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THE EAST AFRICAN REGIONAL BIOECONOMY STRATEGY 2021/22–2031/32

June 2022

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2021/22 – 2031/32

VISION

"A vibrant, inclusive and innovative bioeconomy contributing to sustainable economic growth and development in East Africa."

MISSION

"To catalyse and support innovative and sustainable use of bioresources as the major driver of inclusive economic growth and job creation in East Africa."

THEME

"Creating sustainable economic growth through innovation"

June 2022

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List of Acronyms

AfDB	African Development Bank
B2B	Business to Business
BecA	Biosciences East and central Africa
CAGR	Compounded Annual Growth Rate
CFTA	Continental Free Trade Area
COSTECH	Commission for Science and Technology
CSO	Civil Society Organisation
CTA	Cotton, Textiles and Apparel
EAAPP	East African Agricultural Productivity Program
EAC	East African Community
EU	European Union
GDP	Gross Domestic Product
GHG	Green House Gas
ICT	Information, Communication and Technology
IEA	International Energy Agency
ILRI	International Livestock Research Institute
IP	Intellectual Property
KRA	Key Result Area
NARI	National Agricultural Research Institute
OECD	Organisation for Economic Cooperation and Development
PPP	Public Private Partnership
R&D	Research and Development
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
SDG	Sustainable Development Goal
SME	Small and Medium Enterprises
SSA	Sub-Saharan Africa
STA	Strategic Thematic Area
STI	Science, Technology, and Innovation
TAGDev	Transforming African Universities to Meaningfully Contribute to Africa's Growth and Development
UK	United Kingdom
UNECA	United Nations Economic Commission for Africa
US$	United States Dollar
WHO	World Health Organisation

Foreword

Bioeconomy is the knowledge-based production and use of biological resources to provide products, processes and services in all economic sectors within the frame of a sustainable economic system. The promotion of bioeconomy is high on the agenda of many East African Community (EAC) Partner States 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 bioeconomy is that it builds value around local bioresources, maximising and using all parts of primary produce and their products.

Countries in the region are at the phase of rapid population growth, and are confronted with the urgent need to stimulate 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.

Currently, 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. This therefore provides a huge potential to add value to these biological resources through the development of a bioeconomy. The growth of Bioeconomy, therefore, offers an opportunity for countries in Eastern Africa to advance towards achieving many of the Sustainable Development Goals by 2030, through 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 growth of bioeconomy offers opportunity for exploring new forms of sustainable bioenergy, and the conversion of waste materials to useful products, which play an important role in protecting the environment and combating climate change.

EAC Partner States share many bioresources, have similar agro-ecological conditions, and host a number of similar bio-industrial platforms. This is therefore an opportunity to build a regional framework to harmonize and synergize bioeconomy activities in the region. EASTECO in collaboration with stakeholders, developed the East African Community Regional Bioeconomy Strategy to respond to this need. The 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. Development of modern bioeconomy is envisaged to deliver sustainable industrialization; job creation and green growth; improved food security; improved health; new bio-based products; link 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 *EAC Regional Bioeconomy Strategy* as a tool to catalyze and support innovative and sustainable use of bioresources as the major driver of inclusive economic growth and job creation in East Africa.

Hon. Betty Maina
Chairperson
EAC Council of Ministers

Preface

Article 5 (1) of the Treaty on the establishment of the East African Community (EAC) outlines the objectives of the Community as, “to develop policies and programs aimed at widening and deepening cooperation among the EAC Partner States in political, economic, social and cultural fields, research and technology, defence, security and legal and judicial affairs, for their mutual benefit.

The development of policies and strategies aimed at sustainable use of bio-resources is one among many interventions necessary to achieve the objectives of the Community. Promotion of the Bioeconomy is highly placed on the political and business agenda for many countries globally, as a major strategic driver for the transformation of bio-based 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. The central element of bioeconomy is to build value around local bioresources.

A regional Bioeconomy Strategy is therefore important in setting the regional agenda on priorities interventions, besides creating harmony and synergy in the judicious use of bioresources among Partner States. It will enhance collaboration in many areas including; aligning policies promoting innovation and trade; harmonization of regulations and standards for bio-based 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; and increasing the attractiveness of the region for investments, for both local and foreign investors in bio-based industrial development.

The development of the Regional Bioeconomy Strategy for East Africa began in 2018, under the project aimed at developing an Innovation-led Bioeconomy Strategy for Eastern Africa (BiSEA). The BiSEA project was implemented by the East African Science and Technology Commission (EASTECO) and was supported by the BioInnovate Africa Programme based at the International Centre of Insect Physiology and Ecology *(icipe*) in Nairobi, Kenya. The participating countries included Burundi, Kenya, Rwanda, South Sudan, Tanzania, and Uganda. *The strategy* provides a framework for the consolidation of agreed goals and interventions that countries in East Africa can use to achieve the SDG Agenda 2030, the continental aspirations in AU Agenda 2063, and the regional aspirations in EAC Vision 2050. This strategy builds upon existing national and regional science, technology, and innovation (STI) policies and related instruments aimed at creating an enabling environment for increased STI investments to support sustainable development and socio-economic transformation. The strategy is aligned to expressed commitments to environmental sustainability, climate change adaptation and mitigation aimed at reversing unsustainable policies and practices. This strategy will therefore offer an opportunity for countries in East Africa to achieve many of their individual aspirations, making use of the region’s abundant natural resources, including underutilized agricultural waste materials, to produce value-added products with applications in many sectors including food, health, energy and industrial goods, thereby creating jobs opportunities, generating wealth, and connecting smallholder farmers to new bio-based value chains.

Further, the strategy will enhance the sustainable production and exploitation of biological resources and knowledge to support; food and industrial feedstock production; a diversified industrial sector producing a range of bio-based products including high-quality foods, feeds, chemicals, pharmaceuticals, textiles, and construction products, and protection of ecosystem

services and mitigation of climate change. The strategy will enhance the transformation of economies and place innovation in bio-based products and processes at the centre, with a bio-based circular economy as the organising framework. The strategy is anchored on four thematic areas including: Food security and sustainable agriculture; Health and well-being; Sustainable Energy, and bio-based Industrial Development.

The private sector has been earmarked as a key stakeholder in bio-based products, processes and business. It is envisaged that the East African Regional Bioeconomy Strategy will contribute immensely to the East Africa we want, through effective, efficient and sustainable production and use of biobased materials, products, processes and business models to drive the sustainable development of our region.

Hon. (Dr). Peter Mutuku Mathuki
Secretary General
The East African Community

Executive Summary

Bioeconomy Development – An Opportunity for East Africa

Modern biology allows for the development of a diverse range of novel bio-products with new functionalities and with potential applications in many areas, e.g., food, pharmaceuticals, chemical and energy sectors. 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 the products thereof.

The development of a modern bioeconomy in East Africa including Burundi, Kenya, Rwanda, South Sudan, Tanzania, and Uganda, 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., bio-fertilizers, bio-packaging) to substitute products derived from petrochemicals (or to satisfy growing demands from consumers (e.g., functional foods, special dietary needs, novel health, and well-being products).
- **Linking farmers and bio-entrepreneurs to market opportunities** and to local, national, regional, and international markets. New biobased value-added products attractive on a world market can assist the private sector in East Africa to expand and improve their 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 fuelwood that leads to deforestation and environmental degradation.
- **Protecting the environment** through converting waste, which today threatens ecosystems and freshwater resources, to useful products**.**

This Regional Bioeconomy Strategy provides a compelling framework for putting in place agreed goals and interventions which countries in East Africa can use to achieve the continental aspiration of integrating its *Agenda 2063 and the UN 2030 Agenda for Sustainable Development* into intersectoral national development plans, and the regional aspiration contained *in EAC Vision 2050,* in which Member States aspire to become middle-income countries.

Bioeconomy in the Regional Context of East Africa

Countries in East Africa have a rich biodiversity and strong bio-resource production base. Over 30% of the region's GDP can be directly attributed to agriculture and other bioeconomy related sectors. However, the region has, only to a limited degree, been able to apply technologies and skills 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. Moreover, rural East Africa offers opportunities for expansion of biomass production that would create 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. To date, there has been insufficient development of industrial capacity relevant to the bioeconomy. Fortunately, many 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.

There are, however, generally weak linkages between researchers, research institutions and industry, and funding and financial systems to support the innovation chain through all the stages from research and development to the market are lacking. Inadequate business incubation, financing resources and lack of venture capital severely hamper industrialisation, expansion of biobased production, small and medium enterprise (SME) growth and job creation. Inadequate systems for standard setting, certification, and accreditation of products limits trade of biobased products and makes it difficult for private sector actors to meet regulatory requirements and access markets in developed countries.

There is a positive current trend for harmonisation of policies and strategies in the region, linked to strong regional institutions such as the East African Community, which can facilitate a regional approach to bioeconomy development.

The above is in brief the context that underpins the need for a regional bioeconomy strategy, which considers, harnesses and/or responds to the challenges, and opportunities. This Strategy builds upon existing national and regional science, technology, and innovation (STI) policies and related instruments aimed at creating an enabling environment for increased STI investments to support sustainable development and socio-economic transformation. Moreover, the strategy is aligned with expressed commitments to environmental sustainability, climate change adaptation and mitigation, reversing or changing unsustainable practices.

Strategic direction

This 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 optimization 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, Tanzania, and Uganda.

Vision

A vibrant, inclusive, and innovative bioeconomy contributing to sustainable economic growth and development in East Africa.

Mission

To catalyse and support innovative and sustainable use of bioresources as the major driver of inclusive economic growth and job creation in East Africa.

Overall objective

The overall objective of this Strategy is to achieve economic growth and job creation, making use of the region's bioresources to develop products and services, while contributing to an improved environment and climate change mitigation.

Specific objectives

- *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.

Strategic Thematic Areas

Four priority Strategic Thematic Areas (STAs) form the core of this Strategy (see below). The Key Result Areas (KRAs) within each of the four STAs are also summarised below.

Strategic Thematic Area 1: Food security and sustainable agriculture
The strategic objective of this STA is to *introduce new biobased technologies and solutions to strengthen food and feed production, ensuring food security.* It has three KRAs:

- **Value addition to food crops, livestock, and microbial products:** To promote food crops, livestock, forestry, marine and aquatic resources, and microbial resources to deliver economic growth and provide opportunity to farmers and SMEs by improving productivity and value addition.
- **Novel food and feed products:** To produce a variety of new safe and healthy food and feed products for growing local, regional, and international markets.
- **Biobased agricultural inputs:** To support and enhance sustainable agricultural production through the growth of bio-based agricultural inputs (e.g., biopesticides and bio-fertilizers) produced in the region.

Strategic Thematic Area 2: Health and Wellbeing
The strategic objective of this STA is *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*. It has three KRAs:

- **Biobased pharmaceuticals:** To strengthen bioprospecting and innovation capabilities to screen for and manufacture biopharmaceuticals, diagnostics and vaccines targeting key diseases in the region.
- **Biobased traditional medicines:** To promote indigenous knowledge in traditional medicines through the identification of available biological resources in the region with verifiable and validated health benefits, and to understand the active ingredients involved.

- **Bio-based cosmetics and well-being products:** To develop an East African based personal care industry, basing production on local bioresources and targeting expanding regional and international niche markets. Such production would be based on fair trade values while protecting and sustainably using the biodiversity of the region.

Strategic Thematic Area 3: Biobased Industrial Development
The strategic objective of this STA is *to develop industries that stimulate sustainable economic growth and that add value to under-utilized renewable resources in the region.* It has five KRAs:

- **Bio-based and biodegradable packaging materials:** To develop manufacturing capabilities for standardised bio-packaging materials, together with appropriate regulatory systems and infrastructure.
- **Bioprocessing enzymes:** To maximise the opportunity arising from the region's microbial diversity, through the development of enzymes for industrial applications.
- **Biobased construction materials:** To transform the local construction industry into one that is low carbon and climate smart, and based on locally produced renewable building materials.
- **Bio-based textile fibres:** To achieve a more productive and sustainable textile fibre industry, complemented by the production of a range of textile fibres generated from local agro-waste materials.
- **Renewable bio-based oils:** To develop an industry based on sustainable production of renewable oils derived from the bioresources of the region.

Strategic Thematic Area 4: Sustainable Energy
The strategic objective of this STA *to increase the production and use of sustainable bioenergy, and develop a range of bioenergy products for both household and industrial purposes*. It has three KRAs*:*

- **Biomass briquettes and pellets as alternative to charcoal and firewood:** To promote initiatives in bioenergy briquette and pellet production from waste materials to substantially reduce the unsustainable use of wood fuel.
- **Production of biogas from organic waste:** To stimulate and support uptake of biogas technologies in the region for household and industrial use.
- **Advanced biofuels:** To support the research and development of biofuels produced from lignocellulosic materials and algae.

Key Strategic Operational Enabling Actions

Strategic operational enabling actions are required to help translate the strategic intentions into programmes, and ultimately into outcomes and impacts. The key enablers for successful delivery of the East Africa Bioeconomy Strategy include:

- **An enabling policy environmen**t will be crucial for the successful delivery of the bioeconomy strategy in the region by developing, enacting, and harmonising legislation, policies, and standards in the region to support bio-innovation, and bio-businesses. It is crucial for the region to ensure that bioeconomy development helps to achieve the Sustainable Development Goals (SDGs) and does not undermine food security. Governance polices and strategies are therefore needed to ensure that bioeconomy development is used as a vehicle to promote food security and safeguard the environment.

- **Enhancing the bioeconomy innovation system** will be essential, facilitating the connection of R&D actors and entrepreneurs, especially start-up businesses, to affordable financing. Access to capital and credit facilities under reasonable terms is critical. To successfully bring new bio-products to market, new funding partnerships are necessary, in which innovation, risks and business development costs are borne by several different parties. Professional incubating services are of key importance, supporting the introduction of new biobased products and technologies to the market. Stimulating B2B collaboration and supporting private sector actors in East Africa to collaborate with international companies is also important in this context.

- **Capacity development in all areas of the bioeconomy,** building sufficient capacity in all areas of the bioeconomy value chain. The region will need to build human and infrastructural capacities to harness rapidly emerging technologies and adapt them to local needs, through regional centres and service platforms. Entrepreneurial skills are critical for good ideas to move through to commercialisation. Special support for youth and women entrepreneurs will allow for improvement in gender balance in the region.

- **Coordination, partnerships, communication, public awareness, and effective regional collaboration** are crucial to delivering the objectives of the Bioeconomy Strategy. This requires an understanding of the ever-changing contexts and needs of individual countries. This Strategy proposes a lean, but-fit-for-purpose, coordination and partnership unit embedded in the EAC Secretariat that will provide leadership and coordination to drive implementation.

Glossary of Terms

Agricultural residues. This term is used to describe all the organic materials which are produced as by-products from harvesting and processing of agricultural crops. Agricultural residues which are generated in the field at the time of harvest, are defined as primary or field-based residues whereas those co-produced during processing are called secondary or processing-based residues.

