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Opportunities for youth in the bioeconomy

Opportunities and barriers for youth employment
and entrepreneurship in the emerging
bioeconomy sectors



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Preface

This technical study supports the Programme Priority Area (PPA) Bioeconomy for Sustainable Food and Agriculture (BE2) and is aligned with the Strategic Framework 2022–2031 of the Food and Agriculture Organization of the United Nations (FAO), approved by the 42nd Session of the FAO Conference in 2021.

The PPA promotes sustainable bioeconomy in food and agriculture through technological, organizational and social innovations that are inclusive of rural, indigenous and vulnerable or disadvantaged communities, youth and women producers and consumers.¹ The team leading the BE2 work functions as an information hub with a coordination task across FAO to fill information gaps and create awareness within FAO and among partners about what bioeconomy is and what its impacts are.

One identified gap is in the area of socioeconomic development, including the role of and future opportunities for youth in the bioeconomy. FAO acknowledges that youth, who will, in the future, manage the earth's ecosystems and agrifood systems, must be explicitly addressed in any development effort in order to ensure inclusive economic development that is resilient to future crises and contributes to the realization of the Sustainable Development Goals (SDGs). As a result, youth have been embedded as a cross-cutting theme in the Strategic Framework and must be considered a priority across all areas of work.

This report, prepared by the FAO Agrifood Economics Division (ESA), focuses on the intersection of youth and the bioeconomy, building on previous FAO work in bioeconomy, rural youth and youth employment. It also contributes to expanding awareness and filling knowledge gaps in the field of bioeconomy.

The report is a first attempt to assess opportunities for youth employment, entrepreneurship and engagement within the bioeconomy, based on a review of the current state of access to and use of existing technology on the part of the youth, and their participation in decision-making in the bioeconomy. The report also outlines a pathway to better address youth employment in the sector, providing initial recommendations.

¹ FAO. 2022a. Sustainable and circular bioeconomy for food systems transformation. In: *FAO*. [Cited 3 October 2022]. <https://www.fao.org/in-action/sustainable-and-circular-bioeconomy>

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The report was prepared by Jana Dietershagen, Programme Specialist at the FAO Agrifood Economics Division (ESA), and co-authored by Heiko Bammann, Economist (ESA), who provided general supervision and written contributions and who has been the driving force behind the conceptualization of this report.

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Abbreviations

ATPS	African Technology Policy Studies Network
B2B	business-to-business
COVID-19	coronavirus disease 2019
ECLAC	Economic Commission for Latin American and the Caribbean
EU-27	European Union 27 Member Countries (from 1 February 2020 onwards)
EU-28	European Union 28 Member Countries (from 1 July 2013 to 31 January 2020)
FAO	Food and Agriculture Organization of the United Nations
GBS 2020	Global Bioeconomy Summit 2020
GPD	gross domestic product
ICT	Information and communications technology
IICA	Inter-American Institute for Cooperation on Agriculture
ILO	International Labour Organization
NEET	not in Education, employment, or training
OECD	Organisation for Economic Co-operation and Development
ODT	oven-dried tonne
PBL	problem-based learning
PIC	Pacific Island Country
RYAP	Rural Youth Action Plan
SDGs	Sustainable Development Goals
SME	small and medium-sized enterprise
STEM	science, technology, engineering and mathematics



Executive summary

According to the International Advisory Council on Global Bioeconomy, the bioeconomy can be defined as:

the production, utilization, conservation and regeneration of biological resources, including related knowledge, science, technology and innovation, to provide sustainable solutions such as information, products, processes and services, within and across all economic sectors, and to enable a transformation to a sustainable economy.¹

This stock-taking report aims to address the following questions: Which push/pull factors are key to supporting youth employment in the bioeconomy? How youth-inclusive are the current bioeconomy strategies and related policies? How do current bioeconomy strategies and related policies support factors to push and pull youth into the bioeconomy? Where are the jobs and employment opportunities for youth in the bioeconomy today and what are the related challenges for the future?

Existing data and literature, as well as information gleaned from interviews with young entrepreneurs and other youth engaged in the bioeconomy, inform the analysis provided in this report. Following the introduction (Chapter 1) and the description of the methodology (Chapter 2), the report contains four major chapters.

Chapter 3 provides a review of relevant push/pull factors for the overall growth of the bioeconomy and, particularly, for greater youth employment in the bioeconomy. The push factors include education, vocational training, skills building, technology development and business development. The pull factors include economic development opportunities, employment and entrepreneurship opportunities, and sustainable resource use. All these factors impact youth employment opportunities and are important to develop the bioeconomy.

Chapter 4 provides an analysis of existing bioeconomy policies and strategies and how they address youth. Six main policy goals that play a key role in addressing the six push/pull factors and, therefore, influencing youth involvement in the bioeconomy, have been identified. (These are also closely aligned with the Sustainable Development Goals, or SDGs.) The six policy goals are: bioeconomy job creation, education, vocational education and training, start-up/incubation support, promoting innovation, transforming rural areas and consultation with youth in policymaking processes.

Chapter 5, which addresses the key objective of this report, examines specific youth employment opportunities and challenges in the different sectors of the bioeconomy and in promising technologies. An attempt is made to address the issue of green jobs in the bioeconomy and how the bioeconomy sectors contribute to rural transformation.

The report ends with Chapter 6, which provides conclusions and generic short-, medium- and long-term recommendations to better include and support youth to participate in and benefit from the growing bioeconomy sectors. While the recommendations are general and can be adopted by any partner, they also provide guidance for FAO for planning future work with Member Nations to support their needs regarding the challenge of offering employment to the fast-growing youth population. The report concludes that bioeconomy for sustainable food and agriculture does provide considerable, attractive opportunities for youth.

¹ International Advisory Council on Global Bioeconomy. 2020. *Expanding the Sustainable Bioeconomy Vision and Way Forward. Communiqué of the Global Bioeconomy Summit 2020*. Berlin. https://gbs2020.net/wp-content/uploads/2020/11/GBS2020_IACGB-Communique.pdf

Key challenges and barriers

Education must adequately prepare youth with knowledge and skills for the bioeconomy. Initial findings indicate that one of the main barriers to greater youth inclusion in the bioeconomy lies in the current education systems, which do not sufficiently support the development of a labour force with interdisciplinary skills. While the bioeconomy is projected to create more jobs, education systems must have the capacity to respond early on (preferably beginning in primary and secondary schools) to avoid skill gaps.

Decline in vocational training can lead to a technical workforce shortage for the bioeconomy. In sub-Saharan Africa, over the past five years, enrolment in bachelor's degree programmes, for both genders, has increased. In contrast, over the same period, enrolment in vocational training programmes for both genders has declined. The difference in enrolment rates in the first two levels of tertiary education could lead to a technical workforce shortage and pose a problem for implementing biotech and high-tech solutions in agrifood systems in the bioeconomy. This is indeed a gap, but it also presents great opportunities for investment into education systems across Africa; for example, in formal studies and new training centres and innovation hubs that target solutions for the bioeconomy.

Youth entrepreneurs face additional barriers to enter the bioeconomy. Young bioeconomy entrepreneurs face the same challenges as their peers and older counterparts face in the traditional economy (such as lack of access to finance, investment and markets). However, as confirmed by the study interviews, bioeconomy entrepreneurs face additional barriers related to the novelty of the bioeconomy sectors. Those barriers include significant lack of information on what the bioeconomy is and what it entails, related market and growth perspectives, and the lack of regulations and procedures.

Lack of data and decision-making power are barriers to youth participation in the bioeconomy. Of the existing 60 bioeconomy strategies worldwide, only 32 country and three regional (European Union, East Africa and the Nordic Countries) bioeconomy-related strategies address at least two youth-related goals in their policies. Although many countries report that a multistakeholder dialogue took place,² no evidence was found that youth groups were involved in the policy consultation process. The majority of the available bioeconomy data is neither age nor gender disaggregated. This presents a gap for supporting youth in bioeconomy as age- and gender-related data would improve decision-making in favour of better youth inclusion in the bioeconomy.

Little attention is given to rural development in public policies. Of the bioeconomy-related strategies that were analysed, only 46 percent of the European strategies (including those of the European Union), 67 percent of the Asian strategies, 60 percent of the African strategies (including the East Africa strategy), and only 20 percent of the Americas strategies include the ambition to transform rural areas. Low policy attention towards transforming rural areas, together with high rates of urbanization, could pose a serious challenge to countries, especially Latin American countries, to developing their full bioeconomy potential and leveraging opportunities to create new job opportunities for youth.

Key opportunities

Rural areas can be sustainable hubs for the bioeconomy. Placing processing plants close to production areas is believed to be the most promising approach to increasing rural jobs. Rural areas worldwide are facing the effects of youth migration to cities and the ageing of the rural

² GBS (Global Bioeconomy Summit). 2018. *Global Bioeconomy Summit Conference Report Innovation in the Global Bioeconomy for Sustainable and Inclusive Transformation and Wellbeing*. Berlin, Office of the Bioeconomy Council. https://gbs2020.net/wp-content/uploads/2021/10/GBS_2018_Report_web.pdf

population. Attractive jobs and living environments must be created in rural areas in order for young people to return and remain there. The findings of the report show that employment rates in rural areas are proportionally higher compared to urban centres. This is an opportunity for youth employment in bioeconomy. Regions such as Central Asia, North America and Latin America, which have large surface areas and high biomass production potential could benefit greatly from the bioeconomy if they are able to transform rural areas effectively.

The incorporation of more information and communications technologies (ICTs) into science, technology, engineering and mathematics (STEM) education can spark youth interest in the bioeconomy and contribute to skills development. Over the past decade, development organizations and donors around the world have invested heavily in youth adoption of ICT. This has paid off. Countries with higher levels of digital technology adoption tend to have fewer youth who are not in education, employment or training (NEET). To increase the adoption of and interest in the bioeconomy among youth, and to support their employment opportunities, organizations can make use of this trend and combine ICT education and skill development with STEM education, together with increased awareness-raising and investment in the development of the bioeconomy. STEM education can especially support and equip youth with the skills required for rapidly evolving biotech job opportunities, which do not lie only in biogas or biofuel production but in the bio-based chemical industries and in the engineered wood products sector.

Potential future youth employment opportunities

Small and medium-sized enterprises (SMEs) in the agriculture, food and beverage and general manufacturing sectors are the biggest employers of youth in the bioeconomy. Looking at age-disaggregated employment data in the bioeconomy-related sectors (including agriculture, education, energy, manufacturing, water and waste management), the agriculture and manufacturing sectors provide the biggest share of employment to youth. Bioeconomy-specific, but not age-disaggregated, employment data available from the European Union, South Africa and Latin America and the Caribbean, show that the agriculture and food and beverage sectors currently absorb the biggest share of the total bioeconomy workforce.

The study attempted to determine whether more jobs for youth are found in the primary, secondary or tertiary sector. The findings indicate that there is no global trend in this regard; rather, that it strongly depends on the bioeconomy priorities of each country.

Canada has estimated the job creation potential of the bioeconomy according to the amount of biomass input and value-creation output. If Canadian estimates hold true for other countries, the biomaterials sector would have the highest potential to create the most jobs, with an average of three to ten jobs per 1 000 oven-dried tonnes (ODT) of biomass feedstock.³

Bioeconomy sectors that have the most processing stages and need the least biomass input, such as the biomaterial, engineered wood products and biochemical sectors, have the highest potential to create the most jobs for youth, if the sectors are scaled. Overall, bioeconomy value chains are likely to create more jobs than traditional value chains, as they have more value-creation stages. For instance, the biomaterial manufacturing sector can create five to ten times more employment than the bioenergy sector, as it entails more complex value chains. According to experts, the trend of increasing employment in bio-based chemicals, bio-based pharmaceuticals and bio-based plastics and rubber, is expected to continue through 2030.⁴ Additionally, employment data from the European Union dating

³ Government of British Columbia. 2022. Bioeconomy and Jobs Creation. In: *British Columbia*. [Cited: 28 June 2022]. www2.gov.bc.ca/gov/content/industry/forestry/supporting-innovation/bio-economy/bioeconomy-jobs

⁴ European Commission. 2021. Bioeconomy strategy. In: *European Commission*. [Cited 28 August 2022]. https://ec.europa.eu/info/research-and-innovation/research-area/environment/bioeconomy/bioeconomy-strategy_en

from the period of the 2008 economic crisis, show that the bioeconomy could act as a buffer against unemployment in times of crisis.

Another relevant factor is that 80 percent of new jobs in the formal sector are created by SMEs.⁵ This trend is likely to continue in the bioeconomy transition. The South African Government confirms that SMEs create the greatest number of jobs in their bioeconomy. This is important for the development of youth entrepreneurship and for youth employment, as youth are more likely to employ other youth.⁶

How to move forward

Unless action is taken to harness the opportunities for youth employment and entrepreneurship and address the barriers, neither young people nor their countries will realize their full potential in the bioeconomy. There is a huge potential to accelerate sustainable and youth-inclusive bioeconomy development by building on existing knowledge products, sharing lessons learned and forging partnerships to avoid duplication of efforts. Overall, an acceleration of existing efforts is needed.

⁵ United Nations. 2020. *World Youth Report – Youth social entrepreneurship and the 2030 Agenda*. New York, USA. <https://www.un.org/development/desa/youth/wp-content/uploads/sites/21/2020/07/2020-World-Youth-Report-FULL-FINAL.pdf>

⁶ Cruickshank, D., Grandelis, I., Barwitzki, S. & Bammann, H., eds. 2022. *Youth-sensitive value chain analysis and development – Guidelines for practitioners*. Rome, FAO. <https://doi.org/10.4060/cb8489en>

1 Introduction

According to a youth participant in a session led by the Bioeconomy Youth Champions during the Global Bioeconomy Summit (GBS) in 2020, “By 2050 the bioeconomy should be so normalized so that we will not have to talk about it” (T. Shai, personal communication, 2022).

The bioeconomy offers many opportunities to sustainably diversify economies and ensure the participation of all, especially youth. The bioeconomy contributes to achieving the Paris Agreement of net zero emissions by 2050. If we aim to achieve that goal, it is urgent that we support youth – the generation who will have to fulfil the goal. If youth are provided with targeted education and skill-building opportunities, as well as start-up and incubation support, they can create the new businesses that are needed to accelerate the transition to the bioeconomy. It is also imperative that we actively include them in policymaking processes.

Currently, young people make up 16 percent of the global population, and 88 percent of them live in developing countries (FAO, 2022b). How can these young people be adequately supported? What exactly is needed to support them? What are the key challenges and opportunities for youth to enter the bioeconomy? And what is the current situation of the bioeconomy that we need to build on in the future? This stock-taking report aims to provide initial answers to these questions by providing an overview of the current situation in education, resource use, youth employment and entrepreneurship, through a socioeconomic analysis. The report further provides an analysis of existing bioeconomy policies with youth-related goals. Innovation, technologies, green jobs and rural opportunities in the bioeconomy are also touched on. The views of youth and their recommendations regarding these issues are incorporated throughout the report. (Box 1 provides definitions of the concepts of bioeconomy, youth and bioeconomy jobs, which are referred to in this report.)

The European Commission distinguishes ten potential areas for optimization within the bioeconomy:

1. agriculture
2. forestry
3. fishing and aquaculture
4. food, beverages and other agromanufacturing
5. bio-based textiles
6. wood products and furniture
7. paper
8. bio-based chemicals and pharmaceuticals, plastics and rubber
9. liquid biofuels
10. bioelectricity.

◆ BOX 1 Concepts of bioeconomy, youth and bioeconomy jobs

The **bioeconomy** can be defined as:

the production, utilization, conservation, and regeneration of biological resources, including related knowledge, science, technology, and innovation, to provide sustainable solutions (information, products, processes and services) within and across all economic sectors and enable a transformation to a sustainable economy (International Advisory Council on Global Bioeconomy, 2020, p. 14).

This report focuses on **youth** between the ages of 15 and 35. However, some of the figures and graphs presented show information for youth from 15 to 29 years old, due to the data that is available from the World Bank (World Bank, 2005) and the International Labour Organization (ILO, 2015a), which define youth as individuals in that age range.*

The report defines **bioeconomy jobs** as positions that contribute to knowledge creation, products, processes and services in all economic sectors, that promote the use of renewable resources and the transition towards a sustainable economy.

Notes: * Important: Outside the focus of this report, FAO generally follows the United Nations youth age frame (15 to 24 years). In this report, however, for statistical purposes, the age range has been expanded to 35 years.

Source: Authors' own elaboration.

While reading this report, the reader should take into account that there are different schools of thought with regard to the concept and vision of bioeconomy. These must be considered when designing future interventions, as different countries and regions will make decisions, design policies and regulations and do business based on one or a mix of these concepts (Brugge *et al.*, 2016). The three main visions of bioeconomy are the following:

- ◆ a biotechnology vision oriented towards biotechnology development and biotechnology commercialization to create economic growth and jobs through global or regional clusters;
- ◆ a bioresource vision centred around new ways of upgrading and converting biological raw materials in different economic sectors to create economic growth and sustainability in rural regions;
- ◆ a bioecology vision that prioritizes environmental sustainability and the importance of ecological processes in economic and technological development.

The objective of this report is to highlight barriers to and opportunities for youth employment in the bioeconomy in existing technologies and policies. The following questions are addressed:

- ◆ Which push and pull factors are key to supporting bioeconomy youth employment?
- ◆ How do current bioeconomy strategies and related policies support factors to push and pull youth into the bioeconomy?
- ◆ Where are the jobs and employment opportunities for youth in the bioeconomy today? What are the challenges for the future?

The primary audience for this report is FAO staff in headquarter units and decentralized offices as well as development partners and Member Nations working on bioeconomy aspects directly and indirectly.

In addition to the analysis provided, this report makes an urgent call to action to world and business leaders who are defining their strategies: Youth must be given a seat at the table to ensure intergenerational equity, as they will be the ones bearing the biggest burden of climate change and biodiversity loss. Youth inclusion in the bioeconomy goes beyond the definition of concepts and norms – it will be critical to human survival and social justice.

In the words of Betty Osei Bonsu, Project Coordinator for Green Africa Youth Organization, in Ghana, “Our leaders have always been the ones deciding our future, it’s time they hand over and trust us to make the changes we want to see” (CIFOR, 2021).



2 Methodology

KEY MESSAGES

- ◆ Push/pull factors and policy interventions play an important role in creating employment, education and decision-making opportunities for youth in the bioeconomy.
- ◆ The methodology of this report was informed by the bioeconomy and youth concepts set forth in the following documents: *Youth-sensitive value chain framework* and FAO's *Aspirational principles and criteria for a sustainable bioeconomy* and *Rural Youth Action Plan*.
- ◆ Four key research issues are addressed in three main chapters of this report: Chapter 3 reviews the key push/pull factors for bioeconomy youth employment; Chapter 4 reviews youth inclusion in current bioeconomy-related strategies, and Chapter 5 provides a situation analysis of opportunities for youth inclusion in the bioeconomy and challenges ahead.

A bioeconomy is youth inclusive when it provides youth with opportunities for decent employment and entrepreneurship, and enables youth participation in decision-making processes. The thorough literature review and 12 youth interviews that were conducted demonstrate that a youth-inclusive bioeconomy is influenced by and depends on several socioeconomic, biophysical (environment and resources) and technological factors supported by policy interventions that push and pull youth into the sector. Policy and regulatory interventions must be considered as they provide the enabling environment for youth to access and participate in employment, education, support mechanisms, innovation, decision-making and rural development.

