



THE STATE OF THE BIOECONOMY IN EASTERN AFRICA: 2022



ABOUT THIS REPORT

The partner institutions in the development of this status report were:

- **The Stockholm Environment Institute (SEI).** SEI is an international non-profit research and policy organization that tackles environment and development challenges connecting science and decision-making to develop solutions for a sustainable future for all (<https://www.sei.org/>).
- **The East African Science and Technology Commission (EASTECO),** Kigali, Rwanda. EASTECO is mandated to promote and coordinate the development, management and application of science and technology in the Partner States for enhanced socioeconomic development and regional integration (<https://easteco.org/>).
- **The International Centre of Insect Physiology and Ecology/BioInnovate Africa Programme.** BioInnovate Africa is a regional science and innovation-driven initiative stimulating a bioeconomy in Eastern Africa. The initiative is supported by the Swedish International Development Cooperation Agency (Sida), and implemented by the International Centre of Insect Physiology and Ecology (*icipe*) (<https://bioinnovate-africa.org/>).

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FOREWORD



The promotion of a bioeconomy is high on the agenda for many East African Community (EAC) countries and globally, as a major strategic driver for the transformation of biobased sectors for sustainable economic growth and development. A central feature of the bioeconomy is that scientific research, knowledge and innovation can be applied not only for the production of food, feed, fibre and fuel but also to produce a wide range of agro-industrial and value-added products. Another critical element of the bioeconomy is to build value around local bioresources, maximising and using all parts of primary produce and their products.

Today, more than 65% of the population in Eastern Africa depends on biological resources for food, energy, medicine, and other uses. They frequently use these biological resources in their raw form and dispose of significant portions as biological waste. There is therefore huge potential to add value to these biological resources through the development of a bioeconomy.

Bioeconomy growth offers an opportunity for countries in Eastern Africa to achieve many of the Sustainable Development Goals by 2030, making use of the region's abundant natural resources to produce value added products, thereby creating jobs, improving health and food security, generating wealth, and connecting smallholder farmers to new biobased value chains. Additionally, the creation of new forms of sustainable bioenergy, and the conversion of waste materials to useful products, will play an important role in protecting the environment and combating climate change.

Countries in the region share many of the same bioresources; have similar agro-ecological conditions and agro- and bio-industrial platforms. There is a positive current trend for harmonisation of policies and strategies in the region under the East African Community (EAC), a number of which are relevant to the bioeconomy. Central to bioeconomy development in the region is the newly developed East African Community Bioeconomy Strategy. The overall mission of the strategy is to catalyse and support innovative and sustainable use of bioresources as the major driver of inclusive economic growth and job creation in East Africa.

Policy makers in Eastern Africa – as is the case elsewhere in Africa – are, in the face of rapid population growth, confronted with the urgent need to generate economic growth, create new jobs, provide opportunities for youth and women, and increase agricultural productivity. At the same time there is the pressing need to protect the environment and ecosystem services and ensure resilience in the face of emerging threats such as climate change and diseases. Long-term economic prospects for the region are also tied to the ability to increase trade in the domestic, regional, and global realms.

The development of a modern bioeconomy in Eastern Africa has significant potential to support several critical development goals and targets for the region, and will help deliver the following outcomes: sustainable industrialisation, job creation and green growth; improved food security; improved health; the creation of new biobased products; linking farmers and bio entrepreneurs to local, national, regional and international markets opportunities; creating new forms of clean sustainable modern bioenergy; and protecting the environment through converting waste, which today threatens ecosystems and freshwater resources, to useful products.

Underpinning this potential for Bioeconomy in the region is the need to bolster scientific knowledge, and innovation capacity through among others strengthening the research, policy and business linkages. I therefore welcome the “*State of the Bioeconomy in Eastern Africa: 2022*” Report which provides the latest scientific evidence of the status of bioeconomy in the region.

Hon. (Dr). Peter Mutuku Mathuki

Secretary General

The East African Community

EXECUTIVE SUMMARY

Introduction

The promotion of a bioeconomy is high on the agenda for many countries globally, as a major strategic driver for the transformation of biobased sectors for sustainable economic growth and development. A central feature of the bioeconomy is that scientific research, knowledge and innovation can be applied not only for the production of food, feed, fibre and fuel but also to produce a wide range of agro-industrial and value-added products. Another critical element of the bioeconomy is to build value around local bioresources, maximising and using all parts of primary produce and their products.

Today, more than 65% of the population in Eastern Africa depends on biological resources for food, energy, medicine, and other uses. They frequently use these biological resources in their raw form and dispose of significant portions as biological waste. There is therefore huge potential to add value to these biological resources through the development of a bioeconomy.

Bioeconomy growth offers an opportunity for countries in Eastern Africa to achieve many of the Sustainable Development Goals by 2030, making use of the region's abundant natural resources to produce value added products, thereby creating jobs, improving health and food security, generating wealth, and connecting smallholder farmers to new biobased value chains. Additionally, the creation of new forms of sustainable bioenergy, and the conversion of waste materials to useful products, will play an important role in protecting the environment and combating climate change.

The regional policy context

Countries in the region share many of the same bioresources; have similar agro-ecological conditions and agro- and bio-industrial platforms. There is a positive current trend towards harmonisation of policies and strategies in the region under the East African Community (EAC), a number of which are relevant to the bioeconomy. Central to bioeconomy development in the region is the newly developed East African Community Bioeconomy Strategy launched in November 2021 and approved by the EAC Council of Ministers in April 2022. The overall mission of the strategy is to catalyse and support innovative and sustainable use of bioresources as the major driver of inclusive economic growth and job creation in East Africa.

Availability and use of bioresources in the region

Bioresource availability

Eastern Africa is rich in land that produces the bioresources of the region, with an agricultural area of over 151 Million Hectares (MHa), and a forest area of 78 MHa, comprising two thirds of the total land mass. However, agricultural productivity is low. There are large areas of potentially productive land that are under-utilised but could be harnessed to contribute to the bioeconomy. There are also extensive aquatic resources, comprised of more than 12 MHa of inland waters, and a coastline of over 2000 km.

There is a large resource of under-utilised biomass residues from food crops, horticulture, industrial crops, livestock and fisheries; key crops in the region generate around 130 million tonnes of agricultural residues per year of which around 30-60 million tonnes is currently not utilised. In addition, forestry activities produce large amounts of residues including over 116,000 cubic metres of sawdust.

Existing biomass value chains in the region

The primary value chains that exist are derived from cash crops including sugar cane, coffee, tea, sisal, and the breweries. Non-food crops such as oil crops, cotton and forest products undergo some limited processing. Even though these value chains are well established, there are many opportunities to produce additional valuable byproducts, and to make use of processing waste that contributes to environmental pollution. The transformation of these industries into “biorefineries” that provide multiple product and revenue streams will be integral to the development of bioeconomies in the region.

Emerging opportunities for value addition

There are significant opportunities for increased value addition to crops such as cassava, sorghum, groundnuts and coconuts. Potential products include health and wellness products, pharmaceuticals, flours, oils, dyes and many others. From the aquatic environment, there are opportunities for value addition to fish and seaweed. Animal hides and chicken feathers also have potential for a range of industrial applications. From the perspective of agricultural production, there are opportunities for biocontrol of pests and diseases. The region also has an opportunity to pursue development of novel, resource-efficient protein production systems such as food and feed products from insects, algae, Spirulina (a type of cyanobacteria), molluscs, etc.

Health and wellbeing products

The pharmaceutical market size of the region is at least US\$ 4 billion annually with a large volume spent on essential medicines, particularly antibiotics, anti-malarials, anthelmintics, disinfectants, analgesics and anti-retroviral medicines. The region currently imports 70-90% of its medicines, with supply chains vulnerable to disruption. A wide range of medicinal plants are already used in the region to treat both human and animal diseases. There are opportunities to stimulate and regulate, with appropriate testing and safety assessment, the use of these plants and their active ingredients.

There is also increasing demand for consumer products such as cosmetics, well-being products such as vitamins and antioxidants, and cosmeceuticals (beauty products that contain beneficial active ingredients). The region has the potential to add value to bioresources such as shea butter, gum arabic, coconut oil, Aloe vera products, and neem tree products in order to move further up in the cosmetic industry value chain.

Biobased and biodegradable packaging and construction material

Bans on plastic packaging in the region are resulting in renewed emphasis on development of packaging and construction materials from renewable resources. Efforts are already under way to produce biodegradable packaging such as fibre board. Bio-composites based on bamboo or sawdust have potential as building material, in furniture construction etc. Several companies producing bamboo products exist in the region.

Sustainable bioenergy

Biomass briquettes and pellets made from agricultural residues are increasingly popular in the region, but there is considerable potential to upscale their production. There is also a nascent industry for biodigesters for the production of biogas from organic waste. Rapidly emerging novel conversion technologies for forest and agroprocessing residues provide a great opportunity for future development of biofuels in the region.

Bioeconomy development at country level

To date, none of the countries in the region have a dedicated bioeconomy policy or strategy, and the concept of bioeconomy is generally not broadly understood. Nevertheless, the majority of countries have strategic initiatives to stimulate economic development, mainly focussed on bio-based resources. All countries in the region have untapped bio-waste materials from the agro-processing sector (sugar, breweries, coffee, tanneries and abattoirs, food processing etc.) that could be used as building blocks for expanded utilisation of bioprocesses and the growth of agro-industries. However, the dominance of the informal sector in countries in the region, and a shortage of investment funds, hamper the development and growth of significant bioprocessing initiatives. Nevertheless, some countries have initiatives in place, such as Ethiopia’s establishment of integrated agro-industrial parks, while Tanzania has funded several innovation hubs focused on bioeconomy development, and Uganda plans to establish a Biosciences Science and Technology Park. Kenya has a growing number of companies engaged in value addition to agricultural resources. Rwanda has initiatives to increase production of biobased fuels and energy.

Creating an enabling environment

Improving agricultural productivity

The Eastern Africa region has the lowest agricultural productivity in the world and a range of efforts is needed to address this fundamental challenge to the low productivity. This includes the development of more functional formal seed and agroinput systems enabling farmers to have access to improved seeds and agro-inputs. Increased efforts to support access to mechanical equipment for small scale farmers are also needed to support productivity growth. Additionally, improved access to extension and advisory services is critical; the use of digital tools can play a role here. Access to markets can be streamlined, cutting out some of the middlemen. Transport infrastructure is particularly important for agricultural produce to reach the markets. Access to microfinance for small scale farmers can be promoted through the use of digital technologies.

Skills development for small and medium enterprises (SMEs)

Building skills in the SME sector, both technological and managerial, is key for success. This requires better linkages between academia and industry, the development of entrepreneurial skills, and support to the creation of public-private partnerships. Bioincubation facilities can provide support that is largely missing in the region.

Improved access to finance and venture capital

Several international investment funds are now offering early stage investment support, but there is a dearth of local capital investment. The cost and complexity of doing business is high; entrepreneurs often lack an understanding of venture capital and fall short in terms of effective operations and governance; these factors hamper the growth of venture capital funds.

Enabling conditions for export

The development of enabling conditions for small scale farmers, processors and bioentrepreneurs to meet quality and regulatory requirements to access markets in developed countries is crucial for the region. Generally, only large firms have the resources to comply with food safety standards, while smaller traders and SMEs navigate around the regulatory system which is poorly enforced in the region. The Africa Free Trade Agreement may open up new market opportunities for trade.

Harmonised and supportive policies and regulations

There are intentions to harmonise legislation within the East African Community, but an ongoing challenge is to ensure that the various policies, strategies and guidelines developed at the EAC level become embedded in legislation at the national level. Harmonised regulations are needed to support the deployment of a wide variety of biobased products. There is currently no harmonisation between intellectual property (IP) laws in the region. The lack of a unified framework causes delays and lack of follow-up on IP enforcement within and across borders.

Way forward

A number of key actions recommended at national and regional level are:

- Develop national bioeconomy strategies
- Monitor and share information on bioeconomy development
- Develop a regional expert Bioeconomy Committee
- Harmonise standards and regulations for biobased products
- Improve the bio-business environment and bio-business incubation
- Attract venture capital and other investment finance
- Support networking and clustering amongst bio-entrepreneurs
- Invest in human capacity building, innovation infrastructure and centres of excellence



1.0

BIOECONOMY DEVELOPMENT – AN OPPORTUNITY FOR EASTERN AFRICA

Policy makers in Eastern Africa – as is the case elsewhere in Africa – are, in the face of rapid population growth, confronted with the urgent need to generate economic growth, create new jobs, provide opportunities for youth and women, and increase agricultural productivity. At the same time there is the pressing need to protect the environment and ecosystem services and ensure resilience in the face of emerging threats such as climate change and diseases. Long-term economic prospects for the region are also tied to the ability to increase trade in the domestic, regional, and global realms.

The promotion of a bioeconomy is highly placed on the political and business agenda for many countries globally, as a major strategic driver for the transformation of biobased sectors for sustainable economic growth and development. A central feature of the bioeconomy is that scientific research, knowledge and innovation can be applied not only for the production of food, feed, fibre and fuel but also to produce a wide range of agro-industrial and value-added products. Another critical element of the bioeconomy is to build value around local bioresources, maximising and using all parts of primary produce and their products.

Today, more than 65% of the population in Eastern Africa depends on biological resources for food, energy, medicine, and other uses. They frequently use these biological resources in their raw form and dispose of significant portions as biological waste. There is therefore huge potential to add value to these biological resources through the development of a bioeconomy.

Bioeconomy growth offers an opportunity for countries in Eastern Africa to achieve many of the Sustainable Development Goals by 2030, making use of the region's abundant natural resources, including under-utilised agricultural waste materials, to produce value added products with applications in many sectors including food, health, energy and industrial goods, thereby creating jobs, generating wealth, and connecting smallholder farmers to new biobased value chains.

The development of a modern bioeconomy in Eastern Africa has significant potential to support several critical development goals and targets for the region, and will help deliver the following outcomes:



Sustainable industrialisation, job creation and green growth, revitalising bioprocessing and biomass value chains in the region, and promoting circular economy production systems with reduced emissions, through productive and efficient use of biowaste.



Improved food security through enhanced value chains and processing, promoting a more secure and resilient food supply while contributing to sustainable, healthy, affordable and nutritious food for the growing population in the region.



Improved health, using the biodiversity in the region to develop cost effective biobased production systems for various biopharmaceutical products that address specific health challenges in the region (HIV, malaria and non-communicable diseases etc).



The creation of new biobased products, including biomaterials for construction, bio-inputs for agriculture, enzymes for industry, and biobased feedstocks (e.g. biofertilisers, bio-packaging) to substitute products derived from petrochemicals and to satisfy growing demands from consumers (e.g. functional foods, special dietary needs, novel health and well-being products).



Linking farmers and bioentrepreneurs to local, national, regional and international market opportunities. New biobased value-added products that are attractive on a world market can assist the private sector in Eastern Africa to expand and improve its global competitiveness and stimulate sustainable economic growth.



Creating new forms of clean sustainable modern bioenergy, such as biofuels, for transportation and electricity generation from biowaste and industrial by-products, mitigating climate change and massive use of woodfuel that leads to deforestation.



Protecting the environment through converting waste, which today threatens ecosystems and freshwater resources, to useful products.



A beneficiary of a biogas project demonstrates its use in a traditional house. Use of clean energy protects communities from air pollution and thus promotes health living. Photo: Lawrence Nzuve/SEI

2.0

BRIEF OVERVIEW OF INTERNATIONAL BIOECONOMY DEVELOPMENTS

2.1 DRIVERS OF THE GLOBAL BIOECONOMY

Throughout history, the global economy has essentially been an economy based on natural resources, frequently leading to resource depletion and ecosystem degradation. With the industrial revolution, and the intensive use of fossil oil, coal and gas, the world entered into a period of tremendous economic growth but also large income gaps and serious ecological and environmental problems, climate impacts and unsustainable use of biological resources. The basis for modern bioeconomies is a sustainable and optimal use of biological renewable resources. The development of modern bioeconomies is therefore increasingly seen as a tool for creating sustainable economic growth based on renewable resources that can support a transition away from the fossil fuel era.

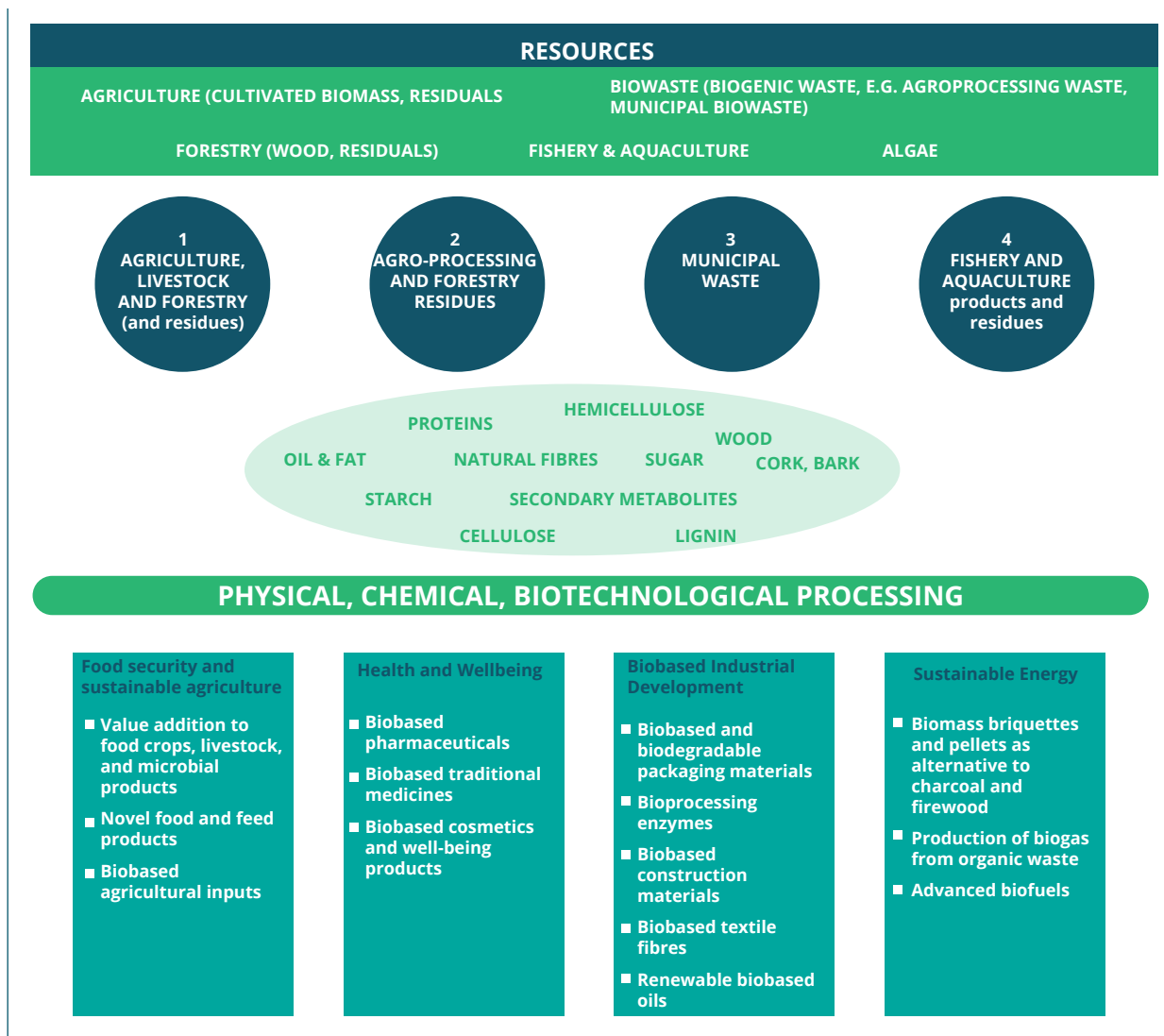
The development of bioeconomies provides a framework for how to address the UN2030 Agenda and the SDGs in an intersectoral and regional manner, including poverty alleviation (SDG1), improved food security and nutrition (SDG2 and 3), good health and wellbeing (SDG3), inclusive and sustainable economic growth (SDG8), affordable energy for all (SDG11), combatting climate change and its impacts (SDG13) and functional ecosystems, clean environment and maintained biodiversity (SDG15). At the same time, bioeconomy will also help to fulfill the Agenda 2063 goals to “boost Africa’s economic growth and development and lead to the rapid transformation of the continent”.

A central feature of bioeconomy is that scientific research, knowledge and innovation can be applied not only for the production of food, fuels, feed and fibre, but also for production of a wide range of agro-industrial and value added products. Modern biology allows for the development of a diverse range of novel bioproducts with new functionalities and with potential applications in many areas, e.g. pharmaceuticals, chemical and energy sectors. The new frontiers in biosciences are not only revolutionising medicines and health treatments, but also the ability to develop more productive and resource-efficient agricultural systems, with improved tolerance to pests, diseases and climate change. Industrial biotechnology and modern bioprocessing can greatly assist the transformation of inefficient and polluting biobased industries into modern biorefineries producing a large array of renewable bioproducts with close to zero emissions. Metabolic engineering can provide novel designs of biological production systems and biological manufacturing, sometimes referred to as the “biologisation“ of industrial value creation. All this combined constitutes a powerful driver of the bioeconomy creating a new production and value chain landscape in which the utilisation of the bioresources and biomass feedstock is more flexible than ever.

Bioeconomy can contribute in several ways to the circular economy, including the utilisation of organic side and waste streams from agriculture, forestry, fishery, food and feed and organic processes. Biodegradable products can be returned to the organic and nutrient cycle. Paper, other wood products, natural fibres, textiles and many more materials can be successfully recycled into value added products. Indeed, there is huge potential to convert biowaste from agro- and bio-processing industries and human consumption, often causing environmental problems, into useful products such as energy, biofertilisers, feed, green chemicals, etc.

