AGRICULTURAL INNOVATION AND PROSPERITY IN AFRICA: CHALLENGES AND OPPORTUNITIES FOR HIGHER EDUCATION AND RESEARCH

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ABSTRACT
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 therefore 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 paper outlines the critical linkages between food security, agricultural development and economic growth and explains why Africa has lagged behind other countries agriculture. It argues that improving Africa's agricultural performance will require deliberate policy efforts to bring higher technical education, especially in universities, to the service of agriculture and the economy.

The current global economic crisis and the rising food prices are forcing the international community to review their outlook for human welfare and prosperity. Much of the current concern on how to foster development and prosperity in developing countries reflects the consequences of recent neglect of sustainable agriculture and infrastructure as drivers of development. Sustainable agriculture has through the ages served as the driving force behind national development. In fact, it has been a historical practice to use returns from investment in sustainable agriculture to stimulate industrial development. Restoring it to its right place in the development process will require world leaders to take a number of bold steps.

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

Science and innovation have always been the key forces behind agricultural growth in particular and economic transformation in general. More specifically, the ability to add value to agricultural produce via the application of scientific knowledge to entrepreneurial activities stands out as one of the most important lessons of economic history. Reshaping sustainable agriculture as a dynamic, innovative and rewarding sector in developing countries will require world leaders to launch new initiatives that include the following strategic elements:

Bold leadership driven by heads of state in developing countries, supported by those of developed and emerging economies, is needed to recognise the real value of sustainable agriculture in the economy of developing countries. High level leadership is essential for establishing national visions for sustainable agriculture and rural development, championing of specific missions for lifting productivity and nutritional levels with quantifiable targets, and the engagement of cross-sectoral ministries in what is a multi sector process.

Sustainable agriculture needs to be recognised as a knowledge-intensive productive sector that is mainly carried out in the informal private economy. The agricultural innovation system has to link the public and private sectors, create close interactions between government, academia, business and civil society. Reforms will need to be introduced in knowledge-based institutions to integrate research, university teaching, farmers' extension and professional training, and bringing them into direct involvement with the production and commercialization of products.

Policies have to urgently address affordable access to communication services for people to use in their everyday lives, as well as broadband Internet connectivity for centers of learning such as Universities and technical colleges. This is vital to access knowledge and which also triggers local innovations, boosting rural development beyond sustainable agriculture. It is an investment with high returns. Improving rural productivity also requires significant investments in basic infrastructure including facilities such as transportation, rural energy, and irrigation. There will be little progress without such foundational investments.

Creating entrepreneurship and facilitating private sector development has to be highest on the agenda to promote the autonomy and support needed to translate opportunity into prosperity. This has to be seen as an investment in itself, with carefully tailored incentives and risk-sharing approaches supported by government.

1.0 INTRODUCTION

Science and technology has historically been implicated as a major source of ecological degradation. This paper explores the role rapid technological innovation in fostering the sustainability transition, with specific emphasis on sustainable agriculture.[5] The paper will use illustrations from advances in information technology, biotechnology and nanotechnology. It builds on recent advances in knowledge on the origin and evolution of technological systems.[6]

Agricultural productivity, entrepreneurship, and value addition have the potential to be drivers of poverty reduction in rural-based economies. In many poor countries, however, farmers, small and medium sized enterprises, and research centres do not interact in ways that accelerate the move beyond low value added subsistence sustainable agriculture. Strengthening rural innovation systems, developing effective clusters that can add value to unprocessed raw materials, and promoting value chains across such diverse sectors as horticulture, food processing and packaging, food storage and transportation, food safety, and distribution systems and exports are all central to moving beyond subsistence sustainable agriculture, generating growth, and moving towards prosperity.

Developed and emerging economies can do much more to identify and support policies and programs that can assist developing countries to break out of poverty by taking a comprehensive approach to agricultural development. This requires rethinking the agenda in terms of innovation systems to foster interactions among government, industry, academia and civil society - all of whom are critical actors.

The paper is guided by the view that innovation is the engine of social and economic development, in both developed and developing countries. There is a particular need to get innovation onto the development agenda, into the development process, and to promote co-operation between developed and developing countries to achieve this.

