# CAPACITY BUILDING FOR BIOTECHNOLOGY IN EASTERN AFRICA: STATUS AND NEEDS FOR PARTICIPATION IN GLOBAL BIOECONOMY

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**Abstract:** This article analyses the status of biotechnology in developing countries with a view to establish their ability to engage in the global bioeconomy. The paper focuses on four Eastern African countries. It attempts to identify the available capacities, current and future efforts in capacity building in the region as well as highlight the major limitations for their effective participation in the global bioeconomy. Approaches to the challenges facing biotechnology capacity building are also suggested.

## Introduction

Biotechnology, a modern science less than 30 years old, is revolutionalising production in both industry and agriculture. Biotechnology has the potential to provide answers to some of the most intractable development challenges including agricultural production, health, nutrition and the environment.

In 1998, in a letter to the President of the World Bank, African Governors observed that "Africa is a continent rich in natural resources but lacked the capacity to transform that potential into a standard of living that would enable the African people to become full partners in the innovation-based global economy [1]. Its share of global trade fell from 3% in the mid 1950s to 1% as of 1997[2], and estimated to be falling further [3]. Thus the continent will continue to be highly vulnerable to commodity prices and global economic developments[4]

Emerging technologies offer new prospects for better integrating the poor into the global market economy [5]. Sustaining the new bioeconomy requires adoption of a global biotechnology governance regime that helps to bring a large number of developing countries into the global trading system. The elements of such a governance system that will minimize public opposition due to presumptions on loss of traditional products market and exploitation by multinationals include development of technological capabilities, access to technology and management of risks and benefits associated with biotechnology use. However, effective participation of developing countries in the bioeconomy, will depend on the level of domestic technological capacity and the kind of global biotechnology governance system that emerges from the current policy debates.

Although biotechnology may be a powerful strategy for sustainable development in the 21st century, its potential is dependent upon effective government action to provide incentives, research and regulation. Biotechnology uses a wide range of disciplines and its safe application draws on various scientific and technical skills combined with effective policy, regulatory and institutional frameworks that can facilitate its sustainable use and safe deployment. The main prerequisite, however, is that there must be the necessary workforce, infrastructure and policy environment for biotechnology deployment[6]. Many developing countries lack both. Lack of capacity building is partly due to the inability of the governments to allocate adequate financial resources to research and development as well as overall lack of commitment to Science and Technology (S&T). This is exemplified by the low spending on S&T which is less than 0.01% of their GDP in many African countries[7]. Therefore, their capacity building needs cannot be considered in the narrow context of biosafety which only deals with risks and hazards posed by the spread of living Modified organisms (LMOs). This calls for an integrated capacity building and management strategy for biotechnology that is mutually supportive and complementary.

## 1 Biotechnology trade requirements

Market access represents the greatest hurdle to international trade and consequently to accessing technology [5]. It serves as a critical signal to the potential for benefiting from investment in technological innovation in developing countries. The two major barriers are high tariffs and standards (sanitary and phytosanitary) requirements.

The Biosafety protocol adopted in 2000 under the auspices of the Convention on Biological Diversity establishes international principles that govern the transfer, handling and use of genetically modified organisms (GMOs) with a particular focus on transboundary movement. Although the Biosafety protocol is not explicitly intended to be a trade agreement, the fact that its scope includes export and import makes it an implicit or de facto trade agreement associated with international trade in GMOs. In contrast, the World Trade Organisation, with the mandate to facilitate free trade between countries by establishing trade rules and to serve as a forum for trade negotiations and dispute settlement, deals with trade in all products including GMOs. The protocol and WTO are meant to be mutually supportive.

For the implementation of the Protocol countries have to meet a number of targets. They have to:

ensure that the development, handling, transport, use, transfer and release of LMOs are undertaken in a manner that prevents or reduces the risks to biological diver-

sity, taking into account human health (Article 2.2);

establish and maintain appropriate mechanisms, measures and strategies to regulate, manage and control risks identified in the risk assessment provisions of the Protocol associated with use, handling and trans boundary movements (Article 16.4);

endeavour to ensure that imported or nationally developed LMOs have undergone an appropriate observation before being put to use (Article 16.4);

fulfil obligations relating to the effective administration of the Protocol (Article 19 and others); and

promote and facilitate public awareness, education and participation including access to information on LMOs (Article 23).