Bioeconomy. In the context of East Africa, bioeconomy is defined as the sustainable production and exploitation of biological resources and knowledge to support: (i) food and industrial feedstock production, (ii) a diversified industrial sector producing a range of bio-based products including high quality foods, chemicals, pharmaceuticals, textiles, construction products, etc., and (iii) robust biodiversity services that support cultural production. An economy which puts innovation in biobased products, processes and business models at the centre and a biobased circular economy as the organising framework.

Bio-incubator. Bio-incubators are typically physical spaces, available on relatively flexible terms, which provide services that generally include provision of training for entrepreneurs, access to networks and specialist equipment. They may also help in developing the business plan and pitch to investors, prototypes, and initial market testing. They may include laboratories with facilities for biological and chemical work.

Biorefinery. Biorefinery is defined as the sustainable processing of biomass into a spectrum of marketable products and energy.

Biowaste. Biowaste is biodegradable organic matter that is currently unused, including waste from households, food processing plants, forestry, and unutilised agricultural residues.

Circular economy. A circular economy is a systemic approach to economic development designed to benefit businesses, society, and the environment. In contrast to the 'take-make-waste' linear model, a circular economy is regenerative by design and aims to gradually decouple growth from the consumption of finite resources.

Ecosystem services. Ecosystem services are the benefits provided by ecosystems that contribute to making human life both possible and worth living. Examples of ecosystem services include products such as food and water, regulation of floods, soil erosion and disease outbreaks, and non-material benefits such as recreational and spiritual benefits in natural areas. The term 'services' is usually used to encompass the tangible and intangible benefits that humans obtain from ecosystems, which are sometimes separated into 'goods' and 'services'. Some ecosystem services involve the direct provision of material and non-material goods to people and depend on the presence of species of plants and animals, for example, food, timber, and medicines. Other ecosystem services arise directly or indirectly from the functioning of ecosystem processes. For example, the service of formation of soils and soil fertility that sustains crop and livestock production depends on the ecosystem processes of decomposition and nutrient cycling by soil micro-organisms.

Fourth industrial revolution. The Fourth Industrial Revolution can be described as the advent of "cyber-physical systems" involving entirely new capabilities for people and machines. The Fourth Industrial Revolution represents entirely new ways in which technology becomes embedded within societies and even our human bodies. Examples include genome

editing, new forms of machine intelligence, breakthrough materials and approaches to governance that rely on cryptographic methods such as the block chain.

Indigenous knowledge. Indigenous knowledge refers to the understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings. It includes specialised knowledge of local ecosystems and human interactions with flora and fauna.

Paris Agreement. The Paris Agreement within the United Nations Framework Convention on Climate Change aims to limit the global increase in temperature to below 1.5°C by reducing Greenhouse Gas emissions. This serves as a driver for fossil fuel divestment.

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Traditional medicine. Traditional medicine refers to the knowledge, skills and practices based on the theories, beliefs, and experiences indigenous to different cultures, used in the maintenance of health and in the prevention, diagnosis, improvement, or treatment of physical and mental illness. Herbal medicines are the most popular forms of traditional medicine.

1. Background

In the face of rapid population growth, policy makers in East Africa – as is the case elsewhere in Africa – are confronted with the urgent need to increase the rate of economic growth, create new jobs, and provide opportunities for youth and women. It is estimated that the population in East Africa will increase from approximately 195 million to 250 million by 2030, and around 380 million by 2050[1]. 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 (domestic, regional, and global).

Historically, the global economy, including the economy in East Africa, has been driven by the exploitation of natural resources, frequently leading to resource depletion and in some cases also to serious ecosystem degradation. The dependence on intensive use of fossil oil, coal, and gas, especially in the developed and emerging economies, has led to serious environmental challenges, and climate impacts. However, in looking to the future, there is an opportunity for East Africa countries to avoid the pitfalls of a fossil energy driven economy by using their bio-resources as a strategic base for sustainable economic growth, social and inclusive development. Bioeconomy growth offers the opportunity for countries in East Africa to achieve many of the Sustainable Development Goals, 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 to produce food, energy, and industrial goods, thereby creating jobs, generating wealth, and connecting smallholder farmers to new biobased value chains. It is thus important to recognise that Bioeconomy is not a stand-alone sector, but also adds value to policies and strategies in a range of other sectors, and must support and interface with other sectoral initiatives.

Definitions of a Bioeconomy are evolving and will continue to change over time. The Global Bioeconomy Summit (2018)[2] defines the bioeconomy, as "*the production, use and conservation of biological resources, including knowledge, science, technology and innovation related, to provide information, products, processes and services in all economic sectors, in order to move towards a sustainable economy"*. In an East African context, and based on a series of national consultations in the region, the Bioeconomy can be described as *"the sustainable production and exploitation of biological resources and knowledge to support: (i) a diversified industrial sector producing a range of bio-based products including high quality foods, feeds, chemicals, pharmaceuticals, textiles, construction products, etc., and (ii) protection of ecosystem services and mitigation of climate change. It is an economy which puts innovation in biobased products, processes and business models at the centre and a biobased circular economy as the organising framework".*

Within this context, a biobased and sustainable circular economy is based on the principles of eliminating waste and pollution, keeping products and materials in use, and regenerating natural systems. The foundation for the modern bioeconomy is optimal and sustainable use of renewable biological resources. This is increasingly seen, among other things, to support a transition away from the fossil fuel era.

[1]https://www.populationpyramid.net/
2 Global Bioeconomy Summit. 2018. https://gbs2018.com/home/

Global trade in bio-based products has been booming over the last decade. While bio-based products (forestry, food, bioenergy, biotechnology, and green chemistry) represented about 10% of total international trade in 2007, this figure reached 13% in 2014[3]. When primary agricultural production and extraction as well as food production are excluded, the turnover in the European Union alone amounts to around US$700 billion and employs 3.7 million people, while the USA turnover is more than US$370 billion[4]. Although equivalent data on bio-based products from other regions and nations are very scarce, an increasing number of countries (currently about 50) are proposing to reinforce and strengthen the share of bio-based products in their economies.

2. Rationale for a Bioeconomy Strategy for East Africa

2.1 A Global Move towards Bioeconomies

Globally, bioeconomy has gained momentum as a new strategy for fostering innovation, sustainable development, and green growth. More than 50 countries have bioeconomy-related policies and strategies, with a growing number producing dedicated bioeconomy strategies. The global interconnectedness of the bioeconomy with respect to trade in biomass resources, global value chains and transfer of technologies increasingly highlights the need for East Africa to develop its own strategy to maximise the opportunity in this domain.

2.2 Economic diversification through value addition

Long-term economic prospects for countries in East Africa—in this case Burundi, Kenya, Rwanda, South Sudan, Tanzania, and Uganda—are tightly bound to their ability to increase their domestic, regional, and overseas trade and to integrate into the global economy. This is particularly important given the growing population in the region (195 million people with an annual growth rate of 2.8%) and the pressure to cater for their needs while efficiently and sustainably managing bio-resources and the environment. Political stability in East Africa is improving and economic growth in most of the East African countries has been resilient for the past decade. Treaties and agreements within the region (e.g., EAC, COMESA) have opened and promoted regional trade, joint infrastructure development and policy harmonisation. Although the COVID-19 pandemic has set back economies both in the region and world-wide for much of 2020, at the same time this has opened opportunities to envisage a new future based on green and sustainable growth as countries emerge from this crisis. In this context, the development of a bioeconomy supporting the domestic production of medical products (drugs, diagnostics, and vaccines) could decrease the disease burden in the region and support its readiness for future pandemics.

The economies of countries in the East African region are mainly agri-based and over 30% of the region's GDP can be directly attributed to agriculture and other bioeconomy related sectors. Agriculture contributed 41% of average real GDP growth in East African Community (EAC) countries in 2017[5]. However, a large part of the economy of the region is based on unprocessed agricultural raw materials and the majority of the more than 200 million tonnes of primary agricultural produce[6] in the region are facing increased global competition (e.g., coffee, tea, etc). In the case of agriculture, processed agricultural products today account for

[3] El-Chichakli B, von Braun J, Lang C, Barben D, Philp J. Five cornerstones of a global bioeconomy. Nature. 2016. 14;535(7611):221–3. 10.1038/535221a

[4] Issa, I., Delbrück, S., & Hamm, U. (2019). Bioeconomy from experts' perspectives - Results of a global expert survey. PloS one, 14(5), e0215917. https://doi.org/10.1371/journal.pone.0215917

[5] African Development Bank, 2019. East Africa Economic Outlook 2019.

some three-quarters of global agricultural exports[6]. Africa performs poorly in terms of participation in world trade, whether intra- or extra regional. A striking feature of African trade is a high concentration of exports in a relatively small number of products, which are often raw or semi-processed. The continent's share in world GDP increased slightly during the period 2005–2017, from 2.6 percent to 3.0 percent. However, Africa's participation in world trade increased only slightly during the same period, from 2.3 percent to 2.7 percent, with its share in world agricultural trade also growing only marginally from 4.3 percent to 5.0 percent[7]. 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. Continued improvements in sustainable agricultural productivity, combined with viable agribusiness that adds value to farmers' production, improves their access to markets, and provides novel value chains, can drive broader biobased economic growth, and improve food and nutrition security in the region.

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 for producing a wide range of agro-industrial and value-added products that add value to local bioresources.* Modern biology allows for the development of a diverse range of novel bio-products with new functionalities and with potential applications in many areas, e.g., pharmaceuticals, chemical and energy sectors.

Bioeconomy has the potential to transform primary production not only in agriculture, but also in sectors like aquaculture, forestry, health, and industry. The fledgling industries in these sectors are not only inefficient in converting biomass into final consumer products, but the bio-waste, some 40 million tonnes per year, generated from these processes is used to a very limited extent and is often a cause of environmental pollution. There is great opportunity 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 usable products, and develop biomaterials such as alternative bio-packaging materials, thus catalysing economic growth, and creating new jobs.

2.3 Regional Policy context

Several policies and strategies have been developed at the regional (EAC) level that support the development of an east African bioeconomy. These include the EAC Agriculture and Rural Development Policy (2006) and The EAC Agriculture and Rural Development Strategy (2005 – 2030), Polythene Materials Control Bill (2016), The East African Community Climate Change Policy (2011) and the 2nd EAC regional Pharmaceutical Manufacturing Plan of Action (2017 – 2027). However, the current policy & regulatory framework does not have adequate incentives to support the development of a bioeconomy.

All EAC Partner States have signed the Paris Agreement on climate change and are at different stages in the ratification processes. 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

[6] FAOSTAT. 2020. http://www.fao.org/faostat/en/#data

[7] Bouet, Antoine; Cosnard, Lionel; and Fall, Cheickh Sadibou. 2019. Africa in global agricultural trade. In Africa agriculture trade monitor 2019. Bouët, Antoine and Odjo, Sunday P. (Eds.) Chapter 2 Pp. 17-41. Washington, DC: International Food Policy Research Institute (IFPRI). https://doi.org/10.2499/9780896296909_02

concrete steps for the Partner States[8]. The EAC also has a Climate Finance Mobilization and Access Strategy covering multiple sectors[9]. The East African Bioeconomy strategy is closely linked to the EAC climate change strategies and NDC targets.

A key limitation in the existing regional policies/strategies is the absence of explicit regional (and national) policy measures/strategies for the effective development of a bioeconomy. Instead, there is a spread of several related and supportive regional level (albeit disjointed) pieces of policy measures and strategies leading to fragmentation and lack of clear articulation of actions. In addition, the bioeconomy is spread across several sectors and production systems including waste streams. There is therefore a need for one overarching strategy that defines strategic choices for sustained economic growth through the bioeconomy. A regional EAC Bioeconomy Strategy has the advantage of riding on regional collaboration benefits including a regional market, economies of scale, knowledge sharing as well as the opportunity to have harmonised policies, standards, and regulations for biobased productions for trade facilitation.

A review of the mainly regional level supporting policies has been undertaken and is attached as Annex III.

2.4 The need for sustainable use of natural resources

The pursuit of *clean energy, energy independence and security* and reduced greenhouse gas emissions is a key driver of a modern bioeconomy for the region, where renewable resources can replace fossil fuels, thereby reducing greenhouse gas (GHG) emissions fulfilling the commitments in the Paris Agreement and decoupling GHG emissions from biobased economic growth.

The new frontiers in biosciences are revolutionising our 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 bio-based industries into modern biorefineries producing a large array of renewable bio-products with close to zero emissions. Biorefineries are dedicated facilities that convert primary produce from renewable biomass into food and feed, but also biofuels, chemicals, and biobased materials. The objective of a biorefinery is to develop as many products and value streams as possible from biomass. Transporting biomass long distances is usually costly and therefore, biomass should ideally be processed close to the site where it is harvested or acquired. This provides an opportunity to revitalise rural communities and diversify agriculture, supporting job creation (particularly for youth and women) and providing opportunities for local value addition.

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 process waste. Biodegradable products can be returned to the organic and nutrient circle. Paper and other wood products, natural biobased fibres, textiles and many more biobased materials and products can be successfully cascaded. Indeed, there is a considerable potential in converting biowaste from agro-and bioprocessing industries and

[8] EAC 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.
[9] East 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

human consumption, often causing environmental problems, into useful products such as energy, biofertilisers, feed, green chemicals, biobased packaging material, etc.

This Regional Bioeconomy Strategy provides a compelling framework for putting in place agreed goals, interventions and roles which countries in East Africa could use to achieve the continental aspiration of integrating its Agenda 2063 (‘*the blueprint and master plan for transforming Africa into the global powerhouse of the future’*) and the UN 2030 Agenda for Sustainable Development into intersectoral national development plans (which could, in turn, be underpinned by national bioeconomy strategies), and the regional aspiration contained *in EAC Vision 2050,* in which Member States aspire to become middle-income countries in the next two to three decades. However, few of these policies and strategies mention efforts to support innovation for value addition to bioresources and biowaste and the development of biobased products in support of job creation and sustainable biobased economic growth. This therefore gives a clear impetus for standalone bioeconomy policies/strategies both regionally and nationally.

The development of a robust economy driven by sustainable use of natural bioresources speaks to a broad set of interrelated goals at national, regional, continental, as well as global (SDG) levels – e.g. 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), functional ecosystems, clean environment and maintained biodiversity (SDG 15), *inter alia*. Furthermore, all countries in the region have national development visions or plans (not all of which have been operationalised) that provide the basis for identifying country-specific bioeconomy priorities as the backbone for a regional strategy. A recently developed East African Regional Science, Technology and Innovation (STI) Policy also speaks to the technology platforms which would be critical for operationalising the bioeconomy strategy.

2.5 Regional and Global Competitiveness

The latest (2019) Global Competitiveness Report indicates that the transition to a greener and more equal economy is not just possible but imperative for restoring productivity. The technologies of the Fourth Industrial Revolution, the ongoing transition of traditional manufacturing and industrial practices, using artificial intelligence, nanotechnologies, 3D printing etc, offer the global community the tools to realise this vision. However, policymakers, business leaders and international multilateral systems must work together to set a new direction and make bold and visionary choices to achieve a win-win-win trajectory for growth, shared prosperity, and sustainability. This is the imperative that underpins both the urgency and the framing of the East Africa Regional Bioeconomy Strategy.

