



**Fostering a bio-economy
in eastern Africa:
Insights from Bio-Innovate**

Fostering a bio-economy in eastern Africa: Insights from Bio-Innovate

Editors

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Acronyms

AATF	African Agricultural Technology Foundation
ABI	African Bioscience Initiative
ASEAN	Association of Southeast Asian Nations
AU	African Union
BecA	Bioscience eastern and central Africa
BGA	Blue-green algae
BIC	Biotechnology innovation centre
BIL	Banana Investments Ltd
BIO-EARN	The Eastern Africa Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development
Bio-Innovate	Bio-resources Innovations Network for Eastern Africa Development
Biotechnology YES	Biotechnology Young Entrepreneurs Scheme
BIPCEA	Bioscience Innovation Policy Consortium for Eastern Africa
BIRAC	Biotechnology Industry Research Assistance Council
CAADP	Comprehensive Africa Agriculture Development Program
CEO	Chief executive officer

CSIR	Council for Scientific and Industrial Research
Danida	Danish International Development Agency
DST	Department of Science and Technology
DTI	Departments of Trade and Industry
ETP	Effluent treatment plant
EU	European Union
ILRI	International Livestock Research Institute
IP	Intellectual property
ISAAA	International Service for the Acquisition of Agribiotech Applications
KALRO	Kenya Agricultural and Livestock Research Organization
KBBE	Knowledge-based bio-economy
KEPHIS	Kenya Plant Health and Inspection Service
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental organization
NSI	National system of innovation
OECD	Organisation for Economic Co-operation and Development
R&D	Research and development
S&T	Science and technology
SDG	Sustainable Development Goal
SEARCH	Southern and Eastern African Regulatory Committee on Harmonization
Sida	Swedish International Development and Cooperation Agency
SME	Small and medium enterprise

SSA	Sub-Saharan Africa
STI	Science, technology and innovation
STISA	Science Technology and Innovation Strategy for Africa
TCBN	Tissue Culture Business Network
TIA	Technology Innovation Agency
UK	United Kingdom
US	United States (of America)
WEMA	Water Efficient Maize for Africa

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Bio-Innovate Africa

Bio-Resources Innovations Network
for Eastern Africa Development

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Chapter 2

‘Africa Rising’ to a sustainable future: Economic prospects of bio-economy development in eastern Africa

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Introduction

Sub-Saharan Africa (SSA) faces both long-standing and new challenges as countries embrace the post-2015 development agenda laid down in the United Nations SDGs. Longer-term strategic questions on how SSA countries could build a solid foundation for sustainable and inclusive economic growth, and respond to emerging issues such as climate change, are critical. This will require African governments and development partners to consider long-term development goals for SSA, which ensure food security, improve livelihoods by diversifying economies and increase the competitiveness of African exports in regional and global trade over the next two decades.

The growing global demand for food, feed and bio-based renewable materials, such as biofuels, is changing the conditions for bio-resource production worldwide. At the same time, modern biosciences are providing an increasingly powerful innovation engine at a global scale, for sustainable agricultural production, waste treatment, energy production and development of a diverse range of novel bio-products. The revolutionary advances in biosciences provide an increasingly powerful engine for innovations, which has led to the concept of a ‘bio-economy’.

The bio-economy concept posits that scientific research and knowledge can be applied to biological resources and agricultural systems not only to produce food and feed, but also to an increasingly-wide range of agro-industrial and value-added products with potential

applications in many sectors, including pharmaceuticals, chemicals, materials and energy. Some have called this phenomenon a 'knowledge-based bio-economy' (KBBE), i.e. the art and science of transforming biological resources into new, sustainable, eco-efficient and value-added products. In essence, it is the coming together of biology, chemistry, material sciences, genomics and information technology to better utilize natural resources in agriculture and industry. The development of a KBBE is important for many reasons, including: (i) development of resource-efficient and productive agricultural systems able to adapt to climate change, (ii) decreased dependence on fossil fuel energy thereby decreasing emission of greenhouse gases, (iii) the possibility to revitalize rural communities, increasing the production base and the opportunities for local value addition, and (iv) increased possibilities to recycle energy and material flows for mitigation of environmental degradation.