All this requires human and financial resources, both of which need to be long- term commitments so that biotechnology products can be used routinely and safely within the framework of the Protocol. More importantly, there is a need for continuous availability of competent human resources so that as biotechnology advances, the tools for its safe use are constantly evaluated, upgraded and applied. In other words, biosafety regulations should be a dynamic management tool for biotechnology[8].

The requirement for exporters to meet product standards similar to those found in importing countries is a critical element in international trade. This requires skilled human resource, accredited laboratories for testing and certification and conducive policy environment. Many developing countries do not have sufficient facilities and personnel to conform to industrialised countries' market demands. Market access is an essential element of market liberalisation and special efforts are needed to create better trading opportunities for developing countries.

## 2 The need for Biotechnology capacity

A host of agricultural products move between countries through international trade. For products of modern biotechnology there may be regulatory compliance implications related to trade in these products depending on the products approval status or decision of the food manufacturer regarding labelling of the final product in a specific country.

As products of biotechnology have entered commerce internationally, over the past decade or so, countries have developed, or begun to develop, safety and identification requirements for new products, and in this process have reviewed the adequacy or applicability of their existing broader regimes for conventional product categories to the new products.

The successful production of GMOs and their products requires an adequate infrastructure, expertise in tissue culture and molecular biology, and a critical mass of researchers with supporting sustainable funding to cover the high cost of such research. In Africa, the only few countries that have the capacity to produce transgenics are still struggling to "commercialize" the products/ technologies to ensure that they reach the end user. Bridging this gap, requires engagement in partnerships with the private sector companies, producer organisations or government institutions which can ensure that the technology/products will be delivered to the market [9].

The biotechnology innovation chain from laboratory to commercialization through regulatory steps requires varied facilities and expertise. The need for capacity building in biosafety arises particularly when a country has an operating biotechnology sector. Capacity is then needed for everything - from ensuring safety in the research laboratory to addressing long-term environmental and food safety concerns. Unless the basic structures needed to harness this collection of powerful techniques are available, the promise may take long to come to fruition or may be lost altogether.

In several African countries, basic infrastructure and facilities even for the simplest tissue culture techniques such as micropropagation are not available. Modern communication systems, telephones, fax and access to e-mail and Internet are also lacking in large areas of Africa which seriously hampers the acquisition of relevant and necessary knowledge, and the application of plant biotechnology which is a rapidly changing and developing field. Furthermore, unreliable power supply in many African countries is a serious constraint for the efficient application of even basic tissue culture techniques. Availability of chemicals and consumables for research is often hindered as a result of poor infrastructure.

## 3 Status of biotechnology infrastructure and human resource in Eastern Africa

According to Wekundah[10] the status of biotechnology infrastructure and human resource in Eastern Africa was shown to be scanty (tables 1 and 2). The data presented included persons with working knowledge of biotechnology both at MSc and PhD levels. These data further indicate that the available capacity lacks the various experts and facilities to meaningfully engage in biotechnology research for development. The data showed the following common characteristics among the four countries involved:

inadequate numbers of trained personnel in modern biotechnology relevant areas.

few and inadequately equipped laboratories to effectively engage in biotechnology research.

minimal private sector involvement which further limits commercialization of biotechnologies and their products..