3. Scope of the Bioeconomy Strategy and Guiding Principles

The scope of this strategy as outlined below is defined by the urgent need for the region to achieve sustainable economic growth and development, given the context described in Chapter 2.

Scope of the Strategy

I. This Strategy focuses on the creation of new or improved biobased products that add value at local level and/or use resources in novel and innovative and sustainable ways.
II. Specifically, the scope of the Strategy covers optimisation and innovative use of biomass and biological resources produced from agriculture, aquaculture, bioprospecting, and forestry
III. The scope of the Strategy includes alternative sources of food and feed, health and bioenergy services and ecosystem services.

Guiding principles

The Strategy focuses on those interventions which:

a. Have a high potential for impact in the region, ideally in the short to medium term, and a high likelihood of success.
b. Are based on sound scientific evidence and risk assessments, as appropriate
c. Focus on actions that can be accomplished at the regional level, while facilitating those at national level that synergise with and amplify regional public goods
d. Use the East African Community (EAC) as an opportunity to leverage relationships with other Regional Economic Communities
e. Are '*trans-boundary*' in nature, such that successful pilot projects can be scaled up to multiple countries in the region
f. Are economically and environmentally sustainable
g. Are aligned with regional policies on intellectual property, access, and benefit sharing
h. Support and strengthen existing and new regional policies and strategies outlined in Annex 1 to this Strategy.

4. Situational analysis for a Bioeconomy in East Africa

4.1 Resource availability

The region has rich biodiversity and a strong bio-resource production base. An important advantage is that tropical and sub-tropical biomass is much more productive than biomass grown in temperate regions in Europe or North America. Key crops in the region generate around 130 million tonnes of agricultural residues per year of which around 30-60 million tonnes[10] is currently unutilised. In addition, forestry activities produce large amounts of residues including over 116,000 cubic metres of sawdust.[11] 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 production[12].

[10] Data 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.
[11] Data extracted from FAOSTAT 2020. http://www.fao.org/faostat/en/#home
[12] UNEP (2018). Africa Waste Management Outlook .United Nations Environment Programme, Nairobi, Kenya.

Box 1: Summary of land use in East Africa (figures in 1000 Ha)[8].

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
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	**245 730**	**233 776**	**114 073**	**61 385**	**11 956**

Moreover, rural East Africa offers opportunities for expansion of biomass production and utilisation that would create added value at negligible opportunity cost simply by improving degraded or poorly maintained lands. The region has large areas of suitable cropland, large areas of pastureland that are currently used sub-optimally, and with improved sustainable agricultural practices there is potential to increase production more than three-fold. In addition to the favourable physical conditions for biomass, the low cost of labour is an important factor that presents a comparative advantage for production of biomass and bioenergy in the region.

4.2 Capacity for research and innovation

So far, the countries in the region have only to a limited degree been able to apply technologies and know-how that could modernise agricultural production, bioprocessing, and value addition. However, the region has increasingly stronger universities, research institutions and innovation and development capabilities, with a growing number of active and well-trained scientists, many of them well connected to leading R&D and innovation centres at global level, and hence with an ability to develop and adopt modern technologies and know-how for local bioinnovations. Valuable indigenous knowledge for producing bio-based products and services and adding value to local bioresources could also be used and spur such innovation. There are several ongoing innovative research and development programmes in the region, with the potential to bring bioeconomy innovations to scale.

4.3 Infrastructure and logistics

To date, there has been insufficient development of industrial capacity, with a low level of industrial investment by both the public and private sector. Additionally, some prerequisites for development of a bioeconomy need improvement, including facilities for storage and processing of agricultural products, and a reliable energy supply. While roads, railroads and ports in the region are being improved and/or constructed, facilitating transport and market access both within and between countries in the region, and supporting regional trade, are still needed regardless of these improvements.

Encouragingly, many countries in the region have embraced or are piloting different tools and platforms to promote agro-industrial development. These include agricultural corridors, growth poles, special economic zones, agro-based clusters, and agro-industrial parks. Agro-Industrial Parks are agro-based spatial development initiatives designed to concentrate agro-processing activities within areas of high agricultural potential to boost productivity and

integrate production, processing, and marketing of selected commodities. They are purpose-built shared facilities, to enable agricultural producers, processors, aggregators, and distributors to operate in close proximity to reduce transaction costs and share business development services for increased productivity and competitiveness. By bringing adequate infrastructure (energy, water, roads, ICT) to rural areas of high agricultural potential, they attract investments from private agro-industrialists/entrepreneurs to contribute to the economic and social development of rural areas. These will serve as excellent platforms for biobased business enterprises. Examples of countries on this path include Ethiopia, which is already investing in several agro-industrial parks, and Kenya with advanced plans to make similar investments. In addition, some countries have operationalised business incubation hubs. In Tanzania, the Commission for Science and Technology (COSTECH) has recently funded 15 innovation hubs, some of them focused on bioeconomy development.

4.4 Political environment

There is current political will to harmonise policies and strategies in the region, through strong regional institutions such as the East African Community, which supports this regional approach to bioeconomy development. The Strategy builds upon existing national and regional science, technology, and innovation (STI) policies and related instruments aimed at creating an enabling environment for increased STI investments to support sustainable development and socio-economic transformation. Moreover, the strategy is aligned with expressed commitments to environmental sustainability, climate change adaptation and mitigation, reversing or changing unsustainable practices (e.g., unsustainable use of fuelwood leading to deforestation). At the same time, it should be recognised that the sectors which bioeconomy has potential to irreversibly transform – food and agriculture, energy, health, environment - are major drivers of the economies of the countries in the region (and Africa and the world at large). Complex political economy is likely to be at play in the decision-making processes, and some of these could undermine what – on the surface – looks logical, obvious, and compelling.

4.5 Agricultural yields

The yields from existing agricultural production systems (both crops and livestock) in the region are generally very low, for several reasons. These include lack of access to improved seeds and agricultural inputs, inefficient and unsustainable agricultural practices that impact soil and other resources, insecure land tenure, inadequate skills and extension services, and inadequate market access. Consequently, inefficient use is made of agricultural land for production of bioresources that serve as raw materials for value addition in the bioeconomy. However, there is great potential to increase agricultural production in the region through producing renewable non-food/feed products complementing but also supporting increased food and feed production, food security and improved rural livelihoods.

4.6 Stakeholders, innovation, and private sector growth

The bioeconomy is complex and interdisciplinary in its nature involving many actors across many sectors. A comprehensive list of bioeconomy stakeholders in the region and a preliminary stakeholder analysis at regional level is provided in a companion report to this strategy. Based on this stakeholder analysis it was found that there are enough actors in the region in many bioeconomy key areas including, governing and regulatory institutions, farmers and farming organisations, civil society organisations (CSOs) and R&D institutions. However, there is still a shortage of actors in some key areas essential for a well-functioning bioeconomy, including (i) private sector actors engaged in innovative bio-based enterprise development, (ii) institutions linking R&D actors and private sector actors and (iii) actors financing Innovation and upscaling Impact. However, there are some emerging initiatives in the region, including the establishment of bio-incubators and business accelerators.

There are several traditional large scale agroprocessing private sector actors in the region involved in processing sugar, coffee and tea, cotton, various fruits, and livestock products. However, there are insufficient new entrants and private sector actors active in novel and innovative emerging areas of the bioeconomy; additionally, they are often informal and with limited capacity to expand, and largely unable to drive the innovation needed for bioeconomy development on their own. Partnership, with R&D actors and business to business (B2B) collaboration both nationally, regionally and internationally will be important for successful Bioeconomy development in the region.

In addition, there are generally weak linkages between researchers and industry, and a lack of funding to support the innovation chain through all the stages from research and development to the market. 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 gap between research, the private sector and commercialisation is wide in the region and needs to be bridged. There is a general shortage of professional incubating services in the region that can assist the bioeconomy innovation process and ensure that all actors in the innovation system are properly supported to fulfil their complementary roles. Inadequate financing resources and lack of venture capital hinder the development of fledgling SMEs. There is a thus a great need to consider novel ways of resourcing and facilitating the functionality of relevant innovation chains.

4.7 Competitiveness, standards, and certification

To achieve competitiveness in global markets, good product quality is essential. Inadequate systems for certification and accreditation of products mean that meeting regulatory requirements to access markets in developed countries is difficult. Regional product standards need to be developed and harmonised with international standards. Additionally, weak intellectual property management systems within member states hamper competitiveness and need to be addressed.

4.8 Regional trade

The growing population of consumers in the region, as well as in other African countries, with the strong emergence of a rapidly growing middle class, is resulting in increasing demand for safe, nutritious food as well as a range of consumer products. The EAC is considered the most successful among all the regional economic communities in Africa, having received the highest score among these communities on the Regional Integration Index of the United Nations Economic Commission for Africa (UNECA). Nonetheless, intra-EAC trade was represented only 13.4% of total EAC country exports in 2019[13]. Hurdles to regional trade remain, and the provisions of the World Trade Organization's Trade Facilitation Agreement have not been fully implemented.

The recent establishment of the continental free trade area (CFTA) has come with an implementation action plan that has potential to remove historical constraints to intra-Africa trade by holistically addressing trade policy, trade facilitation, productive capacity creation, trade-related infrastructure provision, trade finance, trade information, and factor market integration. East African policymakers may draw lessons from this and fine tune their policies along these lines.

4.9 Fossil fuels and renewable energy

Significant oil and gas discoveries in the region in recent years offer opportunities for international investment by multinational oil companies. While in the short term such investment may be seen to stimulate economic growth, its future is unpredictable as pressure mounts world-wide to reduce the use of fossil fuels to meet the targets of the Paris climate agreement and do nothing to mitigate climate change in the region, which is already feeling the impact through drought, interspersed with floods, and locust plagues. To date, countries in the region, which already have limited fossil fuel based industrial development, could make strategic choices to leapfrog into a circular biobased industrial economy.

There are considerable opportunities within the bioeconomy to generate renewable energy from bioresources. The use of agro-residues and other available biomass in the region is of high relevance for the generation of bioenergy. The number of residues can be conservatively estimated in the range of 30-60 Million tonnes in the region depending how calculations are made[14].

In terms of bioenergy, co-generation for heat and power is not fully developed in the region but a few cases exist, such as in Uganda with a potential of 1,650 MW[15], and it is possible to

[13] ADB. 2019. East Africa Economic Outlook 2019.
[14] Text based on FAOSTAT data and calculations on sustainable availability of residues considering amount left on the ground to protect the soil functions and other current uses.
[15] https://unreeea.org/resource-center/overview-of-the-ugandan-energy-sector/

estimate that the whole agroindustry in the region could benefit from expanding it co-generation activities. But the region also can increase its use of other forms of renewable energy, including geothermal, wind, hydro and solar energy, to support bioeconomy activities and reduce dependence on fossil fuels. In particular, the falling cost of solar panels coupled with high levels of sunshine in the region, provides opportunities for local level energy generation to support small-scale biobased businesses.

4.10 Working population

Around 18 million people in the region are aged between 18 and 24 years[16], and the number is increasing fast. A million people or more enter the labour force each year. Interventions and policy development in response to this youth bulge include creating an enabling environment for youth entrepreneurship and jobs, and developing biobased businesses and greater participation of youth and women in the sector. The development of a bioeconomy provides many opportunities for the involvement of this young population.

4.11 Disease burden

HIV/AIDS, lower respiratory infection, and diarrhoeal diseases are among the leading causes of death in the region. In addition, non-communicable diseases (NCDs), including heart disease, stroke, cancer, diabetes, and chronic lung disease, have risen sharply as a share of the total disease burden across countries in the region. On an annual per capita basis, total health expenditure in the EAC varies from about US$24 in Burundi to US$88 in Kenya which is very low compared to the global average of well over US$1110 in 2018[17]. While the region, like the rest of the world, grapples with the challenges of COVID-19, there is also a significant disease burden from malaria, HIV etc, impacting on the population and the economy. It should be recognised that there is ongoing potential for future pandemics that may affect humans, and/or livestock, with negative impacts on both health and economies. Crop diseases and pests also have the potential to reduce agricultural output.

4.12 Environmental status in the region

Some of the most urgent environmental problems in East Africa arise from climate change with all its adverse consequences for bioresource productivity and ecosystem health. The region also suffers from unsustainable land and resource use including overgrazing, deforestation, water shortages, loss of biodiversity and urban-industrial pollution.

The agroprocessing and bioprocessing sector in East Africa has a vital role to play in generating economic growth and is also crucial for creating demand and value chain opportunities for African farmers. A problem, however, is that a large part of the agroprocessing sector in the region runs at a suboptimal level and produces large amounts of waste and environmental problems. The sector is often using biomass inefficiently and agroprocessing industries are to a large extent generating products of relatively low value and opportunities for by-product utilisation and conversion of waste to commercial products are seldom explored.

Uncontrolled wood fuel collection that in many cases leads to deforestation is also a major environmental problem in the region. Use of wood fuel for indoor cooking is also a major

[16] World Population Review 2020. https://worldpopulationreview.com/continents/East-africa-population
[17] World Bank. https://data.worldbank.org/indicator/SH.XPD.CHEX.PC.CD

health issue where women and children in particular face high risks from exposure of household air pollution.

A bioeconomy, where fossil-based resources are replaced with renewable biobased resources provides a great potential for climate change mitigation and adaptation both in terms of carbon neutrality (e.g., carbon sequestration) and improved resilience. Transforming the agro and bio processing sector so that it effectively adds value to the primary production in an environmentally friendly manner will therefore be a key issue in an African bioeconomy agenda. The bioeconomy is also critical for protecting and restoring biological diversity and ecosystems in the areas of agriculture, marine systems, freshwater systems, but also for providing solutions in urban planning and infrastructure. Examples include replacing unsustainable farming practices with sustainable agricultural intensification through innovations using technologies such as microbial-based fertilizers, plant growth-promoting bacteria and bioengineered crops tolerant to crops diseases.

Sustainable intensification of land use offers major opportunities to increase bioresource efficiency, reduce land used for food production and mitigate deforestation. Sustainable aquaculture will also play a key role in the future in contributing to sustainable food systems and to release pressure of overexploited resources. Modern biobased energy carriers replacing unsustainably harvested wood fuel can together with improved cooking stoves offer more efficient energy use and improved household air quality.

More efficient use of biomass, as described above, would also improve the prospects for land conservation and the preservation and restoration of degraded ecosystems. This offers new opportunities for a broader bio-tourism creating new jobs and rural livelihood opportunities. In an era of accelerating regional connectedness and integration, bio-tourism is one of the fastest developing industries in the region and an avenue through which the region can fast-track economic development.

4.13 A Summary SWOT analysis of bioeconomy development in the region

This section summarises the Strengths, Weaknesses, Opportunities and Threats (SWOT) for bioeconomy development in the region.

These provide the context in which a regional Bioeconomy Strategy is situated. These define the landscape in which this Regional Strategy (and ultimately, the national bioeconomy strategies that it will inspire) seeks to provide a framework for guiding biosciences R&D and innovation investments as part of the economic growth agenda of the region, integrating indigenous and scientific knowledge to add value to bioresources to stimulate the demand for biobased products and respond to that demand as a critical component of the economic growth agenda.

