
# FOOD SECURITY, AGRICULTURE AND ECONOMIC GROWTH
## Opportunities for Cooperation between the United States and Sub-Saharan Africa

**CALESTOUS JUMA**
**Professor of the Practice of International Development**
**Belfer Center for Science and International Affairs**
**Kennedy School of Government**
**Harvard University**
**Calestous_Juma@Harvard.Edu**

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## SUMMARY

This year marks the 300th anniversary of the birth of Carl Linnaeus, renowned as the father of taxonomy. Less known are his lifelong efforts to find permanent solutions to the persistent famines in Sweden. Linnaeus drew attention to the economic value of living things: "each country produces something especially useful." He argued, however, for the importance of reason and scientific knowledge for sustainable economies. Three hundred years later, Sweden is among the wealthiest nations on Earth and famines are the subject only of history lessons.

Efforts to promote food security in sub-Saharan Africa must remember the lessons of Sweden: (a) "food security" is inseparable from economic development. Rich countries do not starve; (b) science and innovation are a necessary part of economic development and so of "food security"; and (c) universities in most countries are engines of development and must be so in Africa as well. International cooperation is critical for promoting the adoption of new agricultural technologies such as biotechnology. It is especially regrettable, then, that international agricultural assistance to Africa has been reduced in recent years. This disengagement in turn has weakened cooperation between the US and Africa on strategic economic issues.

African heads of state and the African Union are currently working toward agricultural improvement in particular and economic development in general. Both the tone of policy discussions and the evident results (6% per year growth for the last five years, resulting in a doubling of GDP in sub-Saharan Africa) are cause for optimism. Africa's newfound dynamism offers the opportunity for the US to cooperate in economic initiatives and help bring Africa into the global knowledge economy. Cooperation in agricultural development is one obvious starting point.

Cooperation with the US could involve for key areas. First, special attention needs to be placed on promoting regional integration among Africa states so they can diversify their economic activities beyond local markets. Although increasing food production throughout sub-Saharan Africa is obviously important, lack of regional integration is what makes crop failures so deadly in Africa: although food is produced elsewhere, bad roads mean that transported food is unaffordable, inadequate, spoiled or simply unavailable.

Second is building skills on how to *govern the economy*. Many African countries are reorganizing their state structures to make them more *entrepreneurial* so that government can be responsive to the needs of the people and act as a champion of innovation. The US could help strengthen the capacity of African states to build necessary infrastructure, to train future generations of leaders, businesspeople, and scientists, and to generate and use science and innovation advice for economic development.

A third key area of cooperation is *reforming existing African universities and supporting the creation of new models of higher education.* The US has a long history of sharing its experiences in using universities as engines of regional and community development. For example, it supported a pioneering adaptation of the land-grant model in Costa Rica by helping to create EARTH University in Costa Rica, the first dedicated sustainable development university in the world. The US can help African universities by (a) revamping university infrastructure and missions, especially by providing affordable access to information and telecommunications; (b) reforming curricula to make them more applied and relevant to local needs; (c) making teaching more experiential and promoting exchanges of teachers, students, and researchers; (d) helping universities adopt appropriate management practices including university autonomy.

Finally, the US and Africa should to forge long-term cooperation in advancing specific *technology missions*. Prime candidate is the application of biological innovations in areas such as agriculture, health, industry and environment. These efforts should be supported by additional funding that is devoted to promoting agricultural science and innovation cooperation.

## INTRODUCTION[1]

It is often stated that sub-Saharan Africa continues to suffer from food insecurity because it was bypassed by the "Green Revolution".[2] It is concluded from such statements that an African Green Revolution is needed to help enhance Africa's food security. While some elements of the Green Revolution are essential for addressing Africa's agricultural challenges, food security is not a function of agricultural production alone.[3] "Food security" is a term that covers critical attributes of food such as sufficiency, reliability, quality, safety, timeliness and other aspects of food necessary for healthy and thriving populations. It is therefore intricately linked to economic health.[4]

This testimony outlines the critical linkages between food security, agricultural development and economic growth and explains why Africa has lagged behind the agriculture of other countries. It argues that improving Africa's agricultural performance will require deliberate policy efforts to improve higher technical education, especially in universities, and bring it to the service of agriculture and the economy. It concludes by providing a set of options for strengthening agricultural cooperation between the US and Africa.

## 1. FOOD SECURITY, AGRICULTURE AND ECONOMY

Food security in Africa has worsened since the early 1970s. Food availability has failed to keep up with the growing population, as reflected in the rise of the absolute number of undernourished people. Between 1990-92 and 2001-03, the number of undernourished people in Africa rose from 169 million to 206 million. Of the 39 countries for which data were available, only 15 reported reductions in the number of undernourished people.[5] The situation is projected to worsen if current policies continue. These trends could be reversed through a variety of measures addressing rural development in general and agriculture in particular.[6]

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[1]. I am grateful to colleagues at Iowa State University, particularly Professor John Pesek, for helping to develop many of the ideas contained in this testimony. I want to thank Professor Elisabeth Moyer (Department of Geophysical Sciences at the University of Chicago) for her valuable contributions.

[2]. The term "Africa" is used herein to mean "sub-Saharan Africa".

[3]. This is clearly articulated in InterAcademy Council. 2004. *Realizing the Promise and Potential of African Agriculture*. InterAcademy Council, Amsterdam.

[4]. These connections were graphically captured by UK Prime Minister Gordon Brown: "When I visited Africa…I saw not only the potential and promise of economic and social growth in Africa but also mothers paid only £5 a week begging for free education for their children, supporters of AIDS orphans asking only that they have free healthcare, and men and women everywhere with a yearning that their growing political and constitutional rights now be matched by economic and social opportunities. We know that despite increased aid, trade and debt relief, coupled with improvements in economic growth and governance in Africa, those opportunities will not be realised unless and until the foundations of economic growth–sustained investment, innovation, education, skills, science and technology–are in place and built on over the long term," Brown, G. "Foreword," in Juma, C. 2005. *Going for Growth: Science, Technology and Innovation in Africa*, Smith Institute, London, p. 5.