2.0 SEEDING NEW GROWTH

We are entering a new age where our knowledge of global productive systems requires us to think and act in a more holistic way. Dealing with the challenges of sustainability demands greater imagination, creativity, and innovation than we thought was necessary. Once again humanity is challenged to bring its best talents to the task of renewing sustainable agriculture as a foundation for regional economic development, particularly in Africa. The prospects of building a modern sustainable agriculture that is knowledge-intensive and rewarding are real.[7] The current global economic crisis, rising food prices, and the general uncertainty over global ecological degradation generate new opportunities

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[5]. Belloc, M. *et al*. 2008. "Technology and Environment in the History of the Economic Thought," *International Journal of Global Environmental Issues*, Vol. 8, No. 4, pp. 311-334.

[6]. Arthur, W.A. 2009. *The Nature of Technology: What it is and How it Evolves,* Free Press, New York.

[7]. Juma, C. and Serageldin, I. Lead Authors. 2008. *Freedom to Innovate: Biotechnology in Africa's Development.* Report of the High-Level African Panel on Modern Biotechnology. African Union, Addis Ababa.

and imperatives to create a more adaptable sustainable agriculture in developing countries that is both more productive and more sustainable.

The good news is that the global community has over the centuries amassed considerable knowledge and experience in the field of agricultural development. We live in an age of technological abundance. Scientific and technical knowledge now accumulates at an astounding rate. In addition, our capacity to collect, store, and transmit knowledge has considerably expanded through the use of new technologies. As a result, many of the practices that had previously been a part of traditional knowledge can now be harnessed and put to the service of agricultural development. Moreover, local knowledge can now be applied globally because of advances in information and communications technologies.

The world is now one, both technologically and ecologically. We can now think globally and act globally in every locality. But to do this requires that our political leaders muster the courage needed to put sustainable agriculture in developing countries at the centre of our efforts to renew growth and promote prosperity. They must abandon the view that sustainable agriculture is a transient phase on the linear road to the post-industrial age. A focus on sustainable agriculture as the foundation for new prosperity is not a return to the past, but a new step forward in our socio-economic evolution. The demands of the new sustainable agriculture require executive leadership to align the wide range of actors needed to achieve specific economic and societal goals.

In other words, modern sustainable agriculture in developing countries can no longer thrive without the express guidance and direction of heads of state or government from both developing countries and developed or emerging economies. The success of ministries of sustainable agriculture will depend largely on the extent to which they can secure the executive support needed to implement long-term efforts to put sustainable agriculture at the centre of economic renewal and development. Ministers of sustainable agriculture around the world must take bold measures to advance their cause as a joined-up, cross-economy effort. They must harness the political urgency of the food and sustainable agriculture agenda and the political force of their sovereign leaders, working for coherent policies and action in the national, regional and global arenas.

However, it is not just ministers of sustainable agriculture who need to take bold action. Successful sustainable agriculture means that developing countries need to develop agricultural universities to train farmers, improve the quality of agricultural research and harness it to solving local problems, develop roads, ports, and fiber optic infrastructure to support rural development and access to markets, and promote entrepreneurship and a spirit of innovation. Each of these activities typically falls under the domain of a different ministry. Coordinating all of these activities requires vision and leadership on the part of developing country leaders and the developed or emerging economies who work with them. As things are now, tangible support this holistic approach is not always evident.

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 are available, only 15 reported reductions in the number undernourished

people.[8]. 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 .[9] This can be done through measures such as "investments in education, HIV/AIDS prevention and treatment, water-harvesting technologies and agricultural extension, female schooling, and clean water access."[10]

Agriculture is central to African economies, making up 30-50% of national income, employing nearly 60% of the population and generating about 40% in foreign exchange earnings. But policymakers often treat agriculture as a separate sector with little regard to its relationship with the rest of the economy.[11] 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 organisations 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 directing 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 change across the continent. 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 agribusiness development, and increasing participation in the global economy. These areas that constitute what can be called "the learning economy" should be the foundation upon which to base international development partnerships.

3.0 HARVESTING TECHNOLOGICAL OPPORTUNITIES

The most daring initiative to address hunger was the Green Revolution. This initiative enabled countries in Latin America and Asia to overcome chronic food shortages by focusing on agricultural productivity. There are two important pointers from the Green Revolution. The first was that efforts must be focused on harnessing existing scientific

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

[9]. 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.