Today, more than ever, the global bio-economy is the subject of focused attention from policymakers, corporate decision-makers, researchers in the social and biological sciences and the general public. With both short- and long-term shifts in the world's demand and supply of agricultural and industrial products, there is growing attention to the actual and potential role of bio-based innovations as a means of developing a resource-efficient and productive economy. A key question for the countries in eastern Africa is how to best use science, technology and innovation to foster growth of a bio-economy able to meet the development challenges of the region.

The KBBE: Economic development prospects

The potential of biosciences and the KBBE has been recognized by many OECD countries, including the United States (US) and the United Kingdom (UK). In the European Union (EU), the KBBE is now a central element in the European Commission's science and innovation policy and research programs, acknowledging that the European bio-economy has an approximate market size of over 2 trillion euro, employing more than 22 million people (European Commission 2012). Germany, as a leading country in the biosciences, established a Bioeconomy Council in 2009, which guides the country's National Research Strategy–Bioeconomy 2030.

Most of the existing experiences of, and studies into, the science and implementation of the KBBE, however, cover economies with a strong science base, relatively large home markets and with explicit government policies fostering the bio-economy, such as Germany. This raises the question of whether the concept of the KBBE is relevant to eastern Africa, which, though rich in natural resources, is largely characterized by a nascent but relatively small science base and small-scale agro-industry. In addition, government policies and support programs to promote and guide capacity development and bioscience investments are generally lacking or lacking implementation.

A study by Henry and Trigo (2010), however, clearly points to evidence that the KBBE concept and bio-based industries present opportunities for local production at small and medium scales and prospects for rural development and income generation. Examples used by the authors include:

- Low-cost biofuel production using local biomass: In Colombia, ethanol prepared from cassava by a pilot plant has the capacity to produce an average of 300 litres of hydrated ethanol per day. The pilot plant uses inedible, high-starch cassava varieties, ensuring there is no direct trade-off between fuel and food. The stems of sugarcane, sorghum and sweet potato or banana waste, can also be used. Cassava biofuel can power vehicles and generate electricity, which is often a lifeline for rural communities lacking access to electricity in the national grid. Waste products from biofuel production can also be used as fertilizers and animal feed.
- In Nigeria, cassava is processed on-farm by mobile processing units that are constructed in containers for flexible use in regions with a high concentration of cassava production. Such units process the cassava into an intermediate product thereby significantly reducing perishability, leaving by-products on the farm, reducing transport costs to the factory and increasing farmers' bargaining power with starch factories.
- Across Latin America, advances in biosciences are driving initiatives toward bioprospecting—targeting local biodiversity—to capture its full potential by means of economic and technological interventions. This has resulted in the identification of additional promising candidates for biofuel production (e.g. *Jatropha* and castor bean) and the generation of new high-value products for cosmetic, pharmaceutical and industrial purposes (e.g. the use of guarana in soft drinks).

Henry and Trigo note that although the relevance to small-scale actors and farmers is evident, their role as suppliers of basic raw material needs to evolve by introducing pre-processing steps and hence adding value and increasing economic returns at local level. Their conclusions are in line with a similar analysis from Asia, presented by Teng in Chapter 3 of this book.

Economic prospects for Africa

Considering the overall statistics, eastern African countries take active part in the 'Africa Rising' phenomenon—a label used to describe the past decade of relatively rapid economic growth. For example although average GDP growth in SSA was 3% in 2015, some eastern African countries e.g. Rwanda, Tanzania and Ethiopia registered growth rates exceeding 6.0% (World Bank 2016). Africa's share of global trade has also steadily increased, from USD 277 billion or 2.3% in 2001, to approximately USD 1 trillion or 4.6% in 2011. Consumer spending is increasing in tandem with an expanding middle class. Foreign direct investment has tripled over the past decade (Munang and Mgendi 2015). However, these impressive figures can mask the fact that around half the population in SSA still lives in extreme poverty (on less than

USD 1.25 per day) with limited access to basic requirements such as adequate food, clean water, primary healthcare, education and energy. The overriding challenge to governments is to harness current overall economic growth and encourage more equitable and inclusive development pathways. With its abundance of natural resources, fresh water sources, arable land and labour, it is obvious that agricultural productivity, agribusiness and environmental management will be key to sustained growth and a better future. This vision is reflected in current economic development policies in eastern Africa, which can be summarized as follows (Table 2):

Table 2. Key economic indicators and policy objectives for selected countries in eastern Africa