[5]. FAO. 2006. *The State of Food Insecurity in the World 2006*. Food and Agriculture Organization of the United Nations, Rome, pp. 23.

[6]. Thomas, G. 2005. "Innovation, Agricultural Growth and Poverty Reduction," in Juma, C., ed. *Going for Growth: Science, Technology and Innovation in Africa*. The Smith Institute, London, pp. 74-85.

Agriculture is central to African economies, making up 30-50% of national income, employing nearly 60% of the population and generating about 40% of its foreign exchange earnings. But policymakers often treat agriculture as a separate sector with little regard to its relationship with the rest of the economy.[7] A more realistic view is to treat economies as integrated "systems of innovation" where new actors and institutions constantly are being created, changed, and adapted to suit the dynamics of scientific and technological creation. Government, the private sector, institutions of higher learning such as universities, and civil society organizations are important parts of a larger system of knowledge and interactions that allows diverse actors to come together to pursue broad common goals, including agricultural innovation.

In many African countries, the state still plays a key role in undertaking productive activities. But the private sector is increasingly becoming an important player in adapting existing knowledge and applying it to new areas. This in turn is changing the role of the government, making it largely a facilitator of economic change. Democratic change and elections have helped to bring to power new leaders who are pressing for improvements in public sector performance. They are often at odds with their own bureaucracies that are still steeped in old practices.

Africa's food security can only be guaranteed through long-term economic growth, not by emergency interventions alone. This shift in policy will entail placing emphasis on renewing infrastructure, building human capabilities, stimulating business development, and increasing participation in the global economy through export of manufactured goods. These areas that constitute what can be called "the learning economy" should be the foundation upon which to base international development partnerships.

This view is already informing the reformulation of Africa's foreign policy. African countries are increasingly paying attention to the role of science and innovation in diplomatic interactions and are already starting to assign technology-related tasks to their key missions to countries such as the US and Japan. Others are revising their foreign policies to make economic cooperation a centerpiece of their diplomatic interactions. Part of Africa's growing cooperation with China, for example, is influenced by the higher technical education opportunities granted to African students. In 2006 China admitted nearly 2,000 African students, mostly in science and engineering. The number of African students admitted to Chinese university will double by 2009 and the long-term diplomatic benefits of such arrangements are immeasurable.

This approach is justified by the historical evidence from other developing countries. The main explanation for the success of the industrialized countries was their ability to learn how to improve performance in a diversity of social, economic and political fields: their focus on practical knowledge and the associated improvements in skills needed to solve problems. At least three key factors contributed to their rapid economic transformation. First, governments invested significantly in *basic infrastructure* and more efficiently providing infrastructure services.[8] Secondly, they created and nurtured the development of *small and medium-sized enterprises* (SMEs) through a network of incentives and support systems.[9] And thirdly, 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.[10] These are discussed below. Africa's economic growth will likely follow the same path.

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[7]. Omamo, S. and Lynam, J. 2003. "Agricultural Science and Technology Policy in Africa," *Research Policy*, Vol. 32, pp. 1681–1694.

[8]. Juma, C. 2006. *Redesigning African Economies: The Role of Engineering in International Development*. 2006 Hinton Lecture, Royal Academy of Engineering, London.

[9]. Juma, C. and Lee, Y-C. Lead Authors. 2005. *Innovation: Applying Knowledge in Development.* UN Millennium Project Task Force on Science, Technology and Innovation. Earthscan, London, pp. 100-118.

[10]. Juma, C. 2006. *Reinventing African Economies: Technological Innovation and the Sustainability Transition*. 6th John Pesek Colloquium on Sustainable Agriculture, Iowa State University, Ames, Iowa, USA.

**Basic infrastructure**

Infrastructure is 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; the transport sectors such as roads, railways, ports, waterways and airports; and research facilities, such as laboratories and related equipment.

Poor infrastructure in Africa is a critical barrier to economic growth and improvement of human welfare in general and agricultural improvement in particular.[11] In Uganda, for example, transport costs add the equivalent of an 80% tax on clothing exports. Transport costs directly contribute to food crises by hindering the shipment of food between regions. Infrastructure is also critical in investment decisions. Farmers will not plant crops if there is no way to get them to market. Agribusinesses will not invest if there is no cost-effective way to transport produce to markets. More broadly, infrastructure is essential for the delivery of health and education services, creation of employment and dissemination of knowledge.

Telecommunications infrastructure is an area of particular concern for Africa. Investments in basic telecommunications infrastructure have allowed the rapid diffusion of information technology in recent years: for example, rates of cellular telephone and Internet usage are exploding among people of all income levels. Electronic information systems, which rely on this infrastructure, now account for a substantial proportion of production and distribution activities in the secondary and tertiary sectors of the economy. But investment could be still larger, and high telecommunications costs are at present a substantial drag on economic growth. High costs have also hindered education, training, and the use of advances in fields such as geographical information sciences in sustainable development.

One of the main challenges in African higher education is the isolation of campuses and training facilities. University textbooks are often decades out of date and students have little access to more recent information: road travel is difficult and slow, air travel expensive; and Internet connections are prohibitively expensive. It is not possible to spread information about available agricultural practices when it can cost a day's wages for an African student to log on at an Internet café to download a paper or brochure. Most students have no Internet access at all through their universities. African universities of the size of the University of California Berkeley or the University of Texas at Austin have the Internet capability of a single US household.[12] They do not buy more capacity because even this limited connection can cost up to $15,000 per month.[13] A digitally-isolated Africa cannot effectively educate its students or provide adequate post-graduate training.