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

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

knowledge and technological opportunities to address food security. The second was the creation of a new generation of agricultural research institutions whose focus was to adapt existing varieties to new terrains. With these research institutions came a wide range of institutional innovations in property rights, dissemination of seed, access to inputs, creation of markets and the development of new businesses.

Today, the global community has more access to scientific and technical knowledge than it did in the 1960s. Advances in fields such as information and communications technology, genetics and ecology, as well as global connectivity have put powerful agricultural tools in the hands of the global community.[12] For example, farmers around the world are now using mobile telephony to exchange market information, transfer money, and organise their operations in ways that were not possible only a few years ago.

The emergence of new digital banking standards is replacing conventional currencies and transforming rural business practices. Kenya's Safaricom Ltd, for example, was among the first companies in the world to introduce a service that enables the transfer of money through a mobile phone. The M-PESA service is available to all Safaricom subscribers even if they do not have a bank account. Its advent has transformed banking and created new employment opportunities for agents. It has also simplified money transfers to rural areas that were previously excluded from financial services and made these transactions more secure and affordable.

When officials of British mobile telephony transnational Vodafone chose Kenya as the seed bed for the study of a money transfer service they were piloting; they may not have envisaged the revolution they had just kicked off. The tests, carried out among members of a peri-urban community in Thika, were hugely successful. Buoyed by its phenomenal uptake and potential, the service's promoters could not wait to implement it on a larger scale. The rest is history.

Over two years since it was commercially launched in Kenya by Safaricom as M-PESA (Swahili for mobile money) in March 2007, this pioneering money transfer service, which is recognized as a global first, has evolved into an alternative bank for people who hitherto were disenfranchised from a decidedly elitist and dear formal financial system. Nowhere has this impact been more profound that on the country's farms, which are responsible for eight out of every 10 jobs in Kenya. Such is the importance of agriculture to Kenya that over half of the country's export earnings are directly attributable to foreign exchange from coffee, tea, tobacco, cotton, sisal, pyrethrum and cashew nuts, among others.

Thanks to M-PESA, Kenyan farmer-folk now have access to a stored value account where they can keep their money and get it on demand. Unlike conventional bank accounts which most of cannot afford, all one needs to register for M-PESA service is a Safaricom mobile line and a handset, items whose current affordability make them accessible to almost all farmers. They can also receive and withdraw payment for their

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[12]. Frame, B. and Brown, J. 2008. "Developing Post-modern Technologies for Sustainability," *Ecological Economics*, Vol. 65, pp. 225-241.

produce through the service's extensive network in rural shopping centers without having to make the normally expensive trip to the nearest town with a bank branch or Nairobi.

Rural folk working in tea farms are largely un-banked. Statistics show that only 23 per cent per cent of the Kenyan population is banked thus leaving a whopping 77 per cent with no access. Most farmers are therefore severely challenged when it comes to paying their employees on time and ordering for farm inputs such as fertilizer and machinery. M-PESA has come as a godsend to farmers allowing them to send and receive money at minimal cost. It snugly meets the needs of mobile customers who do have no bank account either by choice, have no access to a bank or do not have sufficient income to run a bank account.

Almost half of all Kenyans have access to a mobile phone as compared to 2006 where the penetration was below 22 per cent. As a result of the increase in mobile phone access farmers are now able to pay his suppliers, purchase farm products and pay wages using M-PESA. M-PESA has positively changed the lives of millions of Kenyans. The statistics tell the rest of the story. In the short time it has been around, the service has attracted over 6.7 million subscribers, overtaking the six million Kenyans who have a bank account.

Similarly, advances in genetics have made new tools available to local farmers that enable them to adapt crops to local conditions, respond to environmental stresses such as drought, and reduce the use of polluting agricultural chemicals.[13] Tools such as digitization of data are transforming property rights and making it easier for farmers to access credit. The digitisation of over 20 million land records under the Bhoomi Project in India's State of Karnataka helped to improve the availability of information on land rights and land use practices, but it also created demand for the establishment of data access kiosks. It not only has lowered the costs of accessing records, but has also become a platform for further innovation. Emboldened by the success of the project, the government of India has launched the National Land Records Modernisation Programme (NLRMP) to cover the entire nation.

Similarly, geographically-referenced information is helping to provide precise information about location and transforming agricultural logistics. Many of these technologies have been developed outside the farming sector but they now can be harnessed to facilitate agricultural innovation.