From the above highlights, a serious deficit of skilled human resources in the plant sciences and biotechnol-

Table 1. Status of Biotechnology Infrastructure in Eastern Africa

| Technology | Ethiopia | Kenya | Tanzania | Uganda | Total |
|---|---|---|---|---|---|
| Tissue culture | 1 | 17 | 5 | 6 | 29 |
| Molecular markers | 3 | 2 | 0 | 5 | 10 |
| Recombinant technology | 1 | 5 | 2 | 0 | 8 |
| Transformation | 0 | 2 | 0 | 0 | 2 |
| Biofertilisers | 1 | 2 | 0 | 1 | 4 |
| Biopesticides | 1 | 1 | 0 | 1 | 3 |
| Fermentation | 0 | 3 | 0 | 0 | 3 |
| TOTAL | 7 | 32 | 7 | 13 | 56 |

Source: J. Wekundah, 2003

Table 2: Biotechnology Human Resource Capacity in Eastern Africa

| Technology | Ethiopia | Kenya | Tanzania | Uganda | TOTAL |
|---|---|---|---|---|---|
| Tissue culture | 11 | 28 | 17 | 10 | 66 |
| Molecular markers | 3 | 2 | 0 | 13 | 18 |
| Recombinant technology | 1 | 14 | 21 | 5 | 41 |
| Transformation | 0 | 2 | 2 | 0 | 4 |
| TOTAL | 15 | 46 | 40 | 28 | 129 |

Source: J. Wekundah, 2003

ogy and infrastructure is evident in Africa. The development of human resource capacity and establishment of well equipped laboratories, is necessary to produce biotechnologies/products as well as to handle imported engineered products. Currently, the above described situation may have improved slightly with a number of actors contributing to both human and infrastructure capacity building.

### 3.1 Biotechnology capacity building efforts in Eastern African Region

Before the launch of The Eastern African Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development (BIO-EARN) Programme in 1999, efforts to harness biotechnology for development in the Eastern Africa region were largely limited to Consultative Group on International Agricultural Research (CGIAR) and International Agricultural Research Centres (IARC) institutions, international research institutes and bilateral arrangements with the north. During the last 5-6 years the biotechnology research landscape has substantially changed, not least through the launch of some major capacity building programmes, icluding, BIO-EARN programme, ASARECA's biotechnology and biosafety programme, the Rockefeller funded programmes of RUFORUM and USHPIEA and a number of bilateral programmes.

The key actors in the region involved in agricultural biotechnology research for development (R4D) and their areas of focus include:

**3.2 The Eastern African Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development (BIO-EARN):** The BIO-EARN Programme, represents a joint effort to strengthen four East African countries; Ethiopia, Kenya, Tanzania and Uganda, in meeting the challenges of modern biotechnology and realizing the potential of the associated techniques under local conditions. The Vision of BIO-EARN Programme is to develop into a Network of Excellence that will significantly contribute to improved food security, more productive agro-industries, sustainable environment management, a viable bio-resource economy and enhanced livelihoods in Eastern Africa. The Mission of BIO-EARN Programme is to promote the application of biotechnology in agriculture, industry and environmental management in order to contribute to sustainable development in Eastern Africa. The programme involves significant efforts in human and infrastructure capacity building in agricultural, industrial and environmental biotechnology.

**3.3 Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA):** Is a sub-regional organisation of 10 eastern and central African countries with an objective of promoting regional economic growth by developing, introducing and disseminating agricultural technologies that respond to the markets and to prevailing future economic opportunities for new technologies as well as maintaining the long-term sustainability of the agricultural resource base.

**3.4 The Biosciences for Eastern and Central Africa (BecA)** is a NEPAD initiative which is in the process of establishing state-of-the-art platform to support eastern and central African countries develop and apply bioscience research and expertise to produce technologies that help poor farmers secure their assets, improve their productivity and income and increase their market opportunities. It will provide a focal point for the African scientific community to support the activities of national, regional, and international agencies as they address agriculturally related problems of the highest priority for alleviating poverty and promoting development.

**3.5 CGIAR Centers and IARCs** These are collaborating with NARS institutions in developing different biotechnologies. A number of collaborative biotechnology research are ongoing on several crop and animal sectors.

**3.6 Programme for Biosafety Systems (PBS):** The USAID funded PBS assists countries to enhance biosafety policy, research and capacity. The programme focuses on assisting national governments in studying the policies and procedures necessary to evaluate and manage the potential harmful effects of modern biotechnology on environment and human health.