The push/pull factors and policy interventions selected for analysis were based on relevant criteria from concepts set forth in the following publications:

- ◆ *Youth-sensitive value chain framework* (Cruickshank *et al.*, 2022), is a combination of an adapted push/pull approach (USAID, 2015) and the Sustainable Food Value Chains Concept (FAO, 2014);
- ◆ *Aspirational principles and criteria for a sustainable bioeconomy* (FAO, 2021a) and related indicators to monitor and evaluate the sustainability of the bioeconomy (Bracco *et al.*, 2019), and the SDGs;
- ◆ *Rural Youth Action Plan* (FAO, 2022c).

Youth-sensitive value chain framework

Building on the work of FAO's *Youth-sensitive value chain framework*, an elaboration of United States Agency for International Development's (USAID's) push/pull approach, combined with the concept of sustainable food value chains (SFVC), the push/pull factor analysis for employment was adopted to explain youth engagement in the bioeconomy.

The theory of change that underpins this USAID approach applies both “push strategies, which build capacities to engage in markets, and pull strategies, which expand the diversity and quality of accessible economic opportunities to drive more beneficial and sustained inclusion of the extreme poor into market systems through a dynamic process of change” (USAID, 2015, p. 1). Within FAO’s *Youth-sensitive value chain framework* it is noted that:

The push factors on the labour supply side can contribute to capacity building and empowerment of youth to increase their likelihood of employment and business ownership ... (and) provide youth with the necessary means to prepare for, access and retain employment opportunities as wage employees or agripreneurs... The pull factors on the labour demand side contribute to increased profitability and efficiency of the value chain which can consequently create more and better employment opportunities for youth. ... Positive changes in these factors may expand the current job opportunities, create new categories of jobs and facilitate disruptions that drive more youth inclusion (Cruickshank *et al.*, 2022, p. 55–56).

USAID’s push/pull factors describe push strategies that build capacities and pull strategies facilitating access to economic opportunities. This market-oriented, pathways-based strategy can be applied to drive sustained inclusion of youth into the bioeconomy related market systems.

Within the broader bioeconomy concept, the sustainability goal of the bioeconomy is aligned with the sustainable food value chain (SFVC) principles, which includes the following three criteria:

- ◆ economic sustainability – it is profitable throughout all of its stages;
- ◆ social sustainability – it has broad-based benefits for society; and
- ◆ environmental sustainability – it has a positive or neutral impact on the natural environment.

Aspirational principles and criteria for a sustainable bioeconomy

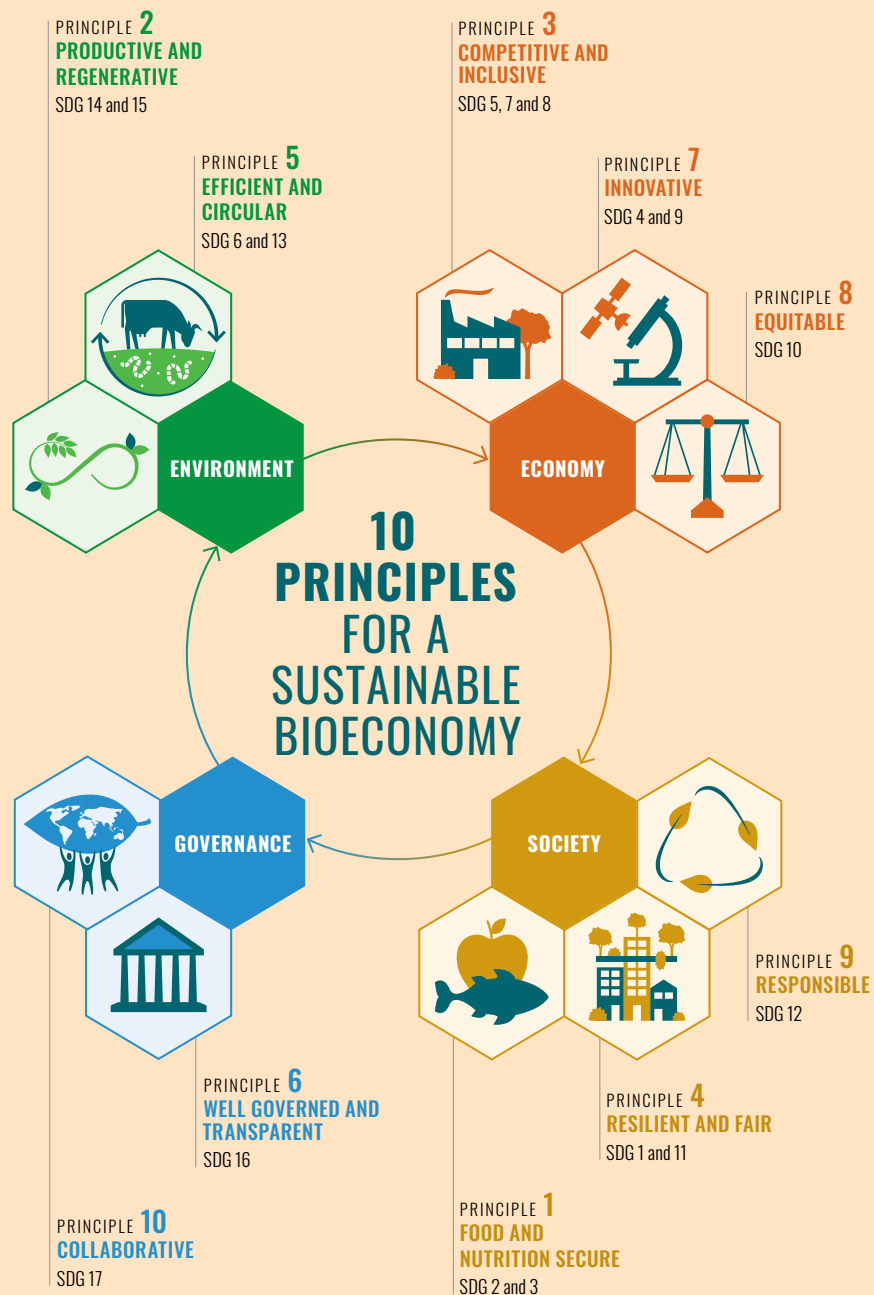
In 2016, the International Sustainable Bioeconomy Working Group agreed to a set of sustainable bioeconomy principles and criteria, which aim to “provide a reference list of issues that should be addressed to develop bioeconomy in a sustainable and circular way at international, national and local levels” (FAO, 2021b). The principles and criteria further aim “to ensure that bioeconomy, when implemented correctly, can benefit individual communities and the global environment in ways that are in line with the SDGs” (FAO, 2021b).

The Working Group proposed ten principles and 24 criteria and provided a framework to transition to a greener, fairer and sustainable bioeconomy (see Figure 1).

For the purpose of this report, eight principles and 16 criteria that are deemed most relevant to fostering youth inclusion in bioeconomy were reviewed and utilized (see Table A1 for the detailed principles, criteria and indicators).

Principles eight and nine were not included, as trade and consumption were determined to be outside the scope of the report, due to time constraints. For the same reason, the study does not report specifically on food security, energy security or climate change mitigation and adaptation, which are also among the objectives of the bioeconomy vision.

◆ **FIGURE 1** Ten principles and 24 criteria for a sustainable bioeconomy



Source: FAO. 2021. *Aspirational Principles and Criteria for a Sustainable Bioeconomy*. Rome.

Rural Youth Action Plan

In 2020, FAO and the Committee on Agriculture, developed the Rural Youth Action Plan (RYAP), consisting of five pillars, which aims to:

contribute to the realization of the SDGs by equally empowering rural young women and men, protecting children and other excluded youth groups, revitalizing rural areas through on-farm and off-farm activities and leaving no one behind (FAO, 2022c, p. 2).

One of the main pathways to achieve its mission is to provide policy guidance by highlighting the need for youth participation in decision-making processes. Eleven organizations, including the United Nations Rome-based Agencies, other United Nations entities and related youth focal groups were consulted during the creation of the plan and committed to jointly implement the plan. Since the bioeconomy is believed to have major potential to contribute to youth employment in rural areas, pillars two, three and four and their respective outcomes have been included in this analysis:

- ◆ Pillar 2: Foster youth employment in an inclusive green economy;
- ◆ Pillar 3: Strengthen rural youth capacities for the use of innovative approaches and technologies in food and agriculture;
- ◆ Pillar 4: Promote rural services for youth and agripreneurs.

Initially, principles, criteria, indicators and pillars from the ‘Aspirational principles and criteria for a sustainable bioeconomy’ (FAO, 2021a), the SDGs and the Rural Youth Action Plan (FAO, 2022c) were chosen and grouped to provide insight into the factors that influence youth employment, entrepreneurship, engagement, and overall opportunities in the bioeconomy. These factors were then appropriately categorized as either push or pull. If these push/pull factors are adequately addressed through strategic, economic and policy responses, this will lead to better youth opportunities and wellbeing in the bioeconomy.

Youth must be more present in bioeconomy implementation and more engaged in decision-making, as they will be in the driver’s seat of the bioeconomy in the coming decades. In the face of combined political, economic, ecological and health crises, youth must lead the transition to a sustainable bioeconomy. Their leadership is key to protecting their wellbeing and that of future generations.

Main research questions

Qualitative and quantitative data sources were analysed and, where applicable, information in the report was complemented with youth interviews. This report makes an attempt to provide answers to the following main questions:

1. What key push/pull factors support youth employment in the bioeconomy?
2. How youth-inclusive are the current bioeconomy strategies and related policies?
3. How do current bioeconomy strategies and related policies support factors to push and pull youth into the bioeconomy?
4. Where are the jobs and employment opportunities for youth in the bioeconomy today and what are the challenges for the future?

Question 1 is addressed in Chapter 3, questions 2 and 3 are addressed in Chapter 4, and question 4 is addressed in Chapter 5. The methodology applied to research each question is outlined in the following sections.

2.1 Review of key push/pull factors for youth employment in the bioeconomy

Key research question: What key push/pull factors support youth employment in the bioeconomy?

With the aim to identify factors that support youth employment, entrepreneurship and engagement within the bioeconomy quantitative data analysis with specific indicators that relate to FAO’s sustainable bioeconomy principles and criteria and to the SDGs were analysed. Where data was not available or was inconsistent for the related indicators,

the closest suitable indicator was chosen in order to provide a quantitative overview that is consistent with the rest of the world regions analysed.

Six factors were identified based on the literature review, data analysis applying FAO's *Aspirational principles and criteria for a sustainable bioeconomy* (2021) and the SDGs indicators (see Table 1).

◆ **TABLE 1** Pull and push factors that influence youth employment and entrepreneurship in the bioeconomy

Pull factors	Push factors
Economic development opportunities	Education, vocational education and training
Employment opportunities	Business development
Sustainable resource use	Technology development
Exports	Used the mirrored reports of partner countries to which exported

Source: Authors' own elaboration.

The principles, criteria, SDGs and RYAP pillars were first examined and grouped according to corresponding attributes. Each group was then aligned to a relevant factor which was then further categorized as either a push or pull factor linked to labour demand and supply. These factors then form the basis for the push/pull factor analysis of this report.

The push factors (Education, vocational education and training, business development and technology development) support youth's capacity building to engage in the bioeconomy. Pull factors (Economic development opportunities, employment opportunities and sustainable resource use) contribute to the development of youth inclusive bioeconomy sectors. These factors are presented in detail in Chapter 3.

For the quantitative socioeconomic data analysis (see Annex 1 for an explanation of the indicators used), data was directly obtained from the databases of the World Bank, the ILO and the Organisation for Economic Co-operation and Development (OECD) (see Table 2). These databases were selected because the data is standardized for the different countries and regions, making it easier to compare them. Additionally, these organizations have verified data sets that are readily available for more than 120 countries.

◆ **TABLE 2** Organizations and databases used in this report

Organization	Database
World Bank	World Development Indicators (WDI), education statistics (EdStats), doing business, and population estimates and projections (World Bank, 2022)
International Labour Organization (ILO)	Youth working-age population by sex, age and rural/urban areas, youth employment by sex, age and status in employment, youth transited by sex and economic activity, and youth working-age population by sex and education (ILO, 2022)
Organisation for Economic Co-operation and Development (OECD)	Environment, main science and technology indicators, patents in environment-related technologies, technology indicators, agriculture, and employment in fisheries (OECD, 2022)

Source: Authors' own elaboration.

The study uses the World Bank’s predefined world regions for which it provides data (see Annex 1 for the full region and country list). In addition, the region “East Africa biostrategy” was created for the purpose of this study, which includes the African countries that have a common East African Regional Bioeconomy Strategy, which is important to FAO’s work.

Throughout the analysis, the European Union and East Africa Biostrategy regions were used for purposes of comparison, as they have advanced bioeconomy strategies in place.

The data analysed quantitatively is divided into the following regions (see Annex 1 for a list of the countries in each region):

- ◆ Africa Eastern and Southern
- ◆ Africa Western and Central
- ◆ Central Europe and Baltics
- ◆ East Africa Biostrategy (countries participating in the East African Regional Bioeconomy Strategy)
- ◆ East Asia and Pacific
- ◆ Europe and Central Asia
- ◆ European Union
- ◆ Latin America and the Caribbean
- ◆ Near East and North Africa
- ◆ North America
- ◆ Pacific Island Small States
- ◆ South Asia and sub-Saharan Africa.

As indicated, the East Africa Biostrategy region includes the countries that have signed the East African Regional Bioeconomy Strategy. The group was created to identify any particularities that can provide more insights into this region, such as potential barriers or success factors regarding the bioeconomy strategy. This is also the case for the European Union group, which also has its own regional bioeconomy strategy.

For some regions, an average value was generated as summarized data was not available through the World Bank database. For those regions, regional average values were calculated by obtaining and combining the single values of each country in the region. The raw data was then cleaned and processed using the open-source statistical program R. After processing, the data was validated by comparing random regional data from the World Bank with data from the ILO. The value for a region was validated by selecting random regions and following the same process used for the regions without validated data. Then, countries and the value reported in the database were compared. For the random regions that were validated, it was found that the two values in all the cases had no significant difference.

2.2 Review of youth inclusion in current bioeconomy-related strategies

Key research questions: How youth-inclusive are the current bioeconomy strategies and related policies? How do current bioeconomy strategies and related policies support factors to push and pull youth into the bioeconomy?

Through the review of policy documents (the RYAP, the SDGs and FAO’s Principles and Criteria for a Sustainable Bioeconomy), six youth-related policy goals were chosen for analysis (see Table 3). These policy goals can have a direct or indirect impact on youth participation (in decision-making and employment) in the bioeconomy. Chapter 4 analyses

how these goals are currently addressed in bioeconomy-related strategies and how they could support the push/pull factors to engage youth in the bioeconomy.

The six bioeconomy policy goals are: job creation, education/skills development, start-up/incubation support, innovation, consultation of youth in policymaking processes and improving rural areas. Only countries that addressed at least two of these youth-related goals were included in the full policy analysis.

◆ **TABLE 3** Youth policy goals identified in relation to the pillars and outcomes of the Rural Youth Action Plan and corresponding Sustainable Development Goals






1. Job creation	
<p>Pillar 2: Foster youth employment in an inclusive green economy. Sustainable and circular bioeconomy policies and strategies are in place to promote inclusive food systems and sustainable decent jobs that are youth- and gender-sensitive.</p> <ul style="list-style-type: none"> ◆ Outcome 2.1: Promote government policies which ensure youth- and gender-sensitive transitions to the green economy. ◆ Outcome 2.2: Initiatives supported that allow young women and men to equally access sustainable jobs and participate in the bioeconomy. 	
<p>8.5: Achieve full and productive employment and decent work for all (including young people).</p> <p>8.6: Reduce the proportion of youth not in employment, education or training.</p>	
2. Education, vocational education and training	
<p>Pillar 3: Strengthen rural youth capacities for the use of innovative approaches and technologies in food and agriculture.</p> <ul style="list-style-type: none"> ◆ Outcome 3.1: Youth- and gender-sensitive education and training programmes developed taking into consideration specific contexts and needs of youth constituencies such as disabled, indigenous, minorities and marginalized groups. 	
<p>4.4: Increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship.</p> <p>8.6: Reduce the proportion of youth not in employment, education or training.</p>	 
3. Start-up/incubation support	
<p>Pillar 4: Promote rural services for youth and agripreneurs. It is essential to strengthen youth access to services, including (micro-) credit and (micro-) financial services, and services to assist with land acquisition.</p> <ul style="list-style-type: none"> ◆ Outcome 4.1: Youth entrepreneurship and decent jobs promoted and investment strengthened. 	
<p>8.3: Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services.</p> <p>8.10: Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all.</p>	



TABLE 3 (cont.) Youth policy goals identified in relation to the pillars and outcomes of the Rural Youth Action Plan and corresponding Sustainable Development Goals

4. Promoting innovation	
Pillar 3: Strengthen rural youth capacities for the use of innovative approaches and technologies in food and agriculture.	
<ul style="list-style-type: none"> ◆ Outcome 3.2: Young men and women capacities developed through ICTs, agribusiness support programmes, Junior Farmer Field and Life Schools, education clubs and related mechanisms. 	
Target 9.b: Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, <i>inter alia</i> , industrial diversification and value addition to commodities.	
	
5. Consultation of youth in policymaking processes	
FAO bioeconomy principles and criteria: Principle 6. Responsible and effective governance mechanisms should underpin sustainable bioeconomy.	
<ul style="list-style-type: none"> ◆ Criterion: 6.2: Inclusive consultation processes and engagement of all relevant sectors of society are adequate and based on transparent sharing of information. Indicator: 6.2.a: Consultation processes and engagement of all relevant sectors of society. 	
10.2: By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status.	
	
5.5: Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life.	
	
6. Transforming rural areas	
Pillar 4: Promote rural services for youth and agripreneurs.	
<ul style="list-style-type: none"> ◆ Outcome 4.2: Youth communities, organizations and networks supported in accessing rural services, including agricultural measures. 	
FAO bioeconomy principles and criteria: Principle 4. Sustainable bioeconomy should make communities healthier, more sustainable, and harness social and ecosystem resilience.	
<ul style="list-style-type: none"> ◆ Criterion 4.2: Resilience of biomass producers, rural communities and ecosystems is developed and/or strengthened. 	
Target 2.a: Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular in least developed countries.	

Sources: Authors' own elaboration based on FAO. 2021. *Aspirational principles and criteria for a sustainable bioeconomy*. Rome; United Nations. 2022. *The 17 Goals*. [Cited 22 June 2022]. <https://sdgs.un.org/goals>; FAO. 2022c. *Rural Youth Action Plan*. Rome. <https://doi.org/10.4060/cc0583en>

After the selection of the policy goals, existing bioeconomy strategies and policies were analysed qualitatively. The starting points were the websites BIOCUM AG (Biocom, 2022), an initiative of the Federal Ministry of Education and Research of Germany, and Knowledge for Policy, of the European Commission (2022a). At the time of the research, these two sources provided the most comprehensive overview of bioeconomy strategy development in the European Union and globally.

In the analysis, documents and reports, scientific literature and individual country bioeconomy and related policy documents were searched for the following terms:

- ◆ youth
- ◆ young
- ◆ next generation
- ◆ adolescent
- ◆ student
- ◆ education/training
- ◆ capacity building
- ◆ skill
- ◆ innovation/innovative
- ◆ start-up/ startup
- ◆ incubation
- ◆ participation
- ◆ consultation
- ◆ job(s)
- ◆ employment
- ◆ green jobs
- ◆ entrepreneur/ship
- ◆ bio-based economy innovation
- ◆ bioeconomy innovation
- ◆ bioinnovation
- ◆ innovation
- ◆ bioeconomy technology innovation
- ◆ rural.