Strengths	Weaknesses
Rich biodiversity and bioresource production base. The East African economy is largely bio- and agro-based, with agriculture contributing on average 33% of the GDP. Africa has a large rural population including a large young easily trainable working population. Increasingly stronger universities, and research institutions and innovation and development capabilities, Increasingly supportive political environment (e.g., specialised innovation ministries, and agencies STI policies) Presence of Regional Institutions (IGAD, EAC, COMESA) that plays an important role for economic integration Undergoing infrastructure development in the region connecting countries (e.g., improving ports, roads, digital infrastructure, and planned railroads) which when ready, will facilitate regional communication and trade. Current trends for harmonisation of policies and strategies (e.g., this bioeconomy strategy) Countries in the region are improving the infrastructure for biobased economic growth, including agro-industrial parks, innovation hubs etc.	Low agricultural productivity due to factors such as lack of access to improved seeds and agricultural inputs, inadequate training, and extension services etc. Current Infrastructure in the region inadequate (roads, harbours, agricultural product storing facilities, energy supply etc. Weak linkages between academia and industry Inadequate financing resources, lack of venture capital to fund innovation and deployment. Inadequate infrastructural industrial capacity, and insufficient technology and human capacity for value addition to primary produce. Low level of industrial investments by both public and private sector and lack of capital and actors funding the movement of novel biobased products from early stages of innovation to the market. Low product quality, poor certification, accreditation of products, lack of quality control labs, etc. leading to poor competitiveness in global markets. Difficulties for small scale farmers processors and bio-entrepreneurs to meet regulatory requirements to access markets in developed countries (e.g., Global Gap certification). Weak IP systems within member states.
Opportunities	**Threats (External)**
Limited “lock in” investments in the fossil fuel economy. Opportunities to leapfrog into a circular biobased industrial base. Late comers may have an advantage in adapting new bioinnovations and biobased technologies Financing opportunities potentially for combatting climate change and replacing fossil fuel from global/multilateral funding institutions (e.g., GEF, the Green Fund). Increasingly growing, regionally inter-connected markets for bio-based products and services. East Africa may be an increasingly interesting market for international investors, B2B Collaboration. Good opportunities for increased use of renewable energy (geothermal, wind, hydro and solar) to support bioeconomy activities. Political good will and support for transformational development in the region.	Effects of climate change on bioresource productivity Non optimal use of biological resources causes degradation of ecosystems services (e.g., land degradation, deforestation, habitat destruction and loss of biodiversity). Political instability and conflicts due to increasing unemployment. Potential resource conflicts. International trade-tariff and non –tariff barriers restrictions. Emerging and re-emerging diseases (crop, animal, and human). High competition in the global market with established multinationals. Oil discoveries in the region (which may not make use of renewable biofuel and biobased material attractive).

5. Strategic Direction

Vision: *A vibrant, socially inclusive, and innovative bioeconomy contributing to sustainable economic growth and development in East Africa.*

Mission: *To catalyse and support innovative and sustainable use of bioresources as the major driver of inclusive economic growth and development in East Africa.*

Objective
The overall objective of this Strategy is to achieve *economic growth and job creation, making use of the region's bioresources to develop products and services while contributing to an improved environment and climate change mitigation.*

Specific Objectives
The overall objective will be achieved through:

i. Building and improving regional and international partnerships and collaboration, sharing knowledge, and building capacity for research, innovation, and entrepreneurship, including the development of PPPs and precompetitive collaborations.
ii. Promoting and strengthening regional trade, markets, and business cooperation for bioeconomy, including fostering opportunities for import substitution.
iii. A harmonised regional approach to mobilise the collective efforts of key stakeholders in the region, creating structures for innovation and deployment of technologies to operationalise the bioeconomy in East Africa
iv. Supporting the creation of technological and business environments in the region that encourage investment, making the region a bio-business attraction where start-ups and PPPs thrive – transforming East Africa's businesses through a shift to clean growth that maximises the share of the region's businesses in Africa's markets
v. Catalysing the development of national bioeconomy strategies, appropriate policies, and socioeconomic conditions to allow innovative and sustainable biobased products and services to thrive.
vi. Supporting and harmonising the improvement of necessary infrastructure for the bioeconomy (e.g., roads, harbours, storage facilities)
vii. Fostering an integration of indigenous and scientific knowledge to add value to bio-resources and meet the demand for bio-based products
viii. Joint monitoring and information sharing of bioeconomy development.

5.1 Strategic Thematic Areas

A combination of a comprehensive situational analysis of strengths, weaknesses, opportunities, and threats incorporating perspectives of key stakeholders have informed the strategic choices for this Regional Strategy. In addition, the strategic focus of the Strategy has been informed by a careful consideration of both what is needed and what is possible, while recognising that there are other potentially important areas within the bioeconomy that are not addressed here. While the Strategy is regional in its scope, it is recognised that implementation will be operationalised at country levels, but that regionally coordinated action will be required to achieve synergies and significant multiplier effects. Care has been taken to build on existing sectoral priorities (in sectors such food and agriculture, health, environment, and energy), not duplicating priorities therein, but rather complementing and

enriching these with priorities that are relevant from a bioeconomy perspective. It is recognised that there exists national (and for some, regional) strategic priorities that specifically address food security, health, environment, and energy. This Strategy provides a means to enhance the delivery of those strategic goals, but specifically leveraging on the use of bioresources across the sectors, and capitalising on the growing possibilities provided by the power of biosciences and innovation to optimise value creation from these resources while delivering a sustainable economy.

The priorities in this strategy are based on the functions, processes, and tools central to bioeconomy development. Four priority Strategic Thematic Areas (STAs) emerged from this analysis and relate directly to the Overall Objective of this Strategy.

The priority STAs are:

- *Food security and sustainable agriculture*
- *Health and well-being*
- *Bio-based Industrial Development*
- *Sustainable Energy*

The Key Result Areas (KRAs) within each of the four STAs are summarised in the sections below.

5.1.1 Strategic Thematic Area 1: Food security and sustainable agriculture

***Strategic Objective 1**: To introduce new biobased technologies and solutions to strengthen food and feed production, ensuring food security.*

Increasing agricultural productivity has for a long time been a central priority in many agricultural strategies and development plans for all the countries. Emerging technologies in modern bioeconomies – not least modern biosciences – provide an increasingly powerful innovation engine to support and enhance sustainable agricultural production.

KRA 1.1: Value addition to food crops, livestock, and microbial products

***Strategic Objective 1.1**: To deliver economic growth and create opportunities for smallholder farmers and SMEs by adding more value to primary produce and the use of agricultural residues*

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 algal produce 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. For example, 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. 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. In East Africa several value chains exist that have emerged in recent years. In Kenya a company has been working with croton (*Croton megalocarpus* Hutch.), an indigenous tree in East and Southern Africa whose seeds have been used to produce vinegar, fertiliser, poultry feed and oil for biodiesel in a sustainable form by collecting the fruits of trees planted on farms.

Another value chain in the region is the coconut. Tanzania produces over 400,000 tonnes of coconuts annually, while Kenya produces over 100,000 tonnes[18]. 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 realised[19], with some estimates as low as 25%[20]. The many products including coconut wine, oil, roofing materials, broom 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 coconuts[21]. Many micro-enterprises are engaged in value addition, but the sector faces several 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.

Box 2: Coastal and freshwater resources for the bioeconomy.

The shores of East Africa, with its bays, mangrove stands have many resources such as shells, crabs, seagrasses, seaweeds (algae), starfish, small fish, shrimps etc. Large fishery resources are in the rivers and in the many lakes of East Africa (e.g., Lake Victoria, Turkana, Tanganyika, and Kyoga).

The fish market in East Africa is estimated at 1,300 million tonnes and there is an estimated market for fish and fish products for Africa of US$24 billion. Job creation in the sector is estimated at a ratio of 1.4 to 3.5 onshore jobs for each fisherman. The average waste or by-product from the sector is around 600,000 cubic meters per year [22],[23],[24]. 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 export[25]. 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.

Potential impact: The potential in the region to add more value to primary produce is large for many food crops, livestock, and seafood produce. There is also high potential to use more

[18] FAOSTAT data.
[19] Nuts and Oil Crops Directorate. Coconut Value Chain Status Report, 2020.
[20] Mwachofi, H.P. 2016, Value chain analysis of the coconut subsector in Kenya. MSc Thesis, University of Nairobi.
[21] https://www.thecitizen.co.tz/tanzania/news/business/-time-tanzania-used-coconuts-to-boost-edible-oil-production-3554890
[22] Obiero K, et al. 2019. The Contribution of Fish to Food and Nutrition Security in East Africa: Emerging Trends and Future Outlooks. Sustainability 2019, 11(6), 1636; https://doi.org/10.3390/su11061636
[23] IPSOS, 2018. EAST AFRICA FISH MARKET ASSESSMENT Size, Sustainability and Opportunities for growth in Aquaculture: Kenya, Uganda, Tanzania, and Rwanda. STUDY REPORT. Kenya.
[24] The World Bank. 2020. Africa Program for Fisheries https://www.worldbank.org/en/programs/africa-program-for-fisheries
[25] Gumisiriza 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

agricultural residues, and processing by-products in new value chains, providing additional income to farmers and other value chain actors. One example is cassava, which can be processed into chips, flour and alcoholic beverage and biofuel production. Cassava waste can also be converted to useful products such as bioenergy bio-packaging materials, and biofertiliser.

KRA 1.2: Novel food and feed products

Strategic Objective 1.2*: To produce a variety of novel, safe and healthy food, and feed products for growing local, regional, and international markets*

The global market for novel functional foods, feeds and food/feed additives and nutraceuticals (foods with health-giving/medicinal benefits) are growing rapidly. Probiotic feed products also have a large potential in the region. With its large biodiversity and rapidly increasing demand for novel food products, the region seeks to build and develop an industry based on functional food derivatives from locally sourced bioresources. Such an industry will 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 will 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 3: Novel prebiotics from African plants.

Prebiotics are non-digestible food ingredients that increase populations of healthy bacteria in the gut, aid digestion and enhance the production of valuable vitamins. The global market for prebiotics is set to grow to well over US$9 billion in the next 5 years, with increasing use in both human and animal foods.

The most well-known prebiotic is inulin, mainly derived from the chicory root. However, several African plants also have potential as prebiotics. Yam (*Dioscorea*), is grown mainly in West African countries, but native species of yam have been identified in Kenya and Ethiopia[26]. Despite a lack of information on the structure and mechanism of action, yam is touted as a promising source for developing functional foods that can positively modulate gut microbiota. It contains several phytochemicals including biotin (Vitamin B7) that is crucial to the proliferation and maintenance of gut microbiota[27]. Another preliminary study also showed that orange fleshed sweet potato may have prebiotic potential. There is obviously considerable opportunity for further research and development to enable countries in the region to enter this lucrative and growing market.

Potential impact: The potential impact is huge. As an example, the global market for Spirulina alone is around US$400 million, with an annual growth rate of over 10%[28], while the market for carotenoids (which can be extracted from plants or algae) is over US$1.4 billion[29]. In the case of substitutes for meat protein, the global market is over US$4 billion, and is growing

[26] Wilkin, P. et al. 2009. Systemic Biology 34, 652-659.

[27] Isibor, P.O. et al. 2021. https://doi.org/10.1177/11779322211012697

[28] https://www.prnewswire.com/news-releases/the-global-spirulina-market-generated-346-million-in-2018--and-is-projected-to-reach-779-million-by-2026--growing-at-a-cagr-of-10-6-from-2019-to-2026--300957297.html

[29] Fortune Business Insights. https://www.fortunebusinessinsights.com/industry-reports/carotenoids-market-100180

exponentially[30]. In Africa, although the market for meat substitutes is growing from a low base, the annual growth rate is over 8%, only constrained by product availability. The region is well placed to enter markets of this nature, with a potentially very significant economic impact.

Box 4: The growing market for biopesticides in East Africa.

Both globally and across Africa in particular, there is a pressing need to develop cheaper, more environment-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 will 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 billion[31], 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 bio-pesticide 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 East Africa market largely through acquisitions and licensing deals. There is also an increasing number of East African companies and institutions, such as ICIPE, engaged in developing biopesticides for the East African market, worth roughly US$400 million annually.

With a growing consumer demand for food free of pesticide residues in the lucrative EU export markets and in a growing regional African consumer market, there are significant opportunities for increased bio-pesticide production and use in the region. Such local production can, apart from supporting African farm productivity and sustainability, also benefit job creation and growth of local bio-pesticide companies as well as stimulating investments in local bio-pesticide production by international companies. 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 bio-pesticide efficacy and certification standards at a regional level.

KRA 1.3: Biobased agricultural inputs

Strategic Objective 1.3*: To support and enhance sustainable agricultural production through the growth of bio-based agricultural inputs produced in the region.*

Crop and animal pests and diseases are a challenge for the region, holding back agricultural productivity and having a negative impact on livelihoods and nutritional status. The pest and disease pressure may also be aggravated by climate change impacts. Pesticides, insect-repellents, and fertilisers are mostly imported, represent a major cost for farmers, and are out of reach for many smallholders. Biopesticides, bio-fertilisers and growth enhancing microorganisms, and biocontrol agents based on organic and renewable resources represent a major opportunity for countries in the region. Additionally, they are generally much less toxic to humans and other mammals and have less impact on wildlife and the environment

[30] Allied Market Research. https://www.alliedmarketresearch.com/press-release/global-meat-substitute-market.html
[31] Fortune Business Insights. https://www.fortunebusinessinsights.com/industry-reports/biopesticides-market-100073

than conventional chemical inputs. However, research is needed to improve their efficacy and user friendliness. This KRA seeks to deliver locally made biobased solutions, which could promote agricultural productivity for smallholders, while also creating jobs. The region already has some enterprises in this domain at limited scales that can be built upon. To make this happen (see Chapter 6), interventions will be undertaken to ensure that a supportive regulatory and standards environment is developed, and to build capacity to support the use of these bio-based inputs.

Potential impact: 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 in developed countries for organically produced foods and increasing demand for residue free crop protection products. The lack of 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.

5.1.2 Strategic Thematic Area 2: Health and Wellbeing

***Strategic Objective 2**: To develop a biobased healthcare sector contributing towards a healthy population with improved wellbeing, addressing regional priorities and building on indigenous knowledge and practices.*

The East African region is largely dependent on imported products for diagnosis and treatment of major diseases impacting the health of both humans and animals. However, many diseases that are prevalent in the region, such as malaria, are not priorities for the large pharmaceutical companies. The emergence of the COVID-19 pandemic has highlighted the fragility of global supply chains and the need for the region to develop its own health solutions. This provides a major opportunity within the context of the bioeconomy, particularly harnessing traditional knowledge in the region to complement existing strategies.

KRA 2.1: Biobased pharmaceuticals
***Strategic Objective 2.1**: To strengthen research, development, and innovation capabilities in the region to screen for and manufacture active pharmaceutical ingredients, biopharmaceuticals, diagnostics, and vaccines targeting major diseases in the region.*

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. A biobased health sector, producing health products from local resources will generate jobs and economic growth at the same time as supporting public health goals. An example is bio-based polymers with anti-microbial properties that can be extracted from locally produced materials. A key result here will be to support and strengthen research, development, and innovation capabilities in the region to screen for and manufacture active pharmaceutical ingredients, biopharmaceuticals and vaccines targeting major diseases in the region. Establishment of advanced formulations expertise and modern drug delivery systems, and the necessary infrastructure, such as preclinical testing facilities, will be an important component of this KRA.