The societal pursuit of *clean energy, energy independence and security* and reduced greenhouse gas emissions is also a key driver of modern bioeconomies, where renewable resources can replace petroleum, coal and gas. The bioeconomy can therefore play a fundamental role in the development of a low carbon economy by reducing greenhouse gas (GHG) emissions fulfilling the commitments in the Paris Agreement and decoupling GHG emissions from biobased economic growth.

Figure 1 - Potential range of bio-products (source BIOPRO Baden-Württemberg GmbH)



Another key element of the bioeconomy is to build value around local bioresources, maximising and using all parts of primary produce and the products thereof. In this context, modern biorefineries will play a central role. Biorefineries are dedicated facilities that convert primary produce from renewable biomass into food and feed, biofuels, chemicals and biobased materials such as bioplastics. The objective of a biorefinery is to develop as many product and value streams as possible from biomass. Transporting biomass long distances is usually costly and therefore, it should ideally be processed close to the site where it is harvested or acquired. The development of modern bioeconomies is therefore seen as a tool to revitalize rural communities, diversifying agriculture, supporting job creation and increasing the biomass production base and the opportunities for local value addition and bioprocessing.

While the transition towards modern bioeconomies is often associated with increased sustainability, there is a controversy in scientific and public forums on whether or not such a transition will necessarily lead to a better, more sustainable future. A number of conditions need to be in place, including appropriate innovation infrastructures, policies and governance to achieve sustainable bioeconomies, necessitating an inter-disciplinary approach and carefully laid out strategies and policies. It is clear that a bioeconomy is not a silver bullet solution to food security, increased agricultural productivity and improved health and cannot be considered as something self-evidently sustainable. Instead, it needs to be designed, planned, regulated and supported in such a way that it effectively functions as a driver of efficiency and sustainability in the production, development, use and reuse of bioresources. Governments around the world are now therefore developing their bioeconomy strategies and policy agendas to realise the benefits from the development of modern sustainable bioeconomies.

2.2 GLOBAL BIOECONOMY STRATEGIES

The promotion of a bioeconomy is highly placed on the political and business agenda for many countries globally, as a major strategic driver for the transformation of biobased sectors for sustainable economic growth and development. Consequently, a number of countries and regions in the world have developed bioeconomy strategies (Table 1).

Table 1 Development of national strategies globally

Region/country	Dedicated bioeconomy strategies, policies
Africa	
EAC	The EAC Bioeconomy Strategy (2022)
South Africa	The Bio-Economy Strategy (2013)
Europe	
European Union	A sustainable Bioeconomy for Europe: Strengthening the Connection between Economy, Society and the Environment (2018)
Austria	Bioeconomy. A Strategy for Austria (2019)
Czech Republic	Bioeconomy concept in the Czech Republic from the perspective of the Ministry of Agriculture 2019–2024 (2019)
Denmark	Strategy for a Green Circular Economy (2018)
Finland	The Finnish Bioeconomy Strategy (2014)
France	Grand Est Regional Plan for the Bioeconomy (2019)
Germany	National Bioeconomy Strategy (2020)
Latvia	Latvian Bioeconomy Strategy 2030 (LI-BRA) (2017)
Netherlands	The Position of the Bioeconomy in the Netherlands (2018)
Norway	The Government Bioeconomy Strategy (2019)
United Kingdom	Growing the Bioeconomy: A National Bioeconomy Strategy to 2030 (2018)
North, South and Central America	
United States	The Bioeconomy Blueprint (2012)
Canada	Canada's Bioeconomy Strategy: Leveraging our Strengths for a Sustainable Future (2019)
Argentina	Bioeconomy Argentina (2017)
Brazil	Action Plan on STI and Bioeconomy (2018)
Costa Rica	National Bioeconomy strategy, Costa Rica (2020)
Ecuador	Guidelines for the Promotion of Bioentrepreneurship (2019)
Colombia	Colombia Green Growth Roadmap (2018)
Asia/Pacific	
Australia	(Regional) Queensland Biofutures 10-Year-Roadmap and Action Plan (2016)
Japan	Bio Strategy Japan, 2019
Thailand	BioCircular Green Economy (BCG) in Action: The new Sustainable Growth Engine (2019) and Measures for the Development of BioIndustry in Thailand 2018–2027 (2018)
Malaysia	Bioeconomy Transformation Programme (BTP) (2012)

Source. International Advisory Council on Global Bioeconomy, Global Bioeconomy Policy Report (IV): A decade of bioeconomy policy development around the world (2020)¹

¹https://gbs2020.net/wp-content/uploads/2021/04/GBS-2020_Global-Bioeconomy-Policy-Report_IV_web-2.pdf



3.0

BIOECONOMY IN THE REGIONAL CONTEXT OF EASTERN AFRICA

A biogas plant at Archers Post area at the boundary of Samburu and Isiolo in Kenya. Use of animal waste for biogas fuel conserves trees and provides clean energy. Photo: Lawrence Nzuve/SEI

3.1 THE REGIONAL POLICY CONTEXT

Countries in the region share many of the same bioresources, have the similar types of agro-ecological conditions and agro- and bio-industrial platforms. There is a positive current trend for harmonisation of policies and strategies in the region under the East African Community (EAC), which can facilitate a regional approach to bioeconomy development. Transformative regional integration, collaboration and concerted action in the region can support countries to move towards modern sustainable bioeconomies. Collaboration is possible in many areas including:

- ◇ Aligning and harmonising policies and strategies promoting innovation and trade
- ◇ Harmonisation of regulations and standards for biobased products, facilitating trade and economies of scale
- ◇ Collaborative capacity building in key areas of the Bioeconomy, through building regional competence platforms and knowledge sharing mechanisms
- ◇ Jointly increasing the attractiveness of the region for investments, both from within the region and from foreign investors in biobased industrial development

A number of policies and strategies that support the development of an Eastern African bioeconomy have been developed at the regional (EAC) level. Among these are the recently developed EAC Science Technology and Innovation (STI) and the Intellectual Property (IP) policies. *The East African Regional STI Policy* aims to create an enabling environment for increased investment in Science, Technology and Innovation, as well as their application to support sustainable regional development and socioeconomic transformation. *The EAC Regional Policy for Intellectual Property* aims to encourage technical innovation, and to promote the industrial and commercial use of technical inventions and innovations so as to contribute to the social, economic, industrial and technological development of the Community. These two policies, that are due to be approved by the Council of Ministers (COM), will support bioeconomy development through promoting development and use of technology and innovation as well as development of human capacity to fully embrace and utilise the new green opportunities. All EAC Partner States and Ethiopia have also signed and ratified the Paris Agreement on Climate Change. The EAC has developed a roadmap to implement the key resolution of the Paris Agreement including implementation of the Nationally Determined Contributions (NDCs) and translation of the Paris Agreement into concrete steps for the Partner States². The EAC also has a Climate Finance Mobilization and Access Strategy covering multiple sectors³. In addition, under the African Bioenergy Framework and Policy Guidelines, in 2018 the EAC started the development of Regional Bioenergy Development Strategy and Investment Plans.

3.2 THE EAC REGIONAL BIOECONOMY STRATEGY

The most important action in a policy context and in terms of supporting the Bioeconomy development in the region is the East African Community Bioeconomy Strategy which was developed and approved by the 17th Sectoral Council of Education, Science and Technology, Culture and Sports that was held on 19th -23rd April 2022 in Dar es Salaam, United Republic of Tanzania.

The drafting process of the Regional Bioeconomy Strategy for East Africa started in 2018 through a project called “Developing an Innovation-Led Bioeconomy Strategy for Eastern Africa” (BiSEA). The BiSEA project has been led by the East African Science and Technology Commission (EASTECO) and supported by the BioInnovate Africa Programme (www.bioinnovateafrica.org). The drafting process for the Bioeconomy Strategy has been a transparent and broadly consultative process with a view to include a variety of perspectives and to reflect different contextual realities in the countries in the region. The directions, advice, input and guidance to the drafting process came from a broad set of stakeholders at the national level and through a number of regional consultations.

This Regional Bioeconomy Strategy provides a compelling framework for putting in place agreed goals and interventions which countries in East Africa can use to develop a vibrant, inclusive and innovative bioeconomy contributing to sustainable economic growth and development in East Africa. Moreover, the strategy is aligned with expressed commitments to environmental sustainability, climate change adaptation and mitigation, reversing or changing unsustainable practices. The overall mission of the strategy is to catalyse and support innovative and sustainable use

²EAC Webpage. Available at <https://www.eac.int/press-releases/620-1086-387-eac-develops-road-map-for-implementation-of-paris-agreement-resolution-on-climate-change>.

³East African Community (EAC) Climate Finance Mobilization and Access Strategy, Zanzibar, 19-20 February 2020

Available at <https://unfccc.int/sites/default/files/resource/Richard%20Muyungi%20-Presentation%20on%20EAC%20Needs.pdf>

of bioresources as the major driver of inclusive economic growth and job creation in East Africa.

The Strategy focuses on the creation of new biobased products that add value at local level and/or use resources in novel, innovative and sustainable ways. Specifically, the scope of the Strategy covers optimisation and innovative use of biomass and biological resources produced from agriculture, aquaculture, bioprospecting, and forestry and includes alternative sources of food and feed, health and bioenergy products. The countries covered are Burundi, Kenya, Rwanda, South Sudan and Uganda.

The overall objective of this Strategy is to achieve:

Sustainable economic growth and job creation, making use of the region's bioresources to develop products in the areas of food and nutrition, health, biobased industrial products, and bioenergy, while contributing to an improved environment and climate change mitigation.

This objective will be achieved through, *inter alia*:

- ◇ Regional and international collaboration sharing knowledge and building capacity.
- ◇ Promoting regional markets for biobased trade.
- ◇ A harmonised regional approach to create structures for innovation and deployment of technologies and know-how for value addition to primary produce and biowaste.
- ◇ Development of national bioeconomy strategies and policy agendas in the region.
- ◇ Joint monitoring and information sharing of bioeconomy development, such as a regional Bioeconomy Observatory.

The East African Regional Strategy is anchored on the following thematic areas:

- 1) Food security and sustainable agriculture,
- 2) Health and well-being,
- 3) Biobased Industrial Development and
- 4) Sustainable Energy.

With the East Africa Regional Bioeconomy Strategy, the private sector has been earmarked as a key stakeholder in biobased products, processes and business.



An employee of Sanivation company in Naivasha, Kenya operates a waste briquette cutting machine. Waste can be turned into sustainable fuel, which improves sanitation and reduces the environmental impact of burning wood. Photo: Lawrence Nzuve/SEI

Four priority Strategic Thematic Areas form the core of this Strategy (see below):

Strategic Thematic Area 1:



Food security and sustainable agriculture with the specific objective to introduce new biobased technologies and solutions to strengthen food and feed production, ensuring food security. This thematic area has three Key Result Areas:

- Value addition to food crops, livestock, forestry, marine and aquatic resources and microbial products
- Novel food and feed products
- Biobased agricultural inputs

Strategic Thematic Area 2:



Health and Wellbeing with the specific objective to develop a biobased healthcare sector contributing towards a healthy population with improved well-being, addressing regional priorities and building on indigenous knowledge and practices. This has three Key Result Areas:

- Biobased pharmaceuticals.
- Biobased traditional medicines
- Biobased cosmetics and well-being products

Strategic Thematic Area 3:



Biobased Industrial Development with the specific objective to develop industries that stimulate sustainable economic growth and add value to under-utilised renewable resources in the region. This thematic area has five Key Result Areas:

- Biobased and biodegradable packaging materials
- Bioprocessing enzymes
- Biobased construction materials
- Biobased textile fibres
- Renewable biobased oils

Strategic Thematic Area 4:



Sustainable Energy With the specific objective to increase the production and use of sustainable bioenergy, develop a range of bioenergy products for both household and industrial purposes. This has three Key Result Areas:

- Biomass briquettes and pellets as alternative to charcoal and firewood
- Production of biogas from organic waste
- Advanced biofuels

3.3 THE BIOINNOVATE AFRICA PROGRAMME

The BioInnovate Africa Programme is the largest bioscience and bioeconomy collaboration platform in Eastern Africa. (<https://bioinnovate-africa.org/>). The initiative is supported by the Swedish International Development Cooperation Agency (Sida) and based in and implemented by the International Centre of Insect Physiology and Ecology (*icipe*) in Nairobi, Kenya.

The Programme acts as a capacity building platform and biobusiness incubator supporting scientists and innovators in the region to link biologically based research ideas, inventions, and technologies to business and the market. Current BioInnovate Africa partner countries are Burundi, Ethiopia, Kenya, Rwanda, Tanzania and Uganda.

The purpose of BioInnovate Africa is to enhance the capacity of Eastern African universities, research organisations and firms to translate modern bioscience research outputs into innovations targeting smallholder farmers and agro-process enterprises in the region. The Programme is generating and developing bioinnovations (knowledge, products and services), bio-based business models, new small enterprises, spin-off companies, networks and partnerships and policy analysis. These outputs are expected to harness modern biology and bioscience innovations with the goal of improving productivity and sustainability of farmers, agribusinesses and agro-processors.

The Programme supports the development of innovation multi-actor consortia, involving scientists, private sector and civil society actors and is implemented through three thematic areas:

- ◇ value addition to agro-produce, converting waste to useful products
- ◇ value addition to agro/biowaste, connecting farmers and agribusinesses to new markets and value chains
- ◇ policy development for delivering bioscience innovations and supporting Bioeconomy development

At the moment twelve projects are supported under the value addition theme, seven under the agro/biowaste conversion theme, and one under the policy theme. While funding bio-based innovation projects remains the core activity of BioInnovate Africa, the initiative's strategy now also includes developing and supporting a knowledge-based bioeconomy in Eastern Africa. Consequently, the Programme has supported the development of the EAC Regional Bioeconomy Strategy.



Ms. Marthe Niyibigira, a BioInnovate Africa cohort 2 fellow from Rwanda, carrying out her fellowship research study on edible insects for food. Photo: Valine Moraa/ BioInnovate Africa



4.0

AVAILABILITY AND USE OF BIORESOURCES IN THE REGION

4.1 A LOW DEGREE OF VALUE ADDITION IN EASTERN AFRICA

The economies of countries in the Eastern African region are mainly agri-based and according to World Bank data over 30% of the region's GDP is currently directly attributed to agriculture and other bioeconomy related sectors. Countries in the region have rich but largely unexplored biodiversity, and a strong bioresource production base. However, the region has only to a limited degree, been able to apply technologies and know-how that could modernise agricultural production, bioprocessing and value addition. The low degree of bioprocessing and value addition to primary produce makes it difficult for the region to use its bioresources as an engine for economic growth.

Encouragingly, rural Eastern Africa offers opportunities for expansion of biomass production that would create opportunities for value addition at negligible opportunity cost by improving degraded or poorly maintained lands. The region has increasingly supported stronger universities, research institutions and innovation capabilities, with a growing number of active and well-trained scientists. In addition, all the countries in the region have embraced or are piloting different tools, agro-based clusters and platforms to promote agro-industrial development, which will serve as a base for expansion of biobased business enterprises.

4.2 CURRENT BIORESOURCE PRODUCTION

Eastern Africa is rich in land that produces the bioresources of the region, with an agricultural area of over 151 Million Hectares (MHa), and a forest area of 78 MHa, comprising two thirds of the total land mass. The agricultural area of the region is made up of around 30% arable land⁴, 5% land under permanent crops, and 65% permanent pastures.

Table 2. Summary of land use in Eastern Africa (figures in 1000 Ha)⁵.

Countries	Country area (1000ha)	Land area (1000ha)	Agricultural area (1000ha)	Forest area (1000ha)	Inland waters area (1000ha)
Burundi	2783	2568	2033	280	215
Kenya	58037	56914	27630	3552	1123
Ethiopia	113624	112856	37903	17140	768
Rwanda	2634	2467	1812	272	167
South Sudan	63391	63195	28533	7157	198
Tanzania	94730	88580	39650	47621	6150
Uganda	24155	20052	14415	2503	4103
SUM	359 354	346 632	151 946	78 525	12 724

⁴Arable land is the land under temporary agricultural crops (multiple-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). The abandoned land resulting from shifting cultivation is not included in this category. Data for 'Arable land' are not meant to indicate the amount of land that is potentially cultivable.

⁵<https://www.fao.org/faostat/en/#data>.

Agricultural productivity in the region is low by world standards, offering the potential for a substantial increase in production with increased inputs of improved seeds, fertilisers, irrigation and pesticides, together with improved storage to minimise post-harvest losses. Cereal yields in the region are around 2 tonnes/ha, compared with 5 tonnes/ha in Europe and over 8 tonnes/ha in the USA⁶.

In addition to the known agricultural areas, there are large areas of potentially productive land that are under-utilised and could be harnessed to contribute to the bioeconomy. Africa as a whole contains 60 percent of the world's unutilised but potentially available cropland⁷ but actual figures of unutilised land in the Eastern African region are difficult to find.

The primary food crops produced in the region are maize (20 M tonnes (MT) per annum), cassava (12 MT), sweet potatoes (10 MT), sorghum (7 MT), wheat (5 MT), roots and tubers (5 MT), potatoes (5 MT) along with smaller quantities of rice, beans, millet, yams and pulses. Oil crops average around 4 MT per annum, while cash crops including sugar cane, cotton, coffee, tea, cocoa beans and sisal amount to a further 16 MT. A further 12 MT of fruit (primarily bananas) and fresh vegetables (5 MT) are produced.

Livestock production in the region generates 19 MT of meat (primarily beef, though there are also substantial quantities of chicken, goat and sheep meat), along with 15 MT of milk and 0.3 MT of eggs.

The land resources are supplemented by aquatic resources, comprised of more than 12 MHa of inland waters, and a coastline of over 2000 km. These produce over 1.2 MT of fish annually⁸. However, Lake Victoria, the largest body of inland water in the region, has experienced declining numbers in commercial fish stocks over the last decade due to overfishing, invasive species, pollution, and changing climatic conditions. There are ongoing efforts in the region to stimulate profitable and sustainable aquaculture, which currently contributes less than 10% to total fish production⁹.

Along the coast, 16 MT of seaweed are harvested. There are also 140,000 Ha of mangroves, another potential resource. In addition, there is potential to harness the invasive water hyacinth that covers up to 17,000 Ha of Lake Victoria¹⁰, to produce biofuels and fertiliser.

4.3 CURRENT BIORESOURCE UTILISATION AND PROCESSING

4.3.1 Food value chains

The majority of food produced in the region is only minimally processed. Many crops are processed into flours, like maize, sorghum, millet, soybean, or cassava, while a portion of fruit produced, such as mangos, bananas and pineapples, may be dried. However, there are major opportunities to add additional value to food crops in the region.

Processing of meat and other livestock products is undertaken across the region, but is often variable in quality due to poor food safety and hygiene standards, lack of traceability and analysis of residues. Nevertheless, there has recently been considerable investment by both the public and private sectors to improve this situation by building modern meat processing facilities. Animal byproducts including hides, skins, bones, horns, tallow and dung, as well as feathers from poultry, offer other opportunities for value addition. Leather tanning operations have suffered from the use of environmentally unfriendly processes, and there has been a lack of investment in production of footwear and value-added goods, but nevertheless the trade in leather and leather products is growing at an annual rate of 1.5%¹¹.

Apart from consumption of fresh fish, a portion is frozen, dried, or smoked, either whole or after filleting. Small amounts of fishmeal are also produced. Harvested dried seaweed is largely exported to Europe and the USA where it is further processed to produce a variety of food and cosmetic products. This may represent a missed opportunity for the region to add value.

⁶<https://data.worldbank.org/indicator/AG.YLD.CREL.KG>

⁷McKinsey Global Institute, 2016.

⁸<https://data.worldbank.org/indicator/ER.FSH.PROD.MT>

⁹<https://www.seafoodsource.com/news/aquaculture/eu-financed-project-to-revamp-aquaculture-in-east-africa>

¹⁰Albright, T. et al. (2004). The rise and fall of water hyacinth in Lake Victoria and the Kagera River Basin, 1989-2001. *J. Aquat. Plant Manage.* 42. 73-84.

¹¹<https://allafrica.com/stories/202104290288.html>

4.3.2 Non-food crop value chains

Non-food crops such as oil crops, cotton, coffee and tea are major generators of export revenue, but do undergo some limited local processing. Cotton is processed to produce lint, seed, animal feed and oil. More than 90% of coffee is exported in its raw form, but there are opportunities to export finished roast and ground products.¹² Tea leaves are processed into black tea and most is exported in bulk, but there are some ongoing activities involving blending and supply of finished tea products and tea bags.

Forest products utilised in the region primarily consist of wood fuel (over 200 M cubic metres per annum) and charcoal (10 MT), with smaller levels of production of sawlogs, pulpwood, wood chips and roundwood¹³. However, harvesting and processing in the region are largely unregulated and fragmented, which greatly challenges sustainability¹⁴. Bamboo from the forests is used as a construction material, as well as for decorative products, furniture and flooring. It has potential to be used for a variety of other purposes including clothing, as an antioxidant and food preservative, paper making, biomedicines and cosmetics.

4.3.3 Biomass residues

Agricultural and forestry residues - an under-utilised resource

Eastern Africa has rich biodiversity and a strong bioresource production base, as well as a large resource of unexploited biomass residues. Key crops in the region generate around 130 million tonnes of agricultural residues per year of which around 30-60 million tonnes¹⁵ is currently unutilised. In addition, forestry activities produce large amounts of residues including over 116,000 cubic metres of sawdust.¹⁶ Non-wood forest products including seeds, nuts and fungi have alternative uses, such as croton nuts which can be used to produce biofuels and other bio-products. Municipal organic solid waste amounts to an average of 100kg per person per year, with considerable potential for biogas production¹⁷.

