

## Chapter 2

# TECHNOLOGICAL LEARNING AND SUSTAINABILITY TRANSITION: THE ROLE OF INSTITUTIONS OF HIGHER LEARNING IN AFRICA

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### Introduction<sup>1</sup>

The aim of this paper is to explore the role of science, technology and innovation in sustainable development in Africa. It argues that much of the scientific and technological knowledge needed to help Africa improve its welfare while protecting the environment is available. What is needed is to create institutional mechanisms and build human resources needed to harness the knowledge and put it to effective use. In the age of international relief, donor governments worked closely with non-governmental organisations and their influence flourished. In a new era of emphasis on competence building and enhancement of human resources, higher learning institutions must play a greater role. International support should therefore go to strengthen the capacity of institutions of higher learning (referred herein for purposes of brevity as “universities”) to solve local problems. The presentation focuses on the central role that universities can make in promoting sustainable development in Africa. Placing universities at the centre of economic renewal will entail adjustments in public policy in Africa and in international aid agencies. These changes will involve long periods of learning, but the first steps must be made without delay.

### Technology and the Millennium Development Goals

At the Millennium Summit in September 2000, world leaders adopted the Millennium Declaration, which formally established the Millennium Development Goals (MDGs). Since then MDGs have become the international standard of reference for measuring and tracking improvements in the human condition in developing countries. MDGs are important because they are backed by a political mandate agreed upon by the leaders of all UN member states, offer a comprehensive and multidimensional development framework, and set clear quantifiable targets to be achieved in all countries by 2015.

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1. This paper is partially based on C. Juma (ed.), forthcoming, *Learning to Develop: Universities in Africa's Economic Renewal and Innovation: Applying Knowledge in Development*, the report of the UN Millennium Project's Task Force on Science, Technology and Innovation presented to the UN Secretary-General Kofi Annan in January 2005.

Improving the welfare of developing countries is intricately intertwined with the security of all countries, making development a truly global venture. Indeed, countries such as the United States have started to classify human development challenges prevalent in developing countries, such as HIV/AIDS, as national security issues. This is the beginning of a process that recognises the emergence of a globalised world that requires collective action to deal with issues once considered strictly national.

Experts from anywhere in the world can help apply science and technology to assist developing countries to meet MDGs. But if long-term goals are to be achieved and growth and problem solving to become indigenous and sustainable, developing countries, need to develop their own capabilities for science, technology, and innovation. Meeting this goal requires an approach that views science, technology, and innovation as a system of interconnecting capabilities, including governance, education, institutions, advice, and collaboration.

The proposed strategies are meant to complement, not replace, other approaches. For example, science, technology, and innovation play an important role in addressing the challenges associated with eliminating poverty and hunger, as the case of Southeast Asia demonstrates. They reduce poverty by contributing to economic development (by creating job opportunities and raising agricultural productivity, for example). They alleviate hunger by improving nutrition, increasing yields of cash and subsistence crops, improving soil management, and creating efficient irrigation systems. In themselves, however, these scientific and technological measures do not solve the challenges of poverty and hunger; they need to be part of an integrated strategy aimed at improving overall human welfare.

Science and technology can also play an important role in facilitating implementation of the Goals on education, gender, health, and sustainable development. The World Summit on Sustainable Development affirmed the importance of science and technology, but the scientific, engineering, and technology communities have yet to be fully integrated into a system that encourages and enables development. Very capable engineering organisations and expertise are available to address acute problems, such as natural or other disasters, but the ability to put these resources to use for long-term sustainable development in developing countries is lacking.

ICTs can increase primary, secondary, and tertiary education by facilitating distance learning, providing remote access to educational resources, and enabling other solutions. Many technologies hold the promise of significantly improving the condition of women in developing countries (by improving energy sources, agricultural technology, and access to water and sanitation, for example).

Many health interventions—including the treatment and prevention of malaria, HIV/AIDS, drug-resistant tuberculosis, and vitamin and other micronutrient deficiencies—require new treatments and vaccines. The production of generic medicines holds the promise of improving poor people's access to essential medicines. Science and technology can also improve the monitoring of drug quality.

