

Modelling bioeconomy futures for Eastern Africa

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Abstract

Purpose – This paper aims to explore the potential of Bioeconomy as a pathway for sustainable transformation of economies of East Africa. Although East Africa region has shown good growth, this has been accompanied by rising concerns about sustainability, as population growth is putting significant strain on biodiversity undermining capacity for future growth. The search for a new growth pathways points to leveraging bioeconomy. To get insights on the viability of this pathway, this study simulated several scenarios to help inform a regional bioeconomy strategy.

Design/methodology/approach – To get insights into the viability of this pathway, a conceptual model to capture demand and supply drivers was constructed and simulations were conducted by using the International Futures (IFs) modelling platform.

Findings – The analysis points to the potential of a bioeconomy-driven economic strategy to drive transformation. However, the simulation points to the fact that if not well thought out, it can also be costly in terms of environment, and indeed such a strategy can lead to a disaster in the long run. It is also clear that having a strong Bioeconomy does not necessarily mean being self-sufficient in agricultural production. If saving the forests or increasing forest cover means agricultural imports rise this should be fine. Also, a strong Bioeconomy does not necessarily mean development objectives are fully met.

Research limitations implications – The IFs platform is a general platform and thus cannot capture the specific enablers for a Bioeconomy. So strategy development should use the result as starting point.

Practical implications – Also, a strong bioeconomy does not necessarily mean that development objectives are fully met. A bioeconomy strategy should be part of package of strategy to ensure sustainable and inclusive growth.

Originality/value – While Bioeconomy is increasingly gaining attention, many countries have proposed strategies the analysis tends to be qualitative. No quantitative simulation of this new economic pathways has yet been conducted in East Africa. The IFs platform is a general simulation platform; therefore, the parameters available in the model cannot fully capture what Bioeconomy is. This analysis needs to be supplemented by a qualitative scenarios analysis.

Keywords Sustainable development, Economic forecasting, Modelling, Scenario planning, Forecasting, Bioeconomy, Sustainability, East-Africa

Paper type Research paper

1. Introduction

The region of East Africa is one of the fastest-growing regions in the world with a gross domestic product (GDP) average growth rate of 6.7% between 2013 and 2017, more than double the African average (ECA, 2019). It is also the region showing some of the fastest growth on population (AfDB, 2016). At the same time, economies are largely untransformed with agriculture accounting for around one-third of regional GDP (ECA, 2019). Rapid population growth in an agrarian-based economy combined with changing habitations patterns, overgrazing, biopiracy, deforestation, pollution and the unsustainable exploitation of natural resources, the region, now struggles to sustain water supply, food security and agricultural productivity (Brooks, 2017). This has put into question the sustainability of the high growth realized in recent years. The countries have

acknowledged this challenge and are looking to find economic transformation pathways that are sustainable.

Sustainability is now a global agenda as the Sustainable development goals (SDGs) attest. There is a clear desire to shift economies from the current fossil fuel- and non-renewable-based economies to more sustainable pathways. Though sustainability movement has a long history with the first warning being raised by the Club of Rome ([Meadows et al., 1972](#)), there is now a much greater focus on the issue owing to the threat of climate change which has given a new urgency to develop new growth trajectories. Indeed, sustainability and the need to mitigate climate change impact are now key issues being tackled by global governance institutions with important agreements e.g. SDGs, Convention on Biodiversity, Climate Change (COP21) reached.

In this regard, there has been a call to shift to new bases of the economy towards greener economies and a greater focus on the dematerialization of economies through building circular economies ([Reuter, 2013](#)). While technologies needed to support the transition to these new economic pathways are still in the early stages of development, there is a growing mass of consumers concerned with sustainability and demanding sustainable products. This is creating a market ([Nilsen, 2015](#)) and hastening the transition. With the growing power of global governance institutions and also as local governance institutions grow there is a real chance for making the needed transition. One promising pathway is the bioeconomy. Bioeconomy has been defined as the production, utilization and conservation of biological resources, including related knowledge, science, technology, and innovation, to provide information, products, processes and services across all economic sectors aiming toward a sustainable economy ([GBS, 2015](#), p. 2) [1].

This paper seeks to explore the potential for bio-economy to drive transformation in East African countries. It will use the International Futures (IFs) platform to Model Bioeconomy scenarios and identify potential strategies for bio-based growth. The next section will provide an overview of Bioeconomy as a driver of sustainable development, section three introduce the methodology, section four will develop a conceptual framework for modelling bioeconomy, section five discuss the modelling results and section six will conclude.

2. Bioeconomy and sustainable development

Bioeconomy focus is on new growth opportunities in both traditional and emerging bio-based sectors while considering global challenges (e.g. raw material supply insecurity) and resource and environmental constraints ([EC, 2014](#)). The central feature of a Bioeconomy is the application of science on biological resources including agricultural and bio-production systems. This is not only for the production of food, feed and fibre but also to an increasingly wide range of agro-industrial and value added products. The products have potential applications in many sectors, e.g. pharmaceuticals, industry, chemicals, and energy ([BiSEA, 2020](#)). The fact that biological resources are renewable and can address both traditional sectors (food, feed and fibre) and also modern industrial sectors (chemical, energy etc). implies that Bioeconomy can then provide a sustainable pathway for growth.