Crop residues

Agricultural residues in the Eastern Africa region are mainly from food crops, horticulture, industrial crops, livestock and fisheries. Crop residues are classified as primary residues, which are generated when crops are being harvested and primary processed in farms, and secondary residues produced from secondary processing of agricultural produce at central locations in large quantities.

Due to being scattered and loose, the collection of primary residues for alternative uses is challenging, and moreover a portion needs to be left on the fields to provide organic content and protect soil against wind erosion. There are considerable opportunities to add value to secondary residues through their use in the bioeconomy.

A portion of the available residues is already used for various purposes as indicated in Table 3¹⁸.

¹²More from the cup: better returns for East African coffee producers. <https://www.intracen.org/publication/more-from-cup/>

¹³FAOSTAT 2021.

¹⁴https://www.trafficj.org/publication/17_Timber-trade-East-Southern-Africa.pdf

¹⁵Data extracted from FAOstat for key crops and calculations on sustainable availability of residues after leaving an amount for soil protection, soil carbon storage and other current uses.

¹⁶Data extracted from FAOSTAT 2020. <http://www.fao.org/faostat/en/#home>

¹⁷UNEP (2018). Africa Waste Management Outlook .United Nations Environment Programme, Nairobi, Kenya.

¹⁸Kinyua, G.J. 2020. Quantitative assessment of sustainable availability of bio resources in east Africa region for use in the bioeconomy. Report produced as part of the BiSEA project.

Table 3 - Current usage of agricultural residues

Crop	Process residue	Field residues	Availability of residues
Sugar cane	Bagasse		Already utilised as boiler fuel to generate electricity for the sugar mills & plantations Some is used to make briquettes
		Cane tops and leaves	None—Nearly 100% are burnt in-field to facilitate harvesting or left in the field for fertilising purposes
Coffee	Husks		Available at the processing plants Some is used to make briquettes
		Cherry pulp & skin	Mostly wet coffee processing: pulp and outer skins are removed in decentralised locations during harvest & currently being used for mulching
Sisal	Sisal pulp		All available at the processing plants, currently not utilised due to liquid nature (besides small amount in a biogas pilot plant); in the future possible use as fodder (testing stage)
		Sisal ball	Currently burnt or broken down & ploughed under
Banana	Peels	Stalk	Stalk and peels used to feed cattle Dry peels used to make briquettes and animal feeds
Cassava		Stalk	Some used as seed for replanting Some households use it as a source of cooking energy
Pineapple	Peels	Plant	Peels- Used to feed animals, plant disposed of after uprooting with some used to make briquettes
Maize	Cobs	Husks and stalks	Some of the cobs, husks and stalk used as feed for animals Some cob and stalk used as fuel
Sorghum		Stalk	Used as fuel by some households Some used as animal feed
Wheat		Straw	Used as feed for animals
Rice	Husk	Straw	Straw used as animal feed Husk mixed with other organic residues is used to make briquettes

Figures for the actual amounts of residue sustainably available for further value addition can only be roughly calculated as a percentage of the total residues produced, as indicated in Table 4. However, given that there is potential to at least double the yield of many crops with better inputs, there is considerable potential to increase the sustainable availability by a corresponding amount.

Table 4 Availability of crop residues

Crop residue	Theoretical availability (thousand tonnes)	Sustainable availability (30%) (thousand tonnes)
Avocado residues	268	80
Banana stalk and peels	18,400	5,500
Coconut husk	710	200
Coconut shell	390	118
Coffee husk	195	58
Cassava peelings	3,000	920
Maize cob	5,700	1,700
Maize husk	4,200	1,250
Maize stalk	41,900	12,500
Mango residues	4,500	1,350
Pineapple residues	1,360	407
Rice husk	1,000	320
Sisal ball	240	72
Sisal pulp	1,200	350
Sorghum stalk	1,200	350
Sugarcane cane top	3,200	950
Sugarcane bagasse	5,500	1,640
Wheat straw	8,600	2,600
Total	112,540	33,760

Forestry residues

Offcuts, chips and sawdust are the main forest residues. The offcuts and chips are entirely used by households and local industries, but a portion of the overall available sawdust is potentially also available for alternative uses. This amount has been calculated to be approximately 33,000 cubic metres¹⁹.

Fish and byproducts

When fish is filleted, at least 30-40% is waste.¹⁹ This means that if all the fish production was filleted, approximately 600,000 tonnes of fish remains would be generated. Estimates of the percentage of the catch that is filleted are not readily available, however around Lake Victoria the fish processing industries generate approximately 150,000 tonnes of waste with nearly 80% dumped and not utilised.

¹⁹Gumisiriza, R. et al. 2009. African Journal of Environmental Science and Technology Vol. 3 (1), pp. 013-020.

5.0

BIOECONOMY DEVELOPMENT AND OPTIMISING BIOMASS UTILISATION IN EASTERN AFRICA

5.1 OPTIMISING VALUE ADDITION TO BIORESOURCES

Biomass utilisation is at the core of the bioeconomy, providing an alternative to fossil fuel utilisation. Designing efficient biomass value chains requires an integrated approach involving all the steps from the farm to the market. This can include production, collection, pre-treatment, storage, transport, processing, packaging and market access. Investment in processing equipment may well be required, and the business model needs to be defined. Who will make the investment, and where will benefits accrue? Given that many types of biomass (and particularly biomass residues) are often bulky and widely distributed geographically, the cost and logistics of transport to a central location can often be a prohibitive factor, requiring decisions to be made about where processing should take place.

The production of biomass is seasonal and location-specific, influenced directly by the biophysical, climatic, and socio-economic environments. Because of this, availability of biomass can differ between seasons, years and locations. Moreover, in many cases, biomass is highly perishable and pre-treatment and storage can be crucial stages for the quality of the final products. The quantity, quality and economic viability of the produced final biobased products depend on the technology but also the scale of conversion. Decisions in other industries (e.g., farming, food processing) can influence availability and quality of biomass which can have direct consequences on idle time of machinery and available resources. To design an efficient biomass supply chain, all these aspects must be optimised simultaneously²⁰.

Eastern Africa presents specific challenges in value chain optimisation. The bulk of agricultural production is carried out by smallholder farmers, who often lack market access, as well as lacking capital to enable them to implement value addition processes. Entrepreneurs who wish to establish new biobased businesses face challenges in accessing affordable finance. Accessing local and international markets can also be challenging.

5.2 EXISTING BIOMASS VALUE CHAINS IN THE REGION

An analysis of some existing biomass value chains offers insights into the possibilities for the region. The majority of large agro-processing industries in the region capitalise on the processing of cash crops that are produced in bulk. These industries are in many cases fostering linkages with smallholder farmers through contract farming agreements, which integrate the farmers into global commodity chains. These large industries offer valuable opportunities to add value to the bioprocess residues, since they are transported to a central location at the factory and are therefore readily available.

One of the major agro-processing industries in the region is the sugar milling industry. Around 15M tonnes of sugar cane are grown annually in the region, generating sugarcane tops and leaves which are mostly burned in the field after harvesting the cane or are used as cattle feed. Processing of the cane in the region generates 1.7M tonnes of raw sugar²¹. Typically, from processing 100 tonnes of sugarcane in a factory, 30–34 tonnes of bagasse is obtained of which 22–24 tonnes is used as a source of energy in the factory²². Some bagasse is used in the region for the manufacture of paper products, but there is considerable potential to harness the remainder for use in fillers for building materials, as a substrate for growing mushrooms, and for production of polyhydroxyalkanoate bioplastics. Some sugarcane molasses is processed into ethanol, with the potential to blend it with petrol²³, however this generates a byproduct known as vinasse which is a recalcitrant waste that is produced at rates 10–15 times faster than ethanol. It is primarily used as a liquid fertiliser. Another valuable product from the sugar industry, currently produced only in small quantities in the region, is rum which is fermented from cane juice, syrup or molasses. Opportunities also exist to generate products such as furfural, acetic acid, citric acid, yeast and single cell protein from molasses fermentation²⁴.

Another major industry in the region is the coffee processing industry. Approximately 1M tonnes of green coffee beans are produced annually and traded on international markets. Coffee processing generates residues as pulp during separation of cherry from the bean and coffee husk during the milling. Coffee husk (composed of skin, pulp and parchment) is suitable for carbonized fuel production as it has low moisture content, it is fibrous, uniform in size and low in ash. Coffee husks are used in combustion in boilers, as farm manure and in the making of carbonized charcoal briquettes. They also have potential as a fermentation substrate for production of ethanol, citric acid etc. However, commercialisation of coffee husks has not been fully optimised in the region. The amount of coffee husk theoretically available in the region is close to 200,000 tonnes²⁵. Coffee leaves are used for medicinal purposes, and are also being tested in several other new applications, as vehicle perfume, facial cleanser, tobacco substitute, animal feed, *Lactobacillus* proliferating agent, packaging material, absorbance pads, and deodorizer²⁶.

²⁰Guo, X. et al. *Energies* 2020, 13, 6153; doi:10.3390/en13226153

²¹Data from FAOSTAT

²²Nikodinovic-Runic, J. et al. 2013; *Advances in Applied Microbiology* 84:139-200

²³http://www.xinhuanet.com/english/2017-02/21/c_136074114.htm

²⁴Paturau, J.M. <https://www.fao.org/3/s8850e/S8850E03.htm>

A major cash crop in the region is tea, with around 650,000 tonnes being produced each year. Tea waste consists of dust, bits and pieces of twigs, damaged fragments of leaf, floor sweepings, stalks, and leftover detritus that does not meet the standards or processes that result in it becoming part of the packaged end product. This can amount to around 2% of the total production. The waste is normally burned or buried, but there is considerable potential to extract value from it. Caffeine in the waste has a broad market with substantial export potential. It can be extracted for use in many products, including cosmetics, fertilisers, instant teas, medical and nutritional supplements. Tea waste makes a high protein cattle feed after removal of tannic acid that interferes with protein metabolism. It also has uses as an adsorbent for toxic waste, dyes, heavy metals etc. As a source of energy it can be used to produce briquettes, biochar and biogas²⁷.

The brewery industry in the region produces over 3M tonnes of beer annually²⁸. For every 1000 tonnes of beer produced, 137 to 173 tonnes of solid waste may be created in the form of spent grain, trub (an unwanted material generated during wort production), waste yeast and kieselguhr, the main material used to filter the beer. Spent yeast and spent grains in particular have the potential to be converted into high value products²⁹. The spent grain is a good material for sorption and processing into activated carbon. It can also be used a fuel in raw form, after hydrothermal carbonisation or as a feedstock for anaerobic digestion. It has a high protein content and provided it is stabilised by drying, is valuable for both animal and human nutrition³⁰. The spent yeast is mainly used in animal feed, but there is potential for it to be used in a variety of food products such as meat substitutes, bakery products and savoury snacks³¹.

Around 55,000 tonnes of sisal are produced in the region, the majority in Kenya and Tanzania. Sisal fibre is extracted from the leaves, but makes up only 4% of the leaf weight. It is used to produce carpets, ropes and clothing, as well as paper, reinforcing composites and plastic composites. Sisal pulp and sisal ball are the two types of residues available from the sisal plants, most of which is regarded as waste. However there are initiatives to use sisal residues in the production of biogas, electricity, fertiliser and animal feed. The juice of the plant can be used to make pharmaceuticals like hecogenin, inulin and others³².

The examples above are focused on major cash crops that undergo significant processing, but a different approach to value chain optimisation needs to be taken in the case of crops where there is currently less processing at central points in the region. Examples include cassava, groundnuts and coconuts.

While 16M tonnes of cassava are produced annually, little of it is processed. The reason for this is that after harvesting it needs to be processed within 48 hours. Poor transport infrastructure in rural areas makes it difficult to get harvested cassava from small-scale farmers to urban factories within the available time frame, and there has been little investment in smaller scale processing units in rural areas that could produce a variety of products including cassava flour, starch, ethanol and glucose syrup. A solution to this could be the introduction of a mobile cassava processing facility developed by a Dutch company, that can travel directly to where the crop is grown.

Around 250,000 tonnes of groundnuts (in shell) are produced each year, mainly by smallholder farmers. However yields are low and there is currently little value addition. Another problem is aflatoxin contamination, since farmers do not have incentives or the ability to grow aflatoxin free groundnuts. Exports are largely made up of shelled nuts, with subsequent value addition taking place overseas. There are significant opportunities to add more value locally through the production of groundnut oil (currently less than 15,000 tonnes are produced in the region), as well as butter, confectionery, snack products, extenders in meat product formulations, soups and desserts. Groundnut shells make up

²⁵Kinyua, G.J. 2020. Quantitative assessment of sustainable availability of bio resources in east Africa region for use in the bioeconomy. Report produced as part of the BiSEA project.

²⁶Lachenmeier, D.W. et al. <https://encyclopedia.pub/1466>

²⁷<https://stir-tea-coffee.com/features/the-many-uses-of-tea-waste/>

²⁸FAOSTAT

²⁹<http://www.ibdlearningzone.org.uk/article/show/pdf/55/>

³⁰Jackowski, M. et al, 2020. *Biomolecules* 10, 1669; doi:10.3390/biom10121669

³¹Jaeger, A. et al. 2020. *Fermentation* 2020, 6, 123; doi:10.3390/fermentation6040123

³²<https://www.fao.org/economic/futurefibres/fibres/sisal/en/>

around 20% of the dried peanut pod by weight, and rather than being treated as waste, they have the potential to be converted into various bioproducts such as biodiesel, bioethanol, nanosheets and also have applications in enzyme and hydrogen production, dye and heavy metal adsorption³³. Groundnut skins and skin extracts have value as antioxidants, as functional food ingredients, in animal feed, and as antimicrobial agents³⁴.

A value chain of growing importance in the region is the coconut. Tanzania produces over 400,000 tonnes of coconuts annually, while Kenya produces over 100,000 tonnes³⁵. Around 750,000 households rely on the crop for income and food security. The potential value of the crop is estimated to be over 200M US\$ in Kenya alone, but it is estimated that only 53% of the potential value is actually realised³⁶, with some estimates as low as 25%³⁷. The many products include coconut wine, oil, roofing materials, brooms and coconut wood. However there is huge potential to further develop higher added value products such as face creams, milk powder etc. Tanzania currently produces 13,000 tonnes of coconut oil but there is potential to expand this to 58,000 tonnes based on the current production of coconuts. Production of oil results in a six-fold value addition compared to the value of the coconuts³⁸. Many micro-enterprises are engaged in value addition, but the sector faces a number of hurdles. Nevertheless, there is a real opportunity to transform the coconut value chain into a sustainable and profitable industry. Upgrading the skills and knowledge base of producers and processors and the introduction of new technologies will greatly enhance the value of the subsector.

5.3 EMERGING OPPORTUNITIES FOR BIOECONOMY DEVELOPMENT

5.3.1 Value addition in the agricultural, forestry, marine and aquatic sectors

Improving value addition to food crops, livestock and fish is a central priority in agricultural strategies and development plans of countries in the region. Successful value addition will be a major pull factor for agricultural production and productivity improvement already explicated in these strategies and plans. Currently value chains of major crops, livestock and fish, and algae produced in the region are mostly made up of small- to medium-sized, largely informal, private sector enterprises. The degree of value addition varies considerably between countries and types of primary produce.



Food crops

While value addition to commercial crops such as coffee, tea, and sisal is substantial in the region, crops such as cassava, sorghum and millet undergo limited value addition. The case of cassava was discussed in section 5.2. Emerging technologies in the modern bioeconomy – such as modern bioprocessing provide an increasingly powerful innovation engine which the region will use to improve traditional and current agro-processing and value addition.

³³Pham Anh Duc, P. 2019. <https://doi.org/10.1016/j.bcab.2019.101206>

³⁴Toomer, O.T. et al. 2018. <https://doi.org/10.1080/10408398.2018.1538101>

³⁵FAOSTAT data.

³⁶Nuts and Oil Crops Directorate. Coconut Value Chain Status Report, 2020.

³⁷Mwachofi, H.P. 2016. Value chain analysis of the coconut subsector in Kenya. MSc Thesis, University of Nairobi.

³⁸<https://www.thecitizen.co.tz/tanzania/news/business/-time-tanzania-used-coconuts-to-boost-edible-oil-production-3554890>

Box 1 - Value addition to Sorghum

Almi Foods Manufacturing PLC, Ethiopia

Almi Foods Manufacturing PLC is a start-up company in Ethiopia (Hawassa) that commercializes sorghum based nutritious and healthy foods by incorporating biofortified and nutrient dense ingredients for improved nutrition and socio-economic gain in Ethiopia. The company targets low/middle income groups, specially focusing on young children, mothers and persons with non-communicable diseases (NCD): celiac, diabetes, hypertension, constipation, cancer, etc. Almi (means nutritious) foods produce: (i) gluten free, high antioxidant and fibre rich ingredients for healthy injera and porridge/gruel from blends of whole sorghum and tef targeting mainly patients with NCD, (ii) ingredients for bread, cookies, porridge/gruel made from whole sorghum and wheat flour to the general public. These healthy foods have appealing flavour, texture and are traditionally accepted by both Ethiopians and Eritreans.

The company uses appropriate processing technologies adding value to local farm produce. Since products based on sorghum alone are not well perceived by consumers, the company processes the sorghum to improve nutrition and palatability. The process involves incorporation of chickpeas/beans for protein, tef for minerals, millet and quality protein maize for essential amino acid sources into sorghum which after soaking, germination and roasting are made into sorghum based food products which have increased nutrient bioavailability, digestibility and palatability. The business plan for Almi Foods is to focus on value addition of nutritious and healthy foods from locally grown whole grains acknowledging cultural values/norms, local taste, flavour and texture to tackle malnutrition, industrial use of orphan crops, improving health and creating value for consumers. The company uses modern biosciences for value addition to local climate smart and sustainable orphan crops and plans are to expand operations seeking support and partnerships for additional machine procurement. They aim for a more modernized and efficient crop processing plant to reduce production costs and increase volume for a larger market. The company is supported by BioInnovate Africa.

Bomvitae Agro Industries Limited (BAIL), Uganda

Bomvitae Agro Industries Limited focuses on providing agricultural technological solutions through innovation and partnerships that contribute to food and nutrition security, incomes, resilience and sustainable livelihoods for marginalised rural farm communities in East Africa. The company is involved in establishing small-scale community biorefineries based on full utilisation of high yielding multipurpose sorghum varieties through value addition with little or no waste. They focus on smallholder farmers and communities engaged in sorghum production in Eastern Africa living in arid and semi-arid areas. The biorefinery process encompasses extraction of juice from sorghum stalks to produce intermediary high value biobased products such as bioethanol, sorghum syrup and crystal sugar. Sorghum syrup is being used by the confectionery and bakery industries. Besides the primary products from the biorefinery process, sorghum grain is also harnessed as an additional benefit for the food and beverage industry, including the production of nutritious whole grain snacks, such as Sorghum Pops. Silage derived from sorghum bagasse during the biorefinery process is an additional byproduct marketed as livestock feed.

This start-up company is now in this phase of product promotion, awareness and scale up of operations building links with customers, such as KiRA Bakery in Uganda using sorghum syrup as sweetener and preservative in their bakery products. Links with supermarkets for sale of sorghum pops are also being established. The company has been supported by BioInnovate Africa implementing a project on small-scale community biorefineries and sorghum value addition together with Ethiopian Biotechnology Institute (EBTi); Ethiopia, Soil and More (SME) Ethiopia; Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya; the National Agricultural Research Organisation (NARO)-and National Livestock Resources Research Institute (NaLIRRI).

Information source. Professor. Kabede Abegaz, Ethiopia, Co-founder & adviser to Almi Foods Manufacturing PLC and Alexander Bombom, Co-founder of Bomvitae Agro Industries Limited



Fish

The residues of fish filleting can be used to make low-cost products with a high concentration of essential nutrients. Fish skin, which today is considered as waste, can be processed into leather. There are also opportunities for production of fish oil rich in polyunsaturated fatty acids (PUFAs) including Omega-3-rich fish oils which can be obtained from Nile perch fat pads³⁹. The global market for Omega-3 supplements amounts to over US\$5 billion.

Box 2 - Value addition to fish waste

Fish processing and value addition around lake Victoria

Around Lake Victoria the fish processing industries generate approximately 150,000 tonnes of waste with nearly 80% dumped and not utilised. The residues of fish filleting can however be used to make low-cost products with a high concentration of essential nutrients.

For instance, in Uganda by-products from Nile perch (*Lates niloticus*) are used in development of different micro-nutrient fish powders that could be used to enrich diets. Fish skin, which today is considered as waste, can be processed into leather. In Kisumu about 70 tonnes of fish skin waste are reported to be generated weekly to make leather products for export⁴⁰. This has the potential to boost leather production in the region, since African countries account for only 4% of world leather production and 3.3% of value addition in leather.

Leather exports from Kenya in 2013 amounted to only US\$140 million, which accounts for 0.14 % of the world's exports.



Biobased inputs-Reducing food waste and post-harvest losses

The vast majority of food loss in the region happens between harvest and the point of sale - very little is wasted by consumers after purchase. Some of the leading causes of food loss are a lack of cold chain facilities especially for perishables, unreliable and inadequate storage facilities and insufficient agro-processing skills among smallholder farming communities. On-farm losses of fruits and vegetables are up to 50%, the highest in the world⁴¹. Biological control of insect pests offers one promising opportunity to reduce production and post-harvest losses, while the use of edible films and coatings can help to preserve sensory qualities such as taste, aroma and appearance, prevent oxidative rancidity in meat products, delay ripening in fruits and vegetables, keep pigments in food products and extend shelf life⁴². The development and application of biobased agricultural inputs has potential to allow farmers and rural communities in the region to benefit from the valuable niche markets opening up in developed countries for organically produced foods and increasing demand for residue free crop protection products. The lack of pesticide residues and the positive environmental and toxicological profile of biopesticides also make it much easier for African countries to export crops to countries using ISO and CODEX standards.