In much of Africa, communications prices are far higher than the cost of infrastructure warrants. Africa (other than South Africa) is currently linked to the developed world by a single fiber-optic cable down the West Africa coast. It is the most digitally-isolated region on the globe. Even so, that single cable is still underutilized. That cable is operated as a monopoly, and the owners (a consortium of Africa and foreign, including US companies) have set bandwidth prices so high that most users connect via satellite instead. Bandwidth in much of Africa is sold for prices 40-100 times higher than in the US although operating expenses are not significantly different. Monopoly firms have adopted a

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[11]. 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., Leipziger, M., Wodon, Q. and Yepes, T. 2005. "Achieving Child-Health-Related Millennium Development Goals: The Role of Infrastructure," *World Development*, Vol. 33, No. 8, p. 1267.

[12]. The effectiveness of those internet connections is more or less as one can imagine if 30,000 people all try to share a single household connection.

[13]. Scaled to mean national income in Africa, that is the equivalent of nearly $1 million per month.

"high cost, low volume" business strategy. The vast majority of potential Internet usage is cut off and usage is restricted to those who can afford stratospheric rates. Paradoxically, this makes free information a very expensive resource. The curbing of the monopolies in Africa is a necessary step in its economic development.

Energy is another area that stalls Africa's agricultural development and economic growth. The continent has abundant new and renewable energy resources—hydropower, geothermal, biomass, solar, and in some countries, wind potential. Africa accounts for only about 5% of world primary energy demand and this is unevenly distributed. Only about 36% of the population has access to electricity and most of this is in urban areas. Nearly 80% of the continent's rural population has no access to electricity. The majority of these people rely on traditional biomass such as wood and agricultural residues as their main energy source with far-reaching ecological implications.

Much of the discussion about Africa's energy situation focuses on trends in supply and demand and their environmental implications. What is often ignored is the importance of technological innovation associated with energy use which can be a springboard for technology used to tackle wider conservation challenges. Discussions should be placed in the context of using technological innovation to boost the transition to sustainability.

Geothermal energy is a good example. Using existing technology, Eastern Africa (Djibouti, Eritrea, Ethiopia, Kenya, Tanzania, Uganda, and Zambia) has the potential to generate over 2,500 MW of electricity from geothermal energy (out of the current global output of 8,100 MW). Geothermal energy production involves building capacity in a wide range of fields including ecology, chemistry, geology, engineering and electronics. The expertise needed is similar to that needed for natural resource management. Building geothermal energy capacity can therefore go hand in hand with efforts to meet longer term sustainable development as well as sustainable energy targets. Many have invoked the need for a Marshall Plan for Africa. An even more appropriate metaphor is President Franklin D. Roosevelt's New Deal that focused on providing low-cost infrastructure services. African universities need a telecommunications New Deal now just like farmers need one on low-cost energy and roads.

**Small and medium-sized enterprises**

The development of small and medium-sized enterprises (SMEs) has been an integral part of the development of all industrialized economies. This holds true in Africa. Building these enterprises requires development of pools of capital for investment, of local operational, repair and maintenance expertise, and of a regulatory environment that allows small business to flourish. Africa must review its incentive structures to promote these objectives, and the international community must promote investment in African businesses.[14]

A range of policy measures are needed to create and sustain enterprises—from taxation regimes and market-based instruments to consumption policies and changes in the national system of innovation. Policy-makers also need to ensure that educational systems provide adequate technical training. They need to support agribusiness and technology incubators, export processing zones and production networks as well as sharpening the associated skills through agribusiness education. The US can help in all these avenues.

Banks and financial institutions also play key roles in fostering technological innovation and supporting investment in homegrown domestic businesses. Unfortunately, their record in promoting technological innovation in Africa has been poor. Capital markets have played a critical role in creating SMEs in other developed countries. Venture capitalists not only bring money to the table, they

[14]. Pragnell, M. 2006. "Agriculture, Business and Development," *International Journal of Technology and Globalisation*, Vol. 2, Nos. 3/4, pp. 289–299.

also help groom small and medium-sized start-ups into successful enterprises. Venture capital in Africa, however, barely exists outside of South Africa and needs to be introduced and nurtured.

**Institutions of higher technical learning**

Industrialized countries have supported, funded and promoted institutions of higher technical learning, as well as academies of engineering and technology, professional engineering and technological associations, and industrial and trade associations. Higher technical education is increasingly (and belatedly) being recognized as critical for development.[15] While primary education has been the focus of the donor community for decades, secondary and higher education and research are now beginning to gain policy attention.

Primary education is not unimportant: economic and educational data suggest near-universal primary education is necessary for economic development, it is not sufficient: countries with high primary enrollments can still be quite poor. National per capita income is instead remarkably well correlated with enrollment rates in higher education. Africa has both the lowest income and the lowest mean university enrollment in the world. No rich country other than Switzerland has university enrollment below 50%. Mean enrollments in Africa are close to 5%. For Africa to advance, this must change.

The urgency of investing in higher technical education is compounded by several factors. Increased primary and secondary enrollments have created a generation of students eager for university training but barred from it by the lack of facilities. The impact of HIV/AIDS and other infectious diseases has also struck hard at Africa's university graduates, affecting Africa's economic growth in general and agricultural development in particular.[16]

Finally expansion of women's access to higher technical education is also important, not only for equality and social justice but for the practical purpose of changing social attitudes and preparing the next generation to adapt to changing world conditions.[17] But if universities are already oversubscribed and overcrowded, adding more female students cannot happen without investment in building additional facilities.

In the industrialized world, research and higher education are a valuable resource for business, industry, and society. Higher education and research institutions are integrated 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. African universities should follow suit and play their role.