**3.7 Private Sector:** This a new emerging sector. There are a few private sector institutions such as the Genetics Technology Limited (GTL) and African Harvest in Kenya and Agrogenetic Laboratories Ltd in Uganda. This small but active emerging sector focuses among other things on commercialization of the technologies including promotion of mass propagation and dissemination of tissue culture planting materials.

**3.8 Industrial and environmental biotechnology**: In this area, in addition to capacity building efforts by the BIO-EARN programme, there are a number of initiatives focusing on mitigation of environmental pollution resulting from municipal and industrial effluents. They include the Lake Victoria Environmental Management Project (LVEMP), the Sida funded VICRES initiative focusing on wetlands and land use, ASARECA with research on water quality monitoring, the Water Research Fund for South Africa (WARFSA) supporting research related to water use and conservation technologies, and the UN-HABITAT funded "Sustainable Cities Initiative" which supports capacity building in manpower for waste management.

**3.9 Biopolicy**: In the field of biotechnology policy, the key actors include African Agricultural Transfer Foundation (AATF), whose focus is to facilitate access to patent technologies. The Agricultural Biotechnology Support Program (ABSP II) which facilitates access to GM technologies; and the Programme for Bio-safety Systems (PBS) which is supporting activities for biosafety implementation, biosafety research and public awareness. There are also a number of projects like United Nations Environment Programme – Global Environment Facility (NEP/GEF) which has been supporting the development and implementation of national biosafety frameworks.

**3.10 Public awareness and information dissemination**: Non-Governmental Organisations (NGOs) such as Biotechnology Trust Africa (BTA), African Centre for Technology Services (ACTS), International Service for the Acquisition and Application of Agbiotech (ISAAA) and African Biotechnology Stakeholders Forum (ABSF) are engaged in advocacy, public awareness activities and acquisition of technologies.

**3.11 Biosafety capacity building**: In addition to efforts by BIO-EARN and UNEP-GEF to develop biosafety capacities in the region, other key actors include the Programme for Biosafety Systems (PBS) that focuses on enhancing biosafety policy, research and capacity in partner countries; and the Bio-safe Train project, which builds capacity in risk assessment of transgenics.

From the above highlights of other stakeholders involved in biotechnology in the region, it is clear that although the biotechnology landscape has changed since BIO-EARN Programme inception, most of the actors hardly address the issues of capacity building.

## 4 BIO-EARN Programme contributions and impact on the biotechnology capacity building in the region

Over the past 5-6 years, BIO-EARN Programme equipped 14 laboratories in the region and graduated 20 PhDs in biotechnology related fields (**Table 3**) and 6 MSc students in biosafety. With laboratory capacities improved to handle biotechnology research and availability of human resource, three network institutions (Makerere, Nairobi and Dar es Salaam universities) have introduce courses in biotechnology, bioinformatics and molecular biology at Bachelors, Masters and PhD levels. This is hoped to have a significant multiplier effect in biotechnology capacity building in the region. Fifteen network institutions were assisted to install infrastructure for information and communication technology. This has enhanced access to and communication not only to partners in the region but also a wider world community.

In addition to PhD training, several short courses in biopolicy and biosafety were conducted in collaboration with advanced institutions to build capacity in the region and prepare the region to effectively engage in biotechnology for national and regional development. Since 1999 over 55 individuals from institutions in the region have been trained in biopolicy and 130 trained in biosafety respectively. This capacity has played a key role in their respective countries in shaping and guiding biotechnology policy development processes. In addition, they are involved

Table 3. Biotechnology human resource capacity built under BIO-EARN Programme.

| Thematic area | Ethiopia | Kenya | Tanzania | Uganda | TOTAL |
|---|---|---|---|---|---|
| Agricultural biotechnology | 3 | 2 | 2 | 4 | **11** |
| Environmental biotechnology | 1 | 0 | 1 | 1 | **3** |
| Industrial biotechnology | 0 | 2 | 1 | 0 | **3** |
| Biosafety | 1 | 1 | 1 | 0 | **3** |
| TOTAL | **5** | **5** | **5** | **5** | **20** |

in management and implementation of the various biotechnology organisations activities in the region. The BIO-EARN alumni are actively involved in regional and continental biotechnology programmes and projects highlighting increased levels of collaboration efforts to address development challenges. Furthermore, four of the BIO-EARN alumni secured funding for projects indicating improved capacities to proposal and scientific writing.