³⁹Murage, M.W. et al.2021. <https://www.hindawi.com/journals/ijfs/2021/8838043/>

⁴⁰Gumisiriza R et al. 2009. Nile perch fish processing waste along Lake Victoria in East Africa: Auditing and characterization. African Journal of Environmental Science and Technology Vol. 3 (1), pp. 013-020, January 2009. Available online at <http://www.academicjournals.org/AJEST>

⁴¹<https://www.fao.org/africa/news/detail-news/en/c/1310100/>

⁴²https://www.researchgate.net/publication/329038231_Edible_Films_and_Coatings_A_Good_Idea_From_Past_to_Future_Technology

Box 3 – Biocontrol agents

The growing market for biocontrol agents in Eastern Africa.

Both globally and across Africa in particular, there is a pressing need to develop cheaper, more environmentally friendly alternatives to chemical pesticides. Biopesticides to protect agricultural crops are derived from plants and microorganisms, such as fungi, bacteria, and viruses. They are often much cheaper to develop than new synthetic pesticides. Farmers however need training to use them, since biopesticides often are more complicated to use than synthetic pesticides, in terms of transportation, storage, mixing and application. Currently, global sales of biopesticides are estimated to be worth roughly US\$4.4 billion⁴³, and constitute some 8% of the overall pesticide market with a growth rate of more than 15% per year. Due to the pressing need to produce more food more sustainably, preserving vital ecosystem services, global growth of biopesticide sales is projected to outpace that of chemical pesticides in the years to come. For these reasons, large global agrochemical companies have become involved in production and sales of biopesticides including in the Eastern Africa market largely through acquisitions and licensing deals.

There is also an increasing number of Eastern African companies and institutions engaged in local development of biocontrol agents for the Eastern African market, worth roughly US\$400 million annually. Real IPM is a Kenyan-registered company based in Thika close to Nairobi. The company is a subsidiary of the Belgian Biobest Group, which works with *icipe* and develops, produces and sells biological control agents i.e. bio-pesticides, beneficial insects (natural enemies to plant pests) and bio-fertilisers in order to reduce the use of synthetic pesticides and promote the adoption of biocontrol agents. Their products already have registration in Kenya, Tanzania, Ethiopia, Ghana, Mozambique and South Africa. Historically, Real IPM's largest customer base has been commercial producers in Kenya's export-oriented floriculture and horticulture sectors, but in recent years it has made concerted efforts to make its products more accessible to small scale farmers. They offer training and technical support to promote environmentally friendly farming practices. With a growing consumer demand for food free of pesticide residues in the lucrative EU export markets and also in a growing regional African consumer market, there are significant opportunities for increased biopesticide production and use in the region. Factors that would positively influence such a development, would be an increased awareness among African farmers on the potential benefits of biopesticides, more stringent quality control of biopesticide efficacy and certification standards at a regional level.

Real IPM products



Predatory mites



Biofertiliser



Biopesticide

⁴³Fortune Business Insights. <https://www.fortunebusinessinsights.com/industry-reports/biopesticides-market-100073>



Livestock

Across the region, 12.5M cattle are slaughtered each year, generating an equivalent number of hides. While much of this has a use for leather production, there is a general decline in usage of leather around the world and there is a need to find alternative uses for the hides. One opportunity is the extraction of functional collagen fibres that may be utilised in food, packaging, medical and industrial applications⁴⁴. The development of snacks made up of beef rinds offers another opportunity.⁴⁵ Regionally, 329M chickens are also slaughtered each year, generating around 25,000 tonnes of feathers which are normally disposed of as waste. These are composed of keratin protein, and research has shown that they can be reduced to a powder with thermal insulating properties, used as packaging material, or used to produce biodegradable plastics^{46,47}.



Novel food and feed products:

The global markets for novel functional foods, feeds, food/feed additives and nutraceuticals (foods with health-giving/medicinal benefits) are growing rapidly. Prebiotic and probiotic food/feed products also have a large potential in the region. With its large biodiversity and rapidly increasing demand for novel food products, there is a potential to build and develop an industry based on functional food derivatives from locally sourced bioresources. Such an industry could serve local, regional, and international markets. In addition, there is a growing global trend (especially in the OECD countries) to reduce traditional meat consumption to combat climate change, presenting a market for new sources of proteins, complementing the current animal protein production systems in the region. The region can pursue development and use of novel, resource-efficient protein production systems such as food and feed products from insects, algae, Spirulina (a type of cyanobacteria), molluscs, etc., replacing animal protein, especially from intensive production systems.

Box 4 - Novel feed from soldier fly larvae

Producing high quality feed from soldier fly larvae. BioBuu Kenya Limited

Located in Dar es Salaam and Mombasa, BioBuu solves two problems (i) Scarcity of affordable, sustainable and quality sources of protein for animal feed where the two main choices now are soy beans and feed mills (ii) Greenhouse gas emissions from decomposing waste. BioBuu collects the waste and feed it to the soldier fly larvae to get two products; insect protein and organic fertiliser. Six years of R&D has enabled them to develop a scalable model with each location capable of delivering 30 tons per month of defatted insect protein and 100 tons per month of organic fertiliser. They work with farmers, feed mills and customers buying finished feed or fertiliser replacing fish meal or soy beans. BioBuu builds strategic partnership with actors in the animal, nutrition and environmental impact fields. The company works from 3 locations where investment of some \$500,000 per location has been made. BioBuu also has a support or tech centre where some \$500,000 has been invested. This centre is important providing knowledge and technology support for the other facilities and for keeping up with the changing requirements for the industry. A conservative estimation for a five-year return on investment is between 30 and 40 percent. Besides commercial partners they are exploring partnerships with technical experts such as animal nutritionists and biobusiness incubation expertise assisting in complexities of commercializing products.



⁴⁴https://www.mla.com.au/contentassets/09ffc27dd041455c8c84f1cefd90725/a.bit.0011_final_report.pdf

⁴⁵<https://www.provisioneronline.com/articles/110872-a-tasty-new-use-for-cattle-hides>

⁴⁶<https://www.bbc.com/future/article/20171010-how-chicken-feathers-could-warm-our-homes>

⁴⁷<https://www.poultryworld.net/Home/General/2018/8/Chicken-feathers--giving-waste-a-new-life-320924E/>

Box 5 - Novel food products from honey

Aroma Honey Toffee Ltd

Aroma Honey Toffee Ltd in Uganda is producing high quality aroma honey toffee sweets. The honey value chain in Eastern Africa is reported to be growing steadily with annual honey production valued at approximately US\$ 37M for Uganda and Rwanda only. The growth in demand for honey is partly attributed to income growth, popularity of healthy eating, population growth and opportunities to provide healthier sweet alternatives to processed sugar.

Aroma Honey Toffee has been able to develop and establish a market for honey toffee sweets as a healthier alternative to sweets made from processed sugar. This has been done under a BioInnovate Africa project together with a team of other actors, including Consortium for Enhancing University Responsiveness to Agribusiness Development Ltd. (CURAD), Uganda; Union of Bee keepers of Gishwati (UNICOAPIGI), Rwanda; and Solongo Rehabilitation Group, Kenya. The Aroma Honey Toffee is a registered trademark in Uganda. The honey toffees comes with different tastes and mix which adds to their nutritional quality, There are those that contain ginger, mint arabica coffee, coconut and groundnuts, all sourced from African farmers. The toffees have a shelf life of 2 weeks in hot environments but that can be extended when kept in refrigeration.

The company is expanding its business and sales and now has 5 part-time employees increasing from 2 when first started. The company has plans to add employees if and when there is an increase in annual sales. The greatest employment for Aroma Honey Toffee will be realised in providing business for bee keepers from whom they buy honey and these being service providers. Aroma Honey Toffee Ltd has other honey-based products currently under research which will be released after realising a level of stability in the marketing and sales of the sweets. Apart from developing the honey products, the project also assisted honey producing famers with improved construction of beehives built by sustainably sourced bamboo, particularly in Rwanda. These hives offer cheaper, long-lasting alternatives to the hives traditionally used, which are characterised by low productivity, low quantities and low quality of honey and also cutting of native trees.

Information source: Dr. Sarah Mubiru, Founder Aroma Honey Toffee

5.3.2 Biobased pharmaceuticals and well being products

Developing Biobased pharmaceuticals



Due to a growing population, there will be an increased need for a secure supply of affordable drugs, diagnostics, vaccines and medical devices to address major diseases in the region affecting both humans and livestock. There is an opportunity for the region to develop more drugs, vaccines, and other biologicals locally, based on locally sourced pharmaceutical ingredients. The pharmaceutical market size of the region is at least US\$ 4 billion annually with a large volume spent on essential medicines, particularly antibiotics, anti-malarials, anthelmintics, disinfectants, analgesics and anti-retroviral medicines. The region currently imports 70-90% of its medicines, many from Asia with long lead times and risks of delays and supply failures, resulting from exporting countries' priority policies, especially during epidemics and pandemics. The EAC already has a Regional Pharmaceutical Manufacturing Plan of Action that aims, *inter alia*, to decrease dependency on pharmaceutical imports to less than 50%, and support the expansion of the product portfolio of EAC firms to cater for more than 90% of disease conditions. Biobased pharmaceuticals can complement and support ongoing efforts in this area, integrating local knowledge and bringing modern bioscience to bear on the health issues of the region.

Box 6 - Biobased pharmaceuticals

Eastern African biobased medicines for livestock

A wide range of medicinal plants are used to treat diseases and health conditions in animals, which have been documented in a manual produced by the World Agroforestry Centre.⁴⁸ For some of these plants, considerable data are already available on the active compounds they contain, however many are extremely vulnerable to over-harvesting. This is particularly the case for some medicinal trees such as *Prunus africana*, used to treat redwater fever and *Warburgia ugandensis*, used to treat a range of conditions, including anaplasmosis, redwater fever, contagious pleuropneumonia, East Coast fever, heartwater and sleeping sickness. However tissue culture protocols have been developed to propagate these plants, and on-farm cultivation is being encouraged. There is a major opportunity to stimulate and regulate, with appropriate testing and safety assessment, the use of medicinal plants and their active ingredients for livestock treatment.

In addition to plant based medicines, a project led by the Kenya Agricultural and Livestock Research Organization is adopting an innovative approach to develop improved tsetse fly repellents and attractants based on compounds derived from waterbuck, by means of 'push' and 'pull' tactics acting synergistically and rapidly to suppress tsetse fly populations and consequently improve livestock health.



Biobased Well-being products



With rapidly emerging markets in the region, there is increasing demand for consumer products such as cosmetics, well-being products such as vitamins and antioxidants, and cosmeceuticals (beauty products that contain beneficial active ingredients). The cosmetics, body care and fragrance markets are expanding globally, and with the fashion and cosmetics industry increasingly interested in basing their products on renewable, sustainably sourced raw materials, Eastern Africa has the potential to use and add value to bioresources, such as shea butter, gum arabic, coconut oil, Aloe vera products, and neem tree products in order to move further up in the cosmetic industry value chain. Such production would be based on fair trade values while protecting and sustainably using the biodiversity of the region.

There are also opportunities to exploit the potential of additional plants in the region, such as ylang-ylang (*Cananga odorata*) which is in high demand by the perfumery industry. It also has potential uses as an anti-depressant, an antiseptic, a hypotensive agent, and to combat seborrheic eczema. A recent study at the University of Burundi revealed excellent physico-chemical properties of a local variety of the plant.

The overall African market for personal care products is estimated to be around US\$ 12 billion, with the global market valued at US\$400 billion annually⁴⁹. The Eastern Africa market is fast growing and is becoming increasingly attractive to global cosmetics companies. The development of local producers represents a potentially very large opportunity for the region, and could have significant economic impact. An African based cosmetics industry basing its production on local bioresources could target local as well as expanding international niche markets. Such production could be based on fair trade values and sustainably sourced biomaterials protecting and sustainably using biodiversity of the region.

⁴⁸Dharani N., Yenesew A., Aynekulu E., Tsei B. and Jamnadass R. 2015. Traditional ethnoveterinary medicine in East Africa : a manual on the use of medicinal plants. Nairobi: World Agroforestry Centre.

⁴⁹Global Market Insights. (2020). Compounding pharmacies market share | Statistics report 2026. <https://www.gminsights.com/industry-analysis/compounding-pharmacies-market>

Box 7 - Biobased wellbeing products: Gum arabic

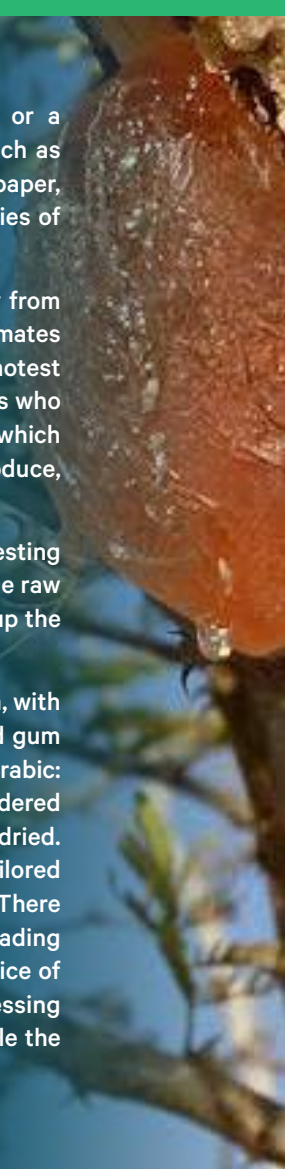
Gum arabic as a source of well-being products

Gum arabic has a wide variety of uses as a stabiliser, a binder, an emulsifier or a viscosity-increasing agent, in a variety of foods, but also for non-food products such as pharmaceuticals, cosmetics, printing, ceramics, photosensitive chemicals, textiles, paper, ink, paints and adhesives. Gum arabic is collected as sap harvested from two species of naturally occurring Acacia trees in the region, *Acacia senegal* and *Acacia seyal*.

A Kenyan company, Acacia EPZ, is seeking to expand the production in the country from the current 400 tonnes per annum towards the potential 12,000 tonnes. The firm estimates that it will create a market for approximately 6,700 households in some of Kenya's remotest and poorest regions. The company is providing training and tools to local households who will be engaged in 'gum tapping,' and aims to establish over 70 collection depots, which they intend to act as a 'one stop shop' where gum harvesters can deposit their produce, and at the same time purchase essential food, medical and farm supplies.⁵⁰

Another company, Inter-Africa Investment Holdings Ltd, is also stimulating the harvesting of gum arabic in Northern Kenya, and has a vision to establish a facility to process the raw material into a variety of products, including essential oils, in order to move further up the value chain.⁵¹

Currently, the majority of crude gum arabic is processed in Europe and North America, with a single French company estimated to hold a 50% global market share in processed gum arabic products.⁵² There are two main ways of undertaking basic processing of gum arabic: dry processing, in which it is crushed and sieved to produce kibbled gum and powdered gum; and the wet processing, in which crude gum is dissolved in water and spray dried. In addition, some processors produce specialty and customized high-grade gums tailored to specific industries and functionalities, and fetching substantially higher prices. There is currently little or no processing in Eastern Africa, with only basic sorting and grading taking place. Gum producers are estimated to capture only around 5% of the unit price of processed gum exported by European and Asian manufacturers. Fostering local processing would increase value addition with additional benefits to producers and would enable the region to capture more of the estimated US\$800 million global market.



⁵⁰<https://selfhelpafrica.org/ie/gum-acacia/>

⁵¹<https://www.kenyacic.org/2021/04/a-better-deal-for-gum-arabic-producers-in-northern-kenya/>

⁵²UNCTAD. 2018. Commodities at a glance. Special issue on gum arabic. https://unctad.org/system/files/official-document/suc2017d4_en.pdf

Box 8 - Biobased wellbeing products: seaweed extracts

Seaweed production in Zanzibar

Seaweed farming in Zanzibar is an important foreign exchange earner, generating up to US\$8 million a year and employing around 25,000 people, the majority of whom are women. However the work is labour intensive and the income is barely enough to provide a sustainable livelihood. In addition, much of the seaweed production has been undertaken unsustainably, and climate change is impacting on yields and the incidence of seaweed disease. The farmers grow the seaweed on ropes suspended between stakes planted in the sea floor. They harvest it at 4-6 weeks, then spread it out and leave it to dry. The dried seaweed is collected by buyers and then transported to warehouses for baling and shipping.

Only one small company, Mwani Zanzibar, is processing any of the seaweed to produce soaps and other skincare products. However globally, hydrocolloids extracted from seaweed, including carrageenan, agar agar and alginates, are big business. Carrageenan is particularly important with a global market size of around US\$800 million. The product is utilised as a viscosity control agent in personal care products and water-based cosmetics due to its water-binding capacity. It functions as a thickening, stabilising, and suspending agent in sunscreens, lotions, and body washes. It is also used in the food industry for gelling, thickening and stabilising products.

There is a variety of processes for extracting carrageenan, but generally it is extracted from the seaweed into an aqueous solution, the seaweed residue is removed by filtration and then the carrageenan is recovered from the solution, eventually as a dry solid containing little else than carrageenan. The development of a processing industry for carrageenan in the region would have a major impact on the economics of production, providing benefits for all concerned in the value chain.

5.3.3 Biobased Industrial Development



Revitalizing the bio and agroprocessing industry in the region

Growing recognition of the extremely high economic, political, and environmental costs of sustaining the fossil economy have opened the door for what has been referred to as the third (after health and agricultural biotechnology) revolution in biotechnology—industrial biotechnology. The region has an abundance of renewable resources, many of which are currently under-utilised, including crop and forest residues, marine and freshwater resources, niche organisms from extreme environments with valuable industrial properties etc. While remaining mindful of the need to avoid diverting agricultural production away from food production, there are many opportunities to develop industries based on these resources in the region.

Integral to the development of industrial biotechnology will be the development of biorefineries that provide multiple product and revenue streams. This also includes the transformation of traditional “agro-industries” such as sugar cane refineries, breweries etc, which today produce large amounts of unused waste, contributing to environmental pollution in the region. An example of an agroprocessing actor optimising its biomass flows and adding value to waste is Banana Investment Limited (BIL) in Tanzania (see Box 9 below). Products and processes that currently rely on non-renewable resources and chemical processes can be replaced with biologically-based production platforms utilising fermentation and other biological conversion platforms. New biorefineries and agro-industrial parks will produce a variety of biobased products, replacing imported products at competitive prices. At the same time there are opportunities to develop smaller, community-based biorefineries.

Box 9 - Agrowaste processing

Converting agrowaste to useful products

Banana Investment Limited (BIL) is located at the heart of a rural community in Arusha, Tanzania and processes 25 metric tonnes of peeled ripe bananas per week to produce wine and banana products in a process that also produces about 400 m³ agrowaste which up to 2015 was directly discharged into the nearby river Kijenge. The company also unsustainably used 3600 m³ of wood fuel and diesel to run the factory costing the company more than US\$ 50,000 per year. The company was also considered an environmental problem, like many agroprocessing factories in East Africa, and due to protests from the community, the environmental regulatory agency threatened to close the facility unless action was taken to treat the waste.

In April 2015 a full-scale integrated wastewater system for treating and processing 100% of the agro-industrial waste from the factory was inaugurated through the support of the BioInnovate Africa Programme and additional investment by BIL in the order of US\$ 170,000. The wastewater undergoes preliminary treatment in screening, flow equalization and clarification before it is digested in a biodigester to produce biogas. The sludge from the equalization tank, clarifier and biodigester is collected in a sludge dryer, dried and directed for reuse as organic manure. The biogas generated is used to supplement Industrial Diesel Oil (IDO) used in their boiler. The treated wastewater from the biodigester is polished in a constructed wetland to meet international and local standards for discharge into the environment and is directed for reuse within the factory for watering their lawns and for horticulture irrigation within the community around the factory. A certificate of compliance has been issued to BIL by regulators certifying that the treated wastewater meets Tanzanian environmental standards and can be used for irrigation of crops.

To date (2021) the system is up and running very well and has become a model wastewater treatment facility in Tanzania demonstrating the benefits accruing in the adoption of circular economy. The waste treatment system generates some 50m³ of biogas/day that is used to substitute a significant portion of the energy used in the processing, that was hitherto produced from diesel and wood fuel. This is equivalent to yearly cost savings of roughly 13,000 litres of diesel per year. Part of the wastewater has been channelled to a commercial horticulture small farm located close to the factory selling vegetables such as amaranth, cabbages, spinach and night shade. The farm does not have any other source of irrigation water and with the treated nutrient rich wastewater, the family farm has been able to boost production and sell a significant surplus attracting some 30-40 customers/day. One major advantage here is that the farm does not have to buy artificial fertiliser since the waste water has a sufficient amount of nutrients. As a result the farm can grow vegetables throughout the year which has increased family household incomes substantially.





Biobased and biodegradable packaging materials:

Plastic pollution has been an increasingly severe problem in Eastern Africa and in many countries the policy and regulatory responses have been extensive. At the same time there is an increasing demand for packaging material in the region that will reduce post-harvest losses, extending the shelf-life of food and consequently reducing food waste. E-commerce is also gaining ground in Africa, requiring increasing amounts of packaging material. Thus, there are excellent opportunities for the countries in the region to replace environmentally polluting and fossil fuel-based plastics, imported to the region, with new bio-packaging material. Several countries in the region, including Kenya, Rwanda and Tanzania now have plastic bag bans that have been shown to be effective in reducing the use of fossil fuel-based single use plastics.

The packaging market in Africa as a whole is estimated to be growing at an annual rate of 8%. The market is driven by an expanding population of youthful consumers and increased demands for consumer products. This, combined with the demand for environmentally friendly packaging, opens up considerable opportunities to develop new industries with associated job creation. Public procurement policies can also serve as a strategic intervention.