Country	Ethiopia	Kenya	Tanzania	Uganda
Economic indicators and development policy objectives				
<i>GDP^a</i>	9.6%	5.6%	7.1%	5.0%
<i>Share of agriculture sector in GDP, 2013^b</i>	42.3%	29.5%	33.8%	27.0%
<i>Economic development policy (year)</i>	Growth and Transformation Plan (2010–2015)	(i) Kenya Vision 2030 (2007) (ii) Second Medium-Term Plan 2013-2017	(i) National Development Vision (2000) (ii) Tanzania Five-Year Development Plan 2012–2016	(i) Uganda Vision 2040 (ii) Second National Development Plan 2015/16–2019/20
<i>Policy vision</i>	Achieve Millennium Development Goals and propel Ethiopia into middle income country status by 2025	(i) A globally competitive and prosperous nation with a high quality of life by 2030 (ii) To maintain sustained economic growth of 10% p.a. over the next 25 years	By 2025, Tanzania will have transformed into a middle-income country, characterized by high-quality livelihood; peace, stability and unity; good governance; a well-educated and learning society; a competitive economy capable of producing sustainable growth and shared benefits; and a diversified semi-industrialized economy with a substantial industrial sector	Attain middle-income status by 2020. This will be realized through strengthening the country's competitiveness for sustainable wealth creation, employment and inclusive growth

<i>Strategic objectives, relevant to the bio-economy</i>	(i) Maintain agriculture as a major source of economic growth	(i) Increase value to agricultural production through processing	(i) Transform the economy from a predominantly agricultural one with low productivity to a diversified and semi-industrialized economy with a modern rural sector and high productivity in agricultural production	(i) Improve agricultural markets and value addition for 12 prioritized commodities
	Shift to production of high value crops	(ii) Increase smallholder specialization in the cash crop sector		Promote private sector investment in value addition
	Scale up best practices of model smallholder farmers	(iii) New cultivation of up to 1.2 million hectares of newly-opened lands	(ii) Dynamic industrialization program focused on local resource-based industries (agro-industries)	Build the capacity of farmers, traders and processors in quality standards and market requirements
	Intensify use and management of water and natural resources			- Promote investment in storage infrastructures to reduce post-harvest losses
	Encourage large-scale extensive commercial farming			(ii) Increase the sustainable use of environment and natural resources
	(ii) Create conditions for the industry to play a key role in the economy			
	Expand cotton, sugar and leather industry			
Raise productivity of agro-processing and beverage industry				

Notes: ^a Figures for 2015 as reported by the World Bank

^b Definition covers agriculture, forestry, fishing and hunting

Sources:

World Bank report (2016)

Republic of Uganda (2015)

Federal Democratic Republic of Ethiopia (2010)

Government of the Republic of Kenya (2007)

United Republic of Tanzania (2000)

Accelerated growth of value addition in agriculture and food production will be key to attaining these ambitious development objectives, as will be the associated challenges of managing and utilizing agro-industrial waste from expanding economic activity. Ethiopia's Growth and Transformation Plan recognizes that if the current high economic performance is to be sustained, there must be a doubling of agricultural value added during the current planning period. Clearly, the KBBE must be a critical element in African economic development policies.

However, while the economic potential and opportunities are evident, few countries in SSA have actually developed and adopted bio-economy policies and strategies. The exception is South Africa (see Chapter 4), where the government adopted a Bio-economy Strategy (DST 2013) to build on the achievements under its predecessor, the National Biotechnology Strategy. However, it is acknowledged that biotechnology is not the only element in a bio-economy strategy. Developing the bio-economy would require a broader range of competencies, including information and communications technology, nanomaterials research and manufacture, entrepreneurship, the social sciences and intellectual property management (DST 2013). The Bio-economy Strategy emphasizes South Africa's comparative advantage in terms of its unique biological diversity and wealth of indigenous knowledge. These assets provide economic opportunities, including raw materials for the natural product sector; bioprospecting for the development of pharmaceutical, cosmetic or industrial applications from plant, animal and microbial compounds; and the use of indigenous plants and animals as food sources. Of the three sectors—agriculture, health, industry/environment—identified as crucial elements of South Africa's bio-economy, it is noted that the agricultural industry has the highest economic impact. The strategy identifies a number of R&D interventions in this field that will help ensure food security, improve nutrition and create jobs in agriculture and in research. It is acknowledged that these interventions should be driven by strategic need as well as market demand, and will require strong private sector involvement. They include, for example (DST 2013):

- Crop/livestock improvement for biotic and physical stresses associated with climate change.
- Agro-processing initiatives to reduce post-harvest losses, extend shelf life and improve the quality and safety of foods.
- Development and adoption of low-cost, low-maintenance energy crops, such as sweet-stem sorghum and sugar beet.