Of note is the overlap between the two other pathways to sustainable economy i.e. circular economy (CE) where the goal is mainly pursued by redesigning the life cycle of the 'product', to have minimal input and minimal production of system 'waste' ([D'Amato et al., 2017](#)) and green economy (GE) whose focus is a low carbon, resource-efficient and socially inclusive' economy (UNEP, 2011 cited in [D'Amato et al., 2017](#)).

[BiSEA \(2020\)](#) argues that Bioeconomy encompasses elements of both GE and CE concepts. They point that Bioeconomy can contribute to the CE as there is a huge potential in converting biowaste from agro-and bioprocessing industries and human consumption into useful products such as energy, biofertilisers, feed, green chemicals. Further, biodegradable products including paper, other wood products, natural fibres textiles and many more can be

returned to the organic and nutrient circle. They also point that renewable biological resources can replace petroleum, coal and gas (in energy and chemical production) thus Bioeconomy can play a fundamental role in the development of low carbon economy. However, some have argued that GE is the umbrella under which both bioeconomy and the CE falls and that a truly strong Bioeconomy must necessarily incorporate CE concepts (D'Amato *et al.*, 2017 for a comparative analysis of the three concepts).

There is no consensus as to what a bioeconomy could or should effectively look like and what type of society it would sustain (Hausknost *et al.*, 2017; Brugge *et al.*, 2016). In an extensive review of literature, Brugge *et al.* (2016) identified three visions of the bioeconomy:

- The biotechnology vision that underlines the importance of research, application and marketing of bio-technology in different sectors of the economy.
- The bio-resource vision that focuses on the processing and upgrading of raw materials as well as the establishment of new value-added chains.
- Bio-ecology vision that highlights the sustainability and ecological processes to optimize the use of energy and nutrients, promoting biodiversity and avoiding monocultures and soil degradation.

The various approaches to bioeconomy are focussed on the traditional (agriculture, forestry, fisheries) and new biotechnology-driven sectors. This is perhaps what makes it a powerful economic paradigm as countries do not need to be highly technologically sophisticated to pursue a Bioeconomy-driven strategy. This perhaps also explains the growing popularity of a Bioeconomy-driven sustainability pathway. The promotion of a Bioeconomy has been placed on the political agenda of more than fifty countries, including the creation of dedicated visions, strategies and action plans (FAO, 2019).

For the developed world, Bioeconomy has been seen from the prism of producing high-value bio-based products especially chemical, pharmaceuticals and development of biotechnology (Hausknost *et al.*, 2017; USA, 2012). Europe has nevertheless evolved and has a broad and ambitious vision of a Bioeconomy which it sees as “a key element for smart and green growth in Europe” (EC, 2012, p 2). The European Commission’s approach, Bioeconomy covers “the production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, feed, bio-based products and bioenergy”, including both traditional and emerging sectors, i.e. “agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of the chemical, biotechnological and energy industries” (EC, 2012). The European Bioeconomy Strategy focuses on three areas:

1. investment in research, innovation and skills;
2. reinforcement of policy interaction; and
3. enhancement of markets and competitiveness in bioeconomy.

For implementation, several technology platforms have been put in place to drive transformation together with policy and regulatory frameworks and funding mechanism. In addition to the EU strategy, several EU Member States have designed national bioeconomy strategies (Scarlat *et al.*, 2015 for a detailed description).

Developing countries have also launched ambitious bioeconomy strategies building on the agriculture bases of their economies. Thailand, an already very competitive agricultural economy, is seeking to build on the highly successful cassava and sugarcane sectors to further add value and diversify to new commodities (Fielding and Aung, 2018). Of note is that Thailand has a significant bioenergy sector and is now one of the largest producers of bioplastics based on cassava (BOI, 2017).

2.1 East Africa bioeconomy-driven transformation

This bioeconomy pathway is particularly apt for many African countries which are largely agrarian [2] and are seeking to transform their economies (ACET, 2014). Bioeconomy provides highly attractive transformation pathways through:

- upgrading traditional food and animal feed sector;
- developing a biofuels sector;
- developing a bio-based products sector; and
- boosting bio-diversity dependent sectors.

Eastern Africa is currently developing a regional bioeconomy strategy (BiSEA, 2020). Agriculture is the base of the economies and agro-processing and value addition are already the industrial backbone of many countries in the region, generating significant export revenues and job opportunities. However, BiSEA (2020) makes the following observations:

- Most agro-processing is focused on food production, with little emphasis on opportunities for bio-industrial products.
- Biomass use is often inefficient, and value chains and bioprocessing industries are mostly generating products of relatively low value.

As a result, a large part of the agro- and bioprocessing sector in the region runs at a suboptimal level and produces large amounts of bio-waste and severe environmental problems (BiSEA, 2020). The strategy is thus premised on the belief that a successful deployment of the bioeconomy has also the potential to promote sustainable, bio-based economic growth, new employment opportunities, improved livelihoods, food security and wealth creation. Indeed, several pathways have been elaborated for leveraging bioeconomy for transformation.