Box 10 - Biodegradable packaging

Hya Bioplastics, Uganda - Musinguzi Mark Musiimenta, Makerere University HYA)

The weak policy and legal regimes necessary for regulating the use of plastic packaging materials from fossil oil have posed serious environmental pollution in Uganda. This concern has served as a driving force for research and innovation into affordable environmentally sound biodegradable packaging alternative materials. Biomaterials from plant fibres present a viable option due to the environmental benefits and the low cost of sourcing the raw materials in nature. Micro fibrillated cellulose (MFC), a component of cellulosic plant fibre, the raw materials of most biomaterials, has been identified as a way of improving the mechanical properties of the plant fibres and overcoming the major drawback of insufficient mechanical properties exhibited by them, thereby limiting their applications.

In an effort to create low-cost biodegradable materials that can be used in various applications such as food packaging, interior designs and ornaments, Denis Ssekimpi and Musinguzi Mark Musiimenta, of Hya Bioplastics, Makerere University are creating biodegradable packaging material from re-engineered fibres from sugarcane, maize and water hyacinth plants. The renewable final fibre product produced by HYA bioplastics using a patent-pending process is coated with beeswax to improve its physical properties, giving good tensile strength and hydrophobicity with a good premium aesthetics. HYA bioplastics has mobilized financial support to enable it to complete its first prototyped fibre board. It has also developed key partnerships for product marketing. It currently produces some fibre boards and plates but has plans for a small-scale industrial facility to scale up production to meet the local market demand as well for export.



Adopted from Ssekimpi Dennis (@SsekimpiDennis) | Twitter Ssekimpi Dennis (@SsekimpiDennis)



Bioprocessing enzymes

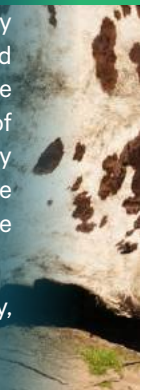
In Eastern Africa, there is a large agro- and bio-processing sector producing products such as leather, textiles, beer, and food commodities, many of which are associated with environmental pollution. Enzymes are used in a wide range of industries including pharmaceuticals, food processing, leather, detergents, paper and pulp and textiles. Enzymes today offer options for decreasing or avoiding environmental pollution and improving product quality and process efficiency. The availability of enzymes locally at an affordable price and with expert support on their use is expected to make a significant contribution in the region by lowering environmental pollution and by replacing several imported enzymes, chemicals and processing aids. Furthermore, because of the availability of unique habitats, such as alkaline environments, hot springs, etc with a large microbial diversity, the region could be, in the long term, highly competitive in the global industrial enzyme market.

In the last few decades, research conducted in different institutions in the region has resulted in the isolation and characterisation of several novel microbial strains producing potentially attractive enzymes for industrial application (see box 11 as an example). Given the importance of these enzymes in serving as processing aids in different industries in the region and their role in significantly reducing environmental pollution, scaling up of local production processes and use of the enzymes at industrial scale is strategic for the region. It is probably unrealistic to expect that industries in the region will be in a position to compete with large scale international producers of commodity enzymes, but there are opportunities in niche areas, and collaboration with multi-national players could bring mutual benefits.

Box 11 - Bioprocessing enzymes

Ever-increasing environmental pollution in the leather industry has resulted in the closure of the majority of tanneries in the region and thus necessitated the development of an eco-friendly enzymebased biotechnology as an alternative to pollution causing chemicals. Scientists at University of Nairobi have developed a zero waste biobased processing technology by removing hair and hydrolysis products of grease by enzyme biocatalysis, reducing and eliminating the need for solvents, chemicals and energy demanding methods in the tannery. Apart from using less chemicals the technology improved the quality of leather, but also helped to improve the waste recovery resulting in a close to zero waste tannery process with full recovery of wool, gelatin, hydroxyapatite, and protein hydrolysate powder.

Information source: Dr.Francis Mula, Department of Public Health Pharmacology and Toxicology, Faculty of Veterinary Medicine, University of Nairobi, Kenya



Biobased construction materials:

Demand for housing is increasing in the region due to urbanisation and a rapidly growing population. The region has the potential to leapfrog into low-carbon climate smart buildings, replacing imported concrete and steel with locally produced renewable building materials. The construction industry in Europe and North America is already increasingly using renewable building materials, replacing concrete and steel and hence reducing Greenhouse Gas emissions, and lower quality soft timber (such as bamboo/eucalyptus, etc.) is being processed into building materials which are equally as strong.

Cities and urban regions in Eastern Africa become the home for thousands of new inhabitants every day, many of whom find themselves without housing. With that in mind, the massive need for new affordable and sustainable housing requires a significant building material sector which has the potential to be a major employer in the region.

At present the majority of construction materials are imported from China, but the COVID-19 crisis has exposed the fragility of this supply chain and the need to develop the local production.

Box 12 - Biobased construction materials

Sawdust

Sawdust is used as a component of fuel chips and briquettes in the region. It can also be used in moulded and laminated wood products, and there is increasing interest in developing this in the region. In addition it can be ground into wood flour, which has major uses in industrial fillers, binders and extenders in industrial products like epoxy resins, fertilisers, adhesives, absorbent materials, felt roofing, inert explosive components, ceramics, floor tiles, cleaning products, wood fillers, caulks and putties, soil extenders and a vast array of plastics⁵³. Eastern African farmers have also recognised that it can be used to extend the shelf life of potatoes, reducing postharvest losses⁵⁴.

Bamboo

Bamboo is a giant grass, which grows naturally in Eastern Africa and covers more than 1.2 million hectares in the region. It is an important fast growing non-timber forest product and has for long been used as a construction material in the region due to its ready availability, ease of workability and its strength. In Ethiopia for instance, over 10 million Ethiopians are living in bamboo houses .

The renewed interest in bamboo as a construction material has revitalised the utilisation of bamboo not only as a cheap renewable resource but also as a durable material with multiple uses and many value addition opportunities. In southern China for example, the bamboo industry has in many areas become a backbone for industry development and created economic growth and poverty alleviation in rural areas. With new technologies, bamboo fibres can serve as a source material for the rapidly growing global market of engineered bio-composite wood, where wood or grass fibres are mixed with various other biobased additives forming renewable, light and durable materials that can be made stronger than steel. Bio-composite material based on bamboo can thus be an important basis for biobased industries in the region, producing building material, furniture, biobased plastics, textiles, pulp for paper, green chemicals, and health products. It is also an important source for bioenergy and can be used carbonised and in chips, and several companies producing bamboo products exist in the region.

Bamboo is considered as one of the fastest growing plants on earth and under good management a hectare of bamboo planted by smallholders in the region could yield approximately 40 tonnes of raw bamboo fibre per year. Sustainable harvesting of bamboo and increased bamboo use can also help to reduce deforestation, contributing to climate change mitigation, improved soil conservation and mitigation of flood disasters.



Renewable bio-based oils

In industry there is increasing demand for oils with special characteristics able to replace fossil oil-based products (as lubricants, or in green chemistry processes). Eastern Africa is home to several oil crops, including tree crops (such as the croton tree), producing oils with attractive nutritional, health, and/or industrial characteristics. There is an opportunity for the development of a plant/tree-based oil industry, sourcing and developing local bioresources as well as sustainable production and use of known plants/crops such as palm, avocado and citrus oil. A focus on local production offers significant opportunities for import replacement, as well as export of specialised bio-based oils.

⁵³<https://www.agmrc.org/commodities-products/biomass/sawdust>

⁵⁴<http://paepard.blogspot.com/2015/07/using-sawdust-to-increase-shelf-life-of.html>

Box 13 - Biobased oils and value added products

Croton nut products

In Kenya, companies including Ecofix and Eco Fuels Kenya have been working with croton (*Croton megalocarpus* Hutch.), an indigenous tree that commonly grows in Eastern and Southern Africa. The croton nuts are harvested sustainably by collecting from trees planted on farms, and have multiple uses but most well-known is the oil, used to make biofuel or biodiesel. Compared with diesel, croton nut oil is self-lubricating and has a higher flash point, making it safer and causing lower exhaust emissions. While the oil needs to be processed before it can be used in cars, it can go directly into diesel generators, water pumps or tractor engines.

Croton seeds contain approximately 30% oil and also have a high protein content of 30%. They have been used to produce vinegar and croton seedcake that can be used in animal feeds due its high protein content. The husks of the nut are processed into fertiliser. Croton seed cake also contains lower levels of aflatoxin (14%) than cotton and sunflower seeds. In a study published by the FAO, incorporating 25% of croton seed cake into chicken diets had positive effects on chicken growth and health.⁵⁵



⁵⁵ Thijssen, J. Croton megalocarpus, the poultry feed tree: how local knowledge could help to feed the world. Food and Agriculture Organization of the United Nations; Diaz-Chavez R. 2020. Emerging Bioeconomy Opportunities In Africa. A Case study of Croton megalocarpus Hutch in Kenya. SEI Technical report

5.3.4 Sustainable bioenergy



Development of bioenergy products for both household and industrial purposes.

Bioenergy is energy for industrial or commercial use that is derived from biological sources (such as plant matter or animal waste). It includes energy from wood, wood waste, straw, manure, sugarcane, and many other byproducts from a variety of agricultural processes that are currently under-utilised or utilised in an inefficient manner in the region.

Modern bioenergy is an important source of renewable energy. However, it is essential to ensure that crop production for biofuels does not impact on food production (the “food vs fuel” debate). Nevertheless, rural regions of Eastern Africa offer significant opportunities for expansion of biomass production that can create value addition at low opportunity cost by improving degraded or poorly maintained lands. There is a high potential to use parts of the crop- and pasture-land that are currently very inefficiently used, for bioenergy purposes and at same time increase the productivity of existing agricultural production systems.

Biomass briquettes as alternative to charcoal and firewood



Firewood and charcoal alone provide more than 40% of energy used in Africa, and about 80% of households on the continent depend on wood and charcoal as a primary energy source. For example, the energy balance of Tanzania shows that petroleum and electricity account for only about 8% and 1.2%, respectively, with biomass use accounting for over 90% of energy consumption and continues to dominate as the main source of energy.⁵⁶

Biomass briquettes, mostly made from agroprocessing, agricultural and forestry residues, are increasingly popular in Eastern Africa (and Africa generally) as an alternative fuel to charcoal and firewood, providing heat for cooking (and lighting). By turning organic waste into clean burning biomass, use of briquettes helps save forests and biodiversity, and cuts Greenhouse Gas emissions. It also reduces the levels of indoor pollution in households which is responsible for deaths of an estimated 15,000 women and children annually in Kenya alone. There are already some factories in the region producing more than 2000 tonnes of briquettes a year from waste materials, but the potential is much greater than this. There is an opportunity to upscale the production of biomass briquettes and improve and extend their industrial use, by refining the technology and developing the supply chain, together with development of improved cooking stoves. It will build on many on-going (but relatively small) initiatives across the region⁵⁷. Tanzania alone uses one million tonnes of wood charcoal each year, resulting in unsustainable deforestation, so the regional market is huge for sustainably produced briquettes as an alternative. Small scale rural initiatives to produce briquettes could create employment for youth in rural areas where it is most needed and thereby reduce the migration into cities.

⁵⁶IEA. 2019. Africa Energy Outlook 2019 World Energy Outlook Special Report. International Energy Agency Publications, 288. Retrieved from www.iaea.org/t&c/

⁵⁷UNEP. 2020. Sustainability Of Sugarcane Bagasse Briquettes And Charcoal Value Chains In Kenya <http://www.globalbioenergy.org/programmeofwork/working-group-on-capacity-building-for-sustainable-bioenergy/activity-group-2/iki2-ethiopia-kenya/it/>

Box 14 - Sustainable energy

Briquettes and pellets

The Eastern Africa region has large potential to produce modern bioenergy from a variety of biomass feedstock resources, including forest and agricultural residues, energy crops and the organic component of municipal solid waste. Briquettes and pellets produced from agroprocessing, agricultural and forest residues such as sugar cane and pineapple bagasse, coffee, maize and sawdust among others provide a more sustainable alternative to unsustainable firewood and charcoal production causing deforestation. Apart from being more efficient energy carriers, the use of briquettes and pellets also results in improved indoor air quality and human health. The technology used depends on the production scale, ranging from informal operations to large industrial operations.

There is an average production of sawn wood in the region of around 970,000 cubic metres with an estimated 120,000 cubic metres of residues with potential use for briquettes and pellets or in combination with other agricultural or forest residues. Other material that is readily available is sugar cane bagasse. The average production of bagasse is around 5.5 million tonnes per year. The production of briquettes and pellets is still low in the region but could be expanded for use for the industrial market including the tea, coffee vegetable oil, and food processing sectors and other sectors that use boilers in their processes. The technology used depends on the production scale, ranging from informal operations to large industrial operations.

UNEP and GBEP supported a project on “Building capacity for enhancing bioenergy sustainability through the use of Global Bioenergy Partnership Indicators” in Ethiopia and Kenya. The case of Kenya focused on the production of sugar cane bagasse briquettes. The country’s 12 sugar mills generate around 2.4 million tons of bagasse annually that remain unutilised. The tea Industry has a demand for firewood of around 1 million tons each year which could be supplied by these sugar cane bagasse briquettes and briquettes from other agricultural residues including nutshells. The new sector is creating jobs and alternative supply chains for farmers, industry and users.

Bioethanol

Bioethanol production for the cooking sector is also an alternative in the region. It has been promoted for humanitarian uses (refugee camps), for rural and urban households with dedicated cooking stoves. CIST Ethanol Fuel is a start-up company utilising an environmental problem plant (Hyacinth) in Lake Victoria to produce ethanol to be used as a cooking fuel. The start-up also produces the cooking stoves which are sold regionally. The company plans to increase bioethanol production to 3000 litres per day which is enough to supply 9000 households with clean cooking energy and 10 schools with alcohol based hand sanitisers. They plan to install 20 automatic ethanol fuel dispenser machines in low income communities which is expected to reduce the cost of ethanol fuel by 50% by eliminating the cost of packaging and branding. They also plan to market 9000 single burner ethanol cook stoves.

Information Source: *UNEP. 2019. Sustainability of Sugarcane Bagasse Briquettes and Charcoal Value Chains In Kenya. Results and recommendations from implementation of the Global Bioenergy Partnership Indicators. Technical Report. ISBN 978-3-948393-01-4*



Production of biogas from organic waste

Biogas is produced from anaerobic digestion of organic waste, and consists primarily of methane and carbon dioxide. Small scale production of biogas from household digesters is growing in popularity in the region. The African Biogas Partnership Program (ABPP) has established a nascent industry for bio-digesters in Tanzania, Uganda and Kenya. While the biogas is used for cooking, a secondary benefit is increased crop yields from the resulting bio-slurry. However, barriers still exist that hamper large scale dissemination, including high installation costs, inadequate user training, insufficient servicing, and inappropriate designs. Poor design choices, mainly due to overlooking the users' energy needs and local conditions, contribute to the short lifespan of many installed biogas systems..

There are also opportunities to recover biogas at a larger scale from sources such as municipal waste systems and sewage treatment plants, for electricity generation and for public transportation. In sewage treatment plants, the sludge can be used to produce biogas by a process of thermal hydrolysis and anaerobic digestion. In landfills, by inserting a series of pipes into landfills at various depths, the biogas produced through natural decomposition can be collected and harnessed. While the potential for this is large, enhanced uptake requires incentives to be in place such as electricity feed-in tariffs and tax incentives. Furthermore, through innovation supported by scientific research, bio-hydrogen can be extracted from biogas and biomass and compressed into liquid hydrogen to be used as environmentally friendly biofuel. As a source of renewable energy, scaling biogas use will make a considerable contribution to reduction of greenhouse gas emissions and reduction in unsustainable use of wood fuels.

Box 15 - Biogas

Slaughterhouse agrowaste conversion in Uganda - the case of Kampala City Abattoir, Uganda

The Kampala City Abattoir (KCA) is one of the biggest slaughterhouses in Uganda located in the heart of Kampala. The abattoir has a slaughter capacity of 900 livestock per day, generating on average some 400 m³ of highly polluted wastewater. This highly polluted effluent contributes to nutrient enrichment and oxygen depletion of Lake Victoria. Scientists from Makerere University, supported by BioInnovate Africa have installed a waste treatment pilot facility at the city abattoir that has been treating some 40% of wastewater generated. Through this pilot facility, the abattoir has been able to produce 60 cubic metres of biogas per day offsetting some 20% of the energy costs of KCA and removing organic matter and pathogens in the wastewater. The biogas has been used to run a generator that powers lights, deep freezers and refrigerators and has helped the abattoir save 3000 US\$/month. The system not only meets regulatory effluent discharge standards but also generates nutrient-rich sludge for cultivation of vegetables, flowers and nutrients for hydroponic systems. There is also a possibility for nearby households and restaurants to use the biogas for cooking. The project has demonstrated technical feasibility and the economic, social and environmental benefits of treating and converting biowaste to useful products. There have been discussions with the owners of the abattoir to invest and scale-up the plant to handle 100% of the waste which has not happened so far. This water treatment technology has not been tried out or been duplicated in any other abattoir. Part of the reason for this is the weak enforcement of effluent regulations by regulatory authorities in Uganda.



Pictures by Joseph Kyambadde, Makerere University



Advanced biofuels

Second generation biofuels are produced from non-food crops and agricultural and forest residues. In the case of some crops, such as sweet sorghum, there may be synergies with food production. For other lignocellulosic crops grown specifically for biofuel production, the choice of crop is important in avoiding conflicts in the supply of food, energy and water. Nevertheless, rapidly emerging novel conversion technologies of forest and agroprocessing residues provide a great opportunity for future development of biofuels in the region. A wide range of conversion options is available, the most widespread being the production of liquid fuels (bioethanol and biodiesel) for transportation.

To date, there has been very limited production of advanced biofuels in the region, in part due to high capital costs and land tenure issues. However in the longer term, small scale rural production offers opportunities for job creation for young people. Ethiopia has recently published a ten year road map for the production of sustainable aviation fuel.⁵⁸

⁵⁸<https://rsb.org/wp-content/uploads/2021/11/Development-of-Sustainable-Aviation-Fuel-in-Ethiopia-A-Roadmap-2021.pdf>





6.0

CURRENT STATUS OF BIOECONOMY DEVELOPMENT IN COUNTRIES IN THE REGION

6.1 THE BIOECONOMY DEVELOPMENT AT COUNTRY LEVEL

Development towards modern bioeconomies in Eastern Africa holds the potential to transform primary production not only in agriculture, the backbone of most economies in the region, but also in sectors like aquaculture, forestry, health, and industry. The region is endowed with vast bioresources, including abundant plant and animal genetic resources, arable land and agricultural residues, forestry resources, marine and freshwater resources that can support a vibrant sustainable bioeconomy. However, the large majority of the more than 350 million tonnes of primary produce⁵⁹ currently is unprocessed in the region. The fledgling agri-food based industries in the region – agro-processing, horticulture, forestry, fisheries and aquaculture - are not only inefficient in converting biomass into final consumer products, but the bio-waste generated from processing is a major cause of environmental pollution. There are great opportunities in the region to develop businesses that efficiently and sustainably add value to the primary produce, invest in the production of biobased novel food, feed, fuel, and health products, convert bio-waste into useable products, and develop bio-materials; such development has the potential to transform primary production not only in agriculture, but also in sectors like aquaculture, forestry, health, and industry.

The process of creating an enabling environment has started in the region, a process which has been catalysed and inspired by the development of the East African Bioeconomy Strategy. The East African Bioeconomy Strategy has inspired countries in the region to develop their own national bioeconomy strategies, a process that has started with Uganda being well on its way. The development and status of Bioeconomy strategy development in individual countries in the region is shown in table 5 (below).

Table 5 - Summary of bioeconomy policy development in countries in Eastern Africa

Country	Has a dedicated Bioeconomy policy/ strategy	Is developing a dedicated Bioeconomy policy/strategy	Has a Science, Technology and Innovation Policy/ Strategy
Burundi	No	No	No
Ethiopia	No	Yes ⁶⁰	Yes
Kenya	No	No	Yes
Rwanda	No	No	Yes
South Sudan	No	No	Draft policy
Tanzania	No	No	Yes
Uganda	No	Currently drafting a bioeconomy Policy	Yes The policy has undergone review by the UNCTAD

Another inspiration has been the two regional bioeconomy conferences, the Eastern Africa Bioeconomy Conference, “Bioeconomy Growth Prospects for Eastern Africa” 21-22 October 2020⁶¹, and the second conference held on 10-11 November 2021, “Building a Sustainable and Resilient African Bioeconomy”⁶². These two conferences, organised by EASTECO, the BioInnovate Africa Programme and SEI have served as convening platforms for policy makers, practitioners and academia to discuss and share ideas on bioeconomy development pathways for the region. In the following section the bioeconomy development at country level in the region is described.

⁵⁹Data from FAOSTAT

⁶⁰In Ethiopia, a National Committee has been established to work on the Draft National Bioeconomy Strategy for Ethiopia

⁶¹<https://1stbioeconomyconference.easteco.org/>

⁶²<https://2ndbioeconomyconference.easteco.org/event/b69a2247-d6af-401e-86a2-85ea1be55e36/summary>

6.2 COUNTRY STATUS - CURRENT DEVELOPMENTS AND FUTURE PROSPECTS OF BIOECONOMY



6.2.1 Burundi

Existing bioeconomy policies, strategies, roadmaps

Burundi has not yet developed the legal framework for scientific research, although a constitutional provision provides for this. Its national policy on scientific research and technological innovation ended in 2018, and has not yet been updated in accordance with the recommendations of the EAC regional policy on science, technology and innovation. From this perspective, without a real legal and institutional framework, the various R&D institutions risk to navigate by sight, struggling to find funding.