2.3 Situation analysis of opportunities for youth inclusion in the bioeconomy and challenges ahead

Key research questions: Where are the jobs and employment opportunities for youth in the bioeconomy today? What are the challenges for the future?

To answer these questions, grey and scientific literature were reviewed and key informant interviews were conducted with youth. Youth were selected through existing contacts of FAO staff, as well as randomly selected through LinkedIn key word searches (bioeconomy, biotechnology). Twelve youth interviews were conducted as open-ended 30 to 60 minute interviews, on Zoom (see Annex 1, Table A3 for list of youth interviewed and questions). This resulted in three youth case studies and various additional key insights from a youth perspective, which are highlighted throughout the report.



3 Review of push/pull factors for bioeconomy youth employment

KEY MESSAGES

- ◆ Rural population growth is declining, but rural areas can be sustainable hubs for the bioeconomy. In transforming rural areas and providing job opportunities, they become more attractive to youth.
- ◆ Instead of converting land for food production, we should first tap into the available agriculture and forestry residues; and make use of abandoned, industrial and urban sites.
- ◆ Globally, the cost of starting a business has decreased, with no significant difference in cost between genders. However, in the African region, a significant percentage of income is still needed to start a business.
- ◆ The bioeconomy requires knowledge and skills that are not adequately provided in current education systems. To avoid future skill gaps, it is necessary to transform education systems, starting from primary and high schools.

Successful youth inclusion, creation of jobs for youth and youth entrepreneurship in the bioeconomy depend on several factors. This chapter will answer the key research question: Which push/pull factors are key to supporting bioeconomy youth employment?

Six socioeconomic, biophysical and technological push/pull factors that affect youth employment in the bioeconomy were identified through the data analysis (see Chapter 2 and Annex 1 for further information on how they were chosen). A push/pull factor analysis is applied to assess the opportunities for and barriers to youth inclusion and employment in the bioeconomy. Push factors (education, vocational education and training, business development and technology development) support youth's capacity building for engagement in the bioeconomy. Pull factors (economic development opportunities, employment opportunities and sustainable resource use) contribute to the development of the overall economy which creates employment and entrepreneurial opportunities for youth in bioeconomy sectors.

This chapter discusses the current situation of these push/pull factors and how they can influence future youth inclusion, employment and entrepreneurship in the bioeconomy. For each factor, an explanation is provided of its importance for youth in bioeconomy (providing the justification for choosing the factor), followed by the key messages from the analysis (Annex 3 provides a more detailed graphic and text interpretation of each factor). The chapter finishes with overall conclusions and recommendations. (For an overview of the six pull and push factors, see Table 1.)

3.1 Pull factors

Economic development

Importance of economic development: This pull factor aligns with Principle 3 of FAO's principles and criteria for a sustainable bioeconomy,⁷ which states, a sustainable bioeconomy should support competitive and inclusive economic growth. The corresponding SDG 8, Decent work and economic growth, provides the indicator SDG 8.1.1, Annual growth rate of real GDP per capita, which was used to analyse the regions in this report (see Annex 3, Figure A1).

Summary: With positive and increased GDP growth rates countries will have more money circulating in the economy which can be invested in new bioeconomy businesses, green jobs, education and innovative technologies which can further spur bioeconomy development. These in turn may lead to increased employment and business opportunities pulling youth into the bioeconomy. However, the current negative GDP growth in almost all the regions of the world could place pressure on emerging sectors linked to the bioeconomy, as this might pose financial gaps for investing in education and technologies.

Employment and entrepreneurial opportunities

Importance of employment and entrepreneurial opportunities: According to FAO's Criterion 3.2, inclusive economic growth is strengthened and a "sustainable bioeconomy should promote equality of opportunity and provide assurances that everyone is able to participate in its development" (FAO, 2021a). As such, increased employment and entrepreneurial opportunities create demand for labour and this can pull youth into the bioeconomy.

At present, one-third of Africa's nearly 420 million youth, ages 15 to 35, are unemployed. Another third are in vulnerable employment, and only one in six is in formal wage employment (AfDB, 2016). The African Technology Policy Studies Network noted that:

Creating jobs for these young people is now a top policy agenda... The huge and rising youth population has placed significant pressure on governments and other stakeholders to create jobs. Agriculture, the key employer, cannot provide decent jobs to these people. There is a realization that jobs will come from transforming economies (ATPS, 2020, p. 5–6).

For example, rural population growth is declining worldwide (World Bank, 2022). However, peer-reviewed literature on the subject suggests that rural areas could be sustainable hubs for the bioeconomy. Locating processing plants close to production areas is believed to be the most important factor to increasing rural and green jobs (Lange *et al.*, 2021). A further decrease in rural populations could lead to a shortage of youth labour in the future, which in turn would have a negative impact on the capacity of countries to realize their full bioeconomy potential. Therefore, it is key to transform rural areas to provide sufficient rural job opportunities making them more attractive to youth.

Summary: The analysed data showed that unemployment rates are higher in urban areas than in rural areas. In countries of the East Africa biostrategy and sub-Saharan African regions where more youth will be at risk of unemployment in the coming years due to declining GDP and high population growth rates the development of sustainable and inclusive bioeconomy industries in those regions could be a crucial solution to counter socioeconomic threats. Increased unemployment, outmigration to urban areas, and the impact of depleting ecosystems and increasing adverse weather events on human health can be mitigated through

⁷ Hereafter these will be referred to as principles and criteria.

transforming their current economy to a bioeconomy. The transition to the bioeconomy has the potential to provide additional employment and entrepreneurial opportunities.

Sustainable resource use

Importance of sustainable resource use: Sustainable resource use is necessary to ensure long-term sustainable biomass production in the bioeconomy and is a key component of poverty eradication, climate-change mitigation, and resilient economic growth. This factor aligns with principles 1, 2 and 5 and Criterion 1.2, 5.1. These indicators note the need for improved efficiency, sustainable intensification of biomass production and the conservation and protection of natural resources.

Various forms of biomass are the primary input for the bioeconomy and present suitable alternatives to fossil raw materials. In order to create bioeconomy jobs for the growing youth population and to transition fully to a bio-based economy, biomass production must be scaled up. However, bioeconomy land use will strongly compete with other land uses (food, building, infrastructure etc.), especially in areas with high population density land is becoming scarce and a sustainable bioeconomy must take these limitations into account and recognize that there may be socially and environmentally desirable resource-use objectives of overriding importance.

Instead of converting land, including agricultural land, into land to produce biomass for the bioeconomy, we must first tap into the available agriculture and forestry residues, as well as side and waste streams with underexploited potential. Secondly, abandoned brownfield, industrial and urban sites (including abandoned refineries) must be converted into biomass-producing and converting locations. These two aspects include the development of necessary technologies and will entail diversifying each value chain, which can lead to more jobs for youth.

Most of the biomass is produced by agriculture and forestry, which depend on soil health and the availability of land. Youth will be the future guardians of soil health and land availability and will determine how land is used. As such, within the sustainable resource use factor, land use is one of the biggest areas to be considered in moving towards a sustainable, youth-inclusive bioeconomy. (The biomass of fisheries and marine sources also have potential as alternative industrial raw materials.) The transition to the bioeconomy is not possible without enhancing and gaining more efficiency in sustainable resource use and in agricultural and forestry production. Sustainable resource use is a pull factor for youth in the bioeconomy, and the activities and markets related to it have a great job-creation potential for youth. It is necessary to increase youth access to land and to increase land availability and productivity.

Summary: Youth must be made aware of these factors and must be included in corresponding decision-making. If the current policy discourse to increase primary biomass production continues, countries (especially those with small surface areas) will face challenges in sustainably developing their bioeconomies.

3.2 Push factors

Education, vocational education and training

Importance of education, vocational education and training: This factor is crucial to preparing the future workforce for the bioeconomy and for embracing its opportunities and understanding its challenges (European Bioeconomy Library, 2019). It is a push factor for youth in bioeconomy that enhances youth's capacity to prepare to enter the labour market. This factor strongly relates to FAO principles 7 and 10 and to SDG 4: Quality education.

The related indicators include quality of workforce (secondary and tertiary education), participation rate of youth and adults in formal and non-formal education, and training (by sex), for which data was analysed in this section. Currently, a large portion of the youth population is left out of the bioeconomy due to the inadequacy of the education they receive and, thus, their lack of the required skills to take advantage of the opportunities offered by the bioeconomy (ICIPE *et al.* 2020).

As several Task Force members noted from their experiences working with America's youth, students are largely unaware of the exciting and rewarding opportunities waiting for them in biology-based occupations, but when they do learn of them, they become excited and want to learn more. Increasing that awareness starts with revamping the way the nation's schools teach biology, moving away from rote memorization of dry facts to an approach that is more hands-on and experiential (Hodgson *et al.*, 2022, p. 30).

This study reveals that embracing an interdisciplinary approach across all educational domains is imperative to foster capacity development, facilitate knowledge sharing, drive behavioural change and ensure a successful transition to a sustainable bioeconomy (see Section 4.1). This inclusive approach is crucial for promoting equal participation of young women and men in the bioeconomy while creating the necessary conditions for a harmonious and environmentally conscious future.

Summary: Worldwide, education systems are not equipped to adequately push youth into the bioeconomy. A transformation that fosters an interdisciplinary approach, starting from primary and secondary schools, is needed to avoid future skill gaps. Africa, for instance, has a high potential to move towards bioeconomy, but it will likely not be able to develop a ready cadre of skilled and knowledgeable personnel and local technological solutions that are needed at present to transition towards a bioeconomy at scale. While this is a gap, it also presents a great opportunity for investment in the education systems across Africa, not just in formal studies but in new training centres and innovation hubs targeting solutions for the bioeconomy.

◆ **BOX 2** Raising awareness of the need for new education materials to transition to a sustainable bioeconomy

Raising awareness about the bioeconomy among youth is a crucial goal for shaping the future generation's understanding of the opportunities it presents. Recognizing the importance of engaging young people and fostering their interest in the bioeconomy, the BioCannDo project has introduced the Think Bio-based Challenge. This initiative aims to encourage the creation of educational materials that capture students' attention and provide them with insights into the bio-based economy.

The Think Bio-based Challenge is open to college and university students who are willing to take on the task of designing teaching tools tailored to primary and secondary school students. The competition invites participants to develop innovative and creative learning modules that can be readily used in classrooms. The materials must be produced in English, and if the participant is a non-native English speaker, they can also be created in their local language.

To incentivize participation and reward excellence, a panel of bioeconomy experts will evaluate the submissions and award a cash prize of EUR 3 000 to the top three entries for each educational grade level, namely primary, secondary and vocational training. The competition emphasizes the importance of thinking outside the box and



BOX 2 (cont.) Raising awareness of the need for new education materials to transition to a sustainable bioeconomy

encourages participants to be imaginative in their approach to engage youngsters and inspire them to “think bio-based”.

By providing an opportunity for college and university students to contribute to the development of educational materials, the Think Bio-based Challenge promotes collaboration between different educational levels and encourages knowledge transfer. “We cannot transition successfully to a bioeconomy-oriented world relying on the educational materials we have at this moment,” say the organizers (European Commission, 2018). That is, the initiative recognizes that existing educational resources may not adequately address the needs of transitioning to a bioeconomy-oriented world and encourages the creation of new ones that will contribute to prepare a generation that is well-informed and embraces the opportunities and challenges presented by the bioeconomy.

Note: For more information, visit www.coebbe.nl/wat-is-biobased/biobased-challenge

Source: European Commission. 2018. Raising the youth’s awareness on the bioeconomy: the Think Bio-based Challenge. In: *European Commission | CORDIS*. [Cited 20 June 2022]. <https://cordis.europa.eu/article/id/124421-raising-the-youths-awareness-on-the-bioeconomy-the-think-biobased-challenge>

Business development

Importance of business development: The economic engagement and overall welfare of young entrepreneurs depend directly on the ease of doing business. A youth-inclusive business environment directly improves the financial situation of youth (United Nations, 2020). If youth can easily do business in the bioeconomy, that is, create companies, access credits and have policy and regulatory support, they will be better off financially. They will also be able to directly invest in and contribute to bioeconomy development. Youth entrepreneurs not only create jobs for themselves, but also for others, including other youth, as well as support the generation of tax revenues.

Business development is a push factor, which, through adequate policy measures, will push youth into the bioeconomy. This aligns with SDG Target 8.3, part of which is to “promote development-oriented policies that ... encourage the formalization and growth of micro-, small- and medium-sized enterprises” (United Nations, 2022). Youth have very specific, age-related constraints and challenges. Not only do they have limited access to capital, land and other resources to fund and operate their businesses, but they are considered high risk by banks and financial institutions and often lack property for use as collateral. They also lack access to valuable networks and to relevant business information (OECD and European Commission, 2020). Furthermore, FAO’s principles and criteria also recognize that “biomass and bioproducts production is a complex activity, and can be an expensive and risky business venture” (FAO, 2021a, p. 11). Business development policies targeted at youth to address their specific challenges can create an enabling youth-inclusive business environment which is crucial to supporting youth bioeconomy entrepreneurs.

Summary: In recent years, the costs associated with creating a new business have dropped in most countries. The analysis showed that there is no significant difference in cost found between genders. Furthermore, the African regions have improved the process of starting a business in recent years, reducing the costs and the number of procedures. However, individuals in this region still need 25 to 55 percent of their annual income to start a business, which is still high and constitutes a barrier, especially for young people.

Technology development

Importance of technology development: To make the most efficient use of these renewable resources, sustainable technologies in the bioeconomy are crucial. The transition to a bio-based economy is fostered through innovation. New bioeconomy technologies today are as diverse as they are innovative (Gomez San Juan *et al.*, 2019). As youth are often drivers of innovation, youth-inclusive technology development can be a central component for the bioeconomy to thrive. Further, innovation is driven by entrepreneurship and underpinned by intellectual property rights and research – key enablers in creating and developing new technological solutions. Technology development is considered a push factor for youth into the bioeconomy. If policies and companies enable technology development that is more youth-inclusive, more youth will be able to access the technologies and, therefore, contribute more to its further advancement. In the long run, this will lead to more youth-led technology development, which in turn will increase the likelihood of youth employment and entrepreneurship opportunities.

The technology development push factor is in line with FAO's bioeconomy Principle 7: Sustainable bioeconomy should make good use of existing relevant knowledge and proven sound technologies and good practices and, where appropriate, promote research and innovations. Related indicators that were analysed in this report include: patent filing, private and public spending on research and development, research and development (R&D) expenditure as a proportion of gross domestic product (GDP) and R&D employment as a percentage of total employment. An analysis of exports of goods and R&D expenditures is also included as this can provide additional indications regarding technology development for the bioeconomy, which in turn could provide new employment possibilities for youth.

Summary: From the data, it is noted that the bioeconomy transition is knowledge intensive. For a successful transition, youth must gain new skills. Along with technological skills (for example, using technologies to produce innovative bio-based products), additional skills within broader technological research, and non-scientific skills, such as business skills, legal and regulatory expertise, and knowledge of financing and patenting, will be needed. Additionally, youth can benefit greatly from innovation hubs and incubator programmes to explore and actualize their businesses.

The following chapter describes in detail the enabling environment (bioeconomy policies, strategies and related youth goals) that could enhance the six push and pull factors to enable youth to take part more fully in the bioeconomy. The interrelationship between policy goals and the push and pull factors is analysed in more detail in Section 4.2.

4 Evaluation of youth-inclusiveness of bioeconomy-related strategies

KEY MESSAGES

- ◆ To achieve a sustainable transition to a bioeconomy and ensure equal participation, it is crucial to adopt an interdisciplinary approach that combines formal and non-formal education. .
- ◆ Seventy percent of the analysed bioeconomy strategies have made commitments to providing support for start-ups and incubation through financial or non-financial mechanisms.
- ◆ All 34 bioeconomy strategies analysed have goals related to innovation, but none of them showed evidence that youth groups were involved in the decision-making and consultation processes of those strategies.
- ◆ High rates of urbanization and lack of policy attention towards transforming rural areas pose a significant challenge to attracting youth to rural areas and creating new job opportunities for them in those areas.

Effective bioeconomy policies would accelerate and deliver long-term support for bioeconomy development, including creating jobs for youth, and would keep our planet habitable for future generations. To answer the key research question “How youth-inclusive are the current bioeconomy strategies and related policies?” six youth-related policy goals were selected and analysed. Section 4.1 of this chapter analyses how these goals are currently addressed in bioeconomy-related strategies. Section 4.2 provides a deeper analysis of how actions within the policy goals could support the push/pull factors analysed in Chapter 3 to engage youth in the bioeconomy and support the SDGs, considering the direct and indirect impacts of such goals on the participation of youth in the bioeconomy (in decision-making and employment). The six policy goals are:

- ◆ job creation
- ◆ bioeconomy education, vocational education and training
- ◆ start-up/incubation support
- ◆ promoting innovation
- ◆ transforming rural areas
- ◆ consultation of youth in policymaking processes.

4.1 Analysis of 34 bioeconomy and related country and regional strategies

Although more than 60 bioeconomy-related strategies exist worldwide, at country and regional levels, and their number is growing (FAO, 2021a), most of them do not have targeted youth goals nor was any evidence found that youth groups were included in the strategy drafting and consultation processes. The policy analysis revealed that, of these 60 strategies, 31 country and 3 regional (European Union, East Africa and Nordic Countries) bioeconomy-related strategies addressed at least two youth-related goals in their policies (Table 4).

Although many countries report that a multistakeholder dialogue took place (GBS, 2018), no evidence was found that any of these strategies explicitly involved youth groups during the policy-consultation process. Dialogue during such processes, in the form of multistakeholder roundtables and consultations, is considered crucial to ensuring mutual learning and inclusive participation in the bioeconomy (GBS, 2018), but also crucial to identifying and considering how to address any potential risks (such as those related to climate-change and food insecurity). There are, however, some indications that countries are involving youth groups, but may not publicly document their involvement. For example, a young policymaker in Colombia stated that youth consultation is being conducted through a partnership with Allbiotech, a network of young people promoting biotechnology and bioeconomy across Latin America (J. Fernando Martínez, personal communication, 2022). Officially documenting the involvement of youth groups during policymaking processes should be considered a good practice and will serve as inspiration for other countries to do the same.

Robust and comprehensive policies and strategies recognize young people as active agents of change and actors in their own and the wider development. However, many policies with a direct or indirect impact on young people are developed and delivered without youth consultation or participation, reflecting both a lack of recognition of the value young people can bring to decision-making and a disregard for the rights of young people to participate in matters that affect them. Involving youth in policy formulation, implementation, monitoring and follow-up can enhance the success of policies and create a sense of ownership among youth — an important condition for inclusion and development (United Nations, 2018, p. 71).

This section presents key outcomes from the analysis of policy documents.