Most African countries already possess the key institutional components they need to become players in the knowledge economy. But the separation between government, industry and academia is

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[15]. The 8th Summit of the African Union adopted far-reaching decisions on science and technology at its January 2007 session in Addis Ababa. The presidents committed themselves to "Encourage more African youth to take up studies in science, technology and engineering, and invite Member States to pay special attention to the teaching of science and technology," African Union. 2007. *Addis Ababa Declaration on Science, Technology and Scientific Research for Development*. Assembly of the African Union, Eight Ordinary Session, African Union, Addis Ababa. They also pledged to ensure "the enhanced role and the revitalization of African universities and other African institutions of higher education as well as scientific research institutions so that they can play an effective role as loci of science, technology and engineering education and development and also contribute to public understanding of science and technology," *Ibid*.

[16]. Corrigan, P., Glomm, G. and Mendez, F. 2005. "AIDS Crisis and Growth," *Journal of Development Economics*, Vol. 77, pp. 107– 124; Misselhorn, A. 2005. "What Drives Food Insecurity in Southern Africa? A Meta-analysis of Household Economy Studies," *Global Environmental Change*, Vol. 15, pp. 33-43.

[17]. InterAcademy Council. 2006. *Women for Science*. InterAcademy Council, Amsterdam.

a source of inertia and waste in Africa's knowledge-based institutions.[18] Africa's economic growth depends on bringing these together to increase the production of university graduates, give students training that meets the needs of the modern business world, and provide capital to help university graduates generate businesses and jobs.

## 2. LAGGING BEHIND

Interest in Africa's future is rising among donors and governments. This trend coincides with a new awakening of interest within international development agencies in the role of technological innovation in economic growth. But the two ideas have not been connected. Much of the discussion on Africa's development focuses on improving the lives of subsistence farmers. It only marginally addresses the need to harness the world's existing fund of knowledge for long-term development. Any long-term strategy for Africa must include assistance to its universities.

To function effectively as engines of development, universities and other institutions of higher learning in Africa must adapt and change, forging closer links with the private sector, training graduates for professional careers, and diffusing knowledge into the economy. In other words, they will need to become "developmental universities," working directly within the communities in which they are located The US, with its long tradition of entrepreneurial private universities and applied land-grant ones, can help with this transformation.

### Hobbled talents

The main role of the original 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 requires deliberate efforts by governments, academia, agribusiness and civil society to reorganize and redirect higher education and reorient it to serve all 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 universities. Laws governing higher education and universities will need to be overhauled and parliaments will need to play a bigger role in this regard. Courage and leadership will be essential because of the political nature of such reforms.

Curriculum reform is needed to create an adaptive generation of professionals.[19] 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 an advanced micro-satellite as part of its training. The aim for the program was to build competence in new technologies in the fields of remote sensing, spacecraft control and earth sciences and to offer other services such as mailbox, speech and data relay experiments to the community. 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 such as infrastructure development and maintenance.

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[18]. Oyelaran-Oyeyinka, B. and Barclay, L. 2004. "Human Capital and Systems of Innovation in African Development," *African Development Review*, Vol. 16, No. 1, pp. 115-138.

[19]. Coursework in most African universities is overly theoretical and lacks an applied focus. High school examinations, for example, are set to reflect the lack of laboratory facilities so there no incentives to spend more time in the laboratory. Similar disincentives prevail in universities.

Many of these examples are the result of isolated initiatives. The challenge is to move away from relying on luck and tenacity, and to create an environment that helps to realize the developmental role of universities. 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. It also, however, requires an infusion of funds and knowledge. International donor agencies in past years have supported the trend of cutting funding for African universities. Though this misguided attitude is changing, most of them are still reluctant to support alternative university models and they support is helping to entrench outmoded practices. They are doing Africa and themselves a disservice.

**Slashed budgets**

International donors started to cut back on international agricultural assistance in the 1980s. In 1980 the US was a leading international advocate for agricultural development assistance, with nearly 25% of official development assistance (ODA) going to this sector. A decade later the share had fallen to about six per cent of the total. By 2003 it stood at one per cent. Although this drop occurred at a time when overall US foreign assistance was rising in constant dollar terms, the net effect is still a dramatic decrease: between 1980 and 2003 total bilateral ODA increased by 69%, but agricultural aid dropped by 98%.

The cutting of agricultural development assistance in the US Agency for International Development (USAID) has been so thorough that the term "agriculture" is hardly used. The agency still has an agriculture office, but its total budget had dropped to just $27 million. The total US development assistance to agriculture from all USAID offices now stands at a mere $169 million, or 1% of the total ODA. This has significantly undercut the capacity of the US to be a serious diplomatic player in Africa where agriculture still remains a core economic activity.

Africa has lagged behind other regions of the world in agricultural development for two main reasons. First, its institutions of higher learning hardly played their role as promoters of agricultural innovation. They focused on producing functionaries for the civil service. Second, reductions in foreign agricultural assistance undermined the local research efforts as well as international university partnership. The challenge now is to forge a new partnership between the US and Africa that will bring new financial resources to enable US universities to team up with their African counterparts.

## 3. BUILDING CAPABILITIES FOR INNOVATION

The role of universities as vehicles of community development is exemplified by the US land-grant system, which led to the founding of 106 universities, including Colorado State, Rutgers, Texas A&M, and the entire University of California system.[20] 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 development. While the model largely is associated with agriculture, its adaptation to industry also occurred. Universities such as the Massachusetts Institute of Technology (MIT) and parts of Stanford University owe their heritage to the land grant system.[21]

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

[20]. McDowell, G. 2001. *Land-Grant Universities and Extension into the 21st Century: Renegotiating or Abandoning a Social Contract*. Iowa State University Press, Ames, Iowa.
[21]. Etzkowitz, H. 2003. "The Evolution of the Entrepreneurial University." *International Journal of Technology and Globalisation*, Vol. 1, No. 1, pp. 64-77.

conditions. 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 off or at the lower end of the academic ladder.