But although not having a document called “bioeconomy” as such, Burundi has drawn up its National Development Plan 2018-2027 which aims to transform the structure of the country’s economy. The 11 pillars on which this macro-economic policy instrument is based nevertheless give it all the features of a bioeconomy strategy. These are: the modernisation of agriculture, considered an essential component of the transformation of the structure of the economy; the increase in energy production, in particular from biomass, and which provides for a regional dimension with South-South partnerships; improving knowledge based on technology and know-how; development of the natural resources sector; diversification and promotion of a competitive and healthy economy; the creation of an environment favourable to industrialisation; strengthening human capital; strengthening transport, trade and ICT infrastructure; promotion of tourism; the strengthening of public-private partnerships, already governed by a specific law, aimed at facing the enormous challenges in the financing of economic and social infrastructures and the creation of jobs; and finally, the regional integration and international cooperation.

Existing, emerging bioeconomy actors or new initiatives in the country

Although the concept of bioeconomy has not yet been adopted by the public sector, the Burundian state has had, for more than 40 years, one of the largest state-owned companies that could be cited as a success story in terms of the bioeconomy: SOSUMO (Société Sucrière du Moso), the largest bioeconomic chain in Burundi. The production of sugar cane is strategic for the country’s economy, so much so that its distribution for marketing, as well as the pricing, are governed by specific legislations. Indeed, SOSUMO is the only State Company involved in the cultivation, processing and marketing of cane sugar and its multiple by-products such as molasses and cane stalk residues which are used to manufacture briquettes for domestic heating. But even if it is legally a state-owned company, the actors involved in the production chain and its ramifications are from the private sector. One example is Brarudi (an industrial beer production company), which uses it as added sugar to increase the alcohol level in the fermentation process of its beers. At the regional level, SOSUMO has all the potential to be able to make an expansion that can be qualified as regional, especially with Tanzania, of which the thousands of hectares exploited by SOSUMO could extend into Tanzania.

The project in Burundi that meets all the components of the definition of the bioeconomy is the Catnip malaria project, aimed to reduce the prevalence of malaria. Malaria (*Plasmodium falciparum*) is currently the most severe infectious disease worldwide, and a critical public health issue in tropical countries. 90% of the population affected worldwide lives in Sub-Saharan Africa. Most of the victims of malaria are children under 5 years old. This tragedy undermines East Africa's development.

The essential oils extracted from catnip (*Nepeta cataria* L., *Lamiaceae*) plants is known to have a repellent activity against mosquitoes. Nepetalactone, the major compound in the composition of catnip essential oil, has insecticidal properties. As mosquito repellent, nepetalactone is 10 times more effective than the chemical most commonly found in commercial insect repellents, known as DEET (N,N-diethyl-metoluamide), without the side effects of the latter. Usage of catnip essential oil will have a huge impact on the environment because it is a harmless natural product that will respect the ecosystem unlike the commonly used synthetic insecticide products. Funded and supported by BioInnovate Africa, the project is all the more interesting in several ways: the project is being developed by the private sector and involves researchers from the largest institution of higher education in Burundi, the University of Burundi, and Karire Products, the private partner involved in the cultivation of the plant, the production and marketing aspects.

This bionnovation is effectively related to the public health in its relation to business while contributing to the achievement of SDGs and AU Agenda 2063, and other related regional development strategies. The Catnip project has the assets on its side to become a regional success story in the bioeconomy.




A truck carrying freshly harvested Catnip leaves, on its way to the factory to extract its healing essences (Source: The Catnip Project)

Emerging
(or future)
bioeconomy
market/
development
opportunities.

It is still premature to speak of discussions at government level on the potential opportunities of the bioeconomy market in Burundi, since the concept of bioeconomy in Burundi still remains confined to a small circle of initiates, limited to those who have participated in the different development fora of the BiSEA Project, at regional and national level.

Burundi has an enormous bioeconomic potential favoured by a climate and rainfall that are ready for all crops throughout the year. Its water resources are also advantageous, with Lake Tanganyika which abounds in thousands of species which could serve as a basis for the development of a chain of industries of bioeconomy diversified in fish products. Unfortunately, due to the lack of processing industries, thousands of tonnes of fruits and vegetables are routinely thrown away, while they could be economically processed and packed for export.



Existing gaps, challenges and needs

Burundi's economy is essentially dominated by the informal sector, which is itself highly individualized. Economic operators often work alone, with little or almost no substantial investment. It should be remembered that this results in a scattering of energy and resources in a sector already weakened by a lack of a formal framework. The development of an economy genuinely based on knowledge and the formalization of this knowledge through an adequate legal and institutional framework is therefore one of the major challenges facing Burundi. The other challenge, which appears as a consequence of the previous one, is the lack of qualified human resources, while the country is already facing a severe shortage of university-level graduates with scientific and technical capacity commensurate with the regional or international market.

Burundi therefore urgently needs to develop its bioeconomy policy and strategy. It would be to its advantage to invest substantially in the processing industry, particularly the agro-food industry and the service industry. With effective partnerships with its neighbours, Tanzania and the Democratic Republic of Congo (soon to be a member of the East African Community), which are reputed to be well-off in terms of space, Burundi can develop its bioeconomy industries with resources drawn from the spaces of land borrowed from its two neighbours. This is how FOMI, the only chemical fertilizer manufacturing plant in Burundi, obtained from the Tanzanian government, the rights for extraction of phosphates from several hectares made available by Tanzania. The same partnerships could be considered in the field of agro-processing, to jointly develop win-win bioeconomy value chains.

In view of all the above, the following actions must be carried out by all relevant stakeholders, especially the Government, to promote the bioeconomy in Burundi: developing a specific legal framework for scientific research as provided for by article 164 paragraph 7 of the constitution; developing a general bill for science, technology and innovation in the form of setting up a structure outside the ministry with the strength and status of a national council under article 275 of the constitution, with provisions which refer to the development of robust specific policies and strategies, in particular on the bioeconomy as a transversal field to all aspects of science. To tell the truth, it is not as if Burundi does not have these documents. Indeed, in 2020, the National Commission for Science, Technology and Innovation, had validated, by more than 70 scholars and experts from several socio-professional backgrounds, a bill entitled: Organic law establishing the National Council of Science, Technology and Innovation, which is now in the hands of the minister in charge of scientific research, to take the other steps that must lead to its promulgation.



6.2.2 Ethiopia

Existing bioeconomy policies, strategies, roadmaps

Ethiopia is recognized as a mega bio-diverse country, and bioeconomy could offer prospects to convert the biological resources into economic wealth and employment opportunities. However, the concept of bioeconomy is new in Ethiopia and there are no standalone policies and strategies. Some of the existing policies, strategies and practices encompass the utilization of bio-resources, renewable resources and biotechnology which are the bases for knowledge-based bioeconomy. These include: Sustainable Development and Poverty Reduction Program (SDPRP), Plan for Accelerated and Sustainable Development to End Poverty (PASDEP), Agricultural Growth Program (AGP), Industrial Development Strategy (2002), STI Policy (2012), the Proclamation on Access to Genetic Resources and Community Knowledge and Community Right (2006), the two Growth and Transformation Plans, GTPs I & II (2011-2020), Women Youth Entrepreneurship Development Programme, biotechnology R&D roadmap (2016), National Biotechnology for Research Development Program (2022-2031) and Climate Resilient Green Economy (CRGE), and biotechnology R&D roadmap (2016). The CRGE aims to transform Ethiopia into a lower-middle income country by 2025 without an increase in its greenhouse gas (GHG) emissions, while the Biotechnology R&D roadmap and the National Biotechnology for Research Development Program are designed to use biotechnology as a tool to transform various economic sectors including agriculture, environment, health and industry.

In recent years, several economic sectors have developed specific roadmaps to stimulate economic development, mainly focusing on bio-based resources. These include roadmaps on Biorefinery Development, Chemical Technology, Coffee Industry, Crop Technology and Innovation, National Energy Technology, National Technological Roadmap for fertilizer industry, Leather Technology, Livestock Development, National Meat Technology, National Pharmaceutical Technology Sugar Technology and Textile Development Technology.

Currently, a 10 year reform agenda is developed by the Government dubbed “A Homegrown Economic Reform Agenda: A Pathway to Prosperity”. The main objectives are to ensure macro-economic stability to sustain the rapid economic growth, rebalance the public and private sectors’ role in the economy and unlock new and existing growth potentials.

The country has favourable policy environments and regulatory frameworks for spurring bioeconomy development. To promote industrial development, for example, there are guiding laws such as Industrial Park Proclamation (Procl. No. 886/2015) and Establishment of Industrial Park Development Corporation, IPDC (Regulation No. 326/2014). For their implementation, regulatory and facilitation roles are played by the Ethiopian Investment Board, Ethiopian Environmental Protection Authority, Ministry of Labor and Social Affairs and Ethiopian Investment Commission (concerning one-stop service). There are also export trade duty incentive schemes through Proclamation No. 768/2012.

To meet national and international quality standards of bio-based products, there are mandated institutions such as Ethiopian Standard Agency, Ethiopian Food and Drug Administration, the Veterinary Drug and Animal Feed Administration and Control Authority and the Environment, Ethiopian Environmental Protection Authority when it relates to food and feed derived from genetically modified organisms (GMOs). Ethiopia is not party to WTO and UPOV, to strictly adhere to international property agreements. However, there are several IPR regimes that are in conformity with TRIPS agreement. Patent applications are handled by the Intellectual Property Office (EIPO) and promotes technological development. There is also Plant Breeder’s Rights legislation which is under the jurisdiction of the Ministry of Agriculture.

Existing bioeconomy actors and new initiatives in Ethiopia

The establishment of Integrated Agro-industrial Parks (IAIPs) is exemplary in the sphere of bioeconomy development in Ethiopia. The idea of IAIP is to integrate various value chain components via the cluster approach. Fresh farm feed and agricultural produce from Rural Transformation Centers (RTC) will be transported to IAIP where the processing, management, and distributing (including export) activities will take place. Accordingly, the clusters gain economies of scale and positive externalities by sharing infrastructure (power, ICT, waste treatment plants, etc.) and taking advantage of opportunities for bulk purchasing and selling, post-harvest management, training courses, and extension services. Currently, four IAIPs are established in four regional states, namely, Bure (Amhara), Baeker (Tigray), Yirgalem (SNNP) and Bulbula (Oromia). They will have specialized agro-processing units depending on the diversity of products of the agro-ecology zones. For example, Yirgalem IAIP has potential value chains for cereals, coffee, fruits and vegetables, dairy, meat and other animal products. This agro-industry is already inaugurated along with Bulbula and Bure very recently; and the former has started to export avocado oil. Out of 11 production facilities in Yirgalem IAIP, three of them are occupied by investors: the Sunvado Avocado Oil Company, Doely Processing, and Hebron Coffee.

Future bioeconomy development and marketing opportunities

The huge potential of investment opportunities in agro-processing industries is detailed by the Ethiopian Agricultural Transformation Agency (ATA) and USAID Investment Support Program. They have featured insights on investment opportunities in soybean meal processing for Ethiopia's booming livestock and poultry sectors; tomato concentrate processing for domestic and export markets; cattle feedlot and abattoir; animal feed processing for poultry, beef, and dairy, etc.

Ethiopia began blending gasoline with ethanol in 2009 for the domestic market to save money used for oil imports with the target of raising the current 10% to 25% using efficient processing technology and also expanding the current facilities. Ethiopia's ethanol generation is currently based on sugarcane, sugar beet, sweet sorghum, and other crops.

There are lot of market opportunities including 110 million people with a 2.5% annual growth rate, duty free access to AGOA, conclusion of Bilateral Investment Treaties (BITs) and Double Taxation Treaties (DTTs) with several countries, Everything but Arms Agreement (EBA) with the European Union, Part of the Cotonou agreement between the European Union and the African, Caribbean and Pacific Group of States (ACP countries); and the Common Market for Eastern and Southern Africa (COMESA), etc.

Existing gaps, challenges and needs

The development of the knowledge-based economy is one of the key challenges and opportunities facing Ethiopia. A low level of scientific and technical capacity coupled with international competition is creating pressure for improvements in efficiency, quality and productivity with a growing need to innovate.

There are large untapped bioresources (bio-wastes) from the agro-processing sector (sugar, coffee, tanneries and abattoirs, food processing etc.) in the country that could be used as building blocks for expanded utilisation of bioprocesses and the growth of agro-industries. This also includes the transformation of traditional agro-industries such as sugar refineries, breweries, tanneries, dairy industry etc., where innovations in biotechnology can convert agro-biowaste into value added products and services. In line with this, attempts have been made by various R&D institutions to develop value added products and services including bioplastic from potato chips food factory waste, pulp from sugarcane bagasse from sugar factories and water hyacinth weed, production of high value enzymes from bacteria from the Great Rift Valley extreme environments, production of high value microalgae for food, feed and biofuel etc.

The following actions need to be done by all relevant stakeholders to promote bioeconomy in Ethiopia: Developing and implementing robust bioeconomy strategies; Leveraging the existing STI policies to promote knowledge and innovation; Developing skilled manpower and infrastructure for bioeconomy related activities; Allocating increased public funding for bioeconomy research; enhancing Private-Public-Partnerships and close cooperation with the private sector; Increasing agricultural productivity by supporting farmers to access modern farm technologies and facilities such as agro-processing centres which have enormous potential for enhancing agribusiness and establish/develop a well-functioning M&E system which provides feedback and information for proper bioeconomy program implementation.





6.2.3 Kenya

Existing bioeconomy policies, strategies, roadmaps

Kenya's economy is dependent on the use of bioresources, with agriculture, forestry and fishing contributing about 35% of GDP in 2019. Kenya has policy frameworks/policies in support of bioeconomy development e.g. land use policy, tourism policy, climate change policy, water policy, food and nutrition policy among others. Although there is currently no overall bioeconomy or bioenergy strategy, plan or policy in Kenya, there is a policy framework that may provide support for the implementation of a Bioeconomy Agenda. These overarching policies include the Vision 2030, the Big Four Agenda and the climate change strategy. Other specific areas on technology include the National Biosafety Act (2009), the National Biotechnology and Development Policy (2006), the Science Technology and Innovation Act (2013). On environmental issues, there is the Environmental Management and Coordination Act (2006), Industrial Property Act (2001), the Forest Conservation and Management Bill (2014). On social issues there is The Community Land Bill 2013, Agriculture and Food Authority Act 2013, The Community Land Bill 2013. On climate change The Climate Change Act 2016 aims to drive growth of Bioeconomy and increase its contribution towards the annual GDP growth while ensuring conservation of the country's biodiversity and sustainable utilization of bio resources. On energy, there is the Strategy for developing the Bio-Diesel Industry in Kenya (2008-2012) and the Bioenergy Strategy adopted in 2020 to guide development and promotion of bioenergy as a formal industry.

In addition, Kenya introduced in 2017 a ban on single use carry plastic bags including their production, sale and use. This law stimulated neighbouring countries such as Uganda and Rwanda to pass similar laws. This ban may serve as an incentive for emerging industries for alternative biobased packaging. Other organisations have acted to regulate and standardise production and products including the Kenya Bureau of Standards.

To promote technological innovation for inclusive economic growth, the Kenyan government established bodies and authorities such as the National Commission for Science, Technology and Innovation (NACOSTI), the Kenya National Innovation Agency (KENIA) and the National Research Fund (NRF) to coordinate innovation and research activities for inclusive benefits for all strategic thematic areas. The government has also developed innovation hubs and business incubation centres such as NaiLab, iHub and C4DLab, a research and development centre at the University of Nairobi; science parks and special economic zones in Mombasa, Lamu and Kisumu for purposes of converting ideas, research, or prototypes into viable products and services.

Existing, emerging bioeconomy actors or new initiatives in the country

Kenya is one of the leading bioeconomy hotspots in Eastern and Central Africa even if there is not yet a specific bioeconomy strategy. The actors include research organisations, government, private sector and academia among others.

For the private sector, there are efforts to support different biobased business models from organizations such as the Kenya Private Sector Alliance (KEPSA) and the Kenya Association of Manufacturers (KAM) which have played an important role in creating awareness, convening value chain actors, catalysing solutions that make business sense and influencing policy.

The country has a large agro- and bio-processing sector, including 13 sugar mills, several large breweries, and many actors in the fruit, vegetable and coffee

and tea processing sector. Kenya also has a number of emerging biobased and circular flow based industries such as Oserian, for instance, which is a flower farm in Naivasha with no organic waste. Ecofix is engaged in croton seeds processing yielding several products which the company has expanded into since its inception including oil production, organic fertiliser, biopesticides and poultry feed, meeting a growing demand to help Kenyan farmers adopt sustainable farming practices. Another example is Safi Organics which helps farmers convert their locally available farm waste to a fertiliser at an affordable cost reducing their reliance on expensive imported fertilisers. Real IPM is another company working with biopesticides in the region based on living organisms and providing an alternative to chemical fertilisers.

Other bioeconomy actors in research include the Biosciences eastern and central Africa (BecA) which is a strategic biosciences platform supporting increased use of bioscience-based technologies; and *icipe* where Bioinnovate Africa is based. Other academic organisations have been working on different value chains including mango, coffee and dairy such as Kenyatta University and E4Impact. The list is not exhaustive, but on the contrary, continues to grow in Kenya.

Emerging
(or future)
bioeconomy
market/
development
opportunities

The pharmaceutical industry in Kenya has a potential of over \$500 M USD, and is expected to grow because of the COVID19 impacts. Although Kenya is part of the EAC Regional Pharmaceutical Manufacturing Plan of Action, it has not yet updated its National Pharmaceutical Plan.


The large agro-based resources of Kenya have grown in the last five years, and there are now local companies producing biobased crop protection and post-harvest solutions using biotechnology. Other areas that Kenya can expand in are modern tissue culture generating disease free planting materials, especially in the area of cash crops. The Bioenergy Strategy in Kenya will provide opportunities to foster other areas in bioeconomy including the use of bioethanol for cooking. An initiative by UNIDO and GIZ proposed an Ethanol for Cooking Masterplan, and evaluated the case for investment into a local bioethanol industry as feedstock for clean cooking which may provide 370,000 jobs, KES 51 billion in new income generated, additional income of KES 180,000 per year for smallholder farmers, 54 million trees saved, and reduction in GHG emissions. The utilisation of agriculture and forestry residues to be used as briquettes in important industries such as the tea, food, oil and others in Kenya demonstrate that the bioenergy sector still has great potential in the country.

On aquatic resources, Kenya has a coastline of around 600 km and also has several lakes including part of Lake Victoria. The aquatic and marine potential resources are quite extensive and not fully utilised from mangroves to residues from the fish industry where new business has emerged utilising the fish residues for leather products. Other potential areas may include the production or utilisation of algae for food, pharmaceutical, well-being products and fuels among others.

Existing gaps, challenges and needs

The current bioeconomy in Kenya is still under development. However, some of the gaps and challenges identified include an inadequate business environment to promote foreign direct investment (FDI), and low uptake of careers in science, technology, engineering and mathematics (STEM) creating a disconnect between education and training with the industry needs. This means there is need for better links between academia, research institutions and industrial applications of bioinnovations. There is also inadequate infrastructure in terms of energy supply and transportation infrastructure.

There is need to mainstream bioeconomy in the existing policies and framework, the development of specific policies and strategies on bioeconomy and possibly the establishment of a National Commission to be in charge of the development of capacity building, national and international cooperation, support for research and academic institutions to develop curricula that support the bioeconomy, research, development and innovation. Government and institutional policies also need to be facilitative rather than regressive in nature in order to create an enabling environment fostering bio-entrepreneurship and the growth of bioeconomy. The financial sector needs to be persuaded to invest in the biotechnology sector, and legislation must be enacted to favourably enable people to invest in the emerging bioeconomy sector, and the concomitant engineering to support biotechnology must also be encouraged. Considering that Kenya is the faster emerging economy in the region, sustainable production and consumption should be linked to the bioeconomy.



Beehives in a small holder farm in Isiolo, Kenya: Planting of fruit trees attracts bees which in turn pollinate the flowers. Photo: Lawrence Nzuve/SEI



6.2.4 Rwanda

Existing
bioeconomy
policies,
strategies,
roadmaps

Rwanda is a land locked country where tapping into available biological resources to drive bio-based industrial growth is considered critical. The concept of bioeconomy in Rwanda is considered to be in its infancy stages. From a macroeconomic point of view, various government of Rwanda policies spur a bioeconomy enabling environment. These include the Science, Technology and Innovation (STI) Policy, which defines the country's priority areas focusing on national socio-economic transformation, and the "Made in Rwanda" policy which promotes the consumption of locally made products and enhancing Rwanda's domestic market through value chain development. Other relevant policies include the Strategic Plan for the Environment and Natural Resources sector (2018 – 2024), Strategic Plan for Agricultural Transformation (2017-2024) which highlights the need for technology use for increased productivity and sustainability, National Pharmacy Policy (2016), Rwanda Biodiversity Policy and National Strategy and Action Plan for the Conservation of Biodiversity in Rwanda which highlights the sustainable use of the biodiversity of natural ecosystems and agro-ecosystems, Rwanda Green Growth and Climate Resilience Strategy, and National Biotechnology Policy.

In recent years, several economic sectors have developed specific roadmaps to stimulate economic development, mainly focusing on bio-based resources. These include roadmaps on use of renewable energy whereby the targets include generating at least 60% of electricity from renewable energy sources. Rwanda also has an initiative to develop green smart cities through the Rwanda Green City project, Kigali Innovation City which is the government's flagship program to create a hi-tech ecosystem centred on innovation and talent.

The country has favourable policy environments and regulatory frameworks for spurring bioeconomy development. For instance, to promote industrial development, Rwanda has put in place a policy to ease access to land in industrial zones to increase the local domestic and foreign supply of manufactured goods. The Government has put in place the Special Economic Zone and nine Industrial parks in different districts. This is aimed at addressing shortcomings in the business environment by developing infrastructure, streamlining business regulations, and facilitating fast-moving investment.