The ability of the sustainable agriculture sector to harness the power of emerging technologies will depend in part on the existence of foundational infrastructure in rural areas. Infrastructure can be defined as the facilities, structures, and associated equipment and services designed to facilitate the flow of goods, services, and ideas. Poor infrastructure is a critical barrier to accelerating economic renewal and prosperity. For example, farmers cannot acquire inputs or sell their outputs without efficient transportation facilities. But more importantly, infrastructure facilities are also the centers for the diffusion of technical skills in society.

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[13]. Brookes, G. and Barfoot, P. 2009. GM Crops: Global Socio-Economic and Environmental Impacts, 1996-2007. PG Economics Ltd., London.

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; 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.[14] 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 of transporting crops and reaching global 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: exploding rates of cellular telephone and internet usage 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. They have also hindered education, training, and the use of advances in fields such as geographical information sciences in sustainable development.

The construction and maintenance of infrastructure facilities have the potential to become "schools" where most basic technical skills that are taught in the classroom are strengthened in the form of on-the-job training. Indeed, many countries have realised this and routinely link formal technical training to the construction and maintenance of infrastructure facilities. Countries such as South Korea, Malaysia, Egypt, Ghana, and Kenya have created universities that are directly connected to the telecommunications ministries and sectors and which seek to train students in skills that are directly relevant to the telecoms sector.

The need to expand infrastructure as a foundation for sustainable agriculture and prosperity is so great that it will require concerned efforts beyond standard private sector investments. It has to be treated as a matter of urgency. Creative approaches which include the use of existing resources, including those of the military for road construction, for example, need to be used to refocus attention on expanding critical rural infrastructure.

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[14]. 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.

4.0 LEARNING TO GROW

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. Universities and other institutions of higher learning are key players in domesticating knowledge and diffusing it into the economy. But they can only accomplish that 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 be changed from being conventional sources of graduates to becoming engines of community development. In other words, they will need to become "developmental universities," working directly within the communities in which they are located.

4.1 Hobbled Minds

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. South Africa's Stellenbosch University offers a shining example of how to adjust curricula to the needs of research and development (R&D) organisations. It was the first university in the world to design and launch a 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, earth sciences, and to offer 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.

Universities should be at the centre of using new telecommunications technologies and should serve as loci for technology diffusion. In addition, the education of the students would include designing radio programs which would prepare them for participation in the emerging creative industries. 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.

4.2 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. This drop was happening at a time when overall US foreign assistance was rising in constant dollar terms. Between 1980 and 2003 total bilateral ODA increased by 69%.

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. A 63-page five-year joint strategic plan developed by the USAID in 2003 did not directly mention agriculture. 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 mean 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.

4.3 New Beginnings

Sustainable agriculture is by definition a networked activity that involves a complex web of actors forming clusters of creativity. Agricultural innovation is a product of interactions between actors from a wide range of fields including agronomy, food processing, export development, food safety, standards, metrology, and packaging. For innovation to occur, the interactions need to be open and draw on the best available knowledge. Defining sustainable agriculture as a knowledge-based activity requires a repositioning of learning institutions such as universities and research institutes. Most importantly, critical functions such as research, teaching, extension and, commercialisation need to be much more closely integrated.

The Brazilian Agricultural Research Corporation (EMBRAPA) represents a recent institutional innovation that has played a pivotal role in transforming Brazilian sustainable agriculture. This example and lessons learnt should be considered in developing knowledge systems in developing countries. Taking a regional approach is also more likely to reflect the growing interest among developing countries in promoting integrated approaches to economic development.

But such agricultural agencies will need to forge close collaboration with local universities and research institutes charged with promoting rural development. Ministries of sustainable agriculture need to work closely with agricultural enterprises and farmers to

create a new generation of universities that combine research, teaching and commercialisation or products. Some of the existing research institutes could be transformed into such universities along the lines of the emerging telecoms universities. These institutions should in turn open their doors to farmers through "open classrooms".

America's land-grant colleges have been pioneers in fostering agricultural growth by combining research, education and extension services. This model is being reinvented around the world to address analogous challenges. One of the most pioneering examples in curriculum reform is EARTH University in Costa Rica, created through a $100 million endowment provided by the US Agency for International Development and Kellogg Foundation. Its curriculum is designed to match the realities of agribusiness. The university dedicates itself to producing a new generation of agents of change who focus on creating enterprises rather than seeking jobs.