Realizing the potential in eastern Africa

Eastern African countries have a similar comparative advantage to South Africa in terms of biological resources and indigenous knowledge. The potential has been documented several times, for example, in the final impact report covering the BIO-EARN (The Eastern Africa

Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development) Program, which ran from 1998–2008 (SIDA 2011). The report presents a wide range of bioscience innovations under development and diffusion in eastern Africa, and points to potential and actual economic and social impacts in the following areas:

- a) *Increased crop productivity and effective value chains:* Improved sorghum lines, selected for tolerance to drought and other abiotic stresses, increased yields by around 25% compared to the local base variety in Kenya. In Kenya and Uganda, local breweries showed strong interest in locally-produced sorghum as a substitute for imported barley. Locally-sourced sorghum on average is 10% cheaper compared to barley, and may constitute up to 40% of the primary ingredients in beer brewing. In Uganda, for example, local sorghum beer is gaining ground and bringing farmers into an agribusiness value chain. The benefits from this process should not be underestimated and include, among other things, that an assured income and access to credit allows farmers to send their children to school, buy more land and oxen for ploughing, eat better, afford improved health care, and employ other people to help them with planting (Nile Breweries 2005).
- b) *Environmental gains and adding value to bio-waste:* Biogas technologies, supported as part of BIO-EARN and Bio-Innovate to enhance production from fish processing and sisal waste, contribute to agro-industrial waste management and reduce the need for firewood—a major cause of deforestation—and imported fuel. These technologies were adopted in Tanzania, among other countries, by agribusiness companies like Katani Limited. At Katani, biogas is produced with waste derived from sisal production. The stored biogas is then used to run two 150kW electricity generators, which are used mainly within the plant while some of the excess is supplied to the national grid. Excess biogas can also be distributed to surrounding communities for cooking and lighting. On a smaller, household and/or farm scale, the current and potential benefits of biogas production are demonstrated under Kenya's National Domestic Biogas Programme, as implemented by the Kenya National Farmers' Federation with international donor support.
- c) *Human health benefits:* Constructed wetlands technology for the treatment of slaughterhouse and tannery effluents has been tested at the pilot scale in several BIO-EARN partner countries, and further refined and scaled up with support from Bio-Innovate. Treatment of wastewater results in much-reduced exposure to chemicals, heavy metals and pathogens. In Tanzania, the innovation has been successfully diffused for wastewater treatment in schools, colleges, municipalities and prisons for on-site wastewater treatment. It was demonstrated that the technology leads to significant cost reductions in treating common diseases such as diarrhoea.

Based on the solid foundation established under BIO-EARN and other regional programs, projects supported by Bio-Innovate aim at further capitalizing on the actual application of bioscience innovations in eastern Africa, and fostering private sector business development particularly in the agricultural and environmental sectors. In a number of cases this has

resulted in successful public-private partnerships, at pilot scale and commercial scale. Examples can be found in Chapter 5 in this book.

Major factors that are currently driving progress in bioscience innovations can be found in: (i) the expanded science base for innovation and (ii) increased business interest to invest in bioscience enterprise.

Expanded bioscience base

Clearly, science, technology and innovation (STI) form a critical driver of the bio-economy. They lay the groundwork for the transition from primary production and the current use of renewable resources to more diverse opportunities for food production, industrial processes and products, and also for biofuels. Aggregate statistics on Africa's capacity in STI still show a very inconsistent pattern—which is probably due to the fact that reliable data is scant and data collection often incomplete. The African Innovation Outlook (2014) by NEPAD reports that major issues of concern are that R&D intensity remains very low in many countries; there is inadequate information about the role of the business sector; and R&D expenditure may be under-reported in many participating countries.