◆ **TABLE 4** Youth inclusion in national and regional bioeconomy strategies

	Countries	Youth-related bioeconomy goals					
		Bioeconomy job creation	Bioeconomy education, vocational education and training	Bioeconomy start-ups/incubation support	Promoting bioeconomy innovation	Consultation of youth in bioeconomy policymaking process	Improving rural areas
EUROPE	Austria	Green	Green	Red	Green	Red	Red
	Estonia	Red	Green	Red	Green	Red	Red
	European Union	Red	Green	Red	Green	Red	Green
	Finland	Green	Green	Green	Green	Yellow	Red
	France	Red	Green	Red	Green	Red	Red



TABLE 4 (cont.) Youth inclusion in national and regional bioeconomy strategies

	Countries	Youth-related bioeconomy goals					
		Bioeconomy job creation	Bioeconomy education, vocational education and training	Bioeconomy start-ups/incubation support	Promoting bioeconomy innovation	Consultation of youth in bioeconomy policymaking process	Improving rural areas
EUROPE	Germany	Red	Green	Green	Green	Yellow	Red
	Ireland	Green	Green	Green	Green	Red	Red
	Italy	Green	Green	Green	Green	Red	Green
	Latvia	Red	Green	Green	Green	Red	Red
	Netherlands (Kingdom of the)	Green	Yellow	Red	Green	Red	Green
	Nordic Countries	Red	Green	Green	Green	Red	Green
	Norway	Red	Green	Green	Green	Red	Red
	United Kingdom of Great Britain and Northern Ireland	Red	Green	Green	Green	Red	Green
ASIA	China	Red	Green	Yellow	Green	Red	Green
	India	Red	Green	Green	Green	Red	Red
	Japan	Red	Green	Green	Green	Red	Green
	Malaysia	Red	Green	Green	Green	Red	Green
	Republic of Korea	Red	Green	Red	Green	Red	Green
	Thailand	Red	Green	Green	Green	Red	Red
AFRICA	Eastern Africa Region	Green	Green	Green	Green	Red	Green
	Mozambique	Red	Red	Red	Green	Red	Green
	Namibia	Red	Green	Green	Green	Red	Red
	South Africa	Green	Green	Green	Green	Red	Green
	United Republic of Tanzania	Red	Green	Red	Green	Red	Red
AMERICAS	Argentina	Red	Green	Green	Green	Yellow	Red
	Brazil	Green	Green	Green	Green	Red	Red
	Canada	Red	Green	Green	Green	Red	Red
	Colombia	Red	Green	Green	Green	Red	Green
	Costa Rica	Green	Green	Red	Green	Red	Red
	Chile	Red	Red	Green	Green	Red	Red
	Mexico	Red	Red	Green	Green	Red	Green



TABLE 4 (cont.) Youth inclusion in national and regional bioeconomy strategies

	Countries	Youth-related bioeconomy goals					
		Bioeconomy job creation	Bioeconomy education, vocational education and training	Bioeconomy start-ups/incubation support	Promoting bioeconomy innovation	Consultation of youth in bioeconomy policymaking process	Improving rural areas
AMERICAS	Paraguay						
	Uruguay						
	United States of America						

Notes: Green indicates that the youth-related goal is explicitly mentioned at least once. Orange indicates that the youth-related goal is mentioned, but not explicitly (mention of goal based on authors’ interpretation or some reference found, either in the strategy itself, supporting documents [see Bioeconomy strategies references in the Bibliography] or personal communications). Red indicates that no evidence of or reference to the youth-related goal was found. (Red fields do not indicate that the supporting policy goal does not exist, but rather that, within the frame of this analysis, the goal was not explicitly mentioned in order to be captured by the analysis performed.)

Source: Authors’ own elaboration, based on: Biotechnology Industry Research Assistance Council, 2020; Bundesministerium für Bildung und Forschung & Bundesministerium für Ernährung und Landwirtschaft, 2020; Carbonell, S.A.M., Cortez, L.A.B., Madi, L.F.C. *et al.*, 2021; Delbrück, S., Griestop, L. & Hamm, U., 2018; Department of Business, Energy and Industrial Strategy, 2021; Department of Science and Technology, 2013; Dieckhoff, P., El-Chichakli, B. & Patermann, C., 2015; Dubois, O. & Gomez San Juan, M., 2016; East African Science & Technology Commission, 2020; EASTECO (East African Science and Technology Commission), 2020; ECLAC (Economic Commission for Latin America and the Caribbean), FAO and IICA (Inter-American Institute for Cooperation on Agriculture), 2019; European Commission, 2018; Federal Ministry for Sustainability and Tourism, Federal Ministry for Transport, Innovation and Technology Federal Ministry & Federal Ministry for Transport, Innovation and Technology, 2019; Fund, C., El-Chichakli, B. & Patermann C., 2018; Fund, C., El-Chichakli, B., Patermann C. & Dieckhoff P., 2015; German Embassy Tokyo, 2020; Inter-ministerial Bioeconomy Committee, 2022; International Advisory Council on Global Bioeconomy, 2020; Ministerio de Economía y Competitividad, 2022; Ministry of Agriculture, 2018; Ministry of Agriculture and Food, 2018; Ministry of Agriculture of the Republic of Lithuania, 2019; Ministry of Economic Affairs and Climate Policy, 2018; Ministry of Employment and the Economy, 2014; Ministry of Science, Technology and Innovation, 2015; Ministry of Trade, Industry and Fisheries, 2016; National Bioeconomy Task Force, 2017; Nordic Council of Ministers, 2018; Republic of Estonia, 2019; Rodríguez, A. G., Rodrigues, M. & Sotomayor, O., 2019; Stockholm Environment Institute, 2021; Teitelbaum, L., Boldt, C. & Patermann, C., 2020; The White House, 2012.

The following sections analyse the six youth-related bioeconomy goals listed in Table 4.

Bioeconomy job creation

This policy goal was chosen based on RYAP Pillar 2: Foster youth employment in an inclusive green economy, and SDG 8: Decent work and economic growth. Of the 34 analysed regional and national bioeconomy-related policy strategies, only 10 (Austria, Brazil, Costa Rica, East Africa, European Union, Finland, Ireland, Italy, the Kingdom of the Netherlands and South Africa) mention the development of green jobs as a policy goal (specifically using the term “green jobs”). The strategies of the European Union and South Africa, for example, consider the creation of green jobs primarily in rural areas, through the promotion of decentralised models, where the first transformation of biomass should take place as close as possible to the areas providing the biomass. Finland aims to create 100 000 green jobs by 2025. Italy aims to create green jobs by stimulating the demand for bioeconomy products and services, through green public procurement and by implementing communication and information actions to increase consumer awareness of bio-based products. Eastern Africa aims to achieve green job growth by revitalising bioprocessing, promoting biomass value chains and biowaste management, increasing primary production of biomass and promoting production systems within a circular economy. Due to the significant lack of data and information,

this report does not investigate further the potential of green jobs for youth inclusion in the bioeconomy. More information on this topic can be found in Section 5.3 of Chapter 5.

Summary: There is no common pattern among the bioeconomy policies regarding creating green bioeconomy jobs in certain sectors. Bioeconomy job-creation goals are closely related to the countries' bioeconomy priorities, and these are different in each country, including, for example: increased biomass processing, increased bioeconomy service provision and green public procurement.

Bioeconomy education, vocational education and training

The choice of this policy goal is based on SDG Target 4.4, Substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship; SDG Target 8.6, Substantially reduce the proportion of youth not in employment, education or training; and RYAP Pillar 3, Strengthen rural youth capacities for the use of innovative approaches and technologies in food and agriculture. Education related to the bioeconomy is often linked to education and training programmes in science, technology, engineering and mathematics (STEM), in order to meet the workforce requirements of technological development and innovation. According to FAO (2018):

However, these aspects rarely come as a key priority in the bioeconomy strategies. One relevant exception is the Finnish bioeconomy strategy, for which developing the bioeconomy competence base by upgrading education, training and research is a key objective (FAO, 2018, p. 50).

Furthermore, as indicated in Section 3.2, the study revealed that embracing an interdisciplinary approach across all educational domains is imperative to foster the development of the diverse capacities youth require to participate in and drive the development of a sustainable bioeconomy. An example of interdisciplinary bioeconomy education is the PBL-BioAfrica Project (see example in Box 3), which integrates problem-based learning (PBL) methods with bio-entrepreneurship education to equip graduates with the practical and entrepreneurial skills needed in working life. The project is funded through the Higher Education Institutions Institutional Cooperation Instrument Programme, which, in turn, is financed by the Ministry for Foreign Affairs of Finland and administered by the Finnish National Agency for Education. The Higher Education Institutions Institutional Cooperation Instrument Programme supports cooperation projects between higher education institutions in Finland and the developing world (see Annex 2). This is also in line with FAO's bioeconomy Criterion 10.1: Cooperation, collaboration and sharing of resources, skills and technologies are enhanced when and where appropriate.

Formal education goals⁸

Most strategies prioritize the establishment of interdisciplinary, academic bioeconomy courses (including master's and doctoral programmes) as well as bioeconomy programmes for postgraduate education to improve both technical and soft skills, and lifelong learning opportunities (GBS, 2018). One example is the establishment of the European Bioeconomy University. Most of the strategies only focus on education and skills development at the tertiary level (this includes China, Estonia, France, Italy, Latvia and the United Kingdom of Great Britain and Northern Ireland). However, India intends to implement measures for biotechnology education in primary and secondary schools and in universities, including in

⁸ Formal education follows a syllabus, and learning outcomes are measured by tests and other forms of assessment.

postgraduate education. Japan explicitly intends to bring about a cultural change in all schools and universities, towards a more interdisciplinary system. Austria and Italy also recognize the complexity and interdisciplinary nature of the bioeconomy. Austria intends to enhance to the education system, based on bioeconomy knowledge and the principle of fairness for the future. Italy intends to address the complexity in the bioeconomy and ultimately foster interdisciplinary innovation in the long run by providing stronger connections among education providers, researchers and private actors. Brazil intends to establish a New Boundaries Programme, which seeks to decrease regional discrepancies by consolidating young-graduate programmes in the North, Centre-West and Northeast of the country.

Non-formal education goals⁹

Italy aims to preserve and valorize traditional knowledge and promote the connection between the ecological and the socioeconomic value of agriculture and forestry systems by transferring good practices to young farmers and entrepreneurs. Malaysia intends to turn unskilled farmers into bio-agripreneurs. Eastern Africa intends to build capacity along the entire bioeconomy value chain through regional centres and service platforms to harness rapidly emerging technologies and adapt them to local needs.

The bioeconomy strategies of Paraguay and the United Republic of Tanzania state that capacity building is a key area to ensure knowledge and technology transfer, both nationally and internationally. Argentina intends to establish biorefinery demonstration plants to transfer and showcase practical knowledge. Costa Rica, Italy and the United States of America see knowledge transfer as a means to enhance greater industry involvement in the creation of bioeconomy solutions.

Summary: An interdisciplinary approach to formal and non-formal education is essential for the capacity development, knowledge sharing and behaviour change required to bring about a sustainable bioeconomy transition and to ensure equal involvement of young women and men in the bioeconomy. Education not only improves employment opportunities but also addresses issues such as informal jobs, as the level of informality decreases as education increases.

◆ BOX 3 Example of interdisciplinary education approaches in the bioeconomy – from bio-trash to cash in Kenya

A group of eight students from Egerton University are working on a Sustainable Biowaste Management and Commercialization project in Nakuru County student challenge. Through the challenge, the students will work together with a local farmers' group to not only improve the quality of organic fertilizer produced by the farmers, but also to build production capacity.



©PBL-BioAfrica project



⁹ Non-formal education takes place outside formal learning environments but within a structured framework.

BOX 3 (cont.) Example of interdisciplinary education approaches in the bioeconomy – from bio-trash to cash in Kenya

The farmers' group, called Griincom waste management, recycles agricultural waste and brings it back into the farming process as organic fertilizer. Griincom was founded in 2015 and operates as a self-help group with a membership of 11, mostly women. It is located in Mzee Wanyama area, pipeline, Nakuru.

The area is densely populated and the residents grow crops and keep livestock. Hence the management of waste became a challenge that resulted in conflicts among the residents. This prompted the students to find a way to make value out of the waste and reduce the conflicts. The group collects crop residues and animal and household waste in a central place. This, together with waste collected from the main market, are composted using the windrow composting system to make organic fertilizer.

The farmers were very excited when the challenge was introduced to them, citing that they look forward to addressing the challenges they are faced with in their group activities with the collaboration of the university students. They further expressed their sentiments of how the student challenge makes them feel a part of the Egerton University ecosystem.

The students will work with the farmers in the student challenge, training them on improving the nutritional quality of organic fertilizer, agricultural marketing, smartphone agrijournalism and farmer-to-farmer training. From the challenge, the students expect to produce a handbook and fact sheets on organic fertilizer production and a module for farmer-to-farmer training in organic fertilizer production.

The students' general opinion of the student challenge learning methodology was positive. They expressed that the student challenge prompts them to be self-driven, proactive and creative in their learning. In particular, they identified the farmer engagement aspect of the student challenge as an opportunity for them to not only learn how to transfer the knowledge they've learned, but also as an ample platform for them to gain confidence and leadership and communication skills.

Notes: This student challenge is part of the PBL-BioAfrica project, which focuses on reforming agripreneurship education in Kenya and Zambia. More stories can be found at: www.pbl-bioafrica.net/news

Source: Fahad Luttah, J. 2021. From Bio-Trash to Cash. In: *PBL-BioAfrica*. Kenya and Zambia. [Cited 20 June]. <https://www.pbl-bioafrica.net/post/from-bio-trash-to-cash>

Start-up/incubation support

The start-up/incubation support policy goal is based on RYAP Pillar 4, Promote rural services for youth and agripreneurs; and SDG targets 8.3, Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services, and 8.10, Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all. Twenty-four of the 34 strategies include commitments to provide start-up and incubation support through increased access to capacity building (training, competitions and mentorship programmes) or through financial support (seed capital, investment funds, venture capital and loans). Seventy-five percent of the national bioeconomy policy documents in Europe and the European Union bioeconomy strategy; 67 percent of the Asian documents, 60 percent of the African documents, including the

East Africa Bioeconomy strategy; and 80 percent of the strategies of the Americas mention start-up/incubation support as one of their goals. India explicitly recognizes the necessity for entrepreneurship development among the youth in the country. East Africa's bioeconomy strategy aims to provide special support for youth and women entrepreneurs to improve the gender balance in the region. In Brazil, start-ups are seen as important elements of the transformation of the productive sector towards the bioeconomy.

Direct public finance support goals

The Nordic Bioeconomy Programme of the Nordic Council of Ministers¹⁰ aims to create an investment fund to bridge the gap between pilot and demonstration initiatives, and between demonstration initiatives and industrialization, in order to boost interest in creating start-ups and help them scale-up. This includes establishing strategic partnerships with existing financial institutions or via new venture capital. Norway wants to strengthen its innovation loan scheme, increasing lending to investment projects related to start-up companies. In South Africa, the goal is to task government-led biotechnology innovation centres with leveraging funding for biotechnology start-ups from the private sector – facilitating a venture capital fund by using government funds to attract private capital.

Non-financial public support goals

Namibia intends to support the establishment of mentorship programmes to help bioinnovators harness their potential. Thailand plans to support start-ups through business plan competitions and the establishment of a Start-up Stock Exchange that provides a regulated marketplace for selling ownership shares to investors. The country also intends to create more incentives for angel and venture investors. Malaysia will use bio-accelerator platforms for bioentrepreneurship, to grant start-up companies a BioNexus Status (Gomez San Juan, 2019) through which they will be able to receive fiscal incentives, legal advisory services and other benefits (see Bioeconomy strategies references in the Bibliography for the full list of policies).

Lack of efficient support mechanisms create unnecessary barriers and keep youth from entering the bioeconomy B2B space. As stated by G. Tien Ngo:

The youth is not well represented in the bioeconomy innovation space; its mostly older people have been working on it for years. I see that youth therefore enter more the B2C (business-to-consumer) space and less the B2B (business-to-business) one. In B2C you can realise a variety of ideas, B2B is often highly-industrial, extremely complex, and there is much fewer youth support, this scares many young people off. While there are big opportunities to grow fast. I was once told by the very same people in the industry that I will not succeed and that I will not get it funded. I believed in myself and the idea and overcame many barriers (personal communication, 2022).

Bioeconomy investments must be customized to youths' needs in order to provide effective support for this group. According to Ahad Katera, Chief Executive Officer of Guavay Company Ltd, in Dar es Salaam, the United Republic of Tanzania:

Bioproducts are not seen on social media, showing that the sector is still at a very preliminary stage for young entrepreneurs. Discussions are still at high levels i.e. international, regional and national levels and need to be brought down to a local context. There is a lack of actors on the ground who can lay down these policies and strategies into the market. Markets don't wait for policies, so there is a need for rapid action before new products arrive from other countries that could have been produced in the region. There are huge needs for investment in research and development

¹⁰ The Council represents Åland, Denmark, the Faroe Islands, Finland, Greenland, Iceland, Norway and Sweden.

work, engaging and including the youth. Guavay Company has been trying to do research and development for five years, supported by BioInnovate Africa, and yet the business is still not profitable due to suboptimal levels of investment. Small businesses lack collateral to be able to attract financing. Most investors find the bioeconomy a risk area. There is a need to find ways to bring in investors with experience in the bioeconomy. Sharing experiences and customizing the processes to engage the youth in the bioeconomy will be vital for the region (ICIPE *et al.*, 2020, p. 37).

Paulus Mungeyi, of the National Commission on Research, Science and Technology of Namibia, further argues that bioeconomy policies must maximise support to youth entrepreneurs:

There is an urgent need to facilitate investments for financial services, and providing incentives aimed at empowering youth and bioentrepreneurs operating along the agriculture supply chain. A sustainable bioeconomy strategy must be an enabling framework that will provide a platform for mentoring programmes. A development bank in Namibia has just launched a Women and Youth loan scheme to encourage their inclusion in the economy. A Finnish funded Southern African Development Community initiative is aimed at developing leadership and entrepreneur skills in female owned biobusinesses. A Bioinnovation Strategy should stimulate other new initiatives (ICIPE *et al.*, 2020, p. 36).

Summary: Seventy percent of the analysed bioeconomy strategies include commitments to providing start-up or incubation support through either non-financial support mechanisms, such as increased access to capacity building (training, competitions, mentorship programmes), or financial support mechanisms (including seed capital, investment funds, venture capital and loans). Only the Indian strategy and the Eastern African Bioeconomy Strategy explicitly mention youth as beneficiaries of the start-up/incubation support goals. In order for youth to access these support mechanisms and benefit from state interventions, interventions must address the needs of youth.

Promoting innovation

RYAP Pillar 3, Strengthen rural youth capacities for the use of innovative approaches and technologies in food and agriculture, and SDG Target 9b, Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities, form the basis for the inclusion of this policy goal. All of the analysed documents have goals related to promoting bioeconomy innovations. Youth innovation is contributing to the renewed, modernized vision of agriculture and agrifood systems in the context of bioeconomy, due to young people's technological and innovation skills – which exceed those of previous generations (Trigo *et al.*, 2021). Each country has its own strategy to promote innovation.

Paraguay, for example, considers strategic alliances between universities, centres of excellence and businesses to be important to spur innovation. Argentina aims to develop four biorefinery pilot plants close to feedstock production and processing areas, where innovations can be tested for their potential to be scaled to industrial application. Other countries intend to foster the use of open-innovation platforms, the creation of interdisciplinary programmes and increased investments. For example, the European Union will set up “living labs” to test their contribution to open, multidisciplinary and multi-stakeholder innovation in primary production on land and sea and its interfaces with bioeconomy value chains. These living labs will be local infrastructures where stakeholders can exchange ideas, co-create, test and replicate ecological and circular solutions in primary production on different scales

(for instance, from pilot to landscape). Austria and Norway aim to innovate in processing methods. Norway also intends to innovate in the pharmaceutical industry. Ireland intends to promote food innovation, and circularity through solutions and innovations that reuse and recycle materials to maximise resource efficiency. France wants to innovate in the construction sector (for instance, using hemp materials), while Japan aims to merge biotechnology with digital technology. The Republic of Korea will innovate in renewable energy (including bioenergy), and Thailand will take steps to produce ethanol from home-grown sugar cane and cassava. Chile will invest in agrivoltaics to increase land-use efficiency by simultaneously providing photovoltaic energy and retaining fertile arable areas for agriculture and food production.