Regarding product standards, the country has mandated institutions such as Rwanda Standard Board (RSB), Rwanda Food and Drugs Authority, Rwanda Inspectorate, Competition and Consumer Protection Authority (RICA). Patent applications and registration are handled by Rwanda Development Board (RDB). The approach to patents under the Rwanda Intellectual Property (IP) Law follows the standard approach in line with the requirements of the WTO's TRIPS Agreement. There is also a law n° 005/2016 of 05/04/2016 governing Seeds and Plant Varieties in Rwanda, which provides for the recognition and protection of seed and plant varieties and plant breeders rights.

Existing, emerging bioeconomy actors or new initiatives in Rwanda

The establishment of industrial special economic zones and promotion of the “Made in Rwanda” provide an indication of bio-economy development initiatives. For example, shifting from traditional bioenergy such as fuelwood or charcoal to processed biofuels such as biomass pellets or ethanol, increased agricultural productivity and higher value added in agro-processing, as well as increased recycling would also increase the availability of biomass for both energy and non-energy uses. Biomass resource planning and modelling bioenergy strategies in Rwanda has provided an opportunity to examine the relationship between the energy use of woody biomass and resource planning related to non-energy products and conservation. In addition, the establishment of “VISIT RWANDA” has potential impact on Eco-tourism development.

Emerging (or future) bio economy market/ development opportunities

Rwanda is a rapidly growing developing country and the demand for more food, better nutrition and employment, and enhanced resilience is increasing. Therefore, effective technologies have been put in place and implemented to accelerate sustainable agriculture achievement as the most important sector to drive bioeconomy development as a source of biomass. Rwanda is fortunate in that it has large untapped clean energy resources in geothermal, hydro and solar, as well as a >300MW methane gas resource in Lake Kivu. In addition, Rwanda plans to house the first vaccine manufacturing plant that uses BioNTech’s messenger RNA technology. The country is home to a number of technological entities such as the African Institute of Mathematical Science (AIMS), hosts EASTECO, Kigali Innovation City and innovation hubs such as the K-Lab and Fab lab which are seen as offering potential for bioeconomy development.

Existing gaps, challenges and needs

Rwanda has an ambition to leverage the transformative potential of Science, Technology and Innovation (STI) to become a globally-competitive knowledge based economy. This requires knowledge creation, use of technology and more innovation which needs improvement. There are large untapped bioresources (bio-wastes) from the agro-processing sector (cassava, coffee, tanneries and food processing etc.), sustainable production of biobased fuels and energy, improving the local production, “Made in Rwanda” (pharmaceuticals, food, feed and fuels), and promotion of eco-tourism in the country that could be explored as priorities for bioeconomy development. Efforts have been made by various public and private institutions and development partners to develop value added products and services such as production of refined concentrate of the flower Pyrethrum, essential oils, use of biotechnology for mass production of clean planting material of bananas, recycling wastes and turning them into valuable products such as chairs.

What needs to be done to foster the bioeconomy in Rwanda consists of development of national bioeconomy policy and implementation frameworks, strengthening the institutions through capacity building (human capacity), infrastructure development (laboratories, incubators, processing equipment) and Public Private Partnerships, strengthening research in bioeconomy based topics (research agenda related to bioeconomy priorities, promotion of bio-based innovations), support for new entrepreneurs (calls for competitive grants, awards. etc), promoting indigenous biobased knowledge (standardisations and Intellectual Property), promoting R&D performance based on knowledge transfer partnerships (KTP), academia-industry collaboration and financing bioeconomy related activities.



6.2.5 Tanzania

Existing bioeconomy policies, strategies, roadmaps to forward the bioeconomy agenda in the country

The Tanzanian economy is agriculture dependent with other sectors like mining, tourism making significant contributions. Agriculture in Tanzania represents almost 30 percent of the country's GDP with three quarters of the country's workforce involved in this sector. Agriculture is undoubtedly the largest and most important sector of the Tanzanian economy, with the country benefitting from a diverse production base that includes livestock, staple food crops and a variety of cash crops. There are plenty of agro- and bio-business opportunities across domestic, regional and international markets, for value addition to agroproduce and new biobased products. Productivity in the agricultural sector is however, low with modest progress over the past two decades. There are now signs of technological innovation and readiness, and the agricultural sector is slowly transforming with improved infrastructure and efforts to make the agricultural sector competitive in the region. The government has sought foreign financing for its flagship project Southern Agricultural Growth Corridor of Tanzania (SAGCOT) designed to quickly develop that region's agricultural potential with the aim increasing crop production and crop productivity and boost value-added processing in the sector. The Commission for Science and Technology (COSTECH) has recently funded 15 innovation hubs in the country, some of them focused on bioeconomy development.

To date Tanzania lacks a designated bioeconomy strategy and policy. Tanzania's commitment to bioeconomy development is however visible in existing cross-sectoral policies and strategic plans. Connection to the bioeconomy in Tanzania is found in various policy and legal documents including the National Agriculture Policy of 2013, National Environmental Policy of 1997, National Biotechnology Policy of 2010, National Environmental Act of 2004. The National Biotechnology Policy is the main policy document that would represent bioeconomy policy in Tanzania. This policy was developed as part of Tanzania's "National Strategy for Growth and Reduction of Poverty". The policy recognises the contribution of biotechnology in the fields of health, food, agriculture and environmental protection. The policy states further that Tanzania will promote biotechnology development and utilisation at the levels of research and technology development; translation of research results into products and commercialisation and marketing of biotechnology products.

The National Environmental Management Act of 2004 encourages a cyclic approach to waste management "wherever practicable, waste should, in order of priority, be reused, recycled, recovered and disposed of safely in a manner...". The environmental policy (1997) of Tanzania states that "Improvement of production systems through technologies and processes that utilise resources more efficiently and at the same time generate less waste; that reclaim, recycle and reuse by-products, to a very large extent is within the province of business and industry". The Agriculture Policy of 2013 has an objective of seeing "Production, productivity and profitability from utilization of agricultural biotechnology techniques increased".

Emerging
(or future)
bioeconomy
market/
development
opportunities.

Tanzania has large potential for bioeconomy development given its large agricultural sector. But so far there is still a low degree of value addition in the sector. For example, the annual Tanzanian production of fruits and vegetables is roughly 2.75 million tons, but only 4 percent is processed.⁶³ Cashews are a major cash crop in Tanzania and production has risen to 120,000 tons annually but only about 10 percent of the cashew nuts are processed in Tanzania. The country also has a large livestock population but a limited degree of value-added livestock products (leather garments, processed dairy products etc). The same pattern, significant production, but low degree of value addition, is also true for the oilseeds, cotton, sugar and sisal sectors.

There are however encouraging signs of new emerging bioeconomy actors and initiatives. These include new actors in agro- and biowaste management such as BioConversion Technology Africa Co. Limited (BIOCON) a spinoff company from research at the Nelson Mandela African Institution of Science and Technology which has been implementing wastewater treatment systems producing energy and reusing water, and nutrients (www.biocon.co.tz). BIOCON has been involved in installing industrial systems for treating wastewater with resource recovery. Two such systems have been implemented for treating banana wine wastewater and one for slaughterhouse wastewater. Several other smaller systems have also been implemented. There is also BORDA-Tanzanian German NGO promoting and commercialising decentralised sanitation systems recovering sludge producing fertiliser and biogas so far with a focus on Dar es Salaam.



⁶³Tanzania - Country Commercial Guide <https://www.trade.gov/country-commercial-guides/tanzania-agriculture-and-agricultural-processing>



6.2.6 Uganda

Existing bioeconomy policies, strategies, roadmaps to forward the bioeconomy agenda in the country

The crosscutting and multi-faceted nature of bioeconomy offers a unique opportunity to address inter-connected societal challenges such as food security, natural resource scarcity, unemployment, fossil resource dependence and climate change, in a comprehensive manner while achieving sustainable economic development. Uganda has largely missed out these opportunities and currently, there is unsustainable production and under-utilisation of living materials and services thereof in Uganda. This is attributed to among others: lack of an enabling policy, legal and regulatory environment; weak coordination of bioeconomy stakeholders; sub-optimal productivity of bio-based enterprises; low use of alternative sustainable bio-innovations as a result of low awareness; cultural barriers; prevalent negative mind-set; negative impacts of climate change; and unfavourable market conditions.

Uganda has now embarked on the development of a bioeconomy policy while a national strategy is also in the offing. The goal of the proposed bioeconomy policy is to facilitate optimal utilisation of bio-resources, their products and services for sustainable development. The policy will strengthen biosciences innovation to ensure food security, enhance nutrition and improve health, as well as enabling creation of decent jobs through expansion and intensification of sustainable production and processing.

The policy is intended to provide a paradigm shift from a capital-based to a knowledge-based economy driven by research and innovation. Its aim is to expedite identification and profiling of key value chains, fast-tracking strategic projects towards commercial development and facilitating efficient systems of production, consumption and processing to generate new sustainable economic growth through enabling existing, new and emerging technologies such as biotechnology and nanotechnology. It is expected that these efforts will foster the efficient use and reuse of bio-resources in congruence with expected environmental, social and economic gains.

The proposed bioeconomy policy is related to; the Plant Variety Protection Act, 2014, the National Drug Policy and Authority Act, 1993, the Forestry and Tree Planting Act, 2003, the Biofuels Act, 2018, and the National Environment Act, 2019 among others. The policy is also closely related to other existing policies such as the National Biotechnology and Biosafety Policy, 2008, the Renewable Energy Policy, 2007, the Animal Feeds Policy, 2005, the Energy Policy, 2002 and the National Environment Management Policy, 1994.

Existing, emerging bioeconomy actors or new initiatives in the country supporting the bioeconomy in the country

Uganda's economy is largely bio-based with 84% of its largely raw form exports being biological in nature. In addition, its bioresources supply goods for consumption and production, as well as providing ecosystem services. Despite Uganda's unique and diverse biodiversity, partly due to its distinctive bio-geographical location, it has not utilized the full potential of its vast biological resources.

Among other things, Uganda also plans to establish a Biosciences Science and Technology Park which will host technological infrastructure such as research laboratories, technology development workshops, prototyping facilities, testing & analytical facilities to facilitate the entire product and technology value chain to final commercialisation. These facilities are expected to (i) Strengthen biobased SMEs' competitiveness and R&D competency through provision of infrastructures for applied research to pilot production and commercialization (ii) Develop and grow biobased industries through scientific knowledge, technology transfer and bio-incubation addressing national challenges of industrial development, export-oriented manufacturing, employment and wealth creation; (iii) Advance biosciences technology and knowledge acquisition through tailor made human resource development programmes to promote local content, generate employment and create wealth. (iv) Strengthen regional and international collaborations with scientists and expertise providing access to world class technology, knowledge critical to industries, and R&D bridging biosciences knowledge gaps and adding value to national bioresources for a bioeconomy led society transformation, and; (v) Ensure sustainable utilisation of the existing abundant biodiversity resources through accelerated R&D for industrialisation, environmental protection and conservation.

The Covid-19 pandemic has catalysed a new wave of innovation that is enhancing the integration of biobased herbal remedies and indigenous knowledge into the health care system. A typical case is the development of a herbal coronavirus disease remedy, Covidex. The remedy was developed at Mbarara University of Science and Technology under the pharm-biotechnology and traditional medicine centre (PHARMBIOTRAC) with support from the government through the ministry of Science, Technology and Innovation. Government has now integrated Covidex into the healthcare system as one of the supportive therapies against Covid-19 and other respiratory viral infections. Government is supporting the scaling up of its production by establishing a production facility in Soroti, Eastern Uganda.

Researchers and innovators have also leveraged modern material process development to develop new biodegradable packaging materials. Researchers from Makerere University have used micro fibrillated cellulose as a novel material from plant fibres to produce a low-cost bioplastics packaging material.

Another contemporary bioeconomy innovation is currently harnessing the lifecycle the black soldier fly to process organic waste into sustainable and high-quality animal feed that can be fed to fish, pigs and chickens. The innovation uses urban organic waste to feed Black Soldier Fly larvae which are then harvested after a 15-day rearing period. They are then dried and processed into high-quality protein feed for livestock production. The processed product provides high quality protein feed for poultry, pigs, and fish, while the leftover by-product is organic fertiliser.

Emerging
(or future)
bioeconomy
market/
development
opportunities.

Availability of ready markets for bioproducts in the neighbouring countries has been identified as one of the opportunities that Uganda could tap into.

One of the objectives of the proposed bioeconomy policy is to promote and utilise bioscience research and innovations for national transformation. The policy seeks to do this by supporting the production of a variety of novel and healthy food and feed products for the growing local and international markets. The proposed policy enjoins government to explore and promote national, regional and international markets for locally generated bio-products and services.

Existing gaps,
challenges and
needs

The development of a vibrant bioeconomy in Uganda is currently hampered by a number of constraints. There is unsustainable production and under-utilisation of living materials and services thereof in Uganda due to limited research and innovation and value addition capability to bioresources. This is attributed to among others; lack of an enabling policy, legal and regulatory environment; weak coordination of bioeconomy stakeholders; sub-optimal productivity of bio-based enterprises; low use of alternative sustainable bio-innovations as a result of low awareness; limited exposure; and unfavourable market conditions.

Uganda does not have legislation over use of Traditional Knowledge associated with Genetic Resources.

Seeking intellectual property rights (IPR) such as patent rights internationally through the World Intellectual Property Organization (WIPO) is a long and expensive process. On the other hand, the alternative of prosecuting IPR through Trade Secret and confidentiality agreements is not yet fully appreciated in Uganda.

Some of the interventions that could be undertaken in order to address the above challenges include:

- Development of a bioeconomy policy and regulatory framework as well as a national strategy.
- Fostering effective collaboration between different Bioeconomy stakeholders
- Increasing stakeholder awareness and acceptance of bio-innovations and empowering the citizens to participate in and take up bioeconomy opportunities.
- Creating awareness about the IPR and its role in promoting bio-innovations
- Developing a catalogue of bioeconomy resources and products in Uganda
- Supporting the development of products and services from biological resources through research and innovation
- Establishing and supporting infrastructure to facilitate current and future industrial bioeconomy development
- Promoting the development of a circular economy to ensure cleaner production programmes.

7.0

CREATING AN ENABLING ENVIRONMENT

A number of enabling factors have been identified that need to be addressed in order to fulfill the promise of bioeconomy development in the region. These are discussed below, with suggestions for actions that would at least go some way towards bridging the gap between the current situation and the building of a vibrant bioeconomy.



The FAO has recently published a Crop Sector Development Strategy for Eastern Africa 2021-2026⁶⁴, which emphasises that Eastern Africa has the lowest agricultural productivity in the world, and details a number of interventions necessary to remedy this situation. This document identifies four strategic pillars, namely: i) an enabling policy environment; ii) a strong institutional environment; iii) enhanced crop production and productivity; iv) processing and value-addition; and v) market access. Since relevant interventions are detailed in the FAO Strategy, these will not be repeated here, but a few examples where progress is being made are given to demonstrate some of the opportunities.

The adoption of improved seeds has been low in the region, in part due to the reliance on traditional seed systems, by which farmers pass on seeds to one another that never enter into a formal channel. Efforts are being made to incorporate partnerships between farmers and the public and private sector actors to develop formal seed systems by which farmers can have access to a wider and more reliable range of seeds. This needs to be ramped up, and moreover access to seeds improved using techniques of modern biotechnology needs to be facilitated.

Eastern African farmers also have very low levels of mechanisation, but mechanisation is increasingly being recognised as a powerful and feasible tool for productivity growth for smallholder farmers. Schemes are emerging to overcome barriers that limit access to tractors and other equipment, such as schemes where farmers can affordably hire tractors for short term use, allowing them to make use of the productivity-enhancing technology without needing the significant capital investment of buying the machines outright. However, there remain considerable challenges for wide access to mechanical tools for smallholders, and continued efforts from both public and private interests will be necessary if mechanisation is to continue playing a role in closing the agricultural productivity gap⁶⁵.

The use of digital tools has the potential to overcome many barriers for small scale farmers, facilitating access to extension and advisory services, as well as access to markets. As an example, one Kenyan company, Twiga Foods, uses a mobile-based platform to connect farmers directly to buyers of horticulture produce, thereby cutting out middlemen in the supply chain. It uses a network of collection points and delivery vehicles to distribute produce efficiently. Similarly, cutting the number of steps in the supply chain could reduce the costs of fertiliser and other inputs for farmers.

Digital tools also provide access to reliable weather information, which can assist farmers in making decisions when to sow, plant or harvest.

While agriculture as a sector is regarded as risky for banks to lend to, smallholder farmers in particular are often deemed risky for loans and investments. This is partially due to low financial literacy, but primarily to the difficulty in determining farmers' creditworthiness and default rates on loans. Although there are some examples of linking smallholder farmers directly to microfinance institutions in rural areas, these have not reached scale. In this context, digital technologies need to be promoted to help lower the risks associated with agricultural lending and establish trust between farmers and other value chain actors, including farmer organisations and financial institutions⁶⁶.

⁶⁴<https://www.fao.org/3/cb5903en/cb5903en.pdf>

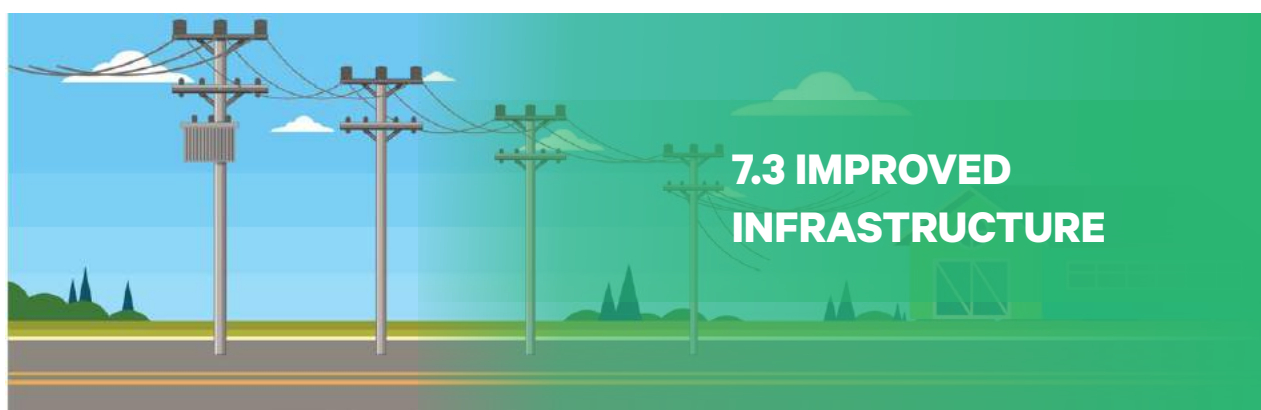
⁶⁵Thompson, T. and Gayatso, T. 2020. <https://globalagriculturalproductivity.org/technology-adoption-for-improving-agricultural-productivity-in-sub-saharan-africa/>

⁶⁶Malabo Montpellier Panel 2019. Byte by Byte. Policy Innovation for Transforming Africa's Food System with Digital Technologies. https://www.mamopanel.org/media/uploads/files/2019_MaMo_Digital_Report_ONLINE_UiUPwum.pdf



7.2 BIOPROSPECTING FOR NOVEL BIORESOURCES AND USE OF INDIGENOUS KNOWLEDGE

The countries in Eastern Africa are endowed with a rich biodiversity, but only a small fraction of what would be potentially useful supporting biobased sustainable economic growth is used. Bioprospecting is the systematic search for biochemical and genetic information in nature in order to develop commercially valuable products for pharmaceutical, agricultural, industrial and other applications. Although there is considerable indigenous knowledge on how to use biodiversity for various purposes, this knowledge is seldom captured and used in efforts to develop biobased business and enterprises. A systematic approach to search for valuable genetic resources and associated indigenous knowledge that can propel economic growth would be strategic for the region. Bioprospecting activities must comply with the Nagoya Protocol and as stated in any national law or policy, ensure proper benefit sharing and acknowledge the ownership of knowledge and the genetic resource. Conserving and protecting the biodiversity and its ecosystem functions, must also be considered in any bioprospecting activity in the region.



7.3 IMPROVED INFRASTRUCTURE

Investments in infrastructure in the region have concentrated on transport, water and sanitation, energy and ICT. There have been steady increases in infrastructure funding in the region, with a 14% increase between 2017 and 2018⁶⁷. However, a considerable part of this investment has come from China, with associated concerns about the extent of Chinese influence. The EAC sees transport and communications infrastructure as a critical enabler for regional integration.

Transport infrastructure is particularly important in facilitating access to markets for agricultural produce. Moreover, much of the untapped agricultural land that could potentially be used is in unreachable areas because of lack of infrastructure⁶⁸.

Another key infrastructure requirement, which has received less attention to date, is the provision of facilities for the storage and preservation of fresh produce. Currently, small scale farmers in the region lose up to 40% of their produce due to post harvest losses caused by inadequate storage. However, there are some private businesses in the region that are starting to produce silos and cold storage solutions. Government support for investment in this area could have a major impact to roll out the implementation of storage facilities.