The US has played a key role in promoting agricultural development around the world. Its role in championing the Green Revolution is well-known. Less known, but probably more important for Africa, is its support to countries seeking to adapt the land-grant model to local conditions so that higher education can help to contribute to human welfare. The case of EARTH University in Costa Rica illustrates the importance of focusing on institutional innovation as a way to bring higher technical education to bear on economic development in general and agriculture in particular.[22] Similar institutions or curricula could be introduced in Africa.

**Supporting innovation in university education**

EARTH University emerged in a context that mirrors today's Africa: economic stagnation, high unemployment, ecological decay, armed conflict. Inspired by the need for new attitudes and paradigms, EARTH University was created in 1990 as a non-profit, private, international university dedicated to sustainable agricultural education in the tropics. It was launched as a joint effort between the private and public sectors in the US and Costa Rica. The WK Kellogg Foundation provided the original grant for a feasibility study at the request by a group of Costa Rican visionaries.

Based on the study, USAID provided the initial funding for the institution. The original mission of the university was to train leaders with ethical values to contribute to the sustainable development of the humid tropics and to build a prosperous and just society. Through its academic, research and outreach programs, the university offers innovative solutions for improving the quality of life of the inhabitants of the humid tropics.

Located in the Atlantic lowlands of Costa Rica, EARTH University admits about 110 students a year and has a total student population of about 400 from 24 countries (mainly in Latin America and the Caribbean) and faculty from 22 countries. Through its endowment, the university provides all students with 50% of the cost of tuition, room and board. In addition, the university provides scholarships to promising young people of limited resources from remote and marginalized regions. Nearly 80% of the students receive full or partial scholarship support. All students live on campus for four intensive years.

EARTH University has developed an innovative, learner-centered and experiential academic program. Its educational process stresses the development of attitudes necessary for graduates to become effective agents of change. They learn to lead, identify with the community, care for the environment and be entrepreneurial. They are committed to life-long learning. There are four activities in particular within the curriculum that embodies EARTH University's experiential approach to learning.

**Learning from work experience and community service**

The first is the Work Experience activity, which is taken by all first, second, and third year students and continues in the fourth year as the Professional Experience course. In the first and second years, students work in crop, animal and forestry production modules on EARTH University's 3,300-hectare farm. In the first year, the work is largely a routine activity and the experience centers on the

[22]. Zaglul, J., Sherrard, D. and Juma, C. 2006. 'Higher Education in Economic Transformation," *International Journal of Technology and Globalisation*, Vol. 2, Nos. 3/4, pp. 241–251.

acquisition of basic skills, work habits and general knowledge and familiarity with production. In the second year, the focus changes to management strategies for these same activities.

Work Experience is later replaced with Professional Experience. In this course students identify work sites or activities on campus, which correspond with their career goals. The student is responsible for contacting the supervisors of the campus operations, requesting an interview, and soliciting "employment". Upon agreement, they develop a joint work plan which the student implements, dedicating a minimum of ten hours per week to the "job".

The second activity is an extension of the Work Experience course. Here third-year students work on an individual basis with small, local producers on their farms. They also come together in small groups under the Community Outreach program that is integral to the learning system. Community outreach is used to develop critical professional skills in students, while at the same time helping to improve the quality of life in nearby rural communities.

The third year internship program exemplifies the emphasis on experiential learning. The 15-week internship is required for all students in the third trimester of their third year of study. It is an opportunity for them to put into practice all they have learned during their first three years of study. For many of them it is also a chance to make connections that may lead to employment after graduation. The international character of the institution allows many students the opportunity to follow their interests, even when they lead to internship destinations other than in their home country.

**Sharpening entrepreneurial skills**

The fourth activity is the Entrepreneurial Projects Program. EARTH University's program promotes the participation of its graduates in the private sector as a critical means by which the institution can achieve its mission of contributing to the sustainable development of the tropics. The development of SMEs is a powerful way to create new employment and improve income distribution in rural communities. For this reason, the university stresses the development of an entrepreneurial spirit and skills. Courses in business administration and economics combined with practical experience prepare the students to engage in business ventures upon graduation.

This course provides students the opportunity to develop a business venture from beginning to end during their first three years at EARTH University. Small groups of 4-6 students from different countries decide on a relevant business activity. They conduct feasibility studies (including financial, social and environmental criteria), borrow money from the university and implement the venture. This includes marketing and selling the final product. After repaying their loan, with interest, the group shares the profits.

This entrepreneurial focus has permeated all aspects of the university's operations and prepared students to become job creators and agents of change rather than job seekers. About 17% of its 1,100 graduates run their own businesses. The university manages its own profitable agribusiness, which has resulted in strong relationships with the private sector.

When the university acquired its campus, it decided to continue operating the commercial banana farm located on the property. Upon taking over the farm, the university implemented a series of measures designed to promote more environmentally-sound and socially-responsible production approaches.

**Going global**

EARTH University has internationalized its operations. It signed an agreement with US-based Whole Foods Market as the sole distributor of bananas in their stores. The university sells nearly 600,000 boxes of bananas a year to Whole Foods Market, as well as mangoes and (through an alliance with a small farmers' cooperative) pineapples. This helps to generate new income for the university and for

small farmers while providing an invaluable educational opportunity for the students and faculty. In addition to internships, students have access to Whole Foods Market's venture capital upon graduation. The university uses part of the income to fund sustainable and organic banana and pineapple production research.

The university has US supporters who raise additional funds through a private foundation. In June 2004 the family of the former Costa Rican President Daniel Oduber donated the La Flor farm to the university to be used to develop techniques to improve the quality of life in the Guanacaste area and the dry tropics of Latin America. EARTH University hopes to achieve its mission at La Flor by establishing world-class research and training that promotes entrepreneurship and contributes to the sustainable development of the tropics. As part of this effort, La Flor will host a Technological Center, a Green Conference Center, an Exhibition Center and a housing complex with the aim of contributing directly to the economic transformation of the region and Costa Rica.