Improved scientific knowledge at the local level will be indispensable for monitoring and managing complex ecosystems, such as watersheds, forests, and seas, and for helping to predict (and thereby manage) the impact of climate change and the loss of biodiversity. Access to water and sanitation will require continuous improvement in low-cost technologies for water delivery and treatment, drip irrigation, and sanitation.

HIV/AIDS and tuberculosis are severe problems in many African and South Asian countries, where the HIV/AIDS is exacerbating what was thought to be a relatively well-controlled tuberculosis phenomenon. Malaria also remains a serious problem, with high mortality rates in most tropical regions (and rising rates in parts of Africa). Science, technology, and innovation policy needs to be oriented toward finding vaccines and cures for these diseases, while creating new institutional frameworks from which new research collaborations can spring.

A nation's ability to solve problems and initiate and sustain economic growth depends partly on its capabilities in science, technology, and innovation. Science and technology are linked to economic growth; scientific and technical capabilities determine the ability to provide clean water, good health care, adequate infrastructure, and safe food. Development trends around the world need to be reviewed to evaluate the role that science, technology, and innovation play in economic transformation in particular and sustainable development in general.

Within just a few decades, the countries of East Asia have employed appropriate science, technology, and innovation in their economic and industrial policies to achieve extraordinary economic progress. At the same time, gains made in the former Soviet bloc, a scientific and technology giant, have been eroded, where life expectancy has declined, the public health infrastructure has decayed, and legal, financial, and political institutions are functioning poorly. Possessing competence in science, technology, and innovation is not sufficient; the proper enabling environment must be present.

Technological innovation is becoming equally critical in the management of fresh water resources. So far much of the attention on fresh water has focused on market-related issues, such as privatisation. Innovation-related responses are just starting to emerge. For example, concern over water scarcity in agriculture is generating interest in alternative approaches that reduce the amount of water used to produce a unit of grain. Attention is also now turning to the development of drought-tolerant crops using both conventional breeding methods and genetic engineering. These applications need not rely only on modern technologies.

But technological innovation can only have the desired impact if it is placed in the context of long-term development strategies, especially those associated with greater regional diversity and experimentation. In this regard, regional integration efforts across Africa represent a major step in creating space for greater application of technological innovation in the implementation of MDGs in particular and the transition toward sustainable development in general.

## **Regional integration and stability**

Promoting prosperity in Africa will require increased integration of the region into the global economy through innovation-based activities. Economic growth propelled by technological innovation can increase social cohesion, stability, and democratisation. Major conflicts in Africa arise from disputes over land, commodities, and natural resources. Diamonds fuelled conflict in Angola and Sierra Leone while oil has been at the centre of violence in Sudan and Chad. The scramble for columbite-tantalite (used in the manufacture of cell phones, jet engines, night vision goggles, fibre optics and capacitors) has helped to fuel the war in the Democratic Republic of Congo.

Opening up markets of the developed world does not automatically increase exports from Africa, unless the goods and services are competitive in price, quality and delivery. Without electric power, mineral extraction and product manufacture are not possible. Without irrigation, increased agricultural productivity is unlikely in many parts of the Africa. Without water and electric power, value-added food processing is not feasible. Without land and inland water transportation facilities together with ports and airports, export cannot be competitive in price and timely delivery and in sufficient volumes that offer economy of scale to producers and consumers alike. Modern trade and commerce presupposes that all trading parties have adequate information and communications facilities to be members of the global financial community.

In other words, African countries must have adequate national basic infrastructure services (defined to include the associated technical skills as well as research and training institutions) with necessary regional physical and electronic connectivity before they can really participate and benefit from global trade for economic growth and development.

With the requisite infrastructure services, integration into the global economy will no longer rely on export of raw materials alone. It will be replaced by knowledge-based innovations. Rudimentary production methods will be replaced by more efficient technologies that add value to Africa's natural resources. For example, mineral processing industries would be enhanced in value by knowledge workers with technical skills that pervade all economic activities.