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 offer 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 marginalised 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.

4.4 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 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.

4.5 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 small and medium-sized enterprises (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.

4.6 Global Outreach

EARTH University has internationalised its operations. It signed an agreement with US-based Whole Foods Market as the sole distributor of bananas in their stores. The university sells bananas and other agricultural products to the US market. 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 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.

Elements of this approach already exist in some African universities. For example, Kenya's Jomo Kenyatta University of Agriculture and Technology - built with the support of Japan International Cooperation Agency (JICA) - works closely with farming communities. Furthermore, variants of the new model are in operation at the African Rural University for Women in Uganda and the University of Development Studies in Ghana.

These models show how to focus agricultural training as a way to improve practical farming activities. Ministries of sustainable agriculture and farming enterprises in developing countries should be encouraged to create entrepreneurial universities, polytechnics and high schools that address agricultural challenges. Such colleges could

link up with counterparts in developed or emerging economies as well as institutions providing venture capital and start to serve as incubators of rural enterprises. Establishing such colleges will require reforming the curriculum, improving pedagogy, and granting greater management autonomy. They should be guided by the curiosity, creativity, and risk-taking inclination of farmers.

5.0 SPROUTING NEW BUSINESSES

Economic change entails the transformation of knowledge into goods and services through business enterprises. In this respect, creating links between knowledge and business development is the most important challenge facing agricultural renewal in developing countries.

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.[15]

A range of government policy 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. 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 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.

One critical starting point is "knowledge prospecting" which involves identifying existing technologies and using them to create new businesses. The Chile Foundation, for example, stands out as an example of a "knowledge prospecting" agency that has played an inspirational role in economic diversification in Chile. Many regions of the developing world have so far been too isolated to benefit from the global stock of technical knowledge. Countries in these regions, particularly Africa, need to make a concerted effort to mobilize the Diaspora, which can serve as a link to existing know-how, establish links to global markets, train local workers to perform new tasks, and organize the production process to produce and market more knowledge intensive, higher value added agricultural products.

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[15]. Pragnell, M. 2006. "Agriculture, business and development', *International Journal of Technology and Globalisation*, Vol. 2, Nos. 3/4, pp. 289–299.

Advances in communications technologies and the advent of lower-cost high-speed Internet will also reduce this isolation dramatically. The laying of new fibre optic cables along the coasts of Africa and, potentially, the use of lower-latency satellite technology can significantly reduce the price of international connectivity and will enable African universities and research institutions to play new roles in rural development. The further development of Internet Exchange Points (IXPs) in those African countries where they do not exisit also has an important role to play. IXPs enable Internet traffic to be exchanged locally, rather than transversing networks located outside the continent, improving the experience of users and lowering the cost to provide service.

Much is already known on how to support business development. The available policy tools include direct financing via matching grants, taxation policies, government or public procurement policies, and rewards to recognize creativity and innovation.

For example, China's mission-oriented "Spark Programme", created to popularize modern technology in rural areas, had spread to more than 90 percent of the country's counties by 2005. The programme helped to improve the capability of young rural people by upgrading their technological skills, creating a nationwide network for distance learning and encouraging rural enterprises to become internationally competitive. The programme was sponsored by the Minister of Science and Technology.

But none of these measures will succeed in the absence of consistent and long-term policy guidance on the one hand, and autonomy of action on the part of farmers and entrepreneurs, on the other hand. The latter is particularly critical because a large part of economic growth entails experimentation and learning. None of these can take place unless farmers and associated entrepreneurs have sufficient freedom to act. In other words, development has to be viewed as an expression of human potentialities and not a product of external interventions.

As the emergence of a vertically integrated silk industry in Rwanda suggests, one motivated foreign entrepreneur and investor supported by the President can improve the financial well-being of hundreds, if not thousands of subsistence farmers without displacing them from rural areas to urban slums.