The East African Regional Bioeconomy Strategy outlines the importance of specifically supporting SMEs and youth in innovation in the value addition sector by equipping this target group with skills not only in technology and production, but also in management:

Apart from being effective in generating employment opportunities, start-ups and SMEs are often pioneers and promoters of innovation in the bioeconomy, but they need access to technology, know-how, capital and markets. It is therefore important to create an enabling environment for bioeconomy innovations, paying attention to the needs of young innovators and the use and deployment of the rapid advancements of the modern biology. Biologically based processes require a new technological and managerial base, which in turn demands a reorganisation of technical, production and management skills. A major barrier for African enterprises is however the lack of skilled staff, engineers and technicians able to adopt, implement and upscale technologies for value addition and processing. Building skills in the SME sector to add value to primary produce and convert waste to useful products is therefore an essential component of the development of the Bioeconomy in Eastern Africa. (Virgin *et al.*, 2022, p. 69)

Summary: Promoting bioeconomy innovations as a policy goal has been found in all 34 analysed bioeconomy strategies. Similar to the job creation goal, there is no real pattern among their innovation priorities. Which innovation the country or region focuses on strongly depends on the country's general bioeconomy goals. Youth have great innovation potential, and bioeconomy strategies must ensure that their skills will be harnessed and further developed for bioeconomy innovation and technology development.

Consultation of youth in policymaking processes

Based on FAO's bioeconomy Criterion 6, Inclusive consultation processes and engagement of all relevant sectors of society are adequate and based on transparent sharing of information, and on SDG Target 10.2, By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status (United Nations, 2022), youth should be part of consultation and policymaking processes. In fact, the consultation of youth is an essential factor for developing a sustainable, youth-inclusive bioeconomy. Therefore, consultation of youth in policymaking processes was included as policy goal in the policy analysis.

The earliest international call for youth participation was made in 1989 through the ratification of the United Nations Convention on the Rights of the Child. The convention emphasized the importance of recognizing youth as individuals whose dignity must be respected:

It promotes the principle that youth are entitled to express their views on all matters that affect them and to have those views taken seriously. Article 12 of the Convention makes it clear that participation is a substantive right of all children and young people. (United Nations, 2003, p. 271)

Furthermore, the Convention advocates for youth participation as the status-quo in policymaking and in the wider development agenda:

Youth participation is an essential strategy for ensuring young people’s optimal development—and for achieving wider development goals for society. ... Youth participation must become an integral component of local, national and international policies for youth, and should provide the framework for decisions and actions that affect the daily lives of children and young people. ... The approach must promote respect for them as social actors, as agents in their own lives, and as citizens of their own societies (United Nations, 2003, p. 287).

Decision-makers can overcome youth participation barriers by actively providing youth a seat at discussion tables:

I am still a young researcher, how can I speak to senior policymakers, that have so much experience? I think many youths feel like this, therefore a conscious push for youth involvement should be made. In Germany there were opportunities for youth to participate in discussions in regional or scientific events, there is a willingness to bring young voices into the conversation. Last year, I participated in the global bioeconomy summit and also there was space made for youth, I think this is the right path, recognizing the need to bring youth into the discussion (R. Vargas Carpintero, personal communication, 2022).

Summary: While all 34 analysed strategy documents have goals related to innovation in new technologies, no written evidence was found that they had included youth groups in the policymaking and consultation processes. If countries want youth to participate effectively in the bioeconomy, an enabling environment must be cultivated for the meaningful participation of youth in all relevant decision-making processes.

Transforming rural areas

The inclusion of the policy goal “Transforming rural areas” is based on RYAP Pillar 4, Promote rural services for youth and agripreneurs, and SDG Target 2.a, Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries. Of the analysed bioeconomy-related strategies, 46 percent of the European strategies (including the European Union strategy), 67 percent of the Asian strategies, 60 percent of the African strategies (including the East African Regional Bioeconomy Strategy), but only 20 percent of the strategies of the Americas, specifically address the transformation of rural areas.

The European Union bioeconomy strategy aims to improve biorefining in rural settings to support the use of local renewable resources in order to help establish attractive rural job opportunities for both primary producers and young skilled entrepreneurs. Italy especially aims to involve and encourage youth to move into farming and other activities in rural, coastal and marine areas. The country aims to support young land managers in the adoption of good practices and young entrepreneurs in the agrifood and forest-wood sectors. Rural areas, or as the Italian bioeconomy strategy calls them, “less favoured areas”, should also be revived through educational programmes and knowledge sharing. Mozambique considers unused land to be the “less favoured areas”, which should create value-added for rural communities. Other bioeconomy strategies also acknowledge that education and knowledge sharing are strongly related to transforming rural areas and making them more attractive, especially for the younger population. In this regard, the Nordic countries bioeconomy strategy highlights

that “development of the bioeconomy requires a well-educated and competent work force with many skills and offers opportunities for young people to either stay in or move to the rural regions” (Nordic Council of Ministers, 2018, p. 10).

Other countries see the transformation or revival of rural areas not as a goal itself, but as a means to an end. For example, in the Mexican bioeconomy strategy, rural transformation should improve agricultural productivity and strengthen the country’s agroindustry. In South Africa, rural transformation actions should develop energy crops and processes to support the country’s emerging biofuels industry.

Rural areas are facing the effects of youth migration to cities and the ageing of the wider population. This trend could have a negative impact on the capacity of countries to realize their full bioeconomy potential. Significant work needs to be done to create attractive jobs and living environments in order to encourage young people to return to rural areas. Rural areas could halt emigration to cities by transforming them into sustainable bioeconomy hubs, by placing processing sites close production areas. This is believed to be one of the most promising approaches to increasing rural jobs. Currently, the manufacturing sector provides more jobs than other sectors (see Figure 7). This could indicate that in the bioeconomy manufacturing can create many new jobs for youth. For example, the United Republic of Tanzania has a large market potential for sustainable wood briquette production (for instance, from waste streams). “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.” (ICIPE *et al.*, 2020, p. 44)

As stated in the article, Food and Non-Food Biomass Production, Processing and Use in sub-Saharan Africa: Towards a Regional Bioeconomy:

Rural policies should focus on extension services as well as capacity building and training. Furthermore, market opportunities and access to markets, in combination with the establishment of cooperatives, have to be developed. Other recommendations for promoting a rural, biomass-based economy range from enterprise regulations, asset acquisition, and contractual issues to social capital development in rural environments (Callo-Concha *et al.*, 2020).

The revival of rural areas is covered by Target 2.a. of SDG 2, which aims to increase investment, including through enhanced international cooperation, in rural infrastructure. This analysis found that increased investment in rural infrastructures was not mentioned in any of the current bioeconomy strategies. Bioeconomy strategies must promote crucial infrastructure-related services that are inclusive of equitable access to innovations such as e-commerce platforms and e-banking.

In addition, the use of specific rural youth-orientated incentive schemes can increase youth attachment, retention and recruitment to rural areas. Rural infrastructure, including internet connectivity and other services, such as social, health and education services will also be essential. (FAO, 2022c, p. 9).

Summary: Regions such as Central Asia, North America and Latin America, which have large surface areas and high biomass production potential, could greatly benefit from the bioeconomy if they are able to transform rural areas effectively. But the lack of policy attention towards transforming rural areas, together with high rates of urbanization, could pose a serious challenge for those countries (especially Latin American countries) to develop their full bioeconomy potential and create new jobs for youth.

4.2 How policy measures can effectively address key challenges and barriers to support push/pull factors

This final section of Chapter 4 aims to answer the question: How do current bioeconomy strategies and related policies support factors to push and pull youth into the bioeconomy? Four examples are provided of how bioeconomy strategies are already supporting some of the push/pull factors. The examples show how policy measures could be included in bioeconomy strategies to better support youth and contribute to reaching the SDGs. The analysis also takes into account key challenges and barriers. Although there are additional combinations of bioeconomy policies and their influence on the different push/pull factors, the following four interrelations stood out in the analysis as particularly relevant and potentially impactful and were selected for more detailed analysis and insights:

1. Investing in education, awareness building and innovation has a positive influence on technology development (push factor).
2. Actions that foster job creation and rural transformation policy goals have a positive impact on youth employment (pull factor).
3. Scaling existing bioeconomy start-up mechanisms spur business development (push factor).
4. Youth involvement in decision-making is key to sustainably influence sustainable resource use (pull factor).

Investing in education, awareness building and innovation has a positive impact on technology development

Adequate general education, vocational education and training is a crucial push factor in preparing the future workforce for the bioeconomy and for embracing its opportunities and understanding its challenges. SDG Target 4.4 aims to increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship. Unfortunately education systems worldwide are not equipped to adequately push youth into the bioeconomy. This is confirmed by the recent report on the South African bioeconomy sector prepared by the National Advisory Council on Innovation (NACI). NACI found out that bioeconomy employment trends show that bioeconomy-related skills are not being sufficiently developed in South Africa. NACI suggests that current policies be reviewed and refined with a view to grow bioeconomy-related skills (NACI, 2022). Inadequate education is a key barrier to youth employment and involvement in the bioeconomy. Embedding bioeconomy in education curricula, starting from primary and secondary schools is necessary to avoid future skill gaps. By using storytelling and graphic illustrations, kids as early as five years old can begin learning about the bioeconomy through the efforts of their teachers, parents and grandparents. The book *What's Bioeconomy?*, which targets children ages five to eight years, is a good example of a book that could be included in elementary education. The book is available in 11 languages and the information it shares has been validated by 32 experts from academia and industry (European Bioeconomy Network, 2022).

Furthermore, the research found that an interdisciplinary approach to all forms of education is essential for the capacity development, knowledge sharing and behavioural change that are necessary for a sustainable bioeconomy transition to occur and for ensuring equal involvement of young women and men in the bioeconomy. This is already recognized in several bioeconomy strategies (including those of Austria, Finland, Italy and Japan). For example, the Finnish government's Higher Education Institutions Institutional Cooperation Instrument Programme funds the PBL-BioAfrica Project, which integrates PBL methods with

bioentrepreneurship education to equip graduates with the practical and entrepreneurial skills needed in working life.

Improvements in bioeconomy education have a direct influence on technology development (push factor). Adequate education will enable youth to contribute to furthering technology development. It will also have an indirect positive impact on youth employment (pull factor) and business development (push factor). For example, in digital technology, countries with higher levels of digital technology adoption tend to have fewer youth who are not in education, employment, or training (NEET). An example of how not addressing challenges in education systems could negatively influence technology development and implementation is the situation in sub-Saharan Africa, where enrolment in vocational training for both male and female youth has declined over the past five years, unlike the rest of the world where enrolment is stable or increasing in the past one to two years. This could lead to a serious shortage of technical workforce and pose a problem for implementing biotech and high-tech in agrifood systems in the bioeconomy. Although this is a gap, it also presents opportunities to invest in the African education systems, not only in formal studies but in new training centres and innovation hubs targeting bioeconomy solutions.

The technology development factor is also influenced by how much countries are investing in innovation. A positive finding from the policy analysis is that all 34 bioeconomy strategies include the promotion of innovation as a policy goal. Similar to the job creation policy goal, there is no real pattern visible in terms of the strategies focusing on a particular innovation. Here again, this strongly depends on what the country is focusing on (for example, ethanol production, construction or food). An identified barrier that could constrain economic development (pull factor), especially that of still-emerging sectors linked to the bioeconomy, is the current observed decline in GDP growth (especially in 2020, due to the COVID-19 pandemic). This might result in financial gaps that could impact investments in education and technologies that are needed to spur bioeconomy development.

Malaysia provides a good example of how policies for investment in innovation can create new jobs in the bioeconomy. According to the government, the target of the 2005 National Biotechnology Policy (NBP), was to create 160 000 job opportunities by 2020. According to the latest accessible data, 84 153 jobs were created by 2015 (Malaysian Bioeconomy Development Corporation, 2017). Furthermore, according to the government, 48 projects within the Bioeconomy Transformation Programme (BTP) contributed to the creation of 23 355 new job opportunities (Arujanan and Singaram, 2018). In view of the 7 percent increase in employment in BioNexus Status companies between 2020 and 2021, the government sees an urgent need to improve efforts to build a skilled workforce “in critical sectors like AgBiotech, which plays an important role in addressing food security and production in the face of crises such as COVID-19” (Razak, 2021, p. 21).

The youth interviewed for this report also shared their perspectives regarding actions that could support education, awareness raising and innovation for a bioeconomy transition. They consider that educational systems should not only showcase traditional jobs, such as doctors and police officers, but also jobs in biotechnology, alternative protein development, etc. A specific suggestion of the youth was to create a massive open online course on bioeconomy in different languages. The youth also said that information and support to youth should be made more accessible. Governments and other actors should communicate the concept of bioeconomy to the public, so that individuals whose projects or businesses are part of the bioeconomy can be aware of this. The government should also showcase examples of bioeconomy businesses in the food and transport sectors, biotechnology developments for home use, etc. Furthermore, youth with ideas and innovations should be encouraged, for example through awards, prizes for start-ups and competitions that include mentorship, in order to lift start-ups to the next level.

Actions that foster job creation and rural-transformation policy goals have a positive impact on youth employment (pull factor)

Of the 34 analysed national and regional bioeconomy-related policy strategies, only ten (those of Austria, Brazil, Costa Rica, East Africa Biostrategy, the European Union, Finland, Ireland, Italy, the Kingdom of the Netherlands and South Africa) mention the development of green jobs (using that specific term) as a policy goal. Furthermore, little attention is given in public policy to transforming rural areas. However, addressing both goals (green job development and the transformation of rural areas) can effectively support youth employment in the bioeconomy. The analysed policy goals of job creation and rural transformation have direct influence on the employment pull factor, as creating jobs for youth and making rural areas more attractive to youth will pull them into the bioeconomy. The analysis did not find a common pattern among the bioeconomy policies to creating bioeconomy jobs in specific sectors. Job creation goals are closely related to the countries' key bioeconomy sector priorities (such as increased biomass processing, increased bioeconomy service provision or biochemical industry development). This emphasis will also determine where the future job opportunities for youth are in each country – geographically (rural or urban) and in which sectors.

Total rural population growth is declining worldwide. This could lead to a youth labour shortage in rural areas in the future, which in turn will likely have a negative impact on the capacity of countries to realize their full bioeconomy potential. This will be especially relevant for countries in biomass-rich regions such as Latin America, where unemployment rates are much higher in urban areas than in rural areas.

If bioeconomy strategies adequately manage to design youth-inclusive policy actions that address job creation in rural areas and the transformation of rural areas, this could also be a crucial solution to socioeconomic threats such as a potential increase in unemployment, rural-to-urban migration and the impact of depleting ecosystems. An adequate policy strategy could transform rural areas into bioeconomy hubs that provide jobs and attractive living environments for youth. Regions such as Central Asia, North America and Latin America, which have large surface areas and high biomass production potential, could especially benefit from youth-inclusive bioeconomy strategies that address job creation and rural transformation. Youth themselves suggest that mechanisms to act locally and build stronger local institutions in areas where the bioeconomy is not yet present are needed.

Scaling existing bioeconomy start-up mechanisms spurs business development (push factor)

Youth must be able to access support mechanisms that will provide them with the needed assistance and access to productive resources so they can establish their own bioeconomy businesses. Seventy percent of the analysed bioeconomy strategies include commitments to providing start-up or incubation support through non-financial support mechanisms (such as increased access to capacity building, including training, competitions and mentorship programmes) or through financial support mechanisms (such as seed capital, investment funds, venture capital and loans). Only the Eastern African and Indian bioeconomy strategies explicitly mention youth as beneficiaries of the start-up/incubation support goals. In order for youth to be able to access and benefit from these support mechanisms, it will be crucial to develop them in a way that addresses the needs of youth. Support mechanisms that are already in place can greatly support the business development factor to push youth into the bioeconomy, equipping them with the needed financial and capacity-building support to establish successful bioeconomy businesses. These policy interventions must be available and accessible at scale in order to benefit the broader youth population. This will improve the situation of youth in the long term, as they will be better prepared to manage the risks

of operating new businesses. This will also improve their financial situation, enabling them to directly contribute to bioeconomy development. Start-up/incubation support policies also need to address the fact that in many countries, especially in Africa, the costs associated with starting a new business are still high and constitute a barrier, especially for young people who do not have enough starting capital nor collateral.

Globally, SMEs are the core engines of job creation. The analysis conducted shows that this also holds true for the bioeconomy. For instance, in their data analysis the South African Government confirms that SME's are the biggest employment creators in their bioeconomy. If youth are supported to turn their businesses into viable SMEs, this could lead directly to an increase in jobs for youth in entrepreneurship and employment, as youth are more likely to employ other youth (FAO, 2022).

Youth involvement in decision-making is key to sustainable resource use (pull factor)

The sustainable resource use pull factor is one of the biggest areas to be considered in moving towards a youth-inclusive bioeconomy. As long as the earth's resources, especially land, are managed sustainably, they will provide biomass for the bioeconomy for generations to come (Stockholm Resilience Centre, 2022). Sustainable biomass production contributes to poverty eradication, climate-change mitigation and resilient economic growth. Youth will be the future guardians of land health and availability, and will be in control of how land is used. As such, they must be aware of factors that potentially threaten the earth's resources and, hence, their future, and they must be included in decision-making.

While all 34 analysed strategy documents have goals related to innovation in new technologies, none of them included youth groups in the policymaking and consultation process. If countries want to ensure that biomass – the main input for the bioeconomy – will be produced in the future, they must provide an enabling environment, empowering youth to access land, to be involved in decision-making and to learn how to implement sustainable land use.

If the current policy discourse, which focuses on increasing primary biomass production continues, countries (especially those with small surface areas) will face challenges in sustainably developing their bioeconomy. In such a scenario, it can be expected that bioeconomy land use will strongly compete with other land uses (such as food production, construction and infrastructure), especially in areas with a high population density. Measures to counter this threat include: First, tapping into the largely available and underexploited residues, side and waste streams, instead of converting more land to biomass production. Second, reconverting abandoned land (including abandoned refineries). Technology is needed to support these two measures. This would diversify bioeconomy value chains (see Section 5.2. in Chapter 5), which in turn can lead to creating more jobs for the youth.

The youth interviewed had strong opinions about their involvement in policymaking and governance and provided a broad set of recommendations for policymakers to consider, including the following:

- ◆ Establish a strong global bioeconomy youth alliance and support existing youth groups, such as iGem and Allbiotech, in contributing to national, regional and international policy and societal discussions.
- ◆ Finance youth-led workshops and conferences. Youth groups find it difficult to obtain funding for such events and this hinders the promotion of youth involvement in the bioeconomy.
- ◆ Organizations should work more closely with youth groups to provide more youth-inclusive policy advice to governments.
- ◆ Support the involvement of youth in policymaking processes in any way possible, for example by establishing national youth councils and parliaments.

5 Situation analysis of opportunities and challenges for youth employment and entrepreneurship in the bioeconomy

KEY MESSAGES

- ◆ In the bioeconomy, the agriculture, food and beverage, and manufacturing sectors, and those with the greatest number of processing stages and the least biomass input, provide the highest number of employment prospects for youth.
- ◆ Young entrepreneurs in the bioeconomy encounter challenges similar to those in the traditional economy, but the novelty of the bioeconomy sector presents them with additional obstacles, such as issues in patenting and regulations.
- ◆ Longer value chains in bio-based products, with decentralized management and logistics, can create new employment opportunities and business models in rural areas, close to production and processing sites.
- ◆ Lack of interest on the part of youth in the bioeconomy is a challenge that can be addressed by promoting ICTs together with bioeconomy to increase youth adoption of and interest in bioeconomy technology jobs.