Potential impact: 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-

malarias, 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. The focus of this KRA on biobased pharmaceuticals will complement and support ongoing efforts in this area, integrating local knowledge and bringing modern bioscience to bear on the health issues of the region. With proper regulatory harmonisation, countries will achieve faster lead times and more responsive local supply chains. This will support socio-economic development and have a major benefit in case of future disease outbreaks.

KRA 2.2: Indigenous knowledge and biobased traditional medicines
Strategic Objective 2.2*: To promote indigenous knowledge in traditional medicines through the identification of available biological resources in the region with verifiable and validated health benefits, and to understand the active ingredients involved.*

Traditional medicines and indigenous knowledge today play an essential role in maintaining health and well-being in the region. Innovative use of traditional medicines and indigenous knowledge would be an essential part of a modern health bioeconomy in the region. It also includes understanding the role of microbes and using products from these in keeping us healthy.

This is closely linked with KRA2.1 above, but a focus here is on Indigenous knowledge for the development of biobased traditional medicines and health products. This KRA will involve four main activity streams, thus: searching or 'bioprospecting' – at local/community levels to identify promising biological resources (e. g. plant species; fungi etc) conducting research on identified materials including safety and efficacy; developing commercial products; and working with rural people to develop skills and competencies for ensuring a pipeline of production where appropriate. In contrast to KRA2.1 where intellectual property (IP) management is based on conventional IP regimes, the IP management in KRA2.2 will be based on the Access and Benefit Sharing regimes, arrangements and principles laid out in the Nagoya protocol of the Biodiversity Convention ensuring that local communities benefit from any developments. Rigorous validation of traditional medicines and support to the indigenous knowledge system, support and advice on household medicinal gardens and the making of home remedy formulations will be important components of the health bioeconomy in the region. Countries in the region have made significant progress in the development of national policies, laws and regulations and national programmes for traditional medicines inspired by the WHO Traditional Medicine Strategy 2014–2023.

Potential impact: Although widely used in the region, there is little data on the safety and efficacy of most traditional medicines. Meanwhile, indigenous knowledge is rapidly disappearing as rapid modernisation causes the youth to be out of touch with their traditions and there is reduced inter-generational knowledge transfer. At the same time, medicinal plant resources are diminishing due to unsustainable harvesting practices and habitat destruction. A focused programme to harness indigenous knowledge and build an evidence-based system for validation of health and safety claims will have a significant impact on the health of the region's population.

Box 5: Developing biobased health products in East Africa.

While the conventional pharmaceutical market in the region has an annual turnover over of some 4 billion US$, the market size for pharmaceutical drugs based on traditional and indigenous knowledge is very difficult to estimate. However, traditional medicines using indigenous knowledge based on local biodiversity are often the primary source of affordable health care for well over half of the rural population in East Africa. The World Health Organisation has reported that traditional and complementary medicine (Including herbal medicine) can make a significant contribution to the goal of Universal Health Cover by being included in the provision of essential health services. Natural product extracts are frequently used as the basis for pharmaceutical research across the region's universities. However, studies rarely progress beyond academia even when the results are promising, partly due to a lack of adequate funding and poor links between academia and industry. The latter is addressed in the BioInnovate Africa, linking academia and industry to co-develop innovative and economically viable biobased technologies.

Within the BioInnovate Africa two innovation projects and consortia are focused on development of biobased health products. The first, focusing on malaria prevention, is led by University of Burundi developing low cost, highly efficient and innovative mosquito-repellent products, that can be used for mosquito net impregnation. The repellent is based on essential oils extracted from catnip and other locally produced plant species. The project is also developing appropriate farming methods for catnip production in the context of smallholder farming in East Africa. The other BioInnovate Africa project, led by the Kenya Agricultural and Livestock Research Organization, aims at improving the control of Tsetse flies transmitting trypanosomiasis in livestock and sleeping sickness in humans. In this project, still at pilot scale, tsetse fly repellents and attractants derived from waterbuck have shown incremental improvements relative to previously formulated blends and have large potential to control tsetse fly populations and disease infestations more efficiently in the region. The waterbuck compound blends are separately formulated and encapsulated on nanoparticles for controlled release and further incorporated in release devices protecting humans and livestock.

KRA 2.3: Bio-based cosmetics and well-being products
Strategic Objective 2.3*: To develop an African based personal care industry, based on local and regional bioresources and targeting expanding regional and international niche markets. Such production will be based on fair trade values while protecting and sustainably using the biodiversity of the region.*

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, East 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.

Potential impact: 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 annually[32]. The East 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.

5.1.3 Strategic Thematic Area 3: Biobased Industrial Development

Strategic Objective 3: *To develop industries that stimulate sustainable economic growth and that add value to under-utilised renewable resources 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. Products and processes that currently rely on non-renewable resources and chemical processes can be replaced with biologically based production platforms based on fermentation and other biological conversion platforms. New biorefineries and agro-industrial parks will produce a variety of biobased products, replacing imported products at competitive

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

prices. At the same time there are opportunities to develop smaller, community-based biorefineries.

KRA 3.1: Bio-based and biodegradable packaging materials
Strategic Objective 3.1*: To establish a manufacturing base for standardised bio-packaging materials, together with appropriate regulatory systems and infrastructure.*

Plastic pollution has been an increasingly severe problem in East 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 grounds 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. A growing bio-packaging industry using biobased materials from renewable resources from the region, will generate jobs and incomes in the region as well as reducing postharvest losses.

Policies and regulations are important here. Several countries in the region, including Kenya, Rwanda and Tanzania now have plastic bag bans that has been shown to be effective in reducing the use of fossil fuel-based single use plastics.

Box 6: Bio-packaging and alternative non-plastic products.

Globally, the biodegradable packaging market is expected to grow from US$90 billion in 2019 to US$126 billion by 2025. The market value of plastic articles traded as packaging materials in East Africa between 2015 and 2019 was estimated at around US$700M (or around 480,000 tons), and the region has over 300 companies selling packaging material of which less than 80 are manufacturers.[33]

Many countries in the region have banned the use, manufacturing and import of plastic bags. These policies, mitigating climate change and limiting plastic waste have also provided opportunities and incentives for the use of biobased renewable material to be used to produce bags. This includes fabric-based bags, non-woven bags, pulp paper-based bags, woven bags (using sisal and cotton fibres) and recycled textile material. It also includes the novel production of bags made from cassava starch. These cassava bags are biodegradable within 6 months and approved by Kenya's National Environment Management Authority (NEMA). So far, cassava starch bags are imported from countries such as Indonesia. However, cassava is a major crop in the region and is a staple food in several countries, with an annual production of over 12 million tonnes. The bags could be produced locally from waste cassava peeling residues, which amount to over 3 million tonnes per year. Such alternative and complementary use of cassava produce would support profitability of cassava farming in the region, and create new jobs in an expanding East African bio-packaging sector[34]. Additional plastic bans in Kenya include cutlery, straws, PET-bottles, sweet wrappers, and other products containing petroleum-based polymers of which most can

[33] Mordor Intelligence. 2020. Biodegradable Packaging Market - Growth, Trends, Forecasts (2020 - 2025). https://www.mordorintelligence.com/industry-reports/gobal-biodegradable-packaging-solutions-market-industry
[34] Maulida, Siagian, M., & Tarigan, P. (2016). Production of starch based bioplastic from cassava peel reinforced with microcrystalline celllulose Avicel PH101 using Sorbitol as plasticizer. Journal of Physics: Conference Series, 710(1), 012012. https://doi.org/10.1088/1742-6596/710/1/012012

be substituted by biobased renewable materials including bamboo, wood, and crop residues. The global biodegradable cutlery market size was valued at US$40 million in 2018 and is expected to grow rapidly in the coming years, including in East Africa.

Potential impact: The packaging market in Africa 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 considerable opportunities to develop new industries with associated job creation. Public procurement policies can also serve as a strategic intervention.

KRA 3.2: Bioprocessing enzymes
Strategic Objective 3.2*: To develop* enzymes for industrial applications *based on the region's microbial biodiversity.*

In East 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 or microorganisms today offer options for decreasing or avoiding environmental pollution and improving product quality and process efficiency. Thus, the availability of enzymes locally at an affordable price and with expert support on their use is expected to have 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 produced isolated and characterised several novel microbial strains producing potentially attractive enzymes for industrial application. 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.

Potential impact: Enzymes are used in a wide range of industries including pharmaceuticals, food processing, leather, detergents, paper and pulp and textiles. It is probably unrealistic to expect that industries in the region will be able 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.

KRA 3.3: Biobased construction materials
Strategic Objective 3.3*: To transform the local construction industry into one that is low-carbon and climate smart, based on locally produced renewable building 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 material. 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 is equally as strong as steel and concrete.

An emerging technology with potential for the region is the use of fungal mycelium to create bricks and insulation materials. Moreover, the region has a diverse bio-resource base – e.g., gums, waxes, resins, and oils that also could be used by the building industry, for production of paint, solvent, and other building materials.

Potential impact: Cities and urban regions in East Africa become the home for thousands of new inhabitants every day, of whom many 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 most 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 7: Using Bamboo for biobased industrial growth.

Bamboo is a giant grass, which grows naturally in East 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[35].

The renewed interest 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 tons 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.

[35] FAO. (2010). Global Forest Resources Assessment 2010. FAO Forestry Paper, 163, 350 pp. https://doi.org/ISBN 978-92-5-106654-6

KRA 3.4: Bio-based textile fibres

Strategic Objective 3.4*: To achieve a more productive and sustainable biobased fibre industry, complemented by the production of a range of textile fibres generated from local agro-waste materials.*

The high and increasing demand for textiles and clothing in the region, together with opportunities to complement cotton with other types of renewable fibres, opens new possibilities for an expanding sustainable textile industry. While cotton production and the associated processing and textile industry is already well established in the region, nevertheless there are substantial opportunities for improvement using all biowaste side-streams, optimising sustainability, and resource efficiency.
In addition, there is an increasing range of new textile biomaterials based on agro waste, which has become a valuable resource being reused into new materials, including such products as grape leather, a process that uses leftovers from wine industry to create vegetal leather; orange fibre made from citrus and orange rinds left over from juice production; yarn made from recycled coffee grounds; fish leather from tilapia skins; and viscose fibres from wood cellulose.

Potential impact: The EAC has recently approved a Cotton, Textiles and Apparel (CTA) Strategy encouraging procurement of institutional uniforms, beddings, and draperies by state bodies from the local textiles and fabrics industries. Member countries are also urged to develop strategies that will boost cotton production. Ethiopia and Kenya both have a growing garment production industry that is attracting inward investment. Exports of garments from the region amount to over US$700 million annually, but there is more than US$3000 million of imports[36]. Over 90 per cent of the material used is imported. This unbalanced trade shows the need to apply the CTA Strategy to improve the production in the region. This KRA offers great potential to support the CTA Strategy not only through the growth of cotton production, but also through the development of a more diversified and sustainable range of fibres for textile production.

KRA 3.5: Renewable bio-based oils

Strategic Objective 3.5*: To develop an industry based on sustainable production of renewable oils derived from the bioresources of the region.*

In industry there is an increasing demand for oils with special characteristics able to replace fossil oil-based products (as lubricants, or in green chemistry processes). East 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. This KRA will focus on facilitating 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.

Potential impact: Sub-Saharan Africa currently produces less than 3% of global plant oils and is reliant on a growing level of imports (an estimated 9 million tonnes annually of sunflower, soybean, and palm oil). Tanzania alone imports 320,000 tonnes annually, despite it being the second largest sunflower seed producer on the continent. A focus on local production offers

[36] USAID. 2018. USAID East Africa Trade and Investment Hub Overview of the Cotton, Textile and Apparel Sectors in East Africa Region (Kenya, Uganda, Tanzania, Ethiopia, Madagascar and Mauritius) and Benchmarking with Sri Lanka and Bangladesh. East Africa Trade & Investment Hub. USA.

significant opportunities for import replacement, as well as export of specialised bio-based oils.

5.1.4 Strategic Thematic Area 4: Sustainable Energy

***Strategic Objective 4**: To increase the* production and use *of sustainable bioenergy and develop a range 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 by-products 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 East Africa offer significant opportunities for expansion of biomass production that can create value-added at low opportunity cost by improving degraded or poorly maintained lands. There is a high potential to use part of the crop and pastureland that are currently very inefficiently used for bioenergy purposes and at same time increase the productivity of existing agricultural production systems. The African Union and countries in East Africa are developing a Bioenergy Development Strategy and Investment Plan, and this Thematic Area supports its operationalisation. Activities under this STA will also be supported by the work conducted by the Global Bioenergy Partnership in Kenya and Ethiopia.

KRA 4.1: Biomass briquettes as alternative to charcoal and firewood
***Strategic Objective 4.1**: To promote initiatives in briquette production from waste materials to substantially reduce the unsustainable use of wood fuel.*

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[37].

Biomass briquettes, mostly made from agroprocessing, agricultural and forestry residues, are increasingly popular in East 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. Work in this KRA will focus on scaling the production of biomass briquettes and improving and extending 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)

[37] IEA. 2019. Africa Energy Outlook 2019 World Energy Outlook Special Report. International Energy Agency Publications, 288. Retrieved from www.iea.org/t&c/

initiatives across the region[38].

Box 8: Briquettes and pellets as sustainable and modern energy carriers.
The East 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 meters with an estimated 120,000 cubic meters 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.

Potential impact: 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.

KRA 4.2: Production of biogas from organic waste

Strategic Objective 4.2*: To stimulate and support uptake of biogas technologies in the region at both household and industrial levels.*

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 user 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, for electricity generation and for public transportation. By inserting a series of pipes into landfills at various depths, the biogas produced through natural

[38] UNEP. 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/

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.
This KRA will seek to further the growth of biogas production and utilisation at all scales to address the current barriers and reach more of the population in the region.

Potential impact: As a source of renewable energy, scaling biogas use will have a considerable contribution to reduction of greenhouse gas emissions and reduction in unsustainable use of wood fuels.

KRA 4.3: Advanced biofuels
Strategic Objective 4.3*: To support the development of biofuels produced from lignocellulosic materials and algae.*

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 provides 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.

As a prospect for the longer term, biofuels are now being developed from microalgae. They are an ideal biofuel feedstock because of their rapid growth rate and greenhouse gas sequestration ability (net zero emission balance). They also do not compete with food or feed crops and can be grown on non-arable land and saline water. Technologies for their production and harvesting are still under development but offer future promise. Work in this KRA will focus on developing and implementing small scale second and third generation technologies that are financially viable and can be implemented at community level.

Potential impact: 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.

6. Key Strategic Enabling Actions

Strategic enabling actions are required to help translate the strategic intentions in Chapter 5 into programmes, and ultimately into outcomes and impacts.