Food and feed are significant sectors, with agro-processing and agribusiness activities included, they are some of the biggest economic sectors in both developed and developing countries. For African countries with highly underdeveloped value chains, the key concern is increasing productivity and upgrading value chains to produce a diverse range of food products. Indeed agro-processing is seen as a key pathway to the transformation of African economies (ACET, 2014).

Bioenergy is another key sector: For many in developing countries biomass is the key source of energy, for example in Kenya biomass contributes 69% of energy (GoK, 2018). However, this has a potentially huge cost of environmental degradation (through deforestation) and health (smoke pollution). More modern fuels (bio-fuels) have been developed through chemical processes. Biofuels have a long history and technologies well developed. They are already a key energy sector in some economies like Brazil (with sugar-cane based ethanol).

The third sector is Bio-based products. Bio-based products made from biological-based resources beyond food and fuel have a long history, i.e. furniture, building material and paper. However, the potential for increasing functionality of old products (e.g. stronger building materials) and developing new materials e.g. bio-plastics, textiles is huge.

Biodiversity services and related sectors form the fourth sector. As bio-economy is also about sustainability and conservation, a bio-economy-based approach also means an improvement in biodiversity and thus ecosystem services that are key to the economy. A major beneficiary of improved biodiversity is the tourism sector, which great potential for job creation (ACET, 2014) [3].

In line with the opportunities offered by a bio-based economy and based on a series of national consultations in the region, the bioeconomy for the East Africa Region has been defined as the sustainable production and exploitation of biological-based 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, chemicals, pharmaceuticals, textiles, construction products, etc.; and
- strong biodiversity services that support cultural production and vibrant tourism sector (BiSEA, 2020).

We will explore the potential impact of this proposed pathway through simulation using the IFs platform.

3. Methodology

The modelling of economy futures for Eastern Africa was done using the IFs computer Modelling platform. The modelling platform has a wide range of data that allows users to analyse trends and interactions within and across agricultural, demographic, economic, educational, energy, environmental, health, infrastructure, and socio-political subsystems, in 186 interacting countries. Users can simulate potential paths of human development by making interventions that will affect, and even potentially reshape, the entire dynamic system.

3.1 International Futures description [4]

IFs is a long-term integrated global forecasting system, designed to facilitate the exploration of global futures. The IFs has foundations that rest in classes of agents and their behaviour, and the structures or systems through which those classes of agents interact. In representing the behaviours of agent classes and the structures of systems, IFs draws upon large bodies of insight in theoretical and modelling literature. IFs has 11 modules that allow exploration and forecasting of a large set of topics. The modules are The population module; The economic module; The agricultural module; The energy module; The infrastructure module; The environmental module; The education module; The health module; The socio-political module; The international political module; and The technology module.

The IFs model allows one to explore trends from historical data and develop scenarios of potential futures through an analysis of the areas of uncertainty and leverage surrounding important variables within the issue being explored. This is accomplished through the Scenario Analysis feature that allows one to alter a large number of parameters (often including multipliers) that drive different variables within the IFs system. This provides users of the model the ability to change parameters and initial conditions of the model to explore a range of uncertainty or to consider policy leverage [5]. The structure of the IF modules and a description is given in in Hughes (2016) and also at <https://pardee.du.edu/access-ifs>

The IFs model has been applied in a wide variety of long term forecast exercises including project commissioned by the European Commission, the World Bank, United States National Intelligence Council (NIC), The United Nations Environmental program, The United Nations Development program among others (Hughes, 2016). The model has also undergone validation as discussed in Hughes (2006).

4. Drivers of bioeconomy – a conceptual framework

Fielding and Aung (2018) points that the transition towards a modern bioeconomy depends on commitment from stakeholders, enabling regulatory and trade environments, and technology for success. There has to be demand and a supply response to meet the demand. Both demand and supply will be mediated by policies and regulations and also by technologies or innovations. This provides a simple conceptual framework for plotting the trajectory of a bioeconomy. Using this framework, we can now identify key trends that are

impacting on the drivers of bioeconomy. An analysis of the trends can then help map potential bioeconomy scenarios and point to pathways for a strong bioeconomy strategy and the policy framework needed.

4.1 Key megatrends

Some megatrends trends that will profoundly impact on the regional bioeconomy are unfolding. Populations in the region are rising rapidly, incomes are rising and urbanization is underway. In the wake, a sizeable middle class is emerging. [Tschirley et al. \(2015\)](#) projects that by 2040, the middle class in East and Southern Africa will rise to nearly three-quarters of the population. These trends are pointing to huge changes in aggregate demand and demand for biological resources to meet food, infrastructure and other needs. This is happening when already the region is food insecure and the land degraded ([Heady and Jayne, 2014](#)) and forests under threat from deforestation [6]. Challenges that are further compounded by the on-going threat of climate change.