This chapter aims to provide a deeper understanding of the present and future youth employment opportunities and challenges in the bioeconomy. It thereby focuses on answering the following two research questions: **1) Where are the jobs and employment opportunities for youth in the bioeconomy today?** and **2) What are challenges for the future?** In estimating the current and future employment capacity of the bioeconomy on a global scale in the framework of this study, two major limitations must be taken into account: 1) the significant lack of quantitative data, and 2) major differences in countries' measuring and reporting of data. As a result, rough estimates are used and the findings can only provide indications and should be interpreted with caution.

This chapter also looks at broader opportunities for scaling youth employment and involvement. The information presented includes findings and lessons learned from the youth interviews, youth-led enterprises and ongoing and past bioeconomy projects that include a youth-inclusion component (See Annex 2 for list of bioeconomy project targeting youth).

5.1 Current estimates of youth employment in the bioeconomy sectors

Employment data in the specific bioeconomy sectors is not readily available (except for the European Union). Furthermore, none of the available bioeconomy employment data is disaggregated by age. Therefore, it is a challenge to estimate how many youth are engaged

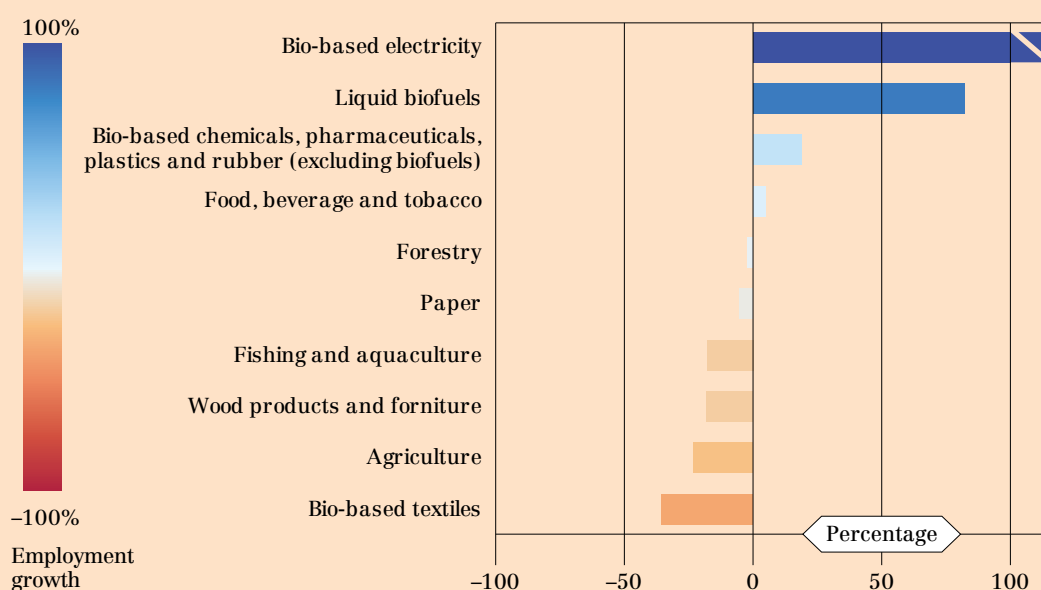
in the bioeconomy and in which specific bioeconomy sectors. However, this section provides some examples and indications of the past and current situation of employment in different bioeconomy sectors and countries based on current employment numbers in bioeconomy sectors. As the data is not age disaggregated, it is only possible to provide a rough estimate of what this could mean in terms of youth employment in the bioeconomy.

It is estimated that, currently, the bioeconomy of the United States of America has an annual turnover of USD 369 billion and supports 4 million jobs. The European Union bioeconomy has a USD 2 trillion annual turnover and supports 17 million bioeconomy jobs. In Argentina, the latest estimates show that there are 2 470 000 jobs in the bioeconomy (IICA, 2020), 27 000 of which are in the biotechnological industry (ILO, 2020).

The European Union

In the European Union, between 2008 and 2020, employment growth in the bioeconomy has been fastest in the following sectors: bio-based electricity (211 percent increase), biofuel (82 percent increase), bio-based chemical industries (including pharmaceuticals, plastics and rubber, excluding biofuels (18.7 percent increase), and the food and beverage sectors (4.8 percent increase) (Figure 2). In 2020, agriculture and the manufacturing of food, beverages and tobacco were the largest sources of employment, with 8 702 820 and 4 597 963 jobs, respectively (European Commission, 2023) (Figure 3 and Table 5). However, overall employment in the bioeconomy has decreased over the same period from 20 million to 17 500 000 people. According to the European Union bioeconomy strategy, the main driver of the decrease in overall employment in the European Union bioeconomy is a 22.3 percent reduction in the number of people employed in the agriculture sector between 2008 and 2019. This is due to a restructuring of the sector. The labour force during this period also declined significantly in other traditional sectors, such as bio-based textile manufacturing (35.6 percent decrease) and wood products manufacturing and wooden furniture (18 percent decrease).

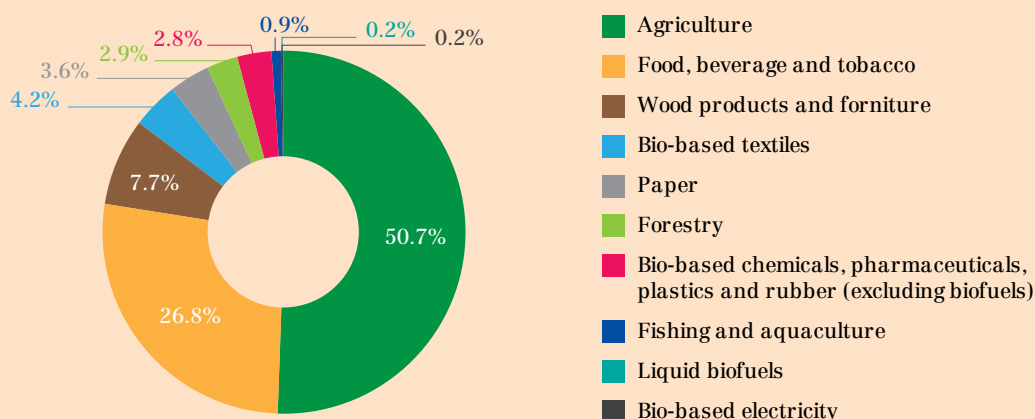
◆ **FIGURE 2** Employment growth between 2008 and 2020 in EU-27*



Note: * EU-27: European Union 27 Member Countries (from 1 February 2020).

Source: European Commission. 2023. Jobs and Wealth in the European Union Bioeconomy. In: *European Commission*. [Cited 11 May 2023]. <https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html>

◆ **FIGURE 3** Employment by bioeconomy sector in EU-27* (2020)



Note: * EU-27: European Union 27 Member Countries (from 1 February 2020).

Source: European Commission. 2022c. Jobs and Wealth in the European Union Bioeconomy. In: *European Commission*. [Cited 20 June 2022]. <https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html>

However, in terms of total employment numbers, the agriculture and food and beverages sectors¹¹ still offer considerable employment possibilities (Fachagentur Nachwachsende Rohstoffe, 2020a). This could be an opportunity for youth employment (in the European Union), at least in the coming years, despite the decrease in the agriculture sector and the steep growth of the other sectors.

◆ **TABLE 5** Number of people employed by bioeconomy sector

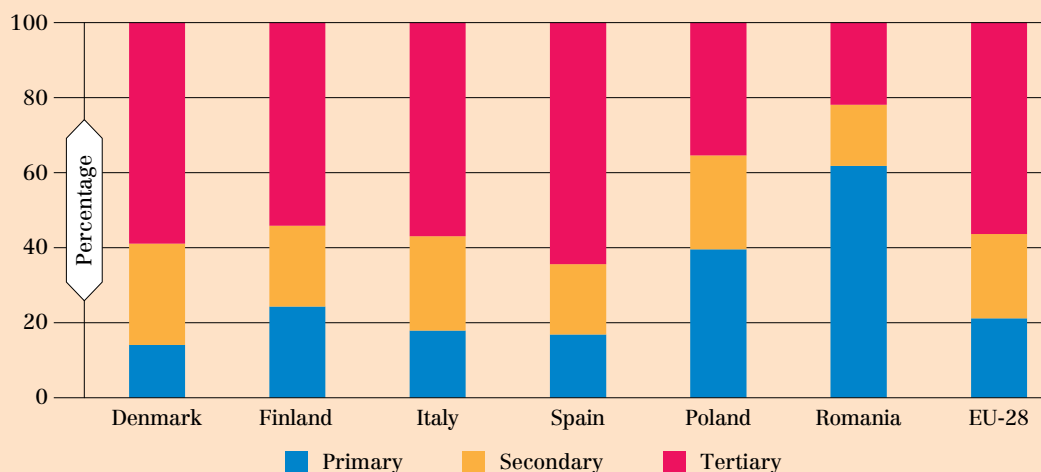
Sector	People employed
Agriculture	8 702 820
Food, beverage and tobacco	4 597 963
Wood products and furniture	1 327 1094
Bio-based textiles	723 814
Paper	616 637
Forestry	502 610
Bio-based chemicals, pharmaceuticals, plastics and rubber (excluding biofuels)	472 947
Fishing and aquaculture	156 210
Liquid biofuels	367 169
Bio-based electricity	2 6579

Source: European Commission. 2022c. Jobs and Wealth in the European Union Bioeconomy. In: *European Commission*. [Cited 20 June 2022]. <https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html>

¹¹ “Today, the food industry is the largest consumer of biomass from agriculture, accounting for more than 80 percent. The energy sector accounts for 14 percent and the manufacturing industry for 2 percent. More than 52 percent of the bioenergy sector is supported by the forest industry. The furniture, construction, pulp and paper industries account for the remaining 48 percent.” (Fachagentur Nachwachsende Rohstoffe, 2020a).

The study estimated the distribution of employment between primary, secondary and tertiary sectors within the bioeconomy of certain European Union Member Countries and the EU-28. (Only data from 2015 was available.) As shown in Figure 4, the numbers show that in 2015 the tertiary sector was the strongest in the EU-28. Looking at individual countries, the primary sector was strongest in Romania (60 percent) and Poland (40 percent) (Kuosmanen *et al.*, 2020).

FIGURE 4 Employment in the bioeconomy by sector in six Member States of EU-28*



Notes: Data from 2015. * EU-28 refers to European Union 28 Member Countries (from 1 July 2013 to 31 January 2020).

Source: Kuosmanen, T., Kuosmanen, N., El-Meligli, A., Ronzon, T., Gurria, P., Lost, S. & M'Barek, R. 2020. *How Big is the Bioeconomy?* Reflections from an economic perspective. Luxembourg, Publications Office of the European Union.

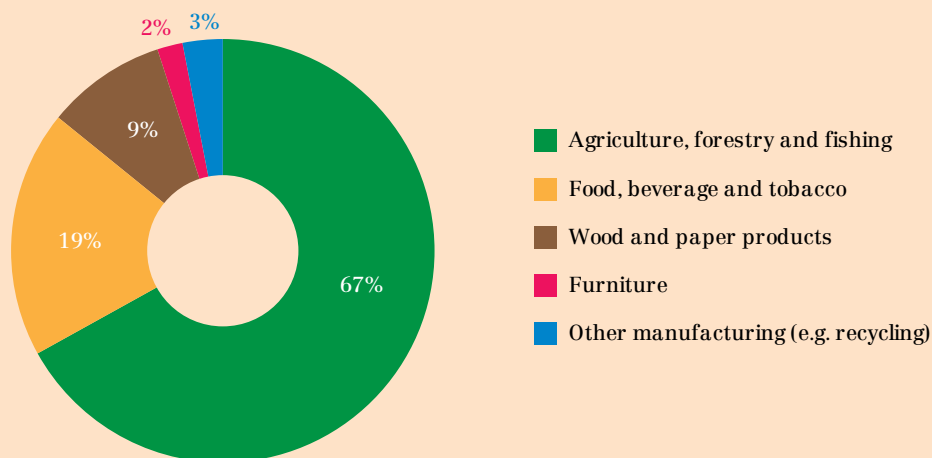
South Africa

South Africa has been measuring its bioeconomy employment according to skilled, semi-skilled, low-skilled and informal workers. According to the Department of Science and Innovation:

Skills development has remained constrained during the period before and after the bioeconomy was implemented. The trends observed in this data show that there is a need to review and refine current policies aimed at growing skills within this sector (NACI, 2022, p. 21).

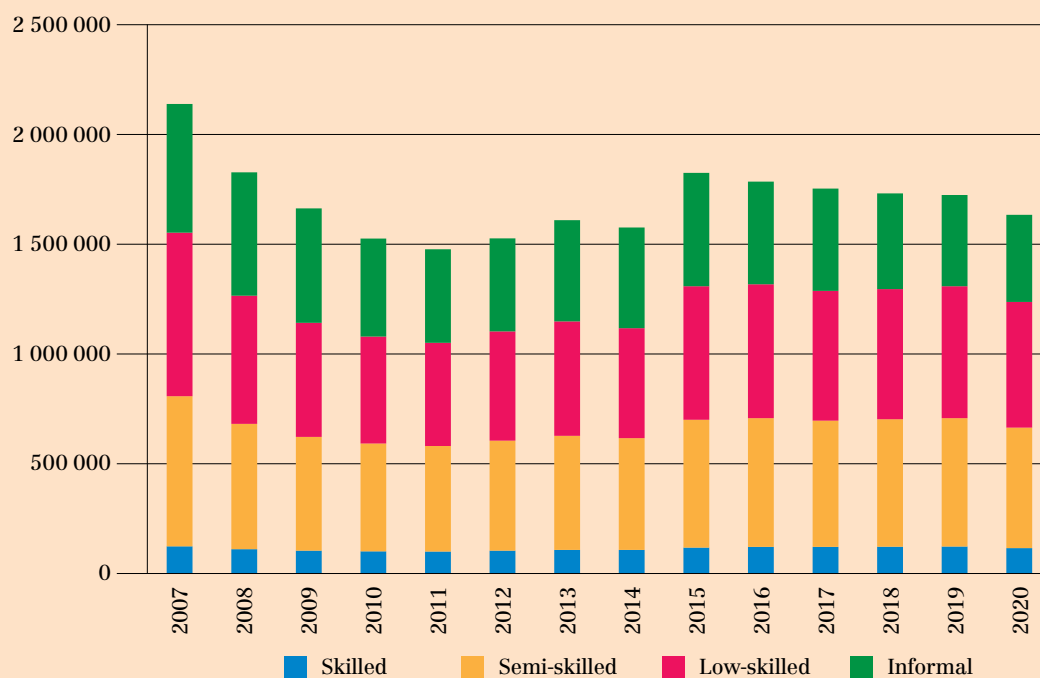
This confirms earlier findings and recommendations presented in Chapter 3 and Chapter 4 – that current education systems are not prepared to adequately equip the young labour force with the necessary skills to participate in the bioeconomy. In South Africa, the bioeconomy sectors that absorb the largest share of workers are the agriculture sector (67 percent), followed by the food and beverage sector (19 percent) (see Figure 5). The numbers show that the bioeconomy offers jobs to various labour segments: skilled, semi-skilled, low-skilled and informal (see Figure 6). According to the Department of Science and Innovation, the bioeconomy “shows the promise of being able to absorb all sectors of formal employment in South Africa and has been responsible for between 14 and 16 million jobs over the period under review” from 2007 to 2020 (NACI, 2022, p. 27). Further, the Department of Science and Innovation suggests that future data collection be disaggregated by race, gender and age.

◆ **FIGURE 5** Employment share in South African bioeconomy sectors



Source: NACI (National Advisory Council on Innovation). 2022. *Audit of the south African bioeconomy sector*. Pretoria.

◆ **FIGURE 6** Bioeconomy employment in South Africa, according to skilled, semi-skilled, low-skilled and informal workers

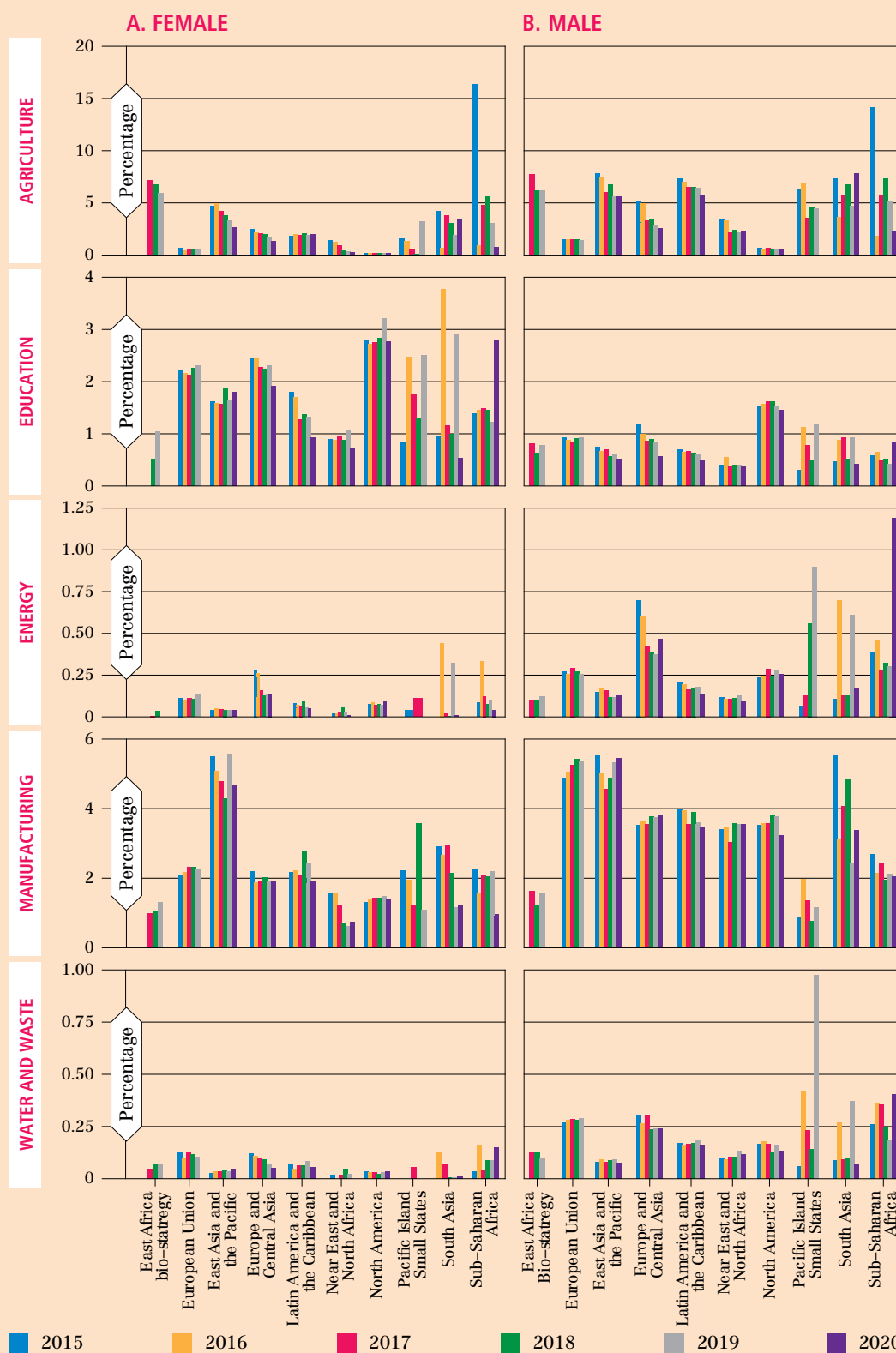


Source: NACI. 2022. *Audit of the South African bioeconomy sector*. Pretoria.