However, the above general findings from NEPAD aside, there are an increasing number of examples showing expanded STI capacity in specific clusters in eastern Africa particularly in the biosciences field. These include:

- At the regional level, the AU-NEPAD, through ABI, set out to establish regional centres of excellence in modern bioscience in the early 2000s. The Bioscience eastern and central Africa-International Livestock Research Institute (BecA-ILRI) Hub in Nairobi, Kenya, is one such centre. BecA provides a central bioscience research platform, research-related services and capacity building and training opportunities. It serves 18 countries in eastern and central Africa. With financial support from Canada, BecA's laboratory facilities were established in 2003, giving scientists from the region access to state-of-the-art equipment and laboratory facilities. The BecA Hub in Nairobi has, over the last decade, evolved to become a focal point for international and regional collaboration in plant and animal biosciences (Kelemu 2014).
- At the national level, as described by Sengooba and Komen (2011), a relevant case is presented by Uganda, which is illustrative of other countries in eastern Africa. In Uganda, an internationally-supported, integrated program for technology transfer and capacity development in agricultural biotechnology and associated policy development has been implemented over the last decade. This is spearheaded by national research and policymaking organizations and financially supported by the government of Uganda and multilateral and bilateral donor agencies. Uganda is now regarded as a regional hub for agricultural biotechnology innovations and is connected with a range of international

projects and programs aimed at developing relevant agricultural innovations. This includes, among others, the development of genetically modified cassava with virus resistance, nutritionally-enhanced and disease-resistant banana, and drought-tolerant maize.

Increased business interest

Advances in bioscience R&D and applications have spurred interest for private sector investment in bioscience innovations. This is evident from case studies presented in Chapter 5 in this book. Additional examples include:

- Early successes in applying tissue culture techniques in cut flower production across eastern Africa stimulated their application in food crops such as banana. A Tissue Culture Business Network (TCBN), supported by Agro-Technologies Ltd (Uganda), currently operates in east and central Africa to facilitate the transfer of banana tissue culture to smallholder farmers, and to develop a tissue culture certification system. TCBN has enabled more than 200 farmers to have access to banana plantlets free from pests and diseases, which may increase their production from the current 5 tonne/ha to potential production of 60 tonne/ha (ASARECA 2013).
- Also driven by the cut flower industry, and intensive horticulture production, the application of bio-pesticides is expanding in Kenya. The country has around 26 registered companies with bio-pesticide products on the local market (Kimani 2014). This growth is expected to continue with increasingly stringent regulations for synthetic pesticide residue levels in high-value horticultural exports.
- An interesting model to actively involve the private sector in bioscience innovations is presented by the Water Efficient Maize for Africa (WEMA) project managed by the African Agricultural Technology Foundation (AATF). AATF has partnered with private sector technology providers to develop drought-tolerant maize hybrids. These hybrids are, in turn, sub-licensed to local seed companies in eastern Africa which take responsibility for seed production, certification and marketing. Initial plantings of WEMA's hybrid seeds in Kenya resulted in substantially higher maize production compared with other local commercial seed varieties. Among 39 sites initially surveyed by AATF, there was an average harvest of 4.5 tonne/ha, more than double the national average of 1.8 tonne/ha in Kenya (AATF 2014).

In summary, modern biosciences are key to transforming eastern African economies, particularly in the agro-processing sector, in such a way that they effectively add value to primary production. Biosciences can also be used to convert waste to valuable products in an environmentally friendly manner. A more effective and environmentally friendly, resource efficient agro-processing sector will be a central component in improving agricultural productivity, creating new jobs and raising profitability for farmers and agribusinesses in the region.

Concluding remarks

Internationally, the community of states undertook an obligation at the United Nations sustainable development conference, in Rio de Janeiro in June 2012, to implement the 'green economy' as an important instrument in sustainable development. The bio-economy would be a central element in this. While the international policy debate on the green economy, the bio-economy, and concepts such as the KBBE are attracting attention from policymakers across Africa, there is still a long way to go for eastern African economies. The viewpoints and actual cases presented in the preceding sections point to the urgent need to fully capture the benefits from the KBBE in eastern Africa. While the critical role of science-led rural and economic development is emphasized in all government development plans, these are often not matched with active government support programs or enabling policies to attract private sector investment. Recommended policy actions will be dealt with elsewhere in this book, which will serve as an agenda for change over the coming decades.

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Bio-resource Innovations Network for Eastern Africa Development Program (Bio-Innovate)

is an initiative that supports and promotes bioscience research and innovation activities in eastern Africa through the creation of effective partnerships along the bio-innovation value chain. The goal of Bio-Innovate is to catalyse the translation of bioscience research outputs into scalable and impactful bioinnovations. Bio-Innovate works in Burundi, Ethiopia, Kenya, Rwanda, Tanzania and Uganda.

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