The key enablers for successful delivery of the East Africa Bioeconomy Strategy will include: a) enabling policy environment ensured by enacting and harmonising policies and legislation in the region to support biosciences training and research, bio-innovation, and bio-businesses; b) enhancing the bioeconomy innovation system including facilitating the connection of entrepreneurs, especially start-up businesses, to affordable financing; c) capacity development in all areas of the bioeconomy; d) catalysing relevant and productive partnerships and collaborations to drive bio-innovations and bio-businesses, and e) effective

leadership and communication to facilitate coordinated and effective implementation within and across countries in the region.

This chapter presents a summary of these enablers, with specific examples of interventions that must be undertaken under each operational enabler.

6.1 Policy and legislation

Action required: *Policy makers should create an enabling policy environment in East Africa for the emergence of bioeconomy as a major driver for environmentally sustainable and inclusive economic development.*

Central to the development of a functional bioeconomy in East Africa will be the creation of demand for biobased products. In its 2019-2024 "*market analysis and forecast*", the International Energy Agency (IEA) identifies policy and regulatory uncertainty, as well as high investment risks as critical determinants of growth in the (bio) energy sector in developing countries. Policies and regulations that clearly benefit innovation and deployment, not only on the supply side, but also on the demand side will be crucial for successful delivery of the Bioeconomy Strategy in the region. Demand can be supported through: conducive long-term policies; efficient national regulatory systems; and appropriate incentive systems, including policies on banning /phasing out plastics, supporting SME growth, manufacture and use of locally made products, and enhancing ease of doing business, supporting actions to reduce Green House Gas emissions and mitigation of climate change, and regulations that foster rather than stifle innovations in support of the bioeconomy, and those that increase biobased trade – within and outside the region.

Regulatory frameworks for intellectual property, the access to and use of genetic resources, biosafety and the ethics of biosciences and industrial standards will need to be examined. While there are a variety of existing policies and strategies at regional and national level that are relevant for bioeconomy development, as listed in regionally in Annex A and including, for instance, National Biodiversity Strategies and Action Plans formulated under the Convention on Biological Diversity, gaps remain in policy and strategy coherence and implementation.

Effective governance will require interdisciplinary assessments and a consideration of insights from a broad set of scientific disciplines, including environmental, social, and economic disciplines. Effective regulatory oversight that does not stifle bioscience innovation needs to be balanced against public pressure for stringent and demanding regulations. Globally agreed standards on the measurement and definition of biobased products — such as their carbon footprint and sustainability— will need to be in place.
An independent and non-partisan certifying and testing body will need to be put in place to establish public confidence and enable countries that lack capacities to benefit from the results. But the policies must be informed by a deep understanding of the needs and aspirations of the region, and to be translated into practices which are reflective of the local contexts and priorities of individual countries and their expectations related to the bioeconomy.

Box 9 provides examples of some of the policy and legislation initiatives that, if addressed, will unlock the potential of bioeconomy in the region.

Box 9: Examples of Bioeconomy-related policy issues	
Sector	**Examples of policy/legislative issues to be addressed**
Food and Agriculture	● Countries are moving at different paces regarding acceptance of novel bioscience techniques to modify and tailor make various genetic resources. This includes new development of biotechnology crops through genetic modification (GM) or genome editing which is increasingly used to increase feedstock yields, net energy gain, and generation of high-value co-products. Legislation is lagging technology development, with new breeding technologies that blur the boundaries of genetic modification. 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. ● Common policies and regulations supporting (not stifling) development and deployment of biobased agrochemicals (e.g., biopesticides, growth promoting biologicals), including standards, ensuring product efficacy and safety, are required. ● The region lacks clear and coherent standards for novel food products and this can hamper innovation on novel foods. Regional harmonisation of food safety and food content regulations is also important for regional trade, not least to safeguard against mycotoxin contamination of food and feed which is a major problem in the region and has an impact on the potential for food value chain development and trade. ● The agriculture sector needs to be generally improved, with attention paid to issues of sustainable intensification, land tenure, governance, extension services etc.
Energy	● Regional clean energy policy: Countries need to move in a synchronised manner towards clean energy, considering likely cost differences among alternative energy sources. ● Conditions must be created to make bioenergy competitive through appropriate incentives: Currently biofuels are often less competitive than solar and wind.
Health	● The EAC is currently aiming to harmonise the systems for registration of human and animal medicines in the region. Disparate medicines regulatory regimes hamper the provision of quality health care. ● Costs and delays in product registration, and the prevalence of counterfeit drugs, must be addressed to facilitate the introduction of new products. ● Requirements for safety and efficacy data, as well as registration systems, for traditional medicines, must be clarified and implemented. Many plants used in traditional medicines are being unsustainably harvested from the wild. ● Policies on how information gathered from traditional medicine may be used as a starting material in the synthesis of conventional medicine should be clarified. Furthermore, countries should streamline their access and benefit sharing regimes.

Environment	• Measures designed to prevent or reduce harmful effects of human activities on the environment, and the protection of natural resources, need to be aligned between countries and adequately enforced. • Plastics vs bio-packaging - balancing environmental impact vs cost, and the need to harmonise policies and practice given the regional trade and citizen movements. Standards and guidelines for bio-packaging materials are needed. • Targeted interventions are needed that support the Paris Climate Change agreement on reducing Greenhouse Gas emissions and mitigating climate change.
Intellectual Property (IP)	• While IP is protected by law (through patents, copyright, trademarks, etc.), for benefits to accrue to inventors, the region will need acceptable systems (policies and practice) that help strike the right balance between the interests of innovators (including public and private institutions) and the wider (regional) public interest, while still fostering an environment in which creativity and innovation can flourish. Access to global intellectual property and knowledge needs to be improved to ensure that the region benefits from new emerging technologies. In the case of traditional knowledge and genetic resources, the region will require the introduction of appropriate regulations to ensure that indigenous knowledge systems are protected and that the conditions of the Nagoya Protocol on Access and Benefit Sharing are adhered to.
Business environment	• Policies are needed that support SME growth, and ease of doing business, incentivising the bio-businesses. • Regional integration through the creation of common markets for biobased products, needs to be developed to support biobased economic growth in the region. • Consideration needs to be given to ensure that import tariffs, such as for bioprocessing equipment, are not punitive. • Public procurement regimes catalysing and supporting the development of biobased value chains and sustainable production need to be developed.

6.2 Capacity strengthening

Action required: *Build human and infrastructural capacity for research, entrepreneurship and business development required to drive strong bioeconomy value chains in the region.*
Inadequate technical training, poor access to research facilities, and lack of strategic partnerships with other African and international research institutions are some of the major capacity constraints the region faces. Beyond human capacity and R&D infrastructure, entrepreneurial skills and competencies are critical for good ideas to move through to commercialisation. These include the ability of companies to embrace disruptive ideas, and the attitude toward entrepreneurial risk.

New and rapidly emerging technologies will continue to provide opportunities for improving biobased production and value chains. The region will need to build human and infrastructural capacities to access and harness these strategically important technologies and adapt them to local needs. Such a capacity could be built at a regional level through regional centres and service platforms. Building on lessons learnt from existing regional biosciences platforms such as the Biosciences East and central Africa (BecA) Hub based at the International

Livestock Research Institute (ILRI) in Nairobi, Kenya, the region will invest in creating robust biosciences platforms – which provide cutting edge technologies - based on institutional arrangements that ensure ownership, affordability, and access by national scientists.

The private sector in East Africa is crucial in the endeavour to build bioeconomies, and key to search for and exploit market opportunities. However, the private sector in East Africa is still weak, particularly around biobased enterprise development and therefore, on its own, is largely unable to drive the innovation needed for bioeconomy development. The establishment of new, and strengthening of existing, business incubators is essential. These incubators will seek to provide collaborative work environments for entrepreneurs, helping them transition from start-ups to independence. Incubator services will include financing facilities and business training courses, as well as in-house services—such as research and development, legal and accounting services which may be too costly for start-ups.

Other services will include physical working spaces, proof of concept support, market testing, business setup, and manufactured products or software assistance. In addition, just as it is important to catalyse cross-disciplinary networks bringing researchers and practitioners from different backgrounds together to share ideas and exchange experiences, start-up businesses also need support in networking.

Box 10: Building new Bioeconomy knowledge platforms.

Generating, promoting, and adopting innovations, technologies, and techniques to convert biomass into goods of higher value and to valorise the primary produce in the region is dependent on scientific and technological skills. These skills are largely inadequate in the region, and capacity building in this field can be enhanced by building shared knowledge platforms. Specific facilities that constitute a 'decentralised platform' could be spread across countries by commodity and/or thematic areas, following the model that was piloted under the East Africa Agricultural Productivity Project (EAAPP), funded by the World Bank. But the new platforms need to be designed to drive '*research into use'* where multi and -inter-disciplinary links are fostered as well.

Links with NARIs and universities will be a major means of ensuring continuing relevance of the science being taught and its application. In this connection, regional initiatives such as the flagship TAGDev program of RUFORUM – which *seeks to transform African agricultural universities and their graduates, to respond better to developmental challenges through the enhanced application of science, technology, business, and innovation for rural agricultural transformation* – will be important implementing partners. Working with universities to develop and/or review graduate programs to ensure continuing context relevance that reflects both the developments in the science and the evolving needs in the region will be important in this regard.

The priority intervention areas are summarised in **Box 11**.

Box 11: Priority areas for capacity strengthening	
Sector	**Actions required**
Science and technology institutions and universities	● Coordinate current institutional arrangements in terms of their mandates, functions, and activities in respect of bioeconomy-related issues. ● Strengthen key institutions and encourage collaboration both regionally and nationally. ● Maintain highly trained academic staff at public R&D institutions offering competitive remuneration and career opportunities.
Human capacity	● Enhance capacity in modern biosciences and related technologies, including synthetic biology, nanotechnology, and bioinformatics, digitalisation, and block chain technologies. ● For the health sector, build expertise in drug development, clinical trials, and regulatory aspects. ● Strengthen capacity in bioprocess engineering and valorisation of primary produce, including the construction and engineering of highly efficient and sustainable bioprocessing facilities of different scales, including modern biorefineries. ● Build 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.
Business development	● Stimulate business to business (B2B) collaboration, including supporting private sector actors with business development. ● Provide professional business incubation services to assist innovation actors with business development and commercialising promising products and technologies. ● Establish and/or strengthen technology transfer offices in universities and research institutes to provide support for techno-economic analysis, IP management, and linkage with the private sector. ● Organise technology fairs to provide an opportunity for entrepreneurs and potential investors to link up. ● Support community driven value addition processes. 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.
Infrastructure	● Develop biorefinery structures and agro-industrial development centres, including the development of local and community-based bioprocessing structures. ● Establish knowledge centres and/or clusters for specific value chains such as waste conversion, biofuels etc.

6.3 Financing

Action required: *Facilitate access to appropriate financing to support implementation of priority strategic initiatives that deliver or catalyse the delivery of regional bioeconomy outcomes and impacts.*

Access to capital and credit facilities under reasonable terms is critical for innovation and for realising the bioeconomy vision in the region. Public funding (from national budget allocations and funding agencies) is often the base for R&D efforts in the public sector and academia. But, to successfully bring R&D products or innovation of new bio-products to market, mechanisms to share risks and new funding partnerships are necessary, in which innovation, risks and business development costs are borne by several different parties. Lack of funding continuity and an inadequate understanding of the capital requirements to bring an innovation to market frequently lead to gaps in the innovation chain. Access to long-term support and capital, enabling the innovation processes for the development of biobased products in an iterative manner, is therefore a crucial success driver of the Bioeconomy Strategy. Creative financing models will need to be explored. For example, matched funding programs could be developed, in which R&D institutions co-invest with industry partners, thereby ensuring commitment from industry and reducing risks for all parties. In many donor-funded projects, funding remains concentrated in the R&D phase of the innovation cycle, with inadequate provision made for large-scale application and commercialisation of technology or products. For innovation to have impact and assist the region to move towards a bioeconomy, a range of funding models for sharing costs and raising necessary capital will be needed. Examples include: Regional and national public sector innovation funds; venture capital; philanthropic investments; blended financing mechanisms, etc. The African Development Bank (AfDB) will be an appropriate partner in this endeavour.

Box 12 presents examples of tailor-made financing mechanisms that could be developed to support bioinnovation towards commercial application.

Box 12: Examples of targeted financing along the innovation delivery chain

Financing mechanism	Actions required
Technology Gateway Funding	Industry-led research in emerging technology areas, and initiatives to deliver technology solutions for industry through collaborative industrial projects.
Small Business Innovation Research Funding	Engagement of public sector with technology-rich companies and organisations.
High Potential Start-up Feasibility Fund	Assist early-stage company or individual entrepreneur to investigate viability of a new business or proposition.
Innovation Partnership Fund	Assist collaborative projects between companies and research teams in tertiary education institutions (possibly with graduate training component).
High Potential Start-up Fund	Provide support for start-up businesses with potential to develop innovative product or service for sale on international markets.
Accelerator Fund	Support for entrepreneurs to launch market-changing companies – i.e., early investment to selected companies with well-defined plans for a technology-based product or service.

Innovation Vouchers	Provide modest grants (e.g.US$10,000) to get innovative solutions to a specific technical and business challenge.

6.4 Coordination and Partnerships

Action required**:** *The EAC must provide leadership and support to the development and deployment of well-coordinated, functional innovative partnerships and collaborations at national, regional, continental, and global levels needed to create a thriving and sustainable bioeconomy across East Africa that leverages on available science, technologies and innovations and has access to critical capacity and financing it needs.*

Effective regional collaboration will be crucial to delivering the objectives of the Bioeconomy Strategy. This will require an understanding of the ever-changing contexts and needs of individual countries and their economic development expectations. A robust coordination and partnership function will be a critical strategic enabler. This Strategy proposes a lean, but-fit-for-purpose, coordination and partnership arrangement that will provide leadership and coordination to drive implementation. This will include, among other things, fostering stakeholder engagements, creation of enabling policy environment, resource mobilisation, strategic partnership and collaboration arrangements, communication about the bioeconomy, and catalysing programme development and implementation mechanisms that are seamlessly integrated into national programming and not seen and treated as separate 'regional projects'. Importantly, this function will ensure on-going *relevance, effectiveness, efficiency,* and *sustainability* of programming at regional level.

Relevance: Actions to align objectives and design of bioeconomy programmes and interventions within them (including policies and practice, as well as financing) with the: (i) challenges and concerns relevant for the contexts of the region and individual countries; and (ii) the specific needs, concerns, and priorities of countries. Relevance of bioeconomy programming will be compromised when: either the supply or the demand for specific regional programs are not well founded; when the program activities at regional level compete with or substitute for activities that individual countries can do more efficiently; or when the program design and implementation is inappropriate for achieving the objectives. Thus, to achieve continuing relevance of programs the coordination and partnership entity will need to ensure that formulation and implementation processes pay due and adequate attention to the challenges, concerns, and priorities of individual countries, including capacities.

Effectiveness: Coordination will also ensure that programmes deliver their stated objectives. Supporting flagship national and regional programmes to undertake analysis of the extent to which projects/programs meet or fail to meet their intended deliverables/targets, and paying special attention to the identification of both success and failure factors will be a crucial function, especially in the early stages of flagship bioeconomy programmes. Lessons-learning across the region aimed at design and process improvements will be part of this function.