East Africa

In the countries that participate in the East Africa Regional Bioeconomy Strategy (Burundi, Ethiopia, Kenya, Rwanda, South Sudan, United Republic of Tanzania and Uganda), agriculture is the biggest employment sector for youth, followed by education, manufacturing, water and waste, and energy (see Figure 7).

FIGURE 7 Youth (ages 15 to 29) employment rates in bioeconomy-related sectors, by region, 2015–2020



Source: Authors' own elaboration based on data from: ILO. 2022. Statistics on Youth. In: *ILOSTAT*. [Cited 22 June 2022]. <https://ilostat.ilo.org/topics/youth>

Employment estimates in bioeconomy-related sectors

Figure 7 shows the analysis of available data from ILOSTAT between 2015 and 2020 on employment rates among youth in five different sectors related to the bioeconomy: agriculture, education, energy, manufacturing and water and waste. The analysed data is not bioeconomy specific, but encompasses five general sectors that can be considered closely related to the bioeconomy. With this analysis, an attempt is made to estimate youth employment worldwide in sectors that are related to the bioeconomy, as age-disaggregated data within specific bioeconomy employment is not available at the moment.

It is no surprise that the countries where agriculture is the backbone of their economy score high in youth employment in agriculture compared to the total percentage of youth employment. By region, in Africa, 40 to 60 percent of youth employment is in agriculture; in the Pacific Island Countries (PICs), 30 percent of youth employment is in agriculture; and in South Asia, 40 percent of youth employment is in agriculture. In North America, Europe and the Baltics, and Latin America and the Caribbean, youth employment in agriculture is 5 percent, 10 percent and 18 percent, respectively, of total youth employment. Data on youth employment in agriculture was only available for a few regions (see Figure 7). Formal employment in agriculture in sub-Saharan Africa decreased drastically for both female and male youth from 2015 to 2020, dropping from 17 percent to 1 percent for females and from 14 percent to 2 percent for males.

Worldwide, twice as many men are employed in agriculture as women. In regions with high potential of bioeconomy development, such as the African regions, South Asia and Latin America and the Caribbean, the rate of female employment in all sectors is between 5 and 10 percent of the total employment. In the education sector, the employment rate for females is higher than for males. (This may be due to a number of reasons, one of which could be that, traditionally, education is a more female-dominated sector, as teaching was seen as a woman's role. This perception might still be common nowadays, leading to more women opting for this profession.) Regarding the manufacturing sector, across all regions and for both genders, average employment rates for this sector are higher than employment rates for other sectors.

Estimates for Latin America and the Caribbean

To provide an approximation of the number of bioeconomy jobs in Latin America and the Caribbean, we refer to an estimation of the number of jobs in sectors that are related to biodiversity and ecosystem services in the region, developed by Saget *et al.* (2020). They include the same bioeconomy sectors that were used by the European Union, such as renewable energy jobs; food, drink and tobacco; etc. According to this estimation, about 64 million jobs (19 percent of employment) rely on ecosystem services.¹² Also, agriculture (40 million) and the food, drink and tobacco industries (8 million) are the sectors with the highest number of workers. Other sectors that also depend on the natural environment are the manufacturing sectors for textiles, chemicals and paper, as well as environment-related tourism (Table 6).

Summary: Based on the information and data available on youth employment in the bioeconomy, the agriculture and food and beverage sectors in the European Union, South Africa and Latin America and the Caribbean, currently absorb the biggest share of the bioeconomy workforce. When we look at the data for the general sectors which are related to the bioeconomy, namely agriculture, education, energy, manufacturing, water and waste,

¹² “Ecosystem services are the multitude of benefits that nature provides to society. Biodiversity is the diversity among living organisms, which is essential to ecosystems function and services delivery” (FAO, 2022d).

(data not disaggregated as bioeconomy specific, but disaggregated by age), the agriculture and manufacturing sectors provide the biggest share of employment to youth. However, estimating if more jobs for youth are found in primary, secondary or tertiary sectors, strongly depends on the bioeconomy priorities of each country.

◆ **TABLE 6** Jobs in sectors dependent on ecosystem services in Latin America and the Caribbean

Sector	Examples of ecosystem services	Number of jobs (in thousands)
Sectors in which almost all activities are related to biodiversity and ecosystem services		
Agriculture	Genetic resources and stock availability, freshwater, pollination, seed dispersal	40 821
Forestry		689
Fishing		1 935
Food, drink and tobacco	Food, fibre and freshwater	8 203
Wood and paper	Fibre, water purification and waste control	2 647
Renewable energy	Fibre for biofuels	91
Water	Availability of freshwater, recycling, regulation, purification and natural risk management	345
Sectors in which activities depend on biodiversity and ecosystem services, but they do not determine the nature of the sector		
Textile	Fibre, water purification and waste control	4 741
Chemicals	Genetic resources, biochemical diversity, freshwater	904
Tourism	Food, freshwater, air quality, education, aesthetic and cultural value	3 542
Regional total	63 918 (19% of total employment)	

Note: The data in the table is from 2014.

Source: Saget, C., Vogt-Schilb, A. & Luu, T. 2020. *Jobs in a Net-Zero Emissions Future in Latin America and the Caribbean*. Washington, DC, IDB (Inter-American Development Bank) and Geneva, Switzerland, ILO (International Labour Organization).

5.2 Future youth employment opportunities

Over the next ten years, over 500 million additional youth will be seeking jobs (UNEP *et al.*, 2008). The World Youth Report confirms that youth NEET rates have remained stubbornly high over the past two decades. Some of the challenges are that:

Youth employment policies and investments regularly fail to generate a sufficient number of decent jobs for young people. Youth who have difficulty finding employment may eventually abandon their search for work or end up with seasonal or hazardous jobs in the informal sector (United Nations, 2020, p. 111).

This section aims to provide an estimate of future job possibilities for youth in different bioeconomy sectors. It provides estimated data at country and regional levels. The section also discusses specific youth employment opportunities that lie in bio-based value chains and the rural bioeconomy.

Engaging the interest of youth in the bioeconomy

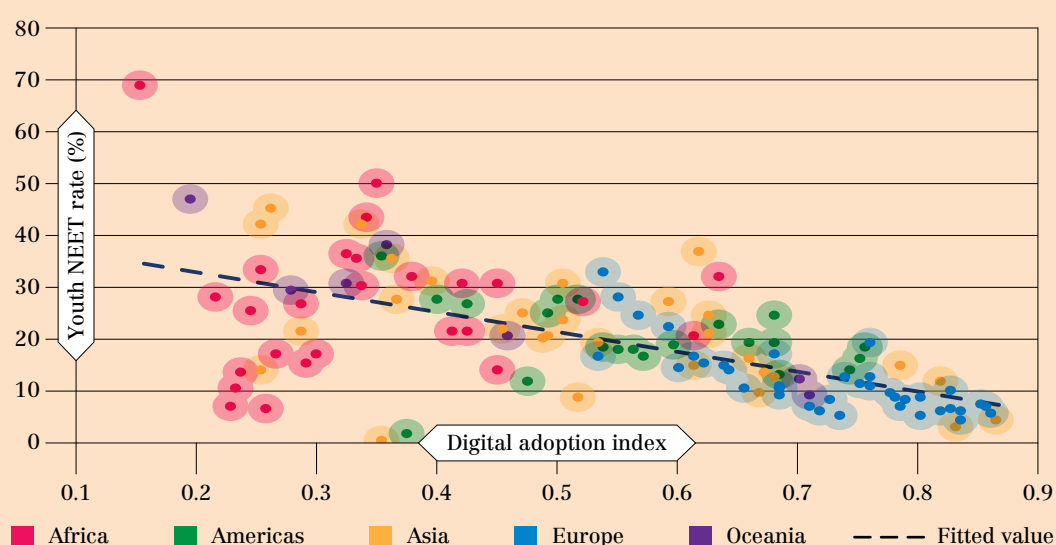
In addition to addressing the economic, education and business challenges discussed in chapters 3 and 4, actions are needed to increase youth awareness of and stimulate their interest in the opportunities of the bioeconomy. To address this issue, this section presents an example from the ICT sector that showcases the importance of getting youth excited about the bioeconomy. This section also aims to provide an indication of how the ICT sector could contribute to future youth employment in the bioeconomy.

A youth interviewee highlighted the challenge of getting youth interested in the bioeconomy due to the complexity of the sector:

Bioeconomy is huge, it is becoming more known among the youth, but it is still something hard to grasp, without having a deep understanding of it, you are not fully aware of what you or your country can bring to the sector. Youth can be engaged and made more interested in the bioeconomy by communicating the topics that they know (N. Rodriguez Muxica, personal communication, 2022).

Over the past decade, major development organizations and donors have invested heavily in youth adoption of digital technology around the world. As demonstrated in Figure 8, this has paid off. There is a strong correlation between the adoption of digital technology and the utilization of the talents of youth (United Nations, 2020). Additionally, countries with higher levels of digital technology adoption tend to have fewer NEET youth. To increase the adoption of and interest in bioeconomy technology among youth, to support their employment in the bioeconomy and to make the bioeconomy more youth inclusive, organizations can make use of this trend by combining ICT education and skill development with increased awareness-raising of and investment in STEM education. This would also be in line with FAOs bioeconomy Principle 3, Sustainable bioeconomy should support competitive and inclusive economic growth; with Criterion 3.2.g, Inclusiveness; and with SDG indicator 4.4.1, Proportion of youth and adults with ICT skills.

◆ **FIGURE 8** Relationship between the adoption of digital technology and the utilization of the talents of youth (ages 15 to 24) across the world



Source: United Nations. 2020. *World Youth Report – Youth social entrepreneurship and the 2030 Agenda*. New York, USA. <https://www.un.org/development/desa/youth/wp-content/uploads/sites/21/2020/07/2020-World-Youth-Report-FULL-FINAL.pdf>

Young people who are already involved in agriculture and other productive rural economic activities can be made aware of the employment options the bioeconomy has to offer by documenting, publicizing and discussing success stories in which the bioeconomy helps to improve initiatives and businesses in different value chains. This would provide greater visibility to and improve the positioning of young people's bio-based enterprises. This outreach work can also contribute to raising awareness about the critical role youth themselves can play in promoting the bioeconomy as a new production, trade and consumption paradigm, as demonstrated by the experience of Gia Tien, the founder of Alpha-Protein:

I remember my first exposure to mealworms as a novel food was through reading FAO publications. The studies and publications of FAO have significantly inspired and motivated me to found our start-up Alpha-Protein and to make the technology that we have developed in such a way that it is available worldwide as a licensing model in order to exploit the sustainability potential of insects globally. Because FAO had positively reported about this topic and shown how necessary it is, it gave me a certain strength to continue working on it (personal communication, 2022).

Furthermore, facilitating collaboration, networking and interaction among young leaders with particular interest in the bioeconomy, its applications and possible business ventures, will assist public and private actors to formulate and implement support services that promote youth-based biobusinesses (IICA, 2019).

The following sections provide rough estimations of where future bioeconomy youth job opportunities could be, based on examples from different countries and sectors.

Advanced biomaterials sector creates the most jobs in Canada's bioeconomy

Figure 9 is a bioeconomy job estimation from Canada, which shows both direct and indirect employment supported through manufacturing bioproducts in a bioproduct-job pyramid. This includes the entire supply chain, from tree harvesting, to processing, to manufacturing of bioproducts. Job estimates are provided per 1 000 oven-dried tonnes (ODT) of biomass feedstock. Each specific bio-based product category has slightly different job estimates. For example, biofuels create approximately 0.4 jobs when looking at ethanol, and approximately 1 job when looking at biodiesel. Biofuels require large amounts of biomass feedstock and involve the least value-added processing. Therefore, this category produces less jobs per 1 000 ODT in comparison to other categories. If we assume that this situation would hold true for other countries, the biomaterials sector could therefore have the highest potential to create the most jobs (3 to 10 [or more] per 1 000 ODT). In essence, bioeconomy sectors that have the most processing steps and depend on only small biomass inputs, such as the biomaterial, engineered wood products and biochemical sectors, are likely to generate more jobs for youth.

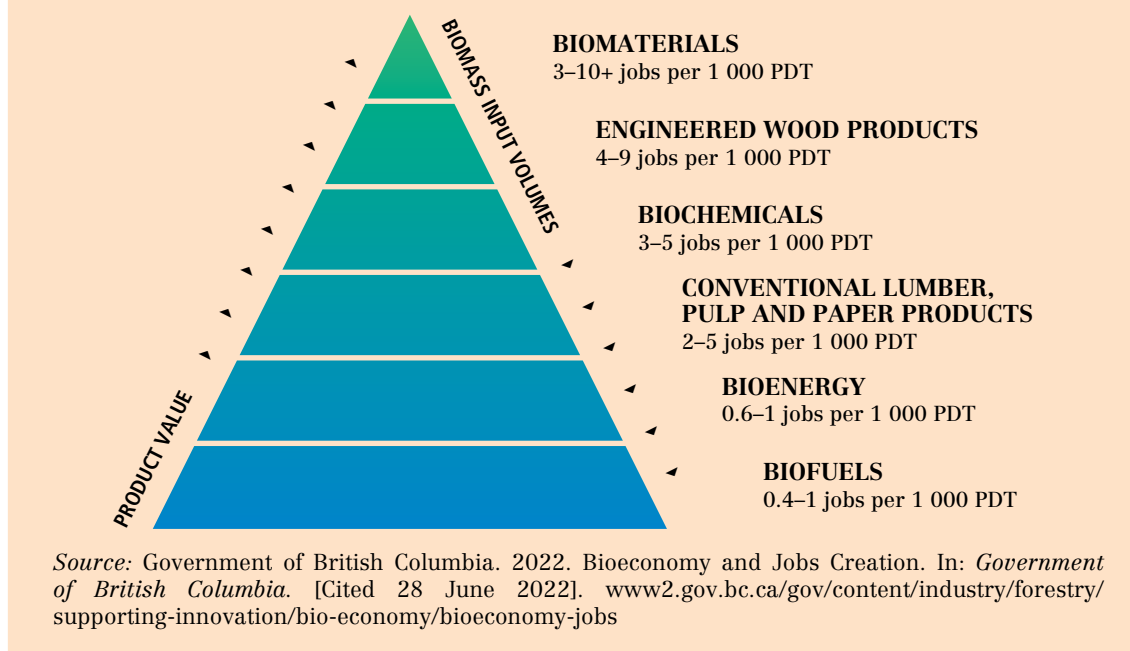
Current bioeconomy employment trends likely to continue

According to experts, the trend of increasing employment in bio-based chemicals, bio-based pharmaceuticals, bio-based plastics and bio-based rubber, is expected to continue through 2030 (European Commission, 2021).

The use of biomass to produce materials can directly support five to ten times more employment, and generate four to nine times more value added, than energy uses, principally due to longer, more complex supply chains for material use (European Commission, 2021, p. 30).

However, the objective of ensuring food and nutrition security, remains critical. Food and farming systems account for about three-quarters of the overall bioeconomy employment and about two-thirds of bioeconomy turnover (European Commission, 2021).

◆ **FIGURE 9** Jobs created per 1 000 oven dried tonnes of biomass feedstock



Bioeconomy as a buffer against unemployment in economic crises

In the 2008 economic crisis, unemployment in the bioeconomy was below that of the rest of the economy in European Union countries such as Bulgaria, Croatia, Greece, Ireland, Latvia and Lithuania. Therefore, the bioeconomy could act as a buffer against unemployment in times of economic crisis (European Commission, 2020).

Small and medium-sized enterprises are the driving force for employment creation

SMEs are the core engines of job creation globally. Eighty percent of new jobs in the formal sector come from SMEs (United Nations, 2020). This trend is probably not going to change in the bioeconomy transition. In fact, in their data analysis, the South African Government confirms that SMEs are the biggest employment creators in their bioeconomy. This is important for youth employment as youth “are more likely to employ young workers than their adult counterparts. Therefore, supporting young agripreneurs is expected to make a significant contribution to employment generation for other youth” (Cruickshank *et al.*, 2022, p. 27). However, young entrepreneurs still face hurdles, especially the high costs associated with establishing a business. Adequate business development support to youth, as discussed in Section 3.1 and Section 4.1, can directly address these hurdles and lead to increased job opportunities for young individuals in entrepreneurship and employment. If policymakers prioritize supporting young entrepreneurs in SMEs, it is likely to create a ripple effect, resulting in an overall increase in youth employment. (Youth entrepreneurship is discussed in more detail in Section 5.4.)

Opportunities in bio-based value chains

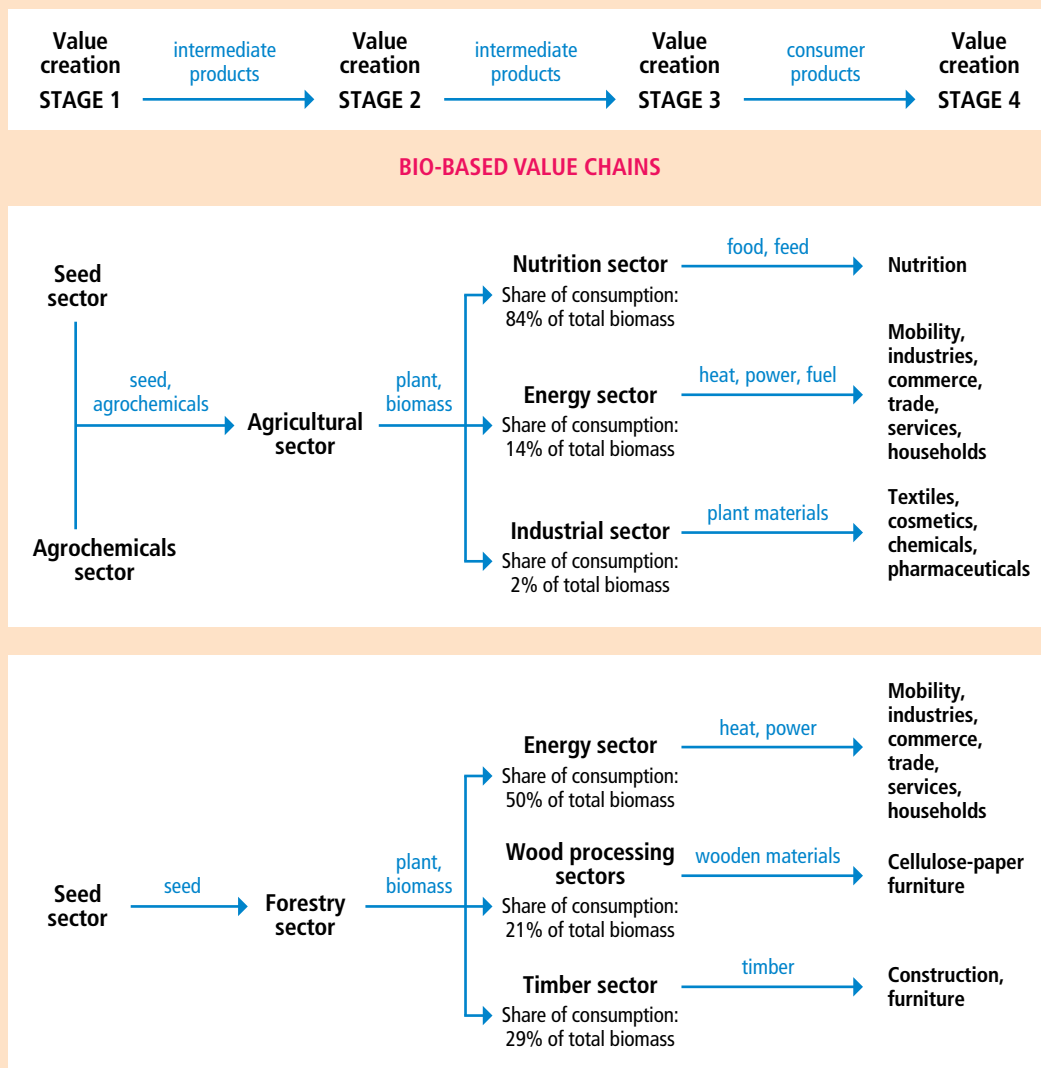
A relevant question regarding youth employment is: How many job opportunities for youth can the bioeconomy value chains provide? This section aims to offer an outlook of the opportunities for youth in the bioeconomy and to briefly explain the difference between traditional and bioeconomy value chains and what this could mean for youth in the bioeconomy.