At the same time, the political economy is becoming favourable. Trends are indicating a growing consensus globally for a shift towards greening the economies ([WEF, 2016b](#)). Sustainability and the need to mitigate climate change impact are now key issues being tackled by global governance institutions with important agreements e.g. SDGs, Convention on Biodiversity, Climate Change (COP21) reached. National policies are also accelerating the shift. Many countries are phasing out single-use plastics especially used for shopping. In East Africa Kenya, Rwanda and Tanzania have already done this. Canada plans to ban single-use plastics by 2021 [7] and other big economies are following suit [8]. Beyond bans, economics can also be improved by incentives. For example, [Chinthapalli et al. \(2019\)](#) argue that if bio-based polymers were to be accepted as a solution and promoted similarly as biofuels, annual growth rates of 10 to 20% could be expected.

Developments in biotechnologies are providing new bio-based products thus enabling a shift to greener economies ([EC, 2012](#)). Governance is also being helped by technological advances. Technologies like satellite mapping, as well as better inventories of the status of threatened species and forests and thus make it possible to hold governments accountable to agreed targets ([Esterman, 2018](#)). Developments in ICTs are ushering the 4th industrial revolution paving way for new ways of organizing human activities and creating new opportunities for greening economies e.g. sharing economies, teleworking etc. ([WEF, 2016a](#)).

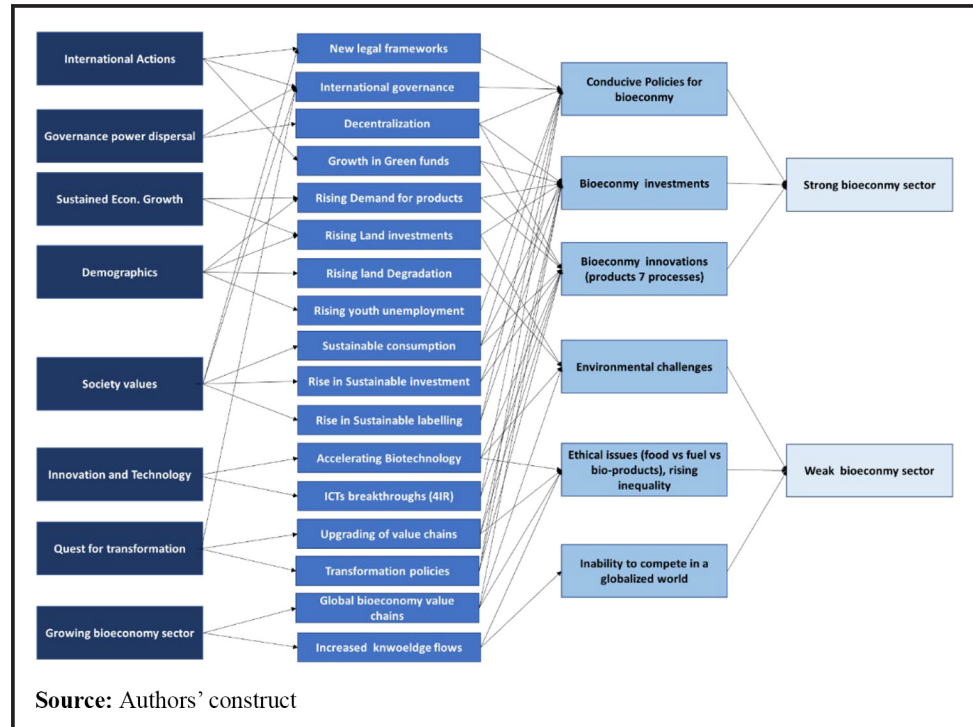
While technologies needed to support the transition to more sustainable economies are still in the early stages of development, a growing mass of consumers concerned with sustainability and demanding sustainable products is creating a market and hastening the transition. A survey found that 66% of global consumers and 73% of global millennials are willing to pay extra for sustainable offering, more so, the survey found that sales of consumer goods from brands with a demonstrated commitment to sustainability have grown 4 times faster ([Nilsen, 2015](#)). This trend is likely to be accelerated by the rise of investment funds dedicated to supporting greening of economies. Sustainability is becoming an essential investment criterion ([Macpherson and Ulrich, 2017](#)) [9].

The megatrends described above are setting in motion several trends that are interacting in various ways. When taken together with the drivers and the trends the results are either pointing to the emergence of a strong or a weak bioeconomy sector. [Figure 1](#) illustrates the conceptual framework that can help analyse potential bioeconomy scenarios.

The trend towards a conducive environment for the emergence of strong bioeconomy sector is supported by:

- Emerging policy frameworks: The rise of international legal frameworks, international governance bodies, strengthened local governments, a new desire for transformative

Figure 1 Conceptual framework bioeconomy scenarios



policies is creating a conducive environment for developing supportive policies for the emergence of a strong bioeconomy;

- **Investments funds:** Green finance funds, the rise of sustainability investment, are creating funds that investors can draw upon. The emergence of a market for sustainable goods and institutions for certifications (that are key to the development of the markets) in inspiring businesses (both start-ups and also existing) to enter into the markets. Note that certification systems can be the basis for setting up legal standards for sustainable goods further boosting the markets;
- **Innovation:** Innovation of bioeconomy products and processes is also being supported by the advance in research biotechnology and ICTs and in particular the emerging technologies that are heralding the 4th Industrial Revolution (4IR). Market demand is also driving innovations as business and start-ups see a new opportunity.