Efficiency: Efficiency function will aim to ensure that resources or inputs (finances, expertise, time, etc.) are converted to results in the most economical manner. This will include analytical support to both regional and national programmes so that the least costly resources that are appropriate and available are used to achieve the desired results or deliverables. As the region begins to roll out major initiatives in bioeconomy, many programmes will be entering

'new territory' and will need support in ensuring resource use efficiency. Addressing duplication of efforts and conflicting investments will be crucial. Good practice analyses, that is, lessons learned from similar endeavours, will be used as benchmarks for assessing efficiency. Close attention will need to be given to coordination and collaboration among countries, especially putting in place practices that pay close attention to opportunities for synergy and complementarity in programming.

Sustainability: Sustainability of the bioeconomy will include all aspects of production, value addition and consumption of biobased products, and include environmental, social, and economic sustainability. Good governance and evidence-based assessments and decision making are also vital components in building a sustainable bioeconomy. Sustainability will be measured as the ability of programme results (outcomes and impacts) to be maintained and scaled for wider use beyond '*project, pilot or demo phase'.* Achievement of sustainability will be evidenced by economic prosperity that can be linked to the realisation of the objectives of this Strategy. In this regard the coordination and partnership functions will be responsible for actions to ensure that countries in the region are individually and together as a block on a consistent journey towards policy and practice that foster an ecosystem of discovery, innovation and commercialisation, and that biobased business enterprises are emerging, thriving, creating jobs and generating solutions that address the most pressing environmental and human livelihood challenges, and improving quality of life. In addition to policy environment, appropriate financing and partnerships will be crucial underpinnings for achieving this desired sustainable, bioeconomy-driven, economic prosperity in the region.

Overall, to deliver on this function, some of the overarching activities to be undertaken will include:

- On-going analysis of trends at country, regional, continental, and global levels that have implications (e.g., they present challenges and opportunities) for bioeconomy programming in the region.
- Working with member countries and engaging with key stakeholders to ensure that changing country contexts and needs inform regional bioeconomy programs and programming approaches.
- Identification of partnerships, including Public-Private Partnerships, (PPP) and other institutional arrangements to improve programming, including to address or harness emerging challenges and opportunities.
- Identifying and addressing duplications and facilitating programming arrangements that optimise exploitation of synergies.
- Identification of resources and matching resourcing models to contexts and needs

6.5 Communication and awareness raising

Action required: *To build an understanding amongst the key actors and the general population of the region about the concept of a bioeconomy, the need for its development in the region, and its contribution to the Sustainable Development Goals and combatting climate change.*

Communication plays an increasingly important role in innovation, and is particularly important in the development of a bioeconomy. It is not a one-way process, but requires a constant dialogue between science, business, and society. Efforts to encourage stakeholders to participate in evidence-based discussions are needed that also allow for discussion of broader issues such as socio-cultural, political, and ethical concerns. Communication is

necessary to build relationships and establish trust and legitimacy with future product-development partners and end-users of the technology. It is also important for obtaining information and feedback about preferences and needs from the public and relevant stakeholder groups (such as farmers, agribusiness actors etc.) which can be built into the programmes within the Strategic Thematic Areas to improve the chances of uptake and acceptance of the technology.

A coordinated plan to communicate the bioeconomy is essential since the messaging must be appropriate for the audience. Information exchange at meetings, seminars, workshops, and hearings is essential and helps stimulate innovations and the development of bioeconomies in the region.

Increasingly, social media plays an important role in information sharing, and platforms such as a Bioeconomy website, as well as Facebook, Twitter, Instagram and TikTok should be used to spread knowledge of the bioeconomy while at the same time it is important to ensure that the information shared is accurate and appropriate.

Establishment of a regional bioeconomy observatory knowledge sharing portal that will publish reports, information on partners, projects, breakthroughs, and funding opportunities among others, will assist with communication. Actors in the innovation system need to be trained to effectively communicate with various market actors and end-users. Finally, communication is integral to coordination and partnership functions.

6.6 Monitoring and Evaluating the Bioeconomy

Monitoring the bioeconomy is becoming increasingly important as bioeconomy strategies are developed and the demand for biobased materials including biomass from agriculture, forestry, fisheries, and organic waste, is increasing and new bio-based technologies are being explored in various sectors. There is, consequently, a growing interest among governments in setting up bioeconomy monitoring systems that can enable the measurement and assessment of bioeconomy progress, from biomass extraction to consumption and recycling, and their implications for sustainability and development in order to facilitate policymaking, design of interventions and enabling frameworks.

However, monitoring bioeconomies and their economic, environmental, and social impacts is difficult for many reasons since the bioeconomy spans across many sectors. Another key issue for bioeconomy monitoring is that when official economic statistics are published, distinctions are rarely made between bio-based and non-bio-based products. Consequently, bioeconomy contributions are not clearly delineated in official statistics, making monitoring very difficult. In addition, generally agreed performance indicators and metrics on monitoring progress of the bioeconomy do not exist today and are also lacking in most bioeconomy strategies worldwide. Work on developing indicators is ongoing and indicators to monitor and evaluate the sustainability of bioeconomy has been published by FAO[39]. In the European Union, European Commission's (EC) Joint Research Centre (JRC) is working towards the development of a coherent monitoring system to track economic, environmental and social progress towards a sustainable bioeconomy outlined in the EU Bioeconomy Strategy[40].

[39] Bracco, S., Tani, A., Çalıcıoğlu, Ö., Gomez San Juan, M. & Bogdanski, A. 2019. *Indicators to monitor and evaluate the sustainability of bioeconomy. Overview and a proposed way forward.* Rome,
[40] Kilsedar, C., Wertz, S., Robert, N. and Mubareka, S., Implementation of the EU Bioeconomy Monitoring System dashboards, Knowledge Centre for Bioeconomy, Ispra, 2021, ISBN 978-92-76-28946-3, doi:10.2760/577115, JRC12367

Within the EU there are national initiatives on monitoring of the bioeconomy such as in Germany [41] as well as other proposed monitoring frameworks [42]. During the recent Global Bioeconomy Summit 2020 (https://gbs2020.net) and in the GBS 2020 Global Bioeconomy Summit Communique[43] there is also clear call for the development of commonly agreed metrics and indicators for measuring the bioeconomy progress at country levels.

As a first step for East Africa, metrics need to be defined that are appropriate for the region to determine the current contribution of the bioeconomy. They also need to relate to the Objectives and Strategic Thematic Areas of the Bioeconomy Strategy. Once these are defined and agreed, they can serve as the baseline from which to monitor and evaluate the growth of the bioeconomy.
As an example, four measures have recently been proposed by economists in South America[44]:

- The biobased content of outputs vs inputs (value addition)
- Contribution of the economy to employment
- Contribution to greenhouse gas emissions
- Knowledge and research capacities of the bioeconomy

The South African Bioeconomy Strategy proposes measures that also relate to inputs and outputs, namely input measures including increased expenditure on research, development, and innovation projects, and on the provision and establishment of equipment and infrastructure. The outcomes from such investment will be measured through the number of patents awarded, the number of bio-innovation firms established, and the number of products available commercially. Particularly for the health sector, regional and international partnerships and technology transfers are included as measures. However South Africa has not yet implemented a comprehensive monitoring framework.

These types of new emerging bioeconomy metrics can, when they have been agreed, be incorporated into the regional Bioeconomy Strategy and into national bioeconomy strategies in the region. Monitoring of the bioeconomy at the regional level, could possibly be done through the Bioeconomy Observatory mechanism once there is a commonly agreed monitoring framework.

The implementation of the Monitoring and Evaluation (M&E) framework for this Bioeconomy Strategy will require the preparation of annual monitoring plans that will provide a framework for tracking of the bioeconomy interventions from objectives outputs to activities of the “EAC Regional Bioeconomy Strategy Implementation Plan matrix (2021-2031)” as presented in appendix I.

The management and coordination of EAC Regional Bioeconomy Strategy implementation activities will be handled by a Regional Technical Working Committee (RTWC) comprising of a high-level group of officials and bioeconomy experts drawn from the region. The membership composition of the experts is indicated in the terms of reference for the RTWC in appendix II.

[41] https://www.nature.com/articles/s41893-021-00725-3
[42] https://cdn.sei.org/wp-content/uploads/2020/01/sei-report-2020-bioeconomy-diaz-chavez.pdf
[43] (https://gbs2020.net/wp-content/uploads/2020/11/GBS2020_IACGB-Communique.pdf)
[44] Alviar, M.; García-Suaza, A.; Ramírez-Gómez, L.; Villegas-Velásquez, S. Measuring the Contribution of the Bioeconomy: The Case of Colombia and Antioquia. Sustainability 2021, 13, 2353. https://doi.org/10.3390/su13042353

7. Future Perspectives

The development of bioeconomies in the countries in the region is an imperative to enable economic growth and sustainable development. However, it will only be achieved through regional cooperation and strong leadership from governments, with the provision of appropriate policies and incentives.
This regional Bioeconomy Strategy therefore needs to be followed by the development of national Bioeconomy Strategies, where detailed action plans can be developed that are relevant and appropriate for each country in the region.
As a vital component of their Bioeconomy Strategies, countries in the region should embrace the concept of a circular economy, whereby resources are re-used instead of being consumed and then discarded, to ensure that the region's irreplaceable bioresources are available for generations to come. So far Rwanda is the only member in the region of the African Circular Economy Alliance. This will require a major drive to ensure that short-term expediency is not prioritised over long-term benefits. Changes in societal attitudes will be an important factor here.

Many new technologies are under development around the world, with the potential to contribute to bioeconomies in the region. The convergence of opportunities through applications of biotechnology and information technology which is termed the "Fourth Industrial Revolution" can have a radical impact on our futures, and it is essential that the region is not left behind.

The short term social and economic impact of the COVID-19 pandemic should not deter governments from seeking a new vision for the future, where economies are rebuilt based on long-term sustainability. The EAC has an important role to play in actively supporting the development of sustainable bioeconomies in the region and in addressing all the issues identified above that are needed to make it happen.
This EAC Bioeconomy Strategy should also be seen in a broader regional and international context. In the recent Global Bioeconomy Summit 2020 (https://gbs2020.net), the development of the EAC Bioeconomy Strategy was acknowledged and discussions during the summit also highlighted the possibility to expand the work in East Africa on bioeconomy strategy and policy development to other regions in Africa. In implementing the EAC Bioeconomy Strategy, it will also be important to see how this can be done in harmonisation with other closely related initiatives, such as the African Circular Economy Alliance[45].

[45] https://www.aceaafrica.org/

Appendix I: Implementation Matrix

No.	Objective output	Activities	Timeline from launch (Years)	Projected Cost (USD)	Responsible Centres/Actors
1	**Increased awareness on bioeconomy**	**Support the Popularization of Bioeconomy in EAC Region through:** i. Promote Bioeconomy and sensitize the stakeholders and the general public in the region ii. Undertake extensive and sustained awareness promotion campaigns iii. Build an understanding amongst the key actors and the general population of the region about the concept of a bioeconomy iv. Development of the bioeconomy communication and awareness plan v. Improve access to bioeconomy information and data through e-platforms such as the regional bioeconomy observatory knowledge sharing portal vi. Convening of Regional Bioeconomy conferences, webinars and scientific workshops vii. Creating a critical mass of bioeconomy awareness and appreciation among stakeholders and the general public;	Y1-Y10	US$5m	• EASTECO • Partner State Governments & MDAs • Technical Steering Committee (TSC), • EAC Regional Bioeconomy Forum • EAC Organs and Institutions • Regional Bioeconomy stakeholders • Regional and International bioeconomy development organizations

No.	Objective output	Activities	Timeline from launch (Years)	Projected Cost (USD)	Responsible Centres/Actors
		viii. Ensuring active stakeholder and public participation during strategy implementation; and ix. Use of print and electronic media publicity and sensitization campaigns tailored to target different bioeconomy stakeholder categories with the aim to consciously utilize and invest in bioeconomy x. Continue with series of the Eastern Africa Bioeconomy Conferences xi. Facilitate the visibility of leading bioeconomy initiatives			
2	**Increased funding for bioeconomy**	**Bioeconomy Financing and Resource Mobilization through:** i. Facilitate access to appropriate financing to support implementation of priority strategic initiatives that deliver or catalyse the delivery of regional bioeconomy outcomes and impacts ii. Mobilize funds for bioeconomy research and innovation from Partner State contributions, regional and international cooperation agencies and development partners iii. Establish the Research and Innovation Fund	Y1-Y10	US$50m	• EASTECO • Partner State Governments & MDAs • Technical Steering Committee (TSC), • EAC Regional Bioeconomy Forum • EAC Organs and Institutions • Regional Bioeconomy stakeholders

No.	Objective output	Activities	Timeline from launch (Years)	Projected Cost (USD)	Responsible Centres/Actors
		iv. Conduct regional bioeconomy infrastructure baseline study v. Support bioeconomy infrastructure development through Partner State contributions, regional and international cooperation agencies and development partners. vi. Establish resource mobilization coordination framework responsible for mapping finance and resources vii. Promote public private partnerships for bioeconomy efficiency management and conservation viii. Development investment prospectus for bioeconomy			• Regional and International bioeconomy development organizations
3	**Adequate Bioeconomy Capacity**	**Bioeconomy Capacity Strengthening through:** i. Coordinate current institutional arrangements in terms of their mandates, functions and activities in respect of bioeconomy-related issues. ii. Establish regional centre of excellence to host programmes that produce new knowledge on how to foster and advance the transition to a bioeconomy-based society in the Partner states by integrating research, innovation and entrepreneurship.	Y1-Y7	US$25m	• EASTECO • Partner State Governments & MDAs • Technical Steering Committee (TSC), • EAC Regional Bioeconomy Forum

No.	Objective output	Activities	Timeline from launch (Years)	Projected Cost (USD)	Responsible Centres/Actors
		iii. Strengthen key institutions and encourage collaboration both regionally and nationally. iv. Maintain highly trained academic staff at public R&D institutions offering competitive remuneration and career opportunities. v. Enhance capacity in modern biosciences and related technologies, including synthetic biology, nanotechnology and bioinformatics, digitalisation and block chain technologies. vi. For the health sector, build expertise in drug development, clinical trials and regulatory aspects. vii. Strengthen capacity in bioprocess engineering and valorisation of primary produce, including the construction and engineering of highly efficient and sustainable bioprocessing facilities of different scales, including modern biorefineries. viii. Build 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. ix. Stimulate business to business (B2B) collaboration, including supporting private sector actors with business development.			• EAC Organs and Institutions • Regional Bioeconomy stakeholders • Regional and International bioeconomy development organizations

No.	Objective output	Activities	Timeline from launch (Years)	Projected Cost (USD)	Responsible Centres/Actors
		x. Provide professional business incubation services to assist innovation actors with business development and commercialising promising products and technologies. xi. Establish and/or strengthen technology transfer offices in universities and research institutes to provide support for techno-economic analysis and linkage with the private sector. xii. Promote establishment of science and technology parks; science, technology and innovation hubs; technology business incubators; and industrial parks in order to spur bioeconomy technology transfer, adaptation and exploitation in the region. xiii. Organise bioeconomy technology fairs to provide an opportunity for entrepreneurs and potential investors to link up. xiv. Support community driven value addition processes. 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. xv. Develop biorefinery structures and agro-industrial development centres, including the development of local and community based bioprocessing structures.			