⁶⁷The Infrastructure Consortium for Africa. 2018. https://www.icafrica.org/fileadmin/documents/IFT_2018/ICA_Infrastructure_Financing_Trends_in_Africa_-_2018_Final_En.pdf

⁶⁸Goedde, L. et al. 2019. Winning in Africa's Agricultural Market. <https://www.mckinsey.com/industries/agriculture/our-insights/winning-in-africas-agricultural-market>



7.4 THE IMPORTANCE OF SMALL AND MEDIUM ENTERPRISES (SMEs)

The development of small and medium enterprises (SMEs) and community driven value addition initiatives, such as cooperatives, in Eastern Africa is crucial for the bioeconomy to have a societal and economic impact in the region. Apart from being effective in generating employment opportunities, start-ups and SMEs are often pioneers and promoters of innovation in the bioeconomy, but they need access to technology, know-how, capital and markets. It is therefore important to create an enabling environment for bioeconomy innovations, paying attention to the needs of young innovators and the use and deployment of the rapid advancements of the modern biology. Biologically based processes require a new technological and managerial base, which in turn demands a reorganisation of technical, production and management skills. A major barrier for African enterprises is however the lack of skilled staff, engineers and technicians able to adopt, implement and upscale technologies for value addition and processing. Building skills in the SME sector to add value to primary produce and convert waste to useful products is therefore an essential component of the development of the Bioeconomy in Eastern Africa.



7.5 BETTER LINKAGES BETWEEN ACADEMIA AND INDUSTRY

There are mutual benefits to be gained from strengthening the links between universities and industry in the region. To remain relevant, universities need to train graduates who fit the job market. Besides their academic training, students need to gain an understanding of business, and develop an entrepreneurial mindset. The public R&D sector often plays a strategic role in the adoption of new knowledge and technologies crucial for the development of bioeconomies in the region. However, for public organisations to be effective in technology transfer and dissemination, they need to build capacity in this area. This includes the development of institutional policies and structures on public-private partnerships that foster entrepreneurship and innovation. Apart from maintaining highly trained academic staff and incorporating new bioeconomy innovation curricula they also need to reward and strengthen entrepreneurship skills and establish conducive institutional policies for university staff disseminating and sharing knowledge with private sector partners, and potentially starting spin-off companies.

Although public R&D is important for inclusive knowledge development, public research organisations and universities have not been effective in moving ideas and technologies beyond research into the market space. The private sector in Eastern Africa is crucial in this endeavour, and is key to search for and exploit market opportunities. However the private sector in Eastern Africa is still weak, particularly in the area of biobased enterprise development and therefore largely unable to drive the innovation needed for bioeconomy development on its own. Encouragingly enough, many industries now realise that universities could open up great opportunities to an enormous global pool of talent and skills.

The challenge is how to build bridges between the sectors, as the gap between research, private sector and commercialisation is large in the region. One opportunity here could be to develop government supported schemes for matchmaking projects. An example from South Africa is the Technology and Human Resources for Industry Programme (THRIP), which is a government-academic-private sector partnership established to respond to the shortage of high-level technical skills required by industry. This government funded programme provides financial support to research collaborations between businesses and the education sector.

Linking private and public actors is however often not enough. There is also need for professional incubating services, assisting the innovation process and ensuring that all actors in the innovation system are properly supported so that they can fill their complementary roles. Bioincubation facilities supporting the introduction of new biobased products and technologies to the market provide a function that is largely missing in Eastern Africa.

Bioincubators also serve a key role in supporting the development of start-up biobusinesses and early stage technologies, while business accelerators promote the growth of existing businesses. Services provided include mentoring, training and networking, as well as funding, however financial sustainability is challenging.⁶⁹ While incubators and accelerators exist in the region, few are focused on the bioeconomy sector. The BioInnovate Africa programme plays a significant role in bioincubation, and has had significant success in funding academic projects that involve an industrial partner. However direct investment from industry for projects of this nature needs to be further stimulated and more dedicated bioincubators are needed.

One successful programme to develop entrepreneurial skills in the region is STEP (Student Training for Entrepreneurial Promotion)⁷⁰. It provides entrepreneurial training to partner educational organisations in various countries around the world, including Uganda, Kenya, Rwanda and Tanzania. In this programme, trainees start their own businesses and learn by doing. Programmes of this nature, where focused on academics and students with an interest in bioeconomy entrepreneurship, have the potential to kickstart the growth of biobased SMEs.

⁶⁹Landscape Study of Accelerators and Incubators in East Africa. <https://www.galidata.org/publications/the-accelerator-and-incubator-landscape-in-east-africa/>

⁷⁰<https://step-training.com/>



All the countries in the region have embraced or are piloting different tools, agro-based clusters and platforms to promote agro-industrial development, which will serve as a base for expansion of biobased business enterprises. A clear example is provided by Ethiopia, which is establishing Integrated Agro-Industrial Parks. These serve to provide economies of scale, as well as offering a variety of training opportunities to support the agroprocessing sector. Across the region, there are also many opportunities to develop smaller, community based integrated processing centres.

In knowledge-based bioeconomies biorefineries will play a central role. The objective of a biorefinery is to develop as many product and value streams as possible from biomass. This optimisation and efficiency are essential for economic and environmental sustainability. To remain economically competitive, they must innovate continuously, increase efficiency, and develop new product and value streams. Biorefineries must seek to maximise the use of biomass, recycle waste streams as input for new product streams, and utilise heat from primary processes as energy for secondary processes. Investment costs into new industrial biorefineries are very high and an option may therefore be to convert and upgrade some of the existing agroprocessing facilities into more fully fledged biorefineries. In most parts of Eastern Africa, systems for cost effective harvesting, collection, transport, storage and processing biomass feedstocks will be complex and challenging and will require capacity building and substantial infrastructure investments. Since it is inefficient to transport biomass long distances, it should ideally be processed close to the site where it is harvested or acquired. This may in many cases overturn the traditional economy of scale model and favour development of a first generation of small scale, local Eastern African biorefineries with low cost, robust, well proven technologies.



The ability to assess the commercialisation potential of technologies and products is weak in the region. If an innovation is expected to be developed and disseminated by a private company, or through a public-private partnership it is important to be able to demonstrate the relevance, the economic viability and the market potential of the technology/new knowledge. This implies, in addition to scientific evidence, economic and/or marketing analysis in the design of innovations, the building of expertise, in academia and in the private sector for market assessment of the economic/market potential and techno- economic viability of innovations. Regular studies on the economic, environmental, resource-effectiveness and health effects of adopting bioscience-derived products in Eastern African countries are also important. These would help answer some of the concerns about safety and socio-economic effects of the use of bioscience technologies and also support future policies and funding strategies. These studies could be made by interdisciplinary consortia of scientists in the region and possibly linked to a peer review by high-quality international experts.



7.8 IMPROVED ACCESS TO FINANCING AND VENTURE CAPITAL FOR INNOVATION AND DEPLOYMENT.

While historically there has been insufficient access to venture capital or private equity funds in the region to facilitate the deployment of innovative ideas, this is starting to change. Several investment funds are now offering early stage investment support, although all these investment funds are incorporated outside Eastern Africa, mostly in European countries, primarily due to beneficial tax arrangements. The vast majority of investment funds are foreign, typically development finance institutions, but there is a dearth of local capital, both from local pension funds and from high net worth individuals in the region. This can be attributed to the fact that venture funding in the region is still a recent development, and local investors tend to be risk-averse to something they are unfamiliar with⁷¹.

Several factors currently hamper the growth of venture capital funds. Transactional costs are high, as well as the complexity of doing business. Entrepreneurs lack trust and understanding of venture capital, being more accustomed to financing their work through commercial loans. The lack of trust can lead to long lead times between identification of a funding opportunity and a deal being struck. In addition, a number of businesses that investors get involved in tend to need a lot of work to bring them up to standard in terms of effective operations and governance. Nevertheless, as familiarity with venture capital grows, and entrepreneurs develop increasing business skills, there is a real prospect of overcoming many of the hurdles in this area.



7.9 ENABLING CONDITIONS FOR EXPORT OF AGRO- AND BIO-PRODUCE

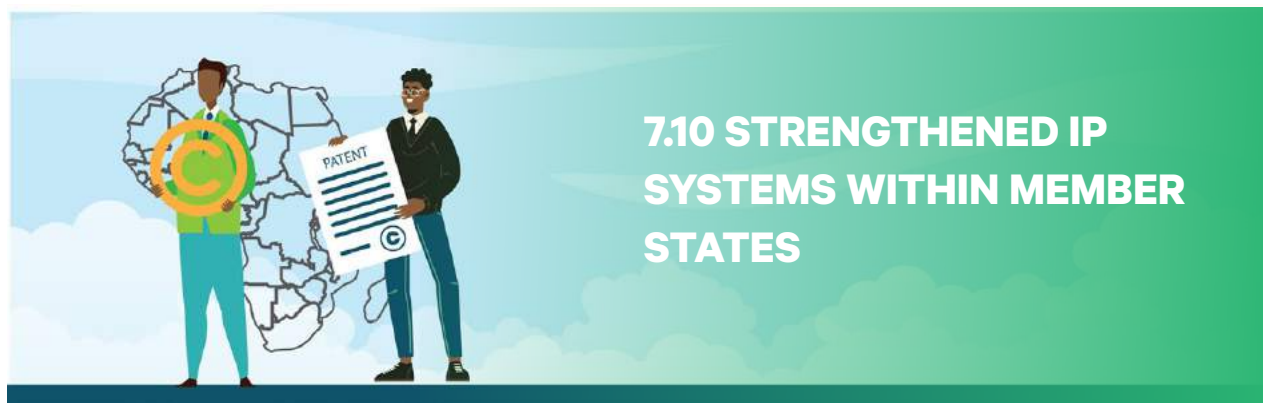
Enabling conditions for small scale farmers, processors and bioentrepreneurs to meet quality and regulatory requirements to access markets in developed countries is crucial for the region.

The European Union in particular has stringent food safety standards, and sets maximum levels for a variety of chemical and biological contaminants. Even within the Eastern Africa region, there are standards on issues such as mycotoxins in food commodities, which regulate trade and make it difficult for small scale entrepreneurs in Eastern Africa to meet the safety requirements. In Uganda, for example, rules require exporters to submit a certificate of aflatoxin analysis from one of the three nationally recognized labs for every consignment. Only large firms have the resources to comply. Similarly, at the consumer end of the value chain, only large industrial mills can afford laboratory tests required by regulators. Meanwhile, smaller traders and SMEs navigate around the regulatory system, which is poorly enforced in the region⁷². Yet, the Africa Free Trade Agreement may favour other exports in the region as is the current case.

⁷¹Gugu, S. and Mworira, W. 2017. Venture Capital in East Africa: Is there a Right Model? https://www.researchgate.net/publication/310499076_Venture_Capital_in_East_Africa_Is_There_a_Right_Model

⁷²Keyser, J.C.; Sela, S.R. 2020. Innovations in Food Trade : Rethinking Aflatoxin Management in East Africa. World Bank Group. <http://documents.worldbank.org/curated/en/278421605883762320/Innovations-in-Food-Trade-Rethinking-Aflatoxin-Management-in-East-Africa>

There are various certification schemes for good agricultural practice such as GlobalGAP, Fairtrade etc which have definitive sets of rules for growers to follow. For products to reach the shelves in supermarkets in developed countries, the suppliers generally have to achieve certification, which is beyond the reach of many smallholder farmers. However, there are some initiatives whereby certification can be achieved at the level of farmer groups. These facilitate joint investments that reduce the cost of investing in assets such as grading sheds, protective gear, shower rooms, disposal pits, incinerators, hessian coolers, packaging crates, soil testing kits and establishing food traceability systems.



All of the countries in Eastern Africa have at least one national IP law or framework that governs intellectual property rights, as well as legislation covering plant variety protection and plant breeders' rights. However there are a number of challenges, not least due to the fact that there is no harmonisation between IP regimes in the region. Only four of the countries in the region are members of the African Regional Intellectual Property Organization (Kenya, Uganda, Tanzania and Rwanda). Even though each of the Partner States has at least a national industrial property or copyright office for administering IPRs, these are in many cases weak and underfunded, and some have inadequate capacity to conduct substantive examination of patent applications.

At the level of the EAC, Article 43 of the Common Market Protocol on co-operation in IPRs obliges the Partners to co-operate in the field of IPRs in order to “promote and protect creativity and innovation for economic, technological, social and cultural development in the Community; and enhance the protection of IPRs”, while Article 47 obliges Partner States to approximate their national laws and to harmonise their policies and systems. Despite this, there is currently no harmonisation of the various IP laws within the EAC region⁷³, and the lack of a unified framework causes delays and lack of action or follow-up on IP enforcement within and across borders. A concerted effort to address this issue at the level of the EAC would result in benefits for all the countries in the region.

There is also a need to increase awareness of intellectual property issues amongst the population at large. For scientists and entrepreneurs who are engaged in developing products for the bioeconomy, more needs to be done to promote knowledge in this area. This relates both to the protection of their own intellectual property, as well as to raise awareness of pre-existing IP that may impact on their freedom to operate.

⁷³Intellectual Property Rights Regime Within the East African Community. 2017. <https://www.aca.go.ke/images/downloads/publications/Intellectual-Property-Rights-Regime-Within-the-East-African-Community.pdf>



An appropriate policy environment needs to be ensured by enacting new but also harmonising existing relevant legislation, policies and standards in the region to support bio-innovation, and bio-businesses. Governance policies and strategies are needed to ensure that bioeconomy development is used as a vehicle to promote food security, sustainable economic growth, job creation and safeguard the environment. Such an enabling policy environment includes harmonised policies, regulations, product efficacy and safety standards supporting (not stifling) innovation, development and deployment of biobased products, such as; biopesticides, growth promoting biologicals, biobased packaging material, health and wellbeing products, novel foods and bioenergy carriers.

The Treaty for the establishment of the EAC requires member states to harmonise all their national laws pertaining to the Community. Much more still needs to be done however, to implement this in practice. There are already some initiatives to harmonise legislation. For example, at the level of the African Union, the African Medicines Regulatory Harmonization (AMRH) Initiative is an attempt to strengthen regulatory capacity, encourage harmonisation of regulatory requirements and expedite access to good quality, safe, and effective medicines. As part of this initiative, the EAC has agreed to harmonise guidelines for registration of medicines and GMP inspections, providing a simplified process for manufacturers intending to lodge an application in any of the countries⁷⁴.

A number of EAC Protocols already exist which relate to harmonisation in the EAC on matters that relate to the bioeconomy. These include a Protocol on Standardization, Quality Assurance, Metrology and Testing; a Protocol on Environment and Natural Resources Management; and a Protocol on Sustainable Development of Lake Victoria Basin. An EAC Sanitary and Phytosanitary Protocol has recently been ratified, which aims to establish common EAC procedures and certification schemes in the regulation of the import and export of food and food products; plants and plant protection agents; and animals and animal protection products, thereby enhancing food safety, animal health and plant health in the region⁷⁵.

Various policies, strategies and guidelines relevant to bioeconomy development have also been published by the EAC⁷⁶. Of particular relevance are the Science, Technology and Innovation Policy, the Food and Nutrition Security Action Plan 2019-2023, an EAC Livestock Policy, as well as Guidelines for the Registration of Biopesticides and Biocontrol Agents.

An ongoing challenge is to ensure that the various policies, strategies and guidelines developed at the EAC level become embedded in legislation at the national level. Additionally, mutual recognition agreements must be in place and implemented in all sectors relevant to the bioeconomy, ensuring that even where legislation is not fully harmonised, a product approved in one country in the region can be automatically approved in other countries in the region without requiring further testing and registration.

⁷⁴Ndomondo-Sigonda, M. et al. 2021. Harmonization of medical products regulation: a key factor for improving regulatory capacity in the East African Community. <https://bmcpublihealth.biomedcentral.com/articles/10.1186/s12889-021-10169-1>

⁷⁵EAC Information Repository. <http://repository.eac.int/handle/11671/467>

⁷⁶<http://repository.eac.int/handle/11671/473>

A close-up, high-angle photograph of a large pile of light-colored wood pellets. The pellets are cylindrical and densely packed, filling the entire frame. The lighting is warm, highlighting the texture and natural grain of the wood. A semi-transparent teal gradient is applied to the bottom half of the image, creating a modern, professional look.

8.0

WAY FORWARD

The development of bioeconomies in the countries in the region has a large potential to support economic growth and sustainable development. However, it will only be achieved through strong leadership from governments, with the provision of appropriate policies and incentives. Regional and international cooperation will also be important components in this endeavour. Below follows a list of ten recommended key actions that can be taken at national and regional level in support of bioeconomy development.



1. Developing national bioeconomy strategies. The newly adopted regional Bioeconomy Strategy needs to be followed by the development of national bioeconomy strategies, anchored and linked to existing bioeconomy related national strategies and policies with detailed action plans, policy agendas and roadmaps relevant and appropriate for bioeconomy development for each country in the region. In concert with this, the EAC Regional Policy for Science, Technology and Innovation (STI) should include mechanisms for the sustainable financing of STI initiatives in partner countries, including bioeconomy initiatives. This should include mechanisms, such as an EAC Research and innovation fund, and calling for EAC Partner States to make annual contributions towards STI initiatives and bioeconomy development



2. Monitoring and sharing information. Monitoring and information sharing on bioeconomy development at national and regional level will enable benchmarking and allow actors across the region to identify progress, challenges, and gaps and weaknesses with regard to bioeconomy development and provide a basis for potential interventions. A functional regional bioeconomy observatory (<https://bioeconomy.easteco.org/>) has been established sharing data and information on the bioeconomy progress in the region, guiding and supporting bioeconomy development at national level. The data and information need to be continuously updated in order for the observatory to be useful for the region. Initiatives to establish projects and programmes evaluating and systematically mapping strategic bioresources providing the basis for future bioeconomy investments and capacity building initiatives would also be important in this regard.



3. Developing a regional expert Bioeconomy Committee/Think Tank sharing information and providing advice to regional bodies and country governments and government institutions in the region on the implementation of bioeconomy strategies.



4. Harmonising standards and regulations for biobased products. Regional integration, through the creation of common markets for biobased products, needs to be developed to support biobased economic growth in the region. Today common standards for biobased trade in regional markets (e.g standards for fuel blending, biofuel, biopackaging, biopesticides etc) are largely lacking in the region. The region also lacks clear and coherent standards for novel food products which hampers innovation on novel foods. Thus, regional harmonisation of food safety and food content regulations and common policies, regulations and standards, including intellectual property regimes, supporting (not stifling) development and deployment of biobased products ensuring product efficacy and safety are required. Consideration also needs to be given to ensure that import tariffs, such as for bioprocessing equipment, are not punitive. Depending on needs, aspirations and willingness to promote innovation in this area policy makers need to consider how to ensure that regulations, including GM legislation can keep pace with the rapid technology development.



5. Improving bio-business environment. Currently the policy environment in the region stifles innovation and entrepreneurship. Policies are needed that provide motivation for innovators to translate innovations into businesses, support SME growth, business-to-business (B2B) collaboration and ease of doing business, incentivising the bio-businesses. Supporting private sector actors to meet their business development needs is also required. Public procurement regimes catalysing and supporting the development of biobased value chains and sustainable production need to be developed.



6. Business incubation. Professional business incubation services to assist innovation actors with business development and commercialising promising products and technologies is a key building block in modern bioeconomies. There are few business incubation actors in the region, and increased Investment by country governments and other donors would catalyse the bioeconomy development in the region. Organisation of technology fairs to provide an opportunity for entrepreneurs and potential investors to link up could be part of such incubation. Support to community driven value addition processes is also needed to ensure an inclusive bioeconomy development. These could be in the form of co-operatives, or formation of smallholder-based companies specialising in value addition to a specific bio-resource or a range of bioresources.



7. Capacity building at multitude levels is needed, including

- ◇ Coordinating current R&D institutional arrangements in terms of their mandates, functions and activities in respect of bioeconomy-related issues.
- ◇ Maintaining highly trained academic staff at public R&D institutions offering competitive remuneration and career opportunities
- ◇ Enhancing capacity and developing up to date curricula in modern biosciences and related technologies, including synthetic biology, nanotechnology and bioinformatics, digitalisation and block chain technologies. For the health sector, building expertise in drug development, clinical trials and regulatory aspects is key.
- ◇ Strengthening capacity in bioprocess engineering and valorisation of primary produce, including the construction and engineering of highly efficient and sustainable bioprocessing facilities at different scales, including modern biorefineries.
- ◇ Building know-how in entrepreneurship at public sector institutions, including business planning and business management. This needs to go hand in hand with policies and incentives for staff to develop spin-off businesses.
- ◇ Establishing and/or strengthening technology transfer offices in universities and research institutes to provide support for techno-economic analysis, IP management, and linkage with the private sector.
- ◇ Strengthening key institutions and encouraging collaboration both regionally and nationally, where countries in the region can share specialised competence centers (e.g. universities, research institutions) distributed within the region through student exchange programmes etc.



8. Investing in Innovation Infrastructure and centres of excellence

Countries in the region need to establish centres of excellence and collaborative regional bioeconomy STI programmes to access new and relevant technologies and bioeconomy know-how and adapting these to local needs and opportunities for value addition to primary produce and biowaste. This includes development of biorefinery structures and agro-industrial development centres, including the development of local and community-based bioprocessing structures.



9. Attracting venture capital and investments. Financing innovation and deployment of novel technologies is a key challenge for the region. Finding functional and innovative funding models will be crucial for development of bioeconomies in Eastern Africa. This will not be easy. Setting up investment agencies for novel technologies including bioeconomy development at regional and national basis with the task of attracting strategic investments in the region is one first step. Government funding, possibly leveraging donor funds, and providing support for start-up businesses with potential to develop innovative bioproducts or services for sale on emerging national, regional but also international markets would be strategic. Such support would also include entrepreneurs ready to launch market-changing companies – i.e., early investment in selected companies with well-defined plans for a technology-based product or services.



10. Supporting networking and clustering. Policy makers in the region need to find ways to support collaborative platforms and clustering of bio-entrepreneurs and biobased SMEs enabling them to share experiences and knowledge and providing them with B2B opportunities. This may involve forming Bioentrepreneurs Associations at local, national and also regional levels providing stronger voices for bio-entrepreneurs and biobased SMEs and their role in propelling bioeconomy development in the region.



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