At the same time, the emerging trends are also raising challenges that do not portend well for a strong bioeconomy sector. These include:

- **Environmental degradation:** The potential for increased environmental challenges (for example a successful forest-based textile sector can mean increased deforestation);
- **Ethical issues:** competition for land between food and other uses and also issues of inequality as value chains are upgraded and new value captured by those ablest; and
- **Losing out in globalized value chains:** In the globalized economy the winners in the emerging bioeconomy sectors are those best able to innovate in products and business model.

5. Simulating East Africa bioeconomy futures

In modelling bioeconomy scenarios, three key points about bioeconomy are crucial:

- It is about innovation: Innovation is a central feature of this economy. Bioeconomy is much more about a shift to knowledge economy rather than a “back to the future” story of biological resources exploitation. It is about revisiting of the old sectors and applying the knowledge to improve old products and processes as well as create new products.
- More than about substitution of products: Also as much as interest in bio-economy has been spurred by the desire to mitigate the impact of the current economy based on largely non-renewable and largely carbon-based natural resources, bioeconomy has potential to develop whole new sectors of the economy that are not about the substitution of current product and services, but on the innovation of new products and services. In essence, with innovation new sectors of the economy can emerge from bioeconomy.
- It is more than a sector: It cuts across many sectors and seeks integration across applications such as agriculture, health and industry. Its cross-cutting nature offers a unique opportunity to comprehensively address interconnected societal challenges such as food security, fossil-resource dependence, natural resource scarcity and climate change while achieving sustainable economic development [10].

Using the IFs Modelling Platform, bioeconomy scenarios were developed to capture the impact of various policy levers. The IFs platform is a general platform and thus cannot capture the specific enablers for a bioeconomy. Nonetheless, it provides a fairly extensive number of levers that can help simulate bioeconomy scenarios. A strong bioeconomy can be impacted through a number of pathways using the IFs platform. This is summarized below:

1. Supply

- Increase agricultural production. This can be through productivity i.e. yields or expansion of land under agriculture.
- Increasing agricultural investment.
- Reducing waste.

2. Innovation

- Increasing investment in education.
- Increasing/expanding tertiary education and in particular STEM.
- Increasing R&D expenditure.

3. Industrial development/policy

- Increasing investment by businesses through conducive environment e.g. incentives, subsidies, PPP opportunities.
- Increasing FDI inflows.
- Building agro-industry through Increasing industrial demand for agricultural raw materials through appropriate incentives.
- Increasing the protection of local industries.
- Exports promotion.

4. International political economy/Governance

- Increase development support inflows.
- Lobby for favourable terms e.g. terms of trade, carbon credits.
- Economic freedom.
- Increase government effectiveness.
- Reduce government corruption.

5.1 Scenario descriptions

Using the levers provided by the IFs platform a number of scenarios were developed to capture potential ways the bioeconomy sector evolves. These were named: moderate bioeconomy, strong bioeconomy-unsustainable and strong bioeconomy-sustainable to reflect various degrees of aggressiveness in pursuing bioeconomy goals over and above the prevailing trends i.e. the Business-As-Usual (BAU) case. The scenario descriptions are:

- *Base Case or Business-As-Usual (BAU) Scenario*: The BAU is the scenario that projects the trends forward. It is already in-built in the IFs model. The other scenarios are built around this by accelerating or decelerating parameters as need be as shown in [Table 1](#).
- *Moderate Bioeconomy (MB) scenario*: This scenario assumes moderate acceleration of key parameters as shown in [Table 1](#). This is can be done within the political framework

Table 1 Bioeconomy scenarios parameters

	Moderate Bioeconomy (%)	Strong Bioeconomy – Unsustainable (%)	Strong Bioeconomy – Sustainable (%)
<i>Supply chain</i>			
Increase agricultural production-Accelerate yields increase	20	50	50
Increase agricultural production. Accelerate land expansion by	20	50	50
Increasing agricultural investment-Accelerate investment	20	50	50
Reducing waste – accelerate reduction rate	50	50	50
<i>Innovation</i>			
Increasing expenditure on education		20	20
Improve the quality of primary education		10	10
Increasing/expanding tertiary education and in particular STEM	10	10	10
Increasing R&D expenditure	20	50	50
<i>Industrial development/policy</i>			
Increasing investment by businesses through conducive environment e. g. incentives, subsidies, PPP opportunities	20	50	50
Increasing FDI inflows		20	20
Building agro-industry through Increasing industrial demand for agricultural raw materials through appropriate incentives	20	50	50
Increasing the protection of local industries			50
Exports promotion (export shift)			2
<i>International political economy/Governance</i>			
Increase development support inflows		20	20
Terms of trade		10	20
Economic freedom		20	20
Government effectiveness		50	50
Government corruption		20	20
<i>Environment</i>			
Cropland increase	20	20	
Forest protection	-20	-20	+20

assuming bioeconomy does not hold a central position. It is indeed more of an enhanced agricultural productivity improvement policy with industrialization incentives.