Raj Rajendran, a textile engineer and entrepreneur, was sent to Rwanda in 1999 to close down a cotton textile factory that was rendered unviable by the events during the civil war. However, he soon realised that Rwanda's volcanic soil and climatic conditions were similar to those of southern India where sericulture was a major industry. Raj also had an occasion to meet President Paul Kagame, who gave his blessing to the silk production. Raj therefore planted mulberry cuttings brought from India and received co-operation from a Korean expert from the Food and Agriculture Organisation who brought silk worm eggs from Korea. After experimentation, the worms grew into quality cocoons by eating the Rwandan mulberry leaves. Furthermore, they discovered that while cocoon production can only have 2-5 cycles in Asia, those in Rwanda could have 8–10 cycles a year due to the fertile soil and abundant rainfall.

Around that time (2003–04), the Ministry of Defense was searching for alternative employment for demobilized soldiers. Raj therefore proposed to provide employment for the ex-soldiers in sericulture. The Ministry of Defense considered this proposal and

informed the President about its viability. The President immediately tasked the Ministries of Agriculture and Defense to expand sericulture in the country by including it as a priority in Rwanda's Vision 2020.

Raj converted an old refrigerator into an incubator to hatch silk worm eggs, imported second-hand machinery from India, and started reeling Rwanda's first silk yarn. He sent Rwandans to India for training and engaged local engineers to design and produce handlooms at local vocational centers. The Ministries of Agriculture and Defense jointly promoted sericulture farms and supported training and formation of co-operatives involving the local population. As a result, the produced silk materials, tested in Bangalore and Lyon, were rated as high quality. Indian experts were then hired to train locals for product development such as ties, scarves and traditional Rwandan attires using vegetable dyes.

The silk products are now ready to be exported to the African region and possibly to the US and Canada, with their own brand name 'Silk Hills', proudly emblazoned with a 'Made in Rwanda' label. Raj's company has also become the largest private employer in Rwanda. He is working towards creating approximately 150 000 jobs in the silk industry in parallel with the Rwandan governments' program of 10 000 hectares of mulberry cultivation. Raj was also able to revive the production of cotton-based textiles using cotton grown in the region, enabling his company to supply products such as bags to Macys and Starbucks. The company has also supplied promotional products for the Obama campaign and the inauguration ceremony. Raj is now working on banana stem and pineapple leaf-based textiles to make use of the abundant resources that are being wasted in Rwanda and elsewhere. As a result of these innovative ideas and support from leaders and government, Raj's company expects revenues to eventually reach the order of USD 250 million per year through exports in the next 5 years, making the company's slogan "Weaving Dreams into Prosperity" become a reality in Rwanda.

This example also illustrates that entrepreneurs are more likely to excel if they feel that they are trusted and are given the autonomy or ownership needed to experiment and take risks. Ownership and risk taking are in fact two elements that need to be emphasised much more in the support by developed and emerging economies.

6.0 PLOUGHING NEW GROUND

6.1 Entrepreneurial Leadership in Developing Countries

It is not enough for governments simply to reduce the cost of doing business. Fostering agricultural renewal will require governments to function as active facilitators of technological learning. Government actions will need to reflect the entrepreneurial character of the farming community; they too will need to be entrepreneurial.[16] Moreover, addressing the challenge will require governments to adopt a mission-oriented approach where they set key targets and provide support to farmers to meet quantifiable targets that the farmers can assimilate to. A mission-oriented approach will require greater reliance on executive coordination of diverse departmental activities.

[16]. von Tunzelmann, N. 2003. "Historical Coevolution of Governance and Technology in the Industrial Revolutions," *Structural Change and Economic Dynamics*, Vol. 14, No. 4, pp. 365-384.

Fostering economic renewal and prosperity in developing countries will entail adjustments in the structure and functions of government. More fundamentally, issues related to agricultural innovation must be addressed in an integrated way at the highest possible levels in government. There is therefore a need to strengthen the capacity of presidential offices to integrate science, technology, and innovation in all sustainable agriculture-related aspects of government. Moreover, such offices will also need to play a greater role in fostering interactions between government, business, academia, and civil society. This task requires champions.

One of the key aspects of executive direction is the extent to which leaders are informed about the role of science and innovation in agricultural development. Systematic advice on science and innovation must be included routinely in policy-making.[17] Such advisory activities must have access to credible scientific or technical information drawing from a diversity of sources including scientific and engineering academies. In fact, the magnitude of the challenge for regions like Africa is so great that a case could be made for new academies dedicated to agricultural science, technology and innovation.

Science and technology diplomacy has become a critical aspect of international relations. Ministries of foreign affairs in developing countries have a responsibility to promote international technology cooperation and forge strategic alliances on issues related to sustainable agriculture. To effectively carry out this task, foreign ministries need to strengthen their internal capability in science and innovation.