No.	Objective output	Activities	Timeline from launch (Years)	Projected Cost (USD)	Responsible Centres/Actors
		xvi. Establish knowledge centres and/or clusters for specific value chains such as waste conversion, biofuels etc.			
4	**Adequate Bioeconomy Coordination mechanisms and Partnerships**	**Bioeconomy Coordination and Partnership through:** i. Establish coordination and partnership unit embedded in the EASTECO Secretariat that will provide leadership and coordination to drive implementation. ii. Establish and catalysing relevant and productive partnerships and collaborations to drive bio-innovations and bio-businesses. iii. Support to the development and deployment of well-coordinated, functional innovative partnerships and collaborations at national, regional, continental and global levels. iv. Promote market-driven technology development and transfer collaborations between regional actors in academia, research and the private sector. v. Facilitate the alignment of the national bioeconomy policies to the regional bioeconomy strategy	Y1-Y10	US$5m	• EASTECO • Partner State Governments & MDAs • Technical Steering Committee (TSC), • EAC Regional Bioeconomy Forum • EAC Organs and Institutions • Regional Bioeconomy stakeholders • Regional and International bioeconomy development organizations

No.	Objective output	Activities	Timeline from launch (Years)	Projected Cost (USD)	Responsible Centres/Actors
5	**Enabled Bioeconomy Policy and regulatory environment**	**Enabling Bioeconomy Policy and regulatory environment through:** i. Create an enabling policy environment in East Africa for the emergence of bioeconomy as a major driver for environmentally sustainable and inclusive economic development. ii. Facilitate the development/review and implement of National Bioeconomy policies of the partner States. iii. Establishment of National and Regional bioeconomy advisory committee of the EASTECO. iv. Develop and operationalize EAC Regional Bioeconomy Strategy Monitoring and Evaluation Framework.	Y1-Y10	US$1.5m	• EASTECO • Partner State Governments & MDAs • Technical Steering Committee (TSC), • EAC Regional Bioeconomy Forum • EAC Organs and Institutions • Regional Bioeconomy stakeholders • Regional and International bioeconomy development organizations
	Estimated Cost for EAC Regional Bioeconomy Implementation (spread over 10-year time horizon)			**US$86.5m**	

Appendix II- Terms of Reference for the Regional Bioeconomy Technical Working Committee

The management and coordination of EAC Regional Bioeconomy Strategy implementation activities will be handled by a Regional Technical Working Committee (RTWC) comprising of a high-level group of officials and bioeconomy experts drawn from the region. Members of the Regional Technical Working Committee will include representatives from the following institutions;

i. Ministry responsible for Science, Technology and Innovation
ii. National Councils/Commissions of Science and Technology
iii. Ministry responsible for EAC Affairs
iv. Agriculture Research Institutions
v. Academia/University
vi. Private Sector
vii. Industrial Research Organisations

EASTECO Secretariat will be a member of the RTWC and responsible for coordination and operationalization of working group activities and informing EASTECO Governing Board of Bioeconomy development plans, strategies and activities organized by the RTWC.

Upon request from EASTECO, the members will nominated by Ministry responsible for EAC Affairs from each Partner State.

The Regional Bioeconomy Technical Committee will oversee and provide technical guidance and advice to the EAC Regional Bioeconomy Implementation Plan. The RTWC will develop their own operational manual spelling out working procedures.

The functions of the EAC Regional Technical Working Committee (RTWC) will include:

i. Managing the activities of the EAC Regional Technical Working Committee;
ii. Advocating for accelerated establishment and operationalization of National bioeconomy Policies in all Partner States;
iii. Ensuring a multi-disciplinary approach to strategy implementation by embracing the role of environmental, social sciences, humanities, and ethics in the development of a socially and economically viable and workable bioeconomy that can sustainably drive

innovation and creativity in the region;

iv. Conceptualizing the establishment of an EAC Regional Bioeconomy Centre of Excellent for specialized skills capacity building across the entire bioeconomy value chain;

v. Providing expert advice and guidance on processes related to Bioeconomy-driven knowledge transfer; technology development, transfer, and adaptation; Foreign Direct Investments (FDIs); and commercialization of research outputs and innovations;

vi. Instigating and coordinating the sharing of existing Bioeconomy-related physical and technology infrastructure, as well as the establishment of new shared facilities/resources in the EAC region;

vii. Monitoring the integration of Bioeconomy into the regional development agenda through an agreed regional framework and system that provides context to it;

viii. Participating at regional and international Bioeconomy development meetings, conferences, and symposia, with a view to establishing/deepening linkages and collaborations with strategic partners;

ix. Developing a framework for effective linkage between Partner State national Bioeconomy policies and EAC Regional Bioeconomy programs and activities;

x. Formulating a high-profile regional bioeconomy program for recognizing and rewarding bioeconomy innovation and creativity in the EAC region;

xi. Organising regional conferences and activities related to Bioeconomy development in the region;

xii. Compiling evidence-based status reports on bioeconomy development in the region;

xiii. Advising EASTECO on integration of Bioeconomy in emerging regional development issues;

xiv. Advising EASTECO on strategies, plans and activities related to development of bioeconomy infrastructure, human capital and utilization;

xv. Promoting Bioeconomy-centric collaborations and partnerships at regional and international level;

xvi. Advising EASTECO on the appropriate structure and institutional arrangements for Bioeconomy developments in the region; and

xvii. Sharing and disseminating relevant bioeconomy information with regional stakeholders and incentivising the use of the Regional Observatory.

Appendix III: Review of regional level bioeconomy related policies and strategies

No.	Policy/Strategy/Priority	Main Focus
1	The **EAC Vision 2050**	The Vision aims to transform the region into middle income status by 2050. It defines six broad pillars, including Infrastructure Development; Agriculture, Food Security and Rural Development; Industrialisation; Natural Resources and Environment Management; Tourism, Trade and Services Development; and Human Capital Development. The bioeconomy is expected to support these pillars to ensure sustainable production of goods and services and enhance economic competitiveness of the region.
2	**The Fifth EAC Development Strategy (2011 – 2021)**	The strategy envisions an integrated, prosperous, and resilient East African region. Its main focus is on enhancing the region's economic growth and resilience through cross sector development opportunities. This strategy recognises that sustainable management of the environment, the natural resources and biodiversity is vital for economic growth and stability. In addition, it affirms that, if well managed, the biological resources can provide a foundation for sustained and inclusive growth and poverty reduction in the region. This strategy therefore underscores the importance of the existing biological resources and their role in regional economic development thus supporting bio-economy development.
3	The **EAC Agriculture and Rural Development Policy (2006)**	The policy purposes to achieve food security in the region and improve agricultural production within the member states. This is achieved through improving the standards of nutrition by increasing output, quality, and availability of food in the region, encouraging the development of new and appropriate agricultural production technologies that improve land and labour productivity as well as promoting sustainable use and management of soil, water, fisheries, and forest resource in order to conserve the environment. This policy supports bio-economy development since it promotes sustainable use and management of various biological resources like fisheries and forests to achieve sustainable development in the region.
4	**The EAC Agriculture and Rural Development Strategy (2005 – 2030)**	The strategy envisions a well-developed agricultural sector for sustainable agricultural economic growth and equitable development. It focusses on promoting and facilitating the development, production and marketing of high-quality agricultural produce thus attaining food security, eradicating poverty, increasing agricultural incomes, and achieving sustainable development within the partner states. The strategic interventions employed to achieve the stated objectives include increasing the quantities and quality of agricultural production, increasing income generation through processing, value addition and marketing, supporting agro-based industrialisation, promoting export of agricultural produce and conservation of natural and biological resources for economic development, thus supporting bio-economy development.

No.	Policy/Strategy/Priority	Main Focus
5	**The East African Community Food and Nutrition Security Action Plan (2018 – 2022)**	This aims to contribute to elimination of hunger, malnutrition, and extreme poverty in the region by 2022. This is to be attained through improving sustainable and inclusive agricultural production, productivity and trade of crops, animals and animal resources, fisheries, aquaculture, apiculture, and forest products. Moreover, it focusses on strengthening the people's resilience through promoting sustainable utilisation of natural resources, environmental conservation, and post-harvest value addition among others. The Plan of Action is cognisant of the need to ensure efficient and sustainable utilisation and conservation of the region's biological resources as a key driver to sustainable agricultural growth, which is supportive bio-economy development.
6	**The EAC Protocol on Environment and Natural Resource Management (2006)**	This gives a directive to all partner states regarding the management of the environment and natural resources within their jurisdiction including transboundary ecosystems and natural resources including the conservation and management of biological diversity, wetlands, forests and tree resources, protection of the ozone layer, tourism development and biosafety and biotechnology development among others. This protocol aims to promote sustainable development and utilization of environment and natural resources, foster closer cooperation for judicious, sustainable, and coordinated management, conservation, protection and utilisation of the environment and natural resources, and promote capacity building and environmental awareness among others, thus supporting bio-economy development.
7	**The East African Community Climate Change Policy (2011)**	This policy focuses on addressing the adverse impacts of climate change in the region and harness any potential opportunities posed by climate change within the principle of sustainable development. This policy is founded on three key pillars, namely; climate change adaptation, mitigation and research, which encompasses monitoring, detection, attribution and prediction. This policy supports proper utilisation and protection of the region's biological resources for sustainable development, which is a key aspect of bioeconomy
8	**The East African Science, Technology, and Innovation Policy (awaiting approval by the EAC Council of Ministers)**	The East African Regional STI Policy is anchored on the following pillars: i) Capacity building for skills and STI Infrastructure; ii) Research, Innovation and Entrepreneurship; iii) Resource mobilisation, partnerships, and collaborations; and iv) Enabling environment. The priority areas are: (1) Agriculture and Food; (2) Health and Life Sciences; (3) Human Resource Development/ Education; (4) Infrastructure; (5) Energy; (6) ICT and Big Data (7) Industrialisation and Trade; (8) Environment and Natural Resources Management; (9) Climate Change; (10) Traditional and Indigenous Knowledge; and (11) Space Science and Technology.
9	**The East African Intellectual Property Policy (awaiting approval by the EAC Council of Ministers)**	The EAC Intellectual Property Policy aims to encourage technical innovation, and to promote the industrial and commercial use of technical inventions and innovations to contribute to the social, economic, industrial, and technological development of the Community.

No.	Policy/Strategy/Priority	Main Focus
10	**Polythene Materials Control Bill (2016)**	The East African Legislative Assembly has already passed this bill which will become a law if implemented fully. This will see a total ban on the production and use of single-use plastics across the member states. So far, some countries like Rwanda and Kenya are implementing this ban, while others like Tanzania are committed to start its implementation soon. This is a great milestone which creates new forms of environmentally friendly jobs, new markets, and innovative production to fill the gap created by the ban. Since this ban aims to substitute the use of plastics with bio-degradable materials, it offers a direct support for bio-economy development in the region.
11	**The EAC Industrialisation Policy (2012 – 2032)**	The policy aims to enhance industrial production and productivity as well as accelerate the structural transformation of the region's economies to enable sustainable wealth creation, improved incomes, and higher standards of living for the people. In addition, it is focused on making structural transformation of the manufacturing sector through high value addition and product diversification based on comparative and competitive advantages of the region. This policy plays a crucial role in raising the investment levels and facilitating the creation of new backward and forward linkages across the region. It is also keen on upgrading the technological capacity of the partner states for the purposes of promoting trade within them and promoting a more strategic integration into the world economy to ensure sustainable industrial growth. Although this policy does not explicitly support bio-economy development, its focus on promoting value addition, development of human capacity and new technologies and innovations as a pre-requisite for successful regional trade which are key components of bioeconomy reveals its significance.
12	**The 2nd EAC Regional Pharmaceutical Manufacturing Plan of Action (2017 – 2027)**	This is a regional roadmap towards attaining an efficient and effective regional pharmaceutical industry that can meet national, regional, and international demands efficiently. The plan recognises the contribution of local production of essential medicines towards attaining the sustainable development goal on universal health coverage in the region. The plan aims to increase local production to cover much of the internal needs as well as investing more on new technologies and innovations, establishing linkages between the industry and academia and intensifying research and development on the industry. The plan prioritises the use of locally available materials and biological resources to develop the industry. Additionally, it is keen to promote local knowledge and technologies in the industry, which are key elements for bio-economy development.

No.	Policy/Strategy/Priority	Main Focus
13	**EAC road map to implement key resolution of the Paris Agreement**	A road map to implement key resolution of the Paris Agreement and Nationally Determined Contributions (NDCs) translating the Paris Agreement into concrete steps for the Partner States such as; internalising the Paris Agreement to come up with country specific implementation framework; identification of common actions across NDCs and develop NDCs Implementation Plans; review of the EAC's existing Regional Climate Change Policy (2011), Climate Change Strategy (2011/12-2015/16) and Climate Change Master Plan (2013-2033) to mainstream the Paris Agreement. Interventions also include; promoting the continental climate resilient and low carbon development initiatives such as the Climate Smart Agriculture; promoting the African Adaptation and Loss and Damage Initiative; and lastly; promoting renewable energy and other sustainable development initiatives to attain global goal of reducing Green House Gas Emissions (GHGEs).
14	**EAC Climate Finance Mobilization and Access Strategy**	The EAC Climate Finance Mobilization and Access Strategy EAC cover several sectors including, water resources, agriculture, energy, infrastructures, forestry, biodiversity and tourism, human settlements, coastal, marine environment and fisheries, human health sector transport
15	**Bioenergy Development Strategy and Investment Plan.**	The Bioenergy Strategy and Investment Plan was launched in 2019 following the adoption of the African Union African Bioenergy Framework and Policy. The Strategy is being developed in collaboration with the EAC. The aim is to increase the pace of investments in bioenergy projects considering the abundant bioenergy resources.
16	**National development Plans and Visions of EAC Partner States**	A review of the member states' long-term visions and national development plans indicates that the countries' national priorities are rather similar. These documents identified the following priorities: Agriculture, Animal husbandry and rural development, Energy, health, and life sciences, Increasing private sector investment, Water & Sanitation, Climate Change, Environment and Natural Resources Management. These are all key in Bioeconomy development

No.	Policy/Strategy/Priority	Main Focus
17	**Other** developments: The African Circular Economy Alliance	This has the long-term ambition of spurring Africa's transformation to a circular economy which delivers economic growth, jobs, and positive environmental outcomes at the national, regional, and continental levels. Rwanda is working with South Africa, Nigeria, the United Nations Environment Programme and World Economic Forum to develop this continent-wide alliance. African countries with their vast untapped natural resources and fast-growing population, have the chance to leapfrog to a low-emission and climate-resilient development model by adopting circular economy principles that enhance social inclusivity. An effective circular model for Africa must emphasise green innovations and job creation to seize local and cross-border market opportunities, as well as enhancing climate resilience through economic diversification. The circular economy approach is complementary to bioeconomy development.

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