionals. Overall, Agronomy at Iowa State strives to make crop production more efficient, more productive, and economically and environmentally sustainable.
www.agron.iastate.edu



LEOPOLD CENTER FOR SUSTAINABLE AGRICULTURE

The Leopold Center for Sustainable Agriculture was created by the Iowa General Assembly as part of the 1987 Iowa Groundwater Protection Act. Its purpose is to identify negative impacts of agriculture, contribute to the development of profitable farming systems that conserve natural resources, and inform the public of new research findings. The Center accomplishes its mission through competitive grants, interdisciplinary research issue teams, and education programs. Results of the Center's programs are disseminated through numerous Center publications and through presentations at conferences and other training opportunities, developed in cooperation with ISU Extension and other organizations.
www.leopold.iastate.edu



COLLEGE OF LIBERAL ARTS AND HUMAN SCIENCES F. WENDELL MILLER LECTURE FUND

This lecture was made possible in part by the generosity of F. Wendell Miller, who left his entire estate jointly to Iowa State University and the University of Iowa. Mr. Miller, who died in 1995 at age 97, was born in Altoona, Illinois, grew up in Rockwell City, graduated from Grinnell College and Harvard Law School and practiced law in Des Moines and Chicago before returning to Rockwell City to manage his family's farm holdings and to practice law. His will helped to establish the F. Wendell Miller Trust, the annual earnings on which, in part, helped to support this activity.
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COLLEGE OF AGRICULTURE

Iowa State University's College of Agriculture enriches the lives of people in Iowa, the nation and the world through excellence in education, scholarship, service and leadership in food, agricultural, environmental and social sciences. The College is one of the world's foremost institutions for agricultural and life sciences research. The College's placement rate for graduates is 98 percent, with two-thirds beginning their careers in Iowa. The College's extension programs are helping Iowa build on the many economic opportunities offered in agriculture. The College is preparing extraordinary students to become future leaders; stimulating faculty excellence in basic and applied sciences; and partnering with Iowans to enhance their lives and livelihoods.
www.ag.iastate.edu

OFFICE OF BIOETHICS

The Mission of the Iowa State University Bioethics program is to support research, teaching, and engagement in bioethics. The term 'bioethics' is often used to refer to biomedical ethics, but the scope of the Bioethics Program at ISU is much broader than this: bioethics includes ethical issues that arise in agricultural and environmental sciences and policy, veterinary and human medicine, and in the life sciences more broadly. As a program, we aim to nurture reasoned examination of bioethical issues pertaining to agriculture, food, animals, and the environment, to provide ongoing assistance to, and education of science faculty members who wish to introduce ethical issues to their students. More broadly we aim to support ISU faculty members as they reflect on various moral dimensions of their research.
<http://www.iastate.edu/~ethics/>



THE PLANT SCIENCES INSTITUTE

The Plant Sciences Institute at Iowa State University is dedicated to becoming one of the world's leading plant science research institutes. More than 200 faculty largely from the College of Agriculture, the College of Liberal Arts and Sciences, the College of Human Sciences, and the College of Engineering conduct research in nine centers of the institute. They seek fundamental knowledge about plant systems to help feed the growing world population, strength human health and nutrition, improve crop quality and yield, foster environmental sustainability and expand the uses of plants for biobased products and bioenergy. The Plant Sciences Institute supports the training of students for exciting career opportunities and promotes new technologies to aid in the economic development of agriculture and industry throughout the state. The institute is supported through public and private funding.
www.plantsciences.iastate.edu/



NORTH CENTRAL REGIONAL CENTER FOR RURAL DEVELOPMENT

pkcooper@iastate.edu
The North Central Regional Center for Rural Development, located at Iowa State University, is one of four regional centers coordinating rural development research and education throughout the United States. The Mission of the NCRCRD is to initiate and facilitate rural development research and education programs to improve the social and economic well-being of rural people and the environmental health of rural places in the region. The NCRCRD also provides leadership in rural development regionally and nationally by identifying, developing and supporting programs on the vanguard of emerging issues.
www.ncrcrd.iastate.edu



KENYAN STUDENT ASSOCIATION

Kenya Student Association (KSA) in Iowa State University was formed with a mission of bringing Kenyans, Africans, students and Ames community together through participation in social events. With a membership of 40, KSA promotes the general and academic welfare of its members. KSA also organizes educational and cultural events for students and residents of Ames City. Through this activities, KSA shares Kenyan culture through food, dresses and stories. KSA has a responsibility of welcoming and orientating new African students at ISU.
www.stuorg.iastate.edu/ksa/homepage

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ALLIANT ENERGY

Alliant Energy is an energy-services provider that serves more than three million customers worldwide. Providing its customers in the Midwest with regulated electricity and natural gas service remains the company's primary focus. Other key business platforms include the international energy market and non-regulated domestic generation.