6.2 New Roles For Developed and Emerging Economies

We have examples which show that, with the appropriate policy space, developing countries can provide creative leadership on critical challenges. For example, Malawi's dramatic achievements in food security can largely be attributed to bold executive actions. Developed and emerging economies should therefore identify and work closely with leaders of these developing countries who demonstrate such leadership. This leadership and the associated institutional innovations may be more important than large financial flows. Indeed, these are essential companions for effective scaling up of financial assistance.

Developed and emerging economies are major repositories of scientific knowledge and lessons of relevance to developing countries. Their most important contributions might lie in their ability to help create new institutional arrangements that support application of existing scientific and technological knowledge in promoting sustainable agriculture in developing countries. They would need to do so as part of new and bold institutional innovations aimed at restoring the standing of sustainable agriculture as a leading driver of economic transformation and prosperity.

Along with support in terms of developing infrastructure and the supply of communications technology, the capacities of developed and emerging economies in serving as honest brokers in linking technical knowledge to funding sources has also become one of the most urgent roles they can play in developing countries. Such brokerage must be done at a scale that can make a difference. In particular, international

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[17]. Science and Technology Committee. 2006. *Scientific Advice, Risk and Evidence Based Policy Making*. House of Commons, The Stationery Office, London.

cooperation can help create agricultural innovation systems in developing countries by supporting local efforts to: improve the quality and relevance of agricultural research; establish new agricultural universities; focus the work of agricultural universities and national and international research institutes on problems that are relevant to the needs of farmers, food processors, and value added exporters; and promote rural entrepreneurship and innovation.[18]

ACKNOWLEDGEMENTS

I am grateful to Professor Joe Lauer, President of the Crop Science Society, for his guidance in the preparation of this paper. Much of the material is drawn heavily from the results of an experts meeting on "Innovating out of Poverty" convened by the Organisation for Economic Co-operation and Development (OECD) in Paris 6-7 April, 2009. It gathered state-of-the-art knowledge on agricultural innovation systems. Nearly 20 experts from academia, government, industry, civil society and intergovernmental agencies from both developed and developing countries as well as international organisations participated in a meeting.

The meeting was guided by the view that innovation is the engine of social and economic development, in both developed and developing countries. There is a particular need to get innovation onto the development agenda, into the development process, and to promote co-operation between developed and developing countries to achieve this. The outputs of the meeting were contributed to the Horizontal Project on Food, Sustainable agriculture, and Development as well as to the OECD Strategy on Innovation and later submitted to the OECD Meeting of the Council at Ministerial level in 2009.

I am particularly grateful to Richard Carey, Kaori Miyamoto and Fred Gault (OECD Development Centre). Addition input was provide by David Angell (Ministry of Foreign Affairs, Ottawa), Hiroyuki Kubota (Japan International Development Cooperation Agency, Tokyo), Jajeev Chawla (Survey Settlements and Land Records Departments, India), David King (International Federation of Agricultural Producers), Raul Montemayor (Federation of Free Farmers, Manila), Charles Gore (United Nations Conference on Trade and Development, Geneva), Paulo Gomes (Africa Finance Corporation), Ren Wang (Consultative Group on International Agricultural Research, Washington, DC), David Birch (Consult Hyperion, London), Laurens van Veldhutzen (ETC Foundation, The Netherlands), Erika Kraemer-Mbula (Centre for Research in Innovation Management, Brighton University, UK), Khalid El_Harizi (International Fund for Agricultural Development, Rome), Adrian Ely (University of Sussex, UK), Watu Wamae (The Open University, UK), Andrew Hall (United Nations University, The Netherlands), Rajendra Ranganathan (Utexrwa, Kigali), Alfred Watkins (World Bank, Washington, DC), Eija Pehu (World Bank, Washington, DC) and Wacege Mugua (Safaricom, Ltd., Nairobi).

Finally, I am grateful to the Bill and Melinda Gates Foundation, and in particular to Gwen Young, for continuing support for my work on agricultural innovation in Africa.

[18]. Juma, C. 2005. "The New Age of Biodiplomacy," *Georgetown Journal of International Affairs,* Winter/Spring, Vol. 6, No. 1, pp. 105-114.