- *Strong Bioeconomy-Unsustainable (SB-U)*: SB-U assumes the potential of bioeconomy seen and it is taken up enthusiastically with a coordinated agricultural and industrial policies undertaken. Also, resources of R&D are increased and also funding for education with particular attention to tertiary education and STEM. Foreign investors are also targeted and land made available through expansion of cropland and relaxation of forest protection.
- *Strong Bioeconomy -Sustainable (SB-S)*: This is an improvement of SB-U where care is taken to protect forest land so that agricultural production does not happen at the expense of deforestation. The protection of forest is rapidly accelerated.

The parameters for the scenarios developed are summarized in [Table 1](#) using the levers available in the IFs platform.

5.2 Simulation results

Using the IFs platforms simulation were run for each of the scenarios with a time horizon of 2040. While the IFs platforms have hundreds of variable for a researcher to explore we will look a few variables to assess the impact of the policy simulations. Four impacts are assessed to get an insight into the potential of bioeconomy. The results are discussed below:

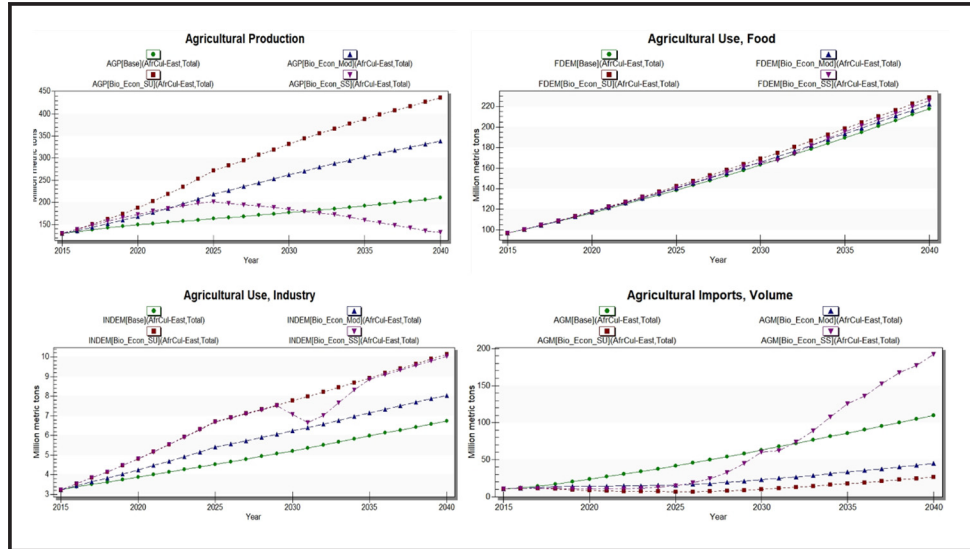
- First, we are keen on agricultural production has been impacted and how resulting output patterns in terms of food use and industrial use. The objective is really to see greater use agricultural product by industry without impact in usage as food, i.e. we want to explore food vs feed competition, a major concern in the region especially given the food security challenges the region experiences.
- The second impact of interest is the economy in particular of the impact on GDP and incomes (i.e. GDP per capita) as a key objective of a bioeconomy strategy is to stimulate growth and economic transformation. To get insight on transformation impact we look at how the value added by agriculture and by the manufacturing sectors are impacted.
- The third impact of interest is the developmental impact. To assess this, we look at the impact on poverty and inequality to get an insight into how the value created is captured. We also assess the environmental impact by looking at how the area under forest is impacted and trajectory of CO₂ emissions.

5.3 Agriculture production and use

As pointed a strong bioeconomy depends on having an adequate supply of raw materials. The Moderate Bioeconomy (MB) and the Strong Bioeconomy-Unsustainable (SB-U) scenarios rapidly increase agricultural production (by 65% and 124% respectively) over the base case scenario (BAU scenario). However, agriculture production under Strong Bioeconomy-Sustainable (SB-S) rises then around 2025 starts to drop to almost the values at the start. The outcome for under the 4 scenarios are given in [Figure 2](#).

The agriculture use for food does not change much from the BAU scenario over the three scenarios. However, the use by industry rises significantly above the base case (BAU). For both strong Bioeconomy scenarios, the rise is 54% while for the moderate scenario a rise of 24% is seen. This is a sign of an emerged bioeconomy industrial sector. However, the sector, in the case of the SB-S scenario, the increasing demand is met by a significant rise in imports. Note that while MB and SB-U reduce agricultural imports, the agricultural imports are not eliminated. The fact the SB-U is a very aggressive scenario with a rise in yields, crop