In an effort to create an enabling policy environment, the programme conducted public awareness creation through national and regional seminars which addressed issues relating to biopolicy, biosafety, technology transfer, intellectual property and public-private partnerships. These efforts resulted in establishment of intellectual property and technology transfer offices in some network institutions.

Similar human and infrastructure capacity building efforts are recognized through the Rockefeller Foundation funded programmes and bilateral cooperation agreements. These efforts therefore have slightly improved the 2003 situation, though a critical mass of human resource and infrastructure is yet to be achieved.

In the next four years (2006-2009) the BIO-EARN Programme hopes to graduate another 8 PhDs and 20 MSc students in various biotechnology thematic areas. These efforts together with those from other regional players, together with improved policy environment are expected to boost the regions capacity to fully engage in biotechnology product development and commercialization.

## 5 Capacity building gaps

According to the NEPAD high-level panel on biotechnology[11], capacity building gaps for effective engagement and full exploitation of biotechnology opportunities in order of their importance among others include:

- *Building a critical mass of technological expertise*: adequate laboratory capacity and high quality personnel with necessary skills are needed to exploit bioeconomy effectively.
- Establishing accredited testing and certification facilities.
- *Organizational coherance*: need to rationalise and harmonise national and regional policies and their implementation.
- *Communication strategy*: Massive bottom-up and audience-and–language friendly communication and training methods and modules need to be developed.
- *Intellectual property rights*: build capacity in IPR issues and institutionalisation of IP.
- *Public participation and awareness*: effective means of public communication to raise levels of awareness and build public confidence.

*Regulatory issues*: need for harmonisation and information sharing to minimise duplication and reduce costs.

## 6 The Challenges

***Personnel retention***: Another serious constraint is the loss of skilled personnel who have received training in developed countries and have added to the brain drain. In Africa, where working opportunities exist, employment terms are often unattractive due to low salaries and working conditions. Due to limited financial support from local governments, few public Research and Development (R&D) institutions are able to plan for the future and strategically employ key staff with the necessary skills. Furthermore, training gained abroad is often not attuned to local needs because of the different research and infrastructural environments in many African countries. As a result the demands and opportunities present in the home country are often not met or remain unanswered. This is further exacerbated by attrition due to HIV/AIDS.

***6.1 Budgetary support by national governments***: Up to now there has been minimal input by countries in the development of the R&D sector including the biotechnology industry. The emergence of the industry has been mainly supported by various development partners. However, this support is dwindling and sustainability of the industry is in question, especially in the absence of national policies on biotechnology and biosafety. This calls for national governments to support this sector if is to effectively contribute to national development.

***6.2 Lack of conducive policy environment***: In Africa, most countries either lack, or are in the process of developing policy frameworks and institutional arrangements to deal with the challenges of biotechnology. Development and implementation of appropriate policies and legal frameworks remains a hindrance for biotechnology development.

## 7 Addressing the challenges: How should countries address these challenges to meet international standards and quality?

The following are proposed to address some of the above mentioned challenges:

- Encouraging/Facilitating bottom-up tailor-made human resource development programmes at various levels for handling, transport, processing, packaging and sale of commodities. Rapid advances in knowledge pose a formidable challenge for developing countries'

capacity to update their technological stock.

- Establish capacity building projects aimed at developing a critical mass of experts at all levels through organised long-term theoretical and practical training at both formal and informal levels rather than short term workshop/seminars. Countries need to retain capacity more effectively channelling capacity to local needs and opportunities. This calls for visionary policies in decision-making and infrastructure development. Therefore, all biotechnology capacity building strategies should be integrated with the overall R&D framework so that national, regional and international actions are mutually supportive and complementary.