Over the years the university has worked closely with African institutions and leaders to share its experiences. Following nearly seven years of study through workshops, discussions, training courses and site visits African participants agreed to the importance of reforms in their own university systems, especially through the creation of new universities along the lines of the EARTH model. This was undertaken through a series of workshops on Sustainability, Education and the Management of Change in the Tropics (SEMICT) funded by the WK Kellogg Foundation and the Norwegian Agency for Development Cooperation (NORAD). The lessons learned during the process provide fertile ground upon which new institutional ideas could grow.

The case of EARTH University is one of many examples around the world involving major collaborative efforts between the US and developing countries to bring scientific and technical knowledge to improve welfare through institutional innovations. Such experiences, and those of US land-grant universities, offer a rich fund of knowledge than should be harnessed for Africa's agricultural development and economic growth.

## 4. FORGING AHEAD

### Facilitating regional economic integration

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. Of these, the African Union (AU) formally recognizes eight Regional Economic Communities (RECs).[23] These RECs represent a new economic governance system for Africa and should be strengthened.

While it is prudent for Africa to emphasize international trade, doing so requires greater investment in developing capabilities to trade, including technological innovation, development of business and human resources, and institutional strengthening. Regional integration is a better initial approach. Regional integration offers larger markets (which also stimulate technological innovation), economies of scale, and the diffusion of technical skills arising from infrastructure development.[24]

Another argument for African regional integration is the importance of engineering in sustainable development. Individual African economies are small and poorly endowed with the human, physical, and financial resources necessary to develop and harness engineering capabilities. The cost of building

[23]. These are: the Community of Sahel-Saharan States (CEN-SAD), Common Market for Eastern and Southern Africa (COMESA), Economic Community of Central African States (ECCAS), Economic Community of West African States (ECOWAS), Intergovernmental Authority for Development (IGAD), Southern African Development Community (SADC), Union du Maghreb Arabe (UMA), and the East African Community (EAC).

[24]. Murenzi, R. and Hughes, M. 2006. "Building a Prosperous Global Knowledge Economy in Africa: Rwanda as a Case Study," *International Journal of Technology and Globalisation*, Vol. 2, Nos. 3/4, pp. 252–267.

science and technology infrastructure often appears to be an overwhelming task for national economies, especially in smaller and poorer states. Pooled on a regional scale, however, resources and expertise may be sufficient.

Cooperation in engineering can take various forms, including joint projects, information sharing, conferences, building and sharing joint laboratories, setting common standards for research and development, and exchange of expertise. Furthermore, the sheer magnitude of the necessary infrastructure development actually requires regional cooperation in project design and implementation to not only reduce costs but also facilitate greater learning.

Some African countries, such as South Africa, are already endowed with robust science and technology infrastructure, which could easily be utilized by less well-equipped countries. New regional initiatives will need to emphasize the use of science and innovation in their sustainable development strategies.

The Common Market for Eastern and Southern Africa (COMESA) illustrates the importance of regional integration in Africa's economic development and food security. The 19-member free trade area was launched in 2000 and accounts for nearly half of Africa's population. It has a combined GDP of $200 billion and is the largest and most vibrant free trade area in Africa. COMESA aims to improve economic integration and business growth by standardizing customs procedures, reducing tariffs, encouraging investments and improving infrastructure. COMESA will launch its Customs Union on December 31, 2008 and has initiated work on a Common Investment Area to facilitate cross-border and foreign direct investment.[25]

The strength of the RECs lies in their diversity. Their objectives range from cooperation among neighboring states in narrow political and economic areas to the ambitious creation of political federations. They focus on improving efficiency, expanding the regional market, bolstering security 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, or poor infrastructure. Those working on security, for example, can learn from the experiences of the Economic Community of West African States (ECOWAS), for example, a REC working on security, has considerable expertise on dealing with crises in countries such as Ivory Coast, Liberia and Sierra Leone. Nigeria has played a key role in providing regional leadership on this. Other RECs have more ambitions plans. The East African Community (EAC), for example, has developed a roadmap that includes the election of a federal president. Such institutions, though nascent, represent major innovations in Africa's economic and political governance and deserve the fullest support of the US.

**Improving economic governance**

Although Africa's economies are currently growing strongly, continuing these trends will require adjustments in the structure and functions of government to make them more entrepreneurial.[26] More fundamentally, science and innovation must be integrated at the highest possible levels in government. This change will be facilitated by creating science and innovation into policy analysis capacity in universities, scientific academies and government departments. Which in turn may have political benefits: good governance and good engineering are not so different, after all. Both involve working to achieve objectives guided by care, diligence, and data.

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[25]. Ngwenya, S. 2007. *The Common Market for Eastern and Southern Africa (COMESA).* Testimony Submitted to the House subcommittee on Africa and Global Health, House Committee on Foreign Affairs. United States House of Representative, Washington, DC.

[26]. Juma, C. 2006. *Entrepreneurship and Development: Opportunities for Private Sector Participation*. Submission to the International Development Select Committee, United Kingdom Parliament, London; Ebner, A. 2007. "Public Policy, Governance and Innovation: Entrepreneurial States in East Asian Economic Development." *International Journal of Technology and Globalisation*, Vol. 3, No. 1, pp. 103-124.

Bringing science and innovation 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. In this case these will be heads of state that will spearhead the task of shaping their economic policies around science and innovation.

So far, most African countries have failed to develop national policies that demonstrate a sense of focus to help channel emerging technologies into solving developmental problems. They still rely on generic strategies dealing with "poverty alleviation", without serious consideration of the sources of economic growth. There are signs of hope, however.

Political leaders must be kept informed about the role of science and innovation in development. Advice on science and innovation must be included routinely in policy-making.[27] An appropriate institutional framework must be created in order for this to happen. Many African cabinet structures are merely a continuation of the colonial model, structured to facilitate the control of local populations rather than to promote economic transformation.