Figure 2 Impact on agricultural production and use

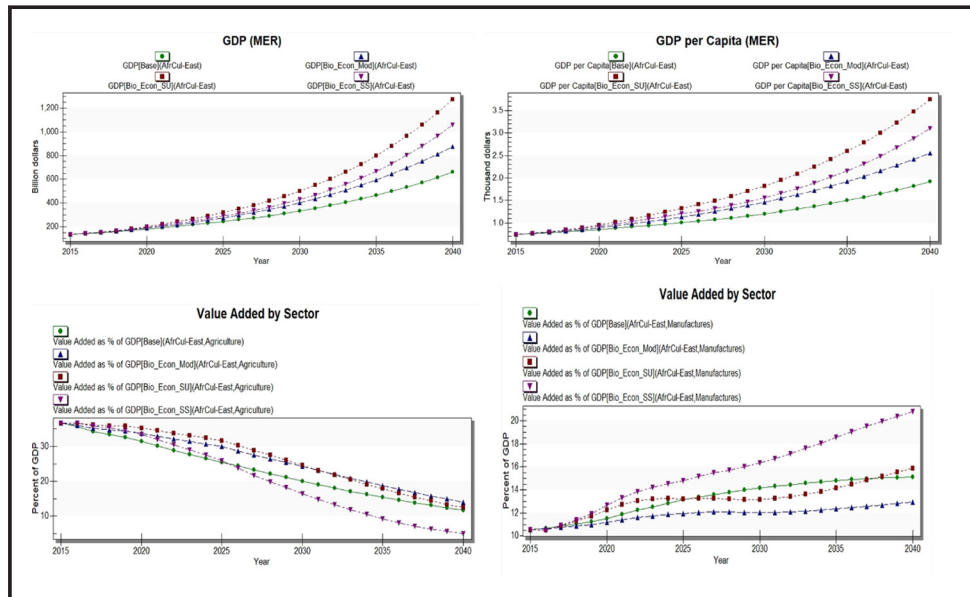


area and relaxation of forest protection underscores how difficult it is to become self-sufficient in food underscoring the need to emphasize specialization and trade rather than food self-sufficiency.

5.4 Economic impact

The economic impact is shown in Figure 3. As expected the GDP rises from the base case with SB-U having the biggest impact at almost double the base case. Similarly, the GDP per capita also rise under the three scenarios.

Figure 3 Impact in economic performance



Of interest is that fact the agriculture contribution falls, underscoring that the bioeconomy strategies are stimulating the part of the value chain beyond agricultural production. This is also reflected in the higher value-added from manufacturing. The most successful strategy is the SB-S where agriculture contribution falls from about 36% to almost 2% of GDP and contribution of manufacturing rise from about 10% to about 24%. Note that the MB and SB-U do not do better than BAU case in terms of stimulating the manufacturing sector.

5.5 Impact on development and environmental impact

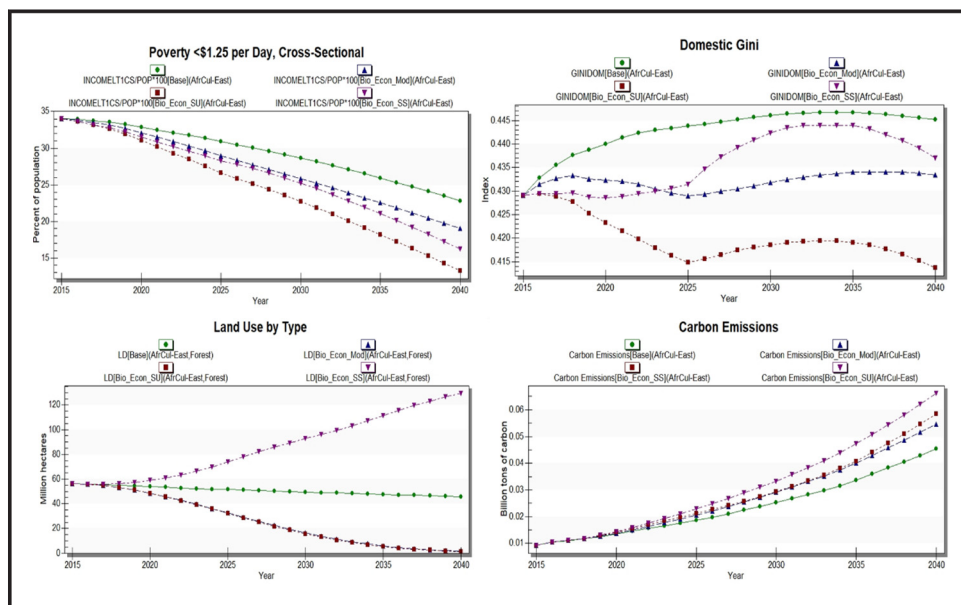
The impact of the scenarios from a development perspective as shown in Figure 4. As can be observed, there is a significant reduction in poverty under all scenarios with SB-U scenario showing the most impact. However, even in this best case, poverty still hovers at around 12% of the population underscoring that a strong bioeconomy is not enough to eradicate poverty. Indeed, as seen gini coefficient does not fall except for the SB-U (and even then it is still high). The fact is that as value chains are upgraded those with more resources and who make the needed investments capture a disproportionate share of the value created. This emphasizes the need for deliberate inclusive policies to ensure growth translated to improved livelihoods for all.

As much as the SB-U shows a good impact on poverty the impact on the environment is devastating. The forest is almost finished. Surprisingly, the moderate bioeconomy scenario also sees forests devastated. The Strong Bioeconomy scenario which also seeks to increase forest cover (SB-S) manages to do so. However, even with this feat, the scenario has a higher emission than the base case. This stresses the need for care in pursuing the strong Bioeconomy strategy.