Additional job creation in bioeconomy value chains

Experts forecast that, by 2050, jobs in fossil fuel sectors might decline from 12 600 000 to 3 100 000 worldwide, while jobs in the renewable energy sector could increase from 4 600 000 to 22 million (De Weerd, 2021). As such, the renewable energy sector could be a major future job market for youth.

In bio-based value chains, product creation involves two intermediate value-creation stages, as compared to one value-creation stage in traditional value chains (Figure 10). This will lead to longer value chains, which, by default, combined with the need for decentralised management, will have a positive impact on the number of employment opportunities. Bioeconomy value chain products will potentially close the gap between the recycling industry and the traditional industries, which in turn will likely create more employment opportunities. Furthermore, decentralized bio-based processing will need more logistics, which could provide another opportunity for new business models and further job creation.

◆ **FIGURE 10 Bio-based agriculture and forestry value chains and their share in biomass consumption**



Source: Kircher, M. 2021. Bioeconomy – present status and future needs of industrial value chains. *New Biotechnology*, 60: 96–104. <https://doi.org/10.1016/J.NBT.2020.09.005>

Opportunities in the rural bioeconomy

Immigration to urban areas, aging populations and lack of youth interest to remain in agriculture *vis-a-vis* the promise of a more attractive future in non-agricultural jobs in the cities, are common concerns in rural communities. The economic viability of farming and the sector's attractiveness to the younger generation are a prerequisite for food security and thriving rural livelihoods. According to a 2018 OECD study that included 24 developing countries, only 45 percent of rural youth are satisfied with their employment situation. Among the reasons for seeking a new job mentioned by rural youth are: better income (36.7 percent), greater contract stability (20 percent), better working conditions (17 percent) and opportunities to increase skills (13 percent) (Trigo *et al.*, 2021).

The bioeconomy offers new opportunities for the economic development of rural territories and, thus, new opportunities for rural youth employment. Innovative technologies in the bioeconomy can open new possibilities of production and in many cases will add value locally. Biorefineries, for example, make it possible to improve and expand many traditional value chains, or to develop new ones. At the same time, a more reliable, decentralized supply of energy could attract new income-generating economic activities to rural areas, which in turn can create more jobs. For example, in Denmark, it is estimated that the bioeconomy sector will create 23 700 jobs, of which 80 percent could be located in rural areas. It is further expected that the highest concentration of jobs will be in close proximity to processing plants, which are typically located in rural areas (United Federation of Danish Workers, 2015).

In the Americas, biorefineries in rural areas and an improved decentralized energy supply could attract youth to the countryside by providing the opportunity to develop new income-generating activities.

As stated in the document *The Outlook for Agriculture and Rural Development in the Americas: A Perspective on Latin America and the Caribbean 2019–2020*:

Many of these initiatives work with raw materials that require a smaller investment per unit of product generated than large factories. This means that, for a given level of total investment, they offer greater opportunities in terms of types of activity and employment. This, together with connectivity and the new information and communication technologies, promotes a structure for more diversified links between agriculture and the rest of the economy, thus opening up the possibility of creating new jobs and capacities, and eliminating the reasons why young people do not find rural areas attractive (ECLAC, FAO and IICA, 2019, p. 92).

In East Africa, despite the energy sector currently employing the least number of youth in the region, in *The state of the bioeconomy in Eastern Africa 2022*, Virgin *et al.* (2022) forecast that small-scale rural biofuel, biopackaging and biomass waste briquette production are expected to provide better job opportunities for youth in the long term.

The nature of biomass offers the possibility of creating more jobs in rural areas, close to production and processing sites, thus counteracting the current concentration of job and income opportunities in urban areas. For example, areas rich in bio-based resources will be able to improve income and development opportunities through policies that foster innovative technologies and job creation, in combination with further developing sustainable rural market trends. For instance, in Eastern Africa the demand for packaging material increased in recent years due to a surge in e-commerce. Simultaneously, plastic pollution has been an increasingly severe problem. Policy and regulatory responses have been extensive, including the banning of plastic bags in several countries. These bans drove greater demand for sustainable biopackaging material that is produced by companies, including youth-led companies, using innovative technologies. One such youth-led biopackaging company is Hya Bioplastics, in Uganda (see Box 4).

◆ BOX 4 Hya Bioplastics – an example of how small grants, combined with mentorship, can help young bioeconomy start-ups grow

Turning agricultural waste fibres into biodegradable food packaging

Technology feedstock: banana leaves, banana pseudo stems, cassava starch, corn stover, potato peelings

Type of process: composting

Technology output: biodegradable bags and food packaging

Location: Uganda

Company website: <http://hyabioplastics.com>



©Bio4Africa

Hya Bioplastics is a youth-led start-up that creates bio-based, 100 percent home-compostable food packaging in Uganda. The idea emerged from the growing demand for green food packaging across the African continent. The drivers are the primarily young customers of the start-up and changing government policies, such as the ban on single-use plastics.

The company buys agricultural wastes from small-scale farmers and uses it as a key raw material to create a range of food packaging including trays, takeaway food boxes and disposable plates, that provide a cost competitive alternative to petroleum-based plastics. In producing the food packaging, the company provides an alternative market for banana leaves and stems, corn stalks, potato seedlings and an abundant commodity that would otherwise go to waste – cassava, which is drought-resistant, is grown in 40 of the 53 African countries, and sells at half the price of alternative starches like cornstarch. In 2019, before establishing their company, four like-minded young men decided to form a research group at Makerere University. Through peer support and mentorship and guidance from their professors, they were able to develop a deep and practical understanding of biomaterials. Their early work received first place in the global Wege Prize competition, for which they received an award of USD 30 000. They then joined the Incubator Fellowship, focused on social entrepreneurship. Hya Bioplastics is now actively working on patenting this technology within Africa and licensing it as an additional revenue stream. Current barriers they face are the high R&D costs and regulation and production certification issues.

Source: Authors' own elaboration, based on: Bio4Africa. 2022. Conversion of agricultural waste fibers into biodegradable food packaging. In: *Bio4Africa*. [Cited 29 June 2022]. www.bio4africa.eu/technologies/technology-catalogue/conversion-of-agricultural-waste-fibers-into-biodegradable-food-packaging

As stated in *The state of the bioeconomy in Eastern Africa 2022*:

The packaging market in Africa as a whole is estimated to be growing at an annual rate of eight percent. The market is driven by an expanding population of youthful consumers and increased demands for consumer products. This, combined with the demand for environmentally friendly packaging, opens up considerable opportunities to develop new industries with associated job creation (Virgin *et al.*, 2020, p. 40).

The document stresses further that the biofuels industry can generate significant employment possibilities for youth in the long term:

To date, there has been very limited production of advanced biofuels in the region, in part due to high capital costs and land tenure issues. However, in the longer term, small scale rural production offers opportunities for job creation for young people. Ethiopia has recently published a ten year road map for the production of sustainable aviation fuel (Virgin *et al.*, 2022, p. 46).

Another important factor for rural job creation is the decentralization of management when developing new sustainable bioeconomy value chains at regional scale. It is therefore vital to explore the potential to develop bioeconomy processing and manufacturing opportunities in rural areas, as opposed to urban areas, where they are usually located (AllThings.Bio, 2021). Potential for biomass growth and processing in rural areas (to produce food, feed and other bio-based products) means a potential for growth in rural career options.

As stated by the European Commission regarding its bioeconomy strategy:

Decentralised models, where at least the first transformation of biomass takes place as close as possible to the biomass provisioning areas, being them rural (agriculture, forestry), coastal (aquatic) or urban and peri-urban (biowaste and waste water), offer potential for reinvigorating local economies through the creation of skilled green jobs (2021, p. 24).

5.3 Preliminary assessment of green jobs in the bioeconomy

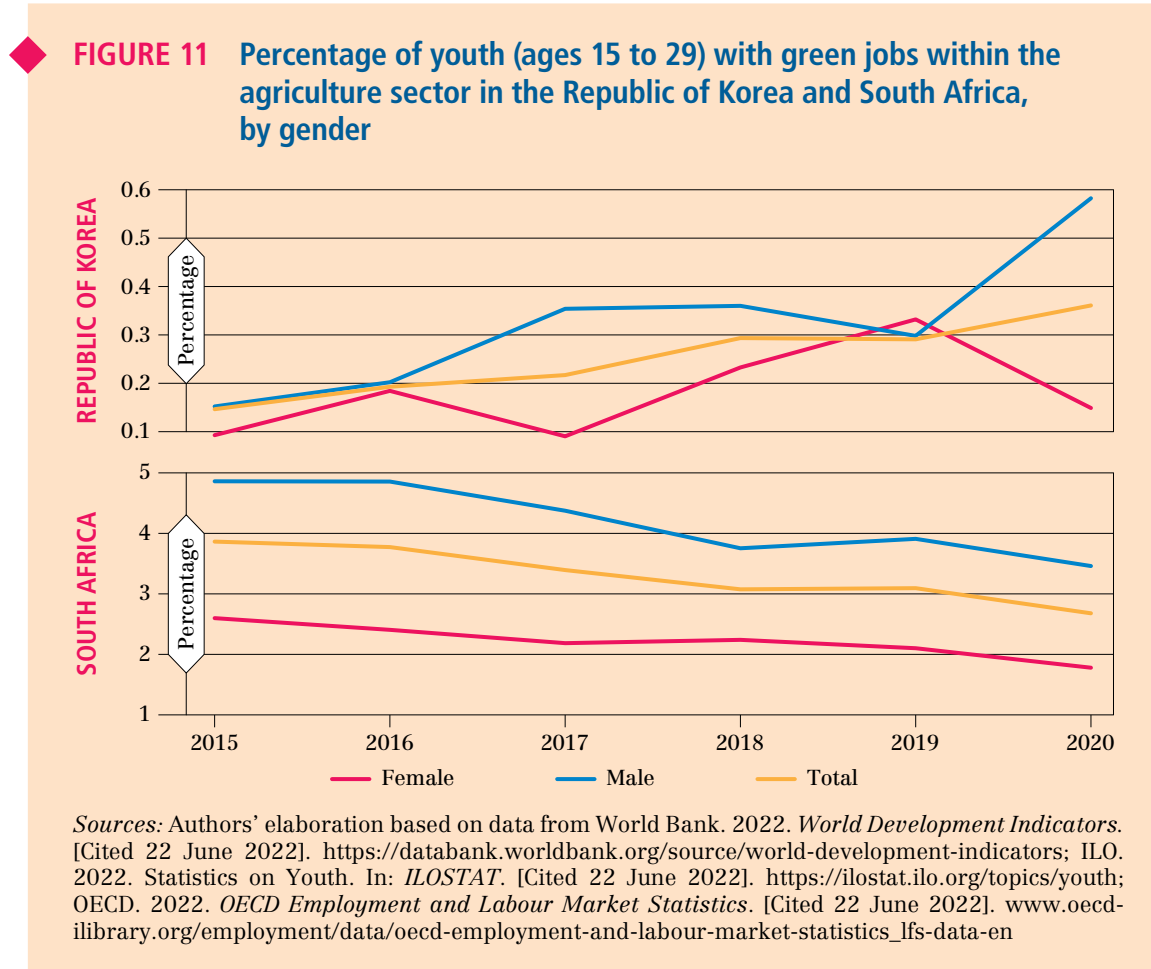
The concept of green jobs is widely debated among sustainability and development practitioners, with various definitions, significant lack of data, the need for specific skills and training to qualify for green jobs, and concerns about the overall availability and accessibility of green jobs. However, for the bioeconomy, it is anticipated that the relevance of green jobs will grow over time. They are more attractive to youth and pull them into the sector. This section provides a short overview of green jobs in the bioeconomy. It does not, however, deliver a complete picture of where the green jobs for youth are in the bioeconomy, due to the absence of data and necessary information. More research is needed to fill this gap.

The ILO defines green jobs as:

Decent jobs that contribute to preserve or restore the environment, be they in traditional sectors such as manufacturing and construction, or in new, emerging green sectors such as renewable energy and energy efficiency (ILO, 2016).

Decent jobs, in turn, are defined as summing up the aspirations of people in their working lives. This involves opportunities for work that is productive and delivers a fair income, security in the workplace and social protection for families, better prospects for personal development and social integration, freedom for people to express their concerns, organize and participate in the decisions that affect their lives and equality of opportunity and treatment for all women and men (ILO, 2015b). However, the extent of the contribution that green jobs will make to bioeconomy will ultimately depend on the quality of these jobs. Currently many existing green jobs are still of poor quality and those in recycling, construction or biofuels for example, are often informal in nature (UNEP *et al.*, 2008). Additionally, there is a significant lack among all countries (except the Republic of Korea and South Africa), of consistent data collection on green jobs.

In many of the bioeconomy policies, countries are using the concept of green growth¹³ rather than focusing on the creation of green jobs. Focusing on green growth as a whole could translate into greener jobs but only if efforts to promote the green economy are accompanied by policies that facilitate the re-allocation of workers, advance decent work and offer local solutions. On a global scale, moving to a greener economy (or at least promoting it) could support the creation of 24 million new jobs worldwide by 2030 and a net increase of 18 million jobs – mostly as a result of the adoption of sustainable practices. For instance, 2 500 000 jobs could be created in renewable-based electricity and 6 million jobs could be created in the circular economy (ILO, 2018).



How are countries currently performing when it comes to youth employment in green jobs? Only two countries measured and provided continuous data on green jobs since 2015, namely the Republic of Korea and South Africa (see Figure 11). The number of green jobs captured in Figure 11 was calculated by combining data on agricultural production from the World Bank, data on youth employment with fair conditions from the ILO, and data on youth employment in sustainable agricultural production from the OCED. The percentage represents the share of employment in youth population between 15 and 29 years with fair working conditions and long-term or temporal contracts in the agriculture sector. The data was also disaggregated by sex. The graph shows the difference between female and male employment in green jobs. Although in the Republic of Korea, equal employment

¹³ According to the OECD (2022), green growth means fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies.

was achieved in 2016 and 2019, since 2019 the employment gap between male and female youth has changed for the worse for females. However, available data seems to indicate that the share of green jobs for youth in agriculture in these two specific countries is low. In South Africa, which has a dedicated bioeconomy strategy, the percentage of youth employment in green jobs has declined in recent years from 5 percent in 2015 to about 1 percent in 2020.

5.4 Youth entrepreneurship – challenges and successes

Chapter 4 covered general challenges of youth employment and how they can be addressed through various policy measures. This section focuses on the challenges that youth bioentrepreneurs face and how they can be better supported.

The challenges that young entrepreneurs in the bioeconomy are encountering are similar to the struggles that young entrepreneurs face in the traditional economy. However, due to the novelty of the bioeconomy, they face a few additional barriers, such as patenting issues (for example, for engineered bacteria) and regulations (regarding, for instance, the use of waste), as many innovative products and technologies in the bioeconomy are not yet defined or regulated. These issues must be addressed as young entrepreneurs and start-ups are especially important for the bioeconomy as they contribute to the needed sustainability transformation by commercializing innovative technologies and new business models.

Young entrepreneurs in any economy and from any background confront hurdles that include age discrimination by suppliers, customers and institutions; barriers to access finance; an absence of support from family or friends; lack of market access and infrastructure; limited sources of training in entrepreneurial skills; and an unfriendly regulatory environment (UNCTAD, 2017). During the second East Africa Bioeconomy Conference, held from 10 to 11 November 2021, a youth panel frequently highlighted that lack of investment and the inability to access markets were the greatest barriers they face.

Young bioeconomy entrepreneurs across the globe were contacted for this report and asked about the main challenges they struggle with. The most prominent answer was lack of financial resources. For some, their level of frustration in this regard was very high. A youth start-up owner in the Caribbean, shared:

Agencies should focus less on rewriting reams on what the issues are and put the funding towards investing in innovation in regions like the Caribbean where venture capital and angel investing markets are not mature. Innovation cannot be financed by banks. The agencies know what the issues are. If we are serious about change and development, less writing, more financing to support innovation (J. Dujon, personal communication, 2022).

Two issues that affect young entrepreneurs in the bioeconomy in particular are 1) a significant lack of information, and 2) a lack of regulations due to the novelty of the sector. FAO could become a driving force in supporting information access and dissemination.

Challenges frequently experienced by young bioeconomy entrepreneurs

According to the young bioeconomy entrepreneurs interviewed for this study, the primary challenges they experienced were in the areas of access to finance and markets, access to information and knowledge, and infrastructure and skills development, as detailed here:

Access to finance and markets

- ♦ Difficulty to obtain economies of scale at the start-up phase, not being able to hire additional staff, grants are available but many are too large for small businesses.

- ◆ General lack of finance and funding, and lack of access to available funding for young entrepreneurs.
- ◆ Inequitable access to funding and resources within countries.
- ◆ Lack of market access.

Access to information and knowledge

- ◆ Lack of access to knowledge: “Only one person in a local government department had the information I needed, which was not publicly available, only upon request” (J. Kendzior, personal communication, 2022).
- ◆ Difficulty to access information about norms and obligations regarding food safety and other regulations.
- ◆ The concept of bioeconomy is not very well known, therefore it is difficult to find the right information: “Nobody had thought about this before” (J. Kendzior, personal communication, 2022).

Infrastructure and skills development

- ◆ Lack of shared facilities, infrastructure and logistics support.
- ◆ Skills gaps, as the need for new green skills is emerging and educational institutions are not yet providing skills development at the scale needed.

With regard to finance and market access issues, difficulties to obtain economies of scale are often the result of a lack of facilities for preindustrial scale-up and ineffective technology transfer, which lead to the failure or slow growth of start-up companies. Preindustrial scale-up facilities can provide the necessary equipment, space and knowledge transfer, which are the elements which are hardest for early start-ups to access and afford.

Young entrepreneurs can be a driving force for putting political vision into action. Bioeconomy policies should acknowledge this fact and include measures and initiatives that help sustainable bioeconomy entrepreneurs to fulfil such visions (Kuckertz, 2020). Programmes, such as the Ideas for Action Competition (Zicklin Center and World Bank, 2018) and the Young Americas Forum (Young Americas Business Trust, 2022) are good examples of how governments, the private sector and youth can work together effectively to make a positive impact in developing countries