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

Successful implementation of science and innovation policy requires civil servants with the capacity for policy analysis–capacity that most current civil servants lack. Providing civil servants with adequate technical training is necessary for wise decision-making. Training diplomats and negotiators in science and innovation also can increase their ability to discuss technological issues in international forums.

Science and innovation diplomacy has become a critical aspect of international relations. Ministries of foreign affairs are increasingly promoting international technology cooperation and forging strategic alliances. To effectively carry out this mandate, foreign ministries need to strengthen their internal capability in science and innovation. To this end, they are creating offices dealing specifically with science and innovation, working in close cooperation with other relevant ministries, industry, academia and civil society.

**Aligning higher education with human needs**

To promote Africa's development and agricultural sustainability the missions of universities and other institutions of higher learning should be aligned with countries' needs. Africa's own experiences illustrate the important role universities can play if their goals are aligned with national policies. Take the case of Rwanda. Rwanda's genocide was one of the worst human tragedies of the post–World War II period and also destroyed much its physical infrastructure and skill base. To contribute to the reconstruction of the country, Rwanda converted the premises of its military academy into a base for a new technical university, the Kigali Institute of Science and Technology (KIST). The institution, created in 1997, has played a critical role in the reconstruction of the country and stands out as a role model for other countries emerging from civil wars and economic decay.

But most of Africa's universities 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

[27]. King, D.A. 2006. "Governing Technology and Economic Growth," *International Journal of Technology and Globalisation*, Vol. 2, Nos. 3/4, pp. 311–322.

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 the locus for research, training and outreach on the management of natural resources.

Universities should work more closely with the private sector in the sustainable development activities. Promoting enterprise development, especially in the urban areas, is one of the most effective ways to stimulate economic growth. Similar efforts need to be adopted in rural areas. More specifically, institutions of higher learning and other mechanisms could serve as business incubators as well as sources of ideas and support for upgrading urban and rural economic activities.

Emphasis should be placed on bringing research, teaching and community outreach together. For example, medical schools should be more integrated into hospitals just as agricultural research stations should have a strong teaching role. Similarly, strong links between universities and the business community should be forged. This process may involve reforms in existing universities, creation of new ones or upgrading existing institutions. Equally critical would be to merge the functions of higher education and science and technology, which in many African countries fall under separate ministries.

There is a need to take stock of research and training facilities in Africa, especially those falling outside universities, and explore how they could be harnessed to supplement the contributions of existing universities. All government ministries are involved in one or another aspect of research and training and they hold the seed for populating the economic space with new species of higher learning institutions adapted to specific needs. But their growth is usually suppressed by custodians of the laws governing higher education as well as universities that fear competition from new entrants. Much of suppression of innovation in higher education is orchestrated under the guide of maintaining academic standards. Much of it is either resistance to change or political gymnastics to maintain control over moribund systems. Upgrading is the name of the new game.

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

Universities should enjoy greater autonomy so that they can adapt in a timely manner to a rapidly-changing world. One practical way of achieving all these reforms is to provide funding to support agricultural science and innovation cooperation between the US and African countries. US universities already operate on a model that Africa could benefit from, and US researchers and engineers can serve as a model for professional training. Such fund would be consistent with the growing interest to place science and innovation at the center of international development cooperation.[28]

Finally, one specific and time-critical area for policy action by the US is championing low-cost Internet services for African universities (and for African consumers in general). License agreements on the overpriced monopoly-run SAT-3 optical fiber cable that links Africa to the developed world are currently being renegotiated, and the current crippling pricing structure can be changed.[29] Investors are also currently negotiating to build another cable down the coast of East Africa. Without international leadership and action to improve the conditions, the new cable may operate in the mode of SAT-3, hobbling entrepreneurs and leaving universities isolated. Pressure is needed to ensure access for all.

Even with the highest prices in the world, African Internet usage is exploding. If prices were lowered, usage would increase significantly boosting education and economy both. No effective

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[28]. See, for example, National Research Council 2006. *The Fundamental Role of Science and Technology in International Development: An Imperative for the US Agency for International Development*. National Academies Press, Washington, DC; House of Commons Science and Technology Committee 2004. *The Use of Science in UK International Development Policy*, Vol. 1. Stationery Office Limited, London.

[29]. Over 15% of that cable is owned by United States companies, and 30% in all by non-African investors.

strategy for health, education, and development in Africa can neglect communications. Many African countries are now recognizing that communications costs and bandwidth limitations are hindering their economic growth. The US should work closely with African countries to ensure that access to the communications infrastructure, especially by educational institutions, is considered an essential infrastructure service and that this is reflected in access and pricing structures.

**Collaborating on new technology missions**

Capturing the wave of emerging technologies is an effective way to galvanize US cooperation with African countries. Indeed, the US has a long history of using its technological pre-eminence to bolster economic strength among its South East Asian allies. Efforts to promote the migration of the semi-conductor industry to South East Asian countries such as South Korea and Taiwan are an illustration of this.[30] Similarly, the Green Revolution was an act of science and innovation diplomacy.[31] Today, emerging fields of biological innovations (which include the application of living processes to economic activities in fields such as agriculture, health, industry and environment) represent new opportunities for cooperation between the US and Africa.[32]

But exploration of technology missions should not be limited to biological innovations. In addition to information and telecommunications technologies, there are extensive opportunities to collaborate in a wide range of infrastructure related fields such as energy and transportation as well as others. Biological innovations are therefore used here purely to illustrate emerging opportunities.

Cooperation in biological innovations can build on the High Level Panel on Modern Biotechnology of the African Union (AU) and the New Partnership for Africa's Development (NEPAD).[33] Its report, *Freedom to Innovate: Biotechnology in Africa's Development*, proposes a 20-year African Biotechnology Strategy with specific regional technology goals to be implemented through the RECs and to develop and harmonize national and regional regulations that promote the application and safe use of modern biotechnology. The African Ministerial Council on Science and Technology (AMCOST) has already endorsed the proposal.