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UNEP GLOBAL 500 FORUM

The United Nations Environmental Programme (UNEP) established the Global 500 Laureate Roll of Honour to recognize the environmental achievements of individuals and organizations around the world. Since

1987, over 600 Laureates have received the prestigious Global 500 Laureate award. Many Laureates devote impressive portions of their lives to such global concerns as climate change, deforestation, ocean pollution,

dumping of toxic waste, and the conservation of biodiversity. The formation of the Global 500 Environmental Forum at the 1992 Earth Summit in Rio de Janeiro made it possible for Laureates to support and communicate with each other. The Forum includes individuals from all walks of life... individuals working alone or in organizations... individuals

whose initiative and courage protect the environment against

all odds. Its network is particularly helpful to those

Laureates who live and work in isolated areas.

www.global500.org/



BETHESDA LUTHERAN CHURCH TANZANIA MINISTRY TEAM

Bethesda Lutheran Church (BLC) is a member of the Southeast Iowa Synod, Evangelical Lutheran Church in America. Since 2003 Bethesda

(2400 members) has had a formal partnership agreement with the Shighatini Lutheran Parish (3000 members), Pare Diocese, Evangelical Lutheran Church in Tanzania. The purpose is to build one to one personal relationships between members of the two congregations.

Several jointly planned programs are in process: developing a sustainable mountainous agriculture while increasing income of Shighatini

subsistence farmers, focusing on dairy, corn, fruit, coffee, and crafts; health/medical, building and equipping new clinic facilities; education, getting every primary child into school; and community development projects focusing on both the quantity and quality of water.

IOWA FARMERS UNION

Iowa Farmers Union is a non-profit advocacy group representing family farmers across the state. IFU also collaborates on legislative work and educational programming with Women, Food and Agriculture Network, NFO-Iowa, United Steelworkers Local 9310, and the Iowa Renewable

Energy Association. IFU is a chapter of National Farmers Union, a general farm organization representing a quarter of a million family farmers and ranchers nationwide. NFU serves its membership by providing educational opportunities, supporting farmer-owned cooperative development, and presenting the organization's policies to lawmakers at the local, state and national levels.

www.iafu.org/



GRINNELL COLLEGE

When Grinnell College framed its charter in the Iowa Territory of the United States in 1846, it set forth a mission to educate its students "for the different professions and for the honorable discharge of the duties of life." The College pursues that mission by educating young men and women in the liberal arts through free inquiry and the open exchange of ideas. As a teaching and learning community, the College holds that

knowledge is a good to be pursued both for its own sake and for the intellectual, moral, and physical well-being of individuals and of society at large. The College exists to provide a lively academic community of students and teachers of high scholarly qualifications from diverse social and cultural circumstances. The College aims to graduate women and men who can think clearly, who can speak and write persuasively and even eloquently, who can evaluate critically both their own and others' ideas, who can acquire new knowledge, and who are prepared in life and work to use their knowledge and their abilities to serve the common good.

<http://www.grinnell.edu/>



BELFER CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS

The Belfer Center for Science and International Affairs (BCSIA) is the hub of the John F Kennedy School of Government's research, teaching and training international security affairs, environmental and resource issues, and science and technology policy. The Center's mission is to provide

leadership in advancing policy-relevant knowledge about the most important challenges of international security and other critical issues where science, technology, environmental policy, and international affairs intersect. The Center's leadership begins with the recognition of science and technology as driving forces transforming threats and opportunities in international affairs. The Center integrates insights of social scientists, natural scientists, technologists and practitioners with experience in government, diplomacy, the military and business to address critical issues.

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