- Have a continuing system of administration to ensure global standards in production, manufacture, and trade in biotechnology commodities and to meet complex domestic and international regulations. The increasing demand to ensure global standards requires a skills administrative and technical skills and dynamic management systems.

- Set-up notified state-of-the-art testing and certification facilities. Certifying and testing facilities are expensive to set up and require skilled human resource designed to the needs of the volume of food trade, the facilities should be established in a cost effective manner. However, research priorities of countries in the region are similar giving hope for development of regional alliances [9]. This would allow countries with limited resources (financial and human, and facilities) benefit from regional alliances by sharing information, human resources and facilities. Therefore, regional and sub-regional testing facilities and their networking is a worthwhile proposition.

Develop effective negotiating strategies. They are needed for technology transfer (including IP management issues) and for creating favourable conditions for trade and sustainable development[8]. Thus a broad based multi-stakeholder approach to capacity building with effective information dissemination that promotes communication in all aspects of risk and benefits of biotechnology could be a step in that direction. This may however, require review and restructuring of existing institutional mechanisms through proper coordination and consultation among the concerned departments within the governments.

In order to effectively participate in the bioeconomy developing countries need to develop a biotechnology sector. This means countries taking steps to upgrade technological infrastructures, enhance human expertise and set up regulatory frameworks. This involves huge investment and countries may be required to enter into complex public-private partnerships and develop the legal, institutional and executive acumen that is necessary to foster biotechnological innovation and its application.

In addition, developing countries need to retain human capacity and open ways of channelling capacity to local level by focusing on interesting and challenging work, working environment and compensation. This calls for visionary policies in decision-making and infrastructure development. Therefore, all capacity building strategies have to be integrated with the overall management of biotechnology so that they are mutually supportive and complementary. The countries also need effective negotiating strategies for technology transfer and for creating favourable conditions for trade and sustainable development. Thus, a broad based multi-stakeholder approach to capacity building with effective information dissemination that promotes communication in all aspects of risk and benefits of biotechnology could be a step in that direction.

## Conclusion:

World trade norms are in transition due to ongoing negotiations at WTO. Capacity building in isolation would not be cost effective. Successful implementation of both domestic and international regulations can be achieved through integration, coordination and cooperation among all stakeholders. Even though the biotech industry in many developing countries is facing tremendous challenges in developing novel products from indigenous research and technology, the biotech industry is picking up. A modest investment in biotechnology capacity building and support to bioindustry offers excellent business development opportunities for Eastern African countries in their efforts to add value, make use of and further develop its natural resource base. The proportion of biotech crops grown in developing countries has consistently increased every year. In 2005, more than one third of the global biotech crop area, equivalent to 33.9 million hectares was grown in developing countries. The percentage growth was almost five times as high (23%) in developing countries of the south, compared to that of industrialised countries of the north (5%)[12]. As was the case with information technology, the biotech industry in developing countries is expected to continue to grow in the next couple of years. However, biotechnology is a hardware-intensive sector requiring highly skilled scientists along with strategic infrastructure investment that cannot be readily accommodated by developing countries budgets. Furthermore, there is always a long incubation period before returns on the heavy investment can be realized and success requires innovative ideas and strong desire to use biotechnology for the development of the region.

To ensure that biotechnology is applied safely across a wide range of sectors, capacity building has to take place on an equally broad level encompassing scientific, technological, organizational and institutional aspects to facilitate development and safe deployment of biotechnology.

For the growth of biotechnology industry, conditions that support the creation of knowledge network are innovative ideas, availability of high quality skills, strong public support and perception of opportunities. Emerging biotechnology companies focused on developing a new generation products will play an important role in the shap-

ing the structure of the future bioindustry. With the changed economic scenario and the TRIPS-compliant patent regime, developing countries biotech companies would be required to compete with multinational biotech companies in R&D, innovation and patenting and products affordability.

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