The panel's main recommendations include the need for individual countries in central, eastern, western, northern and southern Africa to work together at the regional level to scale up the development of biotechnology. It focuses on the key role of clusters of expertise, sharing knowledge, creative ideas, and personnel, and working on problems and projects collaboratively.

The report also recommends the need to: (a) outline priority areas in biotechnology that are of relevance to Africa's development; (b) identify critical capabilities needed for the development and safe use of biotechnology; (c) craft appropriate regulatory measures to advance research, commercialization, trade and consumer protection; and (d) offer strategies for creating and building regional and local biotechnology initiatives in Africa.

The report pays particular attention to the role human capabilities and institutional innovation. It calls for reforms in existing knowledge-based institutions, especially universities, to serve as centers of diffusion of new biotechnologies into the economy. It stresses the need to develop and expand national

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[30]. Hung, C-Y., Hu, C-C., Hsu, C-S., Babington-Ashaye, Y., Nystrom, M. and Badino, J. 2006. "Global Industrial Migration: The Case of the Integrated Circuit Industry," *International Journal of Technology and Globalisation*, Vol. 2, Nos. 3/4, pp. 362–376.

[31]. Juma, C. 2005. "The New Age of Biodiplomacy," *Georgetown Journal of International Affairs*, Winter/Spring, Vol. 6, No. pp. 105-114.

[32]. Juma, C. 2002. "Biotechnology and International Relations: Forging New Strategic Partnerships," *International Journal of Biotechnology*, Vol. 4, Nos. 2/3, pp. 115–128.

[33]. Juma, C. and Serageldin, I., Lead Authors. 2007. *Freedom to Innovate: Biotechnology in Africa's Development, A report of the High-Level African Panel on Modern Biotechnology*. African Union and New Partnership for Africa's Development, Addis Ababa and Pretoria.

and regional human resources development strategies that include: (a) biotechnology curricula that focus on specific areas and targets that offer high economic potential for the regions and the continent; (b) a consortium of clearly identified and designated universities that develop and offer regional biotechnology training courses; (c) a focus on female recruitment in the sciences and engineering. Much of the biotechnology knowledge for Africa's development is currently available in Africa and other parts of the world. But Africa lacks appropriate institutions that can search, identify acquire and transform such knowledge in goods and services. This is a primary function of the modern African university.[34]

## CONCLUSION

Africa may not have benefited from the Green Revolution partly because its institutional arrangements were not in tune with what was possible in Africa. But changes in African governments, the explosive growth in scientific and technical knowledge, and the availability of inspirational institutional models now make, it possible for the US and Africa to forge new partnerships.

Indeed, African countries are starting to redesign their economic policies with technological considerations in mind. Much of the new thinking has been inspired by the rapid diffusion of practical applications in the information and telecommunications technologies. Mobile phones, for example, have had discernible impacts on communication. Many countries are looking for equivalents of the mobile phone for other sectors such as energy, agriculture, industry and transportation. Many of them are starting to reflect these factors in their foreign policy.

The US is in a better position than any other country to lead in forging partnerships with Africa designed to transfer skills and knowledge. Demand for higher education is exploding in Africa, and assistance by the US would be greatly welcomed. The US could serve the needs of both diplomacy and food security by providing funding for cooperation between the US and Africa in agricultural science and in education and training in general, perhaps specifically to enable US land-grant and other universities to pair with African counterparts. Working together will allow US researchers and their African counterpart to adapt today's knowledge to African conditions and will effectively transfer skills. It will also expand cooperation with other universities around the world with relevant experiences. Other avenues to champion these ideas include the next G-8 Summit to help in Japan in 2008. The Cabinet of Japan is already challenging its scientific and technological to explore how innovation can play a key role if finding solutions to Africa's problems.[35] This historical opportunity is one that the US and Africa cannot afford to miss, for the health of millions of people, for economic development, and for building a solid foundation for diplomatic relations.

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[34]. Chile with support from the US experimented with other technology prospecting approaches. However, the country is now looking into how its universities could build on the pioneering technology prospecting work of the Chile Foundation. For a historical account of the model, please see: Bell, Jr. B.W. and Juma, C. 2007. "Technology Prospecting: Lessons from the Early History of the Chile Foundation', *International Technology and Globalisation*, Vol. 3, Nos. 2/3, pp. 296–314.

[35]. Kurokawa, K. 2007. "Challenges for Japan's Scientific Community in the 2008 G8 Summit," *Business Daily*, Nairobi, June 2. http://www.bdafrica.com/index.php?option=com_content&task=view&id=1726&Itemid=5821 Accessed July 15, 2007.

## About the witness

Calestous Juma, Kenyan national, 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. He is a former Executive Secretary of the United Nations Convention on Biological Diversity, Founding Director of the African Centre for Technology Studies in Nairobi, and served as Chancellor of the University of Guyana and is currently on the board of directors of EARTH University in Costa Rica. Juma is co-chair of the African High-Level Panel on Modern Biotechnology of the African Union and the New Partnership for Africa's Development (NEPAD). He has been elected to several scientific academies including the Royal Society of London, the Royal Academy of Engineering, the US National Academy of Sciences and the Academy of Sciences for the Developing World (TWAS). He holds a PhD in science and technology policy and an honorary Doctor of Science from the University of Sussex, UK. He has won several international awards for his work on sustainable development. His recent publications include *Going for Growth: Science, Technology and Innovation in Africa* and lead author of *Innovation: Applying Knowledge in Development* and *Freedom to Innovate: Biotechnology in Africa's Development.* He is editor of the peer-reviewed *International Journal of Technology and Globalisation* and the *International Journal of Biotechnology* and contributes a weekly column on innovation in the Nairobi-based *Business Daily*. He is completing a book on resistance to new technologies.