The need for infrastructure services as prerequisite for trade and development nationally, regionally and globally has been accepted since the end of the World War II with such schemes like the Marshall Plan in Europe and institutions like the World Bank. Billions of dollars have been poured into infrastructure projects in the developing world by donors since then, however without much impact on economic growth in the recipient countries. The lessons are also well known. The majority of projects are designed, supplied and implemented by donors without much indigenous involvement.

Most of the installations were not designed to suit local needs and much of the focus has been on machinery supply rather its economic utility. There is a reawakening of the urgency of infrastructure development that is indigenous in desire, design, installation, operation, repair and maintenance. This would require indigenous technically skilled and knowledge-based human resources to realise. The role of the African universities is pivotal and urgent.

The world is increasingly deriving economic value from scientific and technical knowledge. Unlike conventional sources of wealth, knowledge is not scarce and tends to grow with greater interactions among different sections of the global society. Knowledge-based economies will not develop without conflicts of their own, but warfare based on mercantilism or land grabs will become historical anecdotes.

There are two critical starting points. First, African countries must facilitate regional technology co-operation as a basis for leveraging international partnerships. Second, international assistance to Africa should focus on modernising the region by focusing on building scientific and technological capacities.

African countries are starting to take economic integration seriously. For example, the creation of the regional economic communities could not only serve as mechanisms for creating larger markets; they could also promote peace in the region. Regional technology co-operation should be a central aspect of its implementation. Similar opportunities exist in other regional integration organisations.

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

Developing countries are increasingly entering into bilateral partnerships to develop new technologies. India and China have created a joint steering committee that will promote coordination in their technology development efforts. Such alliances provide examples that could be emulated in new technology and trade partnerships between Africa and its allies in the industrialised countries.

Africa needs similar agreements that promote the use of regional technological capabilities in international trade. But for such alliances to benefit the region, specific measures will need to be put in place to harness the world's scientific and technological knowledge for development. Universities and other institutions of higher learning are central to this process and should therefore be brought to the centre of development planning.

## Universities in development

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. The Commission for Africa has, for example, played an important role in placing the issue on the international policy agenda. The commission also pointed out that using existing knowledge for economic development will require governments and other players to focus on strengthening the role of the academic community (as well as business) in development.

Universities and other institutions of higher learning are key players in domesticating knowledge and diffusing it into the economy. But they can only do that through close linkages with the private sector. This will require major adjustments in the way that universities function in Africa (as well as the rest of the developing world). Many universities will need to be changed from being conventional sources of graduates to becoming engines of community development. They will need to become "developmental universities", working directly in the communities they are located in.

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

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

The good news is that Africa has a large number of important innovations in higher education to learn from, many of which are from the continent itself, or elsewhere in the developing world. Take, for example, curriculum development. One of the most pioneering examples in curriculum reform is EARTH University in Costa Rica, whose curriculum is designed to match the realities of agribusiness, and is dedicated to producing a new generation of young people trained specifically to focus on changing the human condition through entrepreneurial activities. In 1948, Costa Rica abolished its army and used part of the saved revenue for health and higher education. This courageous act helped the country prosper and become an economic force in Central America. Costa Rica's EARTH University has pioneered a new educational model that trains young people to create enterprises and be employers rather than employees.

EARTH University is a private, non-profit, international university founded in 1990 with support from the US International Development Agency (USAID) and the Kellogg Foundation. It seeks to contribute to the sustainable development of the tropics through agricultural education and natural resource management. The university has nearly 400 students from 20 Latin American, African and Asian countries. It is devoted to educating professionals committed to sustainable development through environmental and social awareness, an entrepreneurial spirit, and strong interest in community service. EARTH University focuses on innovation, interactive learning, critical analysis, interdisciplinary synthesis and wider dissemination of knowledge. The overall goal is community development in the tropics.<sup>2</sup> A central mission of the university is to offer education to economically disadvantaged young people. Nearly half of the students receive a full scholarship, while another 30% get partial support from the university.