6. Conclusion – towards a strong bioeconomy

The analysis points to the potential of a bioeconomy-driven economic strategy to drive transformation. However, the simulation point to the fact that if not well thought out it can also be costly in terms of environment and indeed such a strategy can lead to a disaster in the long run. It is also clear that having a strong bioeconomy does not necessarily mean a

Figure 4 Development and environmental impact



being self-sufficient in agricultural production. Indeed, if saving the forests or increasing forest cover means agricultural imports rise this should be fine. Also, a strong bioeconomy does not necessarily mean development objectives are fully met. A bioeconomy strategy should be part of the package of strategy to ensure sustainable and inclusive growth.

Note that this analysis is fairly limited. It is hard to simulate the full picture of a bioeconomy and it is unlikely a general-purpose model like IFs can do this. Doing a proper forecast may require a specially built model which might be very costly and insights generated unlikely to justify the investment in such a model. The insight from this model gives us a good starting point to understand the levers available to transition towards a good bioeconomy future.

The bioeconomy cross-cutting nature offers a unique opportunity to comprehensively address inter-connected societal challenges such as food security, natural resource scarcity, fossil resource dependence and climate change while achieving sustainable production particularly in agriculture (and forestry), food processing, bioenergy, healthcare, biotechnology and green chemistry. Bioeconomy can create decent job and drive rural transformation. However, establishing a Bioeconomy sector will require among other things:

- provide knowledge-base for sustainable intensification of primary production;
- improve understanding of biomass/biowaste availability and demand;
- promote the setting up of networks for integrated and diversified biorefineries;
- establish a PPP for bio-based industries;
- support expansion of new markets;
- facilitate green procurement for bio-based products; and
- develop science-based approaches to inform consumers about product properties.

Policy will be key in enabling the shift and now there is the international framework upon which bioeconomy strategies can be built. The climate change agenda, the SDGs Agenda and other related global agreements stress the interdependence of the challenges they are to address. However, [FAO \(2017\)](#) points out that achieving policy coherence will be challenging. Also, integrating different actions to achieve linked objectives will pose new technical demands on policy-makers, at all levels, as well as new demands on institutional arrangements and coordination at various levels of governance, underscoring the policy challenge ([FAO, 2017](#)).

Beyond policy, bioeconomy approach also touches on ethical and social issues. Agricultural land is limited. The government will need to decide how much land is to be set aside for the production of food and feed, fuels and bio-based materials. The competition between food and fuel calls for a fundamental assessment of the respective fields of action in ethical terms.

6.1 Looking ahead

Biomass, the key input to a bioeconomy is not only a renewable but also a limited resource, as nature limits what can be produced. Thus bioeconomy activities are not necessarily sustainable ([FAO, 2019](#)). Indeed, sustainable bioeconomy development faces many challenges, especially how to address the interrelated concerns of ensuring food security, addressing climate change, sustainably managing natural resources and managing competition between different uses of biomass feedstocks (food, feed, fibre, bio-based materials and bio-energy) and crucially guaranteeing that bioeconomy development benefits everybody. The means policy choices are needed to balance these competing needs ([FAO, 2017](#)).

The shift to bioeconomy has been described as a very large wheel that natural scientists, engineers, economists, ethicists, politicians and others are starting to turn. A wheel that, understandably, is only slowly gaining momentum. It is a question of creating a whole new raw material basis for industry and the economy. It is about developing a new system in which science, industry and value creation interact in different ways than they did before. More than ever before industry and science will have to act as a system, and previously non-existent connections will be established between different value creation chains (Bächtle, 2013).

Notes

1. Some authors make a further differentiation between “Bioeconomy” and “bio-based economy”. While “Bioeconomy” also includes the food and feed sector, the “bio-based economy” only comprises the sectors of bio-based materials and products (incl. pharma) as well as bioenergy/biofuels.
2. Agriculture and related sectors (across the value chains) is the base of many economies of East Africa contributing between 30 and 70% of GDP.
3. In Uganda, nature-based tourism is estimated as having accounted for about 9% of GDP in 2012/13 (NPA, 2017). More crucially it has been estimated that tourism creates more jobs per investment than any other sector.
4. This is a summary of the description given at also <https://pardee.du.edu/access-ifs>
5. Ideally, the scenario analysis should follow causal analysis, a process which should be coupled with some understanding of the relationships between major dependent and independent variables.
6. All countries in the region have lost forest cover between 17% (Tanzania) to 56% (Uganda) between 1990 and 2015. While Rwanda increased cover by 50% (Kiprop, 2018).
7. www.cnn.com/2019/06/10/americas/canada-single-use-plastics-intl-hnk/index.html
8. California became the first state in the USA to ban on single-use plastic bags through a referendum in the November 2016 election and other states are following suit New York bans took effect in May 2020. Cities that have banned plastic bags include New York, Chicago, Seattle, Los Angeles, Boston and San Francisco. Reducing single-use plastic bag can mitigate harmful impacts to oceans, rivers, lakes, forests and the wildlife that inhabit them. It can also relieve pressure on landfills and waste management www.ncsl.org/research/environment-and-natural-resources/plastic-bag-legislation.aspx
9. Globally, these types of investments accounted for \$3.74 trillion in total assets under management at the end of 2011 (Macpherson & Ulrich, 2017).
10. www.fao.org/energy/bioeconomy/en/

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