EARTH University offers a four-year *Licenciatura* degree in agricultural sciences. It focuses on training leaders who will help advance sustainable development in their countries. By training “agents of change”, EARTH University has developed a unique curriculum based on experiential learning. It focuses on agriculture as a human activity, the integration of many academic disciplines, understanding the changing and globalising world, and the linkages between economic, social and environmental concerns.<sup>3</sup>

In their first year, students focus on doing practical work related to crop and animal production. This equips them with work experience and a deeper understanding of rural economies. During the next 18 months, students are required to create and run their own micro-enterprises using a USD 3 000 loan from the university. Groups of five students undertake project design, feasibility assessment, market study and business management. If the business generates a profit, two-thirds of the earnings go to the students and the remainder is paid into a fund maintained by the university to cover those enterprises that suffer losses. At the end of the study period, the enterprises are dissolved to create space for the next generation of students. During their last year, students prepare business plans, write papers or do internships.

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

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2. I would like to thank Ms. Leah Aylward, Prof. Jose Zaglul and Prof. Daniel Sherrard for the information provided here on EARTH University.

3. L. Aylward, personal communication, EARTH University, Costa Rica, 2004.

Another example of business ‘incubation’ is the University of Zambia. This was the midwife of Zamnet, the country’s largest Internet provider. Zambia’s experience demonstrates that universities have great potential for creativity and innovation, even under the most difficult financial conditions. Numerous Brazilian universities have adopted a similar approach as part of their regular mission.

Imagination and creativity are probably the key resource money cannot buy. While in the US universities incubate businesses, in Asia private enterprises are key incubators of universities. For example, South Korea’s Pohang Iron and Steel Company established the Pohang Science and Technology University (POSTECH) in 1986 to serve as a world class research and teaching institution. Today POSTECH is ranked as one of the top technical universities in Asia. Africa’s private enterprises can learn from this example, just as they can benefit from US and other models. Brazil is another rich source of lessons. For example, the Pontifical Catholic University of Rio de Janeiro produces both graduates and enterprises nurtured in the university’s Genesis Institute.

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 micro satellite as part of its training. In Uganda, Makerere University has developed new teaching approaches that allow students to solve public health problems in their communities as part of their training. Similar approaches should be adopted by students in other technical fields. For example, engineering students should spend part of their time solving local problems in fields such as infrastructure development maintenance.

Universities can also play a key role as social entrepreneurs. For example, students at Ghana’s University of Education, Winneba, tune into Radio Windy Bay to listen to lectures. The university could use radio and other tools such as “pod casting” to extend its social mission to the wider community. Universities should exploit using new telecommunications technologies and should serve as loci for diffusing knowledge in society. Education could also include designing radio programmes which would prepare the students for participation in the emerging creative industries.

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

The issue is not simply about more funding, but redefining higher education as a developmental force. This will require efforts to align university activities with development missions. This in turn will influence the location of universities.

Many African countries depend heavily on tourism to earn foreign exchange. Given this, there is a strong case for creating institutions of higher learning that are devoted to wildlife management and are located appropriately. The sustainable management of freshwater resources—such as those of Lake Victoria and Lake Chad—requires similarly dedicated institutions of higher learning.

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

Existing universities can also play an important role in promoting infrastructure development. Road and construction, for example, can benefit from local research results. Countries such as Malaysia have established a long tradition of linking road construction to the creation of civil engineering capacities at local universities. The second type of decision involves upgrading the level of academic competence at technical institutions that have already contributed to community development, while preserving their traditional role.

This, however, is only possible if existing university policies and regulations are sufficiently flexible to accommodate developmental functions. As many are not, such upgrades have often been carried out at the expense of community service. Finally, African governments are currently reviewing an increasing number of applications to set up new universities. This gives them a unique opportunity to shape the curricula, teaching and location of these institutions so that they can perform developmental tasks.

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

## Strategic considerations

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

### ***Strengthening science and technology advice***

Bringing science and technology to support decisions on development require adjustments in the functioning of government. So far over 100 countries worldwide have created commissions on sustainable development aimed at coordinating the diversity of state actors. However, executive leadership in national and local government continues to operate without adequate guidance on the role of science, technology and innovation in sustainable development.

One option to address this challenge is to establish offices of science and technology advice in executive offices dealing with sustainable development issues. Such offices could be established in the offices of presidents, prime ministers and specific ministries. Similar offices need to be established in the executive offices of local governments such as mayors and regional governors. Similar mechanisms are also needed among donors.



### ***Identifying sustainable development missions***

Focusing on specific local problems would serve as an organising framework from which to rally specific knowledge and other resources. This approach would require the clear identification of the problem to address as well as the options available for solving the problem and a choice of delivery mechanisms. An obvious starting point for most African countries is infrastructure development which will also serve as a foundation for technological innovation and accumulation of technological capabilities. Another area that could form a basis for sustainable development missions is the application of biotechnology to development, especially in the areas of human health, food security and environmental management.

For example, mayors can work with government, academia, industry and civil society to design missions aimed at improving the lives of specified slum dwellers. Universities located in such cities could play key roles as loci of expertise, incubator of businesses and overall sources of operational outreach to support private and public sector activities. Similar missions could be established in the natural and water resources fields. The missions would therefore become the organising framework for fostering institutional interactions.

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

### ***Bringing higher education to the service of sustainable development***

Addressing the sustainability challenge requires greater investment in the generation and utilisation of scientific and technical knowledge. This goal can be achieved by aligning the missions of universities and other institutions of higher learning with sustainability goals. For example, most universities in developing countries are located in urban areas, but most do not play significant roles in helping to solve local problems. Much can be gained by adjusting the curricula, pedagogy and management of urban universities to address challenges such as sanitation and improvement of the conditions of slum dwellers. Similarly, universities and research institutions located in rural areas could serve as 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 address poverty. This will require programmes designed to promote enterprise creation and development, especially among the urban poor. Similar efforts need to be adopted in rural areas. More specifically, universities and other mechanisms could serve as business incubators as well as sources of ideas and support for upgrading urban and rural economic activities.

*Policy alignment:* African countries and regional integration organisations must align their policies and government structures with the need to place science and technology at the centre of development. This will involve the appointment of science and innovation advisors to presidents to help leaders focus on the role of innovation in development in a

cost-effective manner. In Malaysia, the president of the national academy of science is also the chief scientific advisor to the prime minister.

*University infrastructure rehabilitation and development:* Government support will need to rehabilitate and develop university infrastructure, especially their information and communications facilities to help them be part of the global knowledge community and network with others around the world. Such links will also help them tap into their experts in diaspora.

*Institutional design:* Emphasise bringing research, teaching and community outreach together. For example, medical schools should be more integrated into hospitals just as agricultural research stations should have a strong teaching role. 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. There is an urgent need to take stock of the full scope of research and training facilities in the various African regions, especially those that fall outside the formal rubric of “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 therefore hold the seed for populating the economic space with new species of higher learning institutions adapted to specific needs.

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

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

## Conclusions and the way ahead

Advancing the agenda of bringing universities to bear on sustainable development will require extensive international consultations and partnerships and institutional design driven by economic imperatives. These consultations should be based on a better understanding of Africa’s intellectual resources and infrastructure as a foundation for economic growth. This knowledge would form a basis for dialogue with the industrialised countries to gain support for networks among higher education institutions and centres of excellence.

The starting point would be to agree on initial priorities based on feasibility and potential for technological learning. In light of the growing globalisation of knowledge, this process of consultation should involve right from the beginning Africans in diaspora with expertise and international connection in research, business and government. All this must be guided by a sense of urgency and determination to deliver results by learning from the experiences of other countries and by creating international partnerships.

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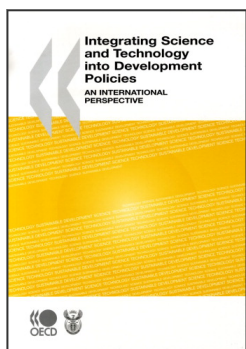
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**From:**  
**Integrating Science & Technology into  
Development Policies**  
An International Perspective

**Access the complete publication at:**  
<https://doi.org/10.1787/9789264032101-en>

**Please cite this chapter as:**

Juma, Calestous (2007), "Technological Learning and Sustainability Transition: The Role of Institutions of Higher Learning in Africa", in OECD/Department of Science and Technology, *Integrating Science & Technology into Development Policies: An International Perspective*, OECD Publishing, Paris.

DOI: <https://doi.org/10.1787/9789264032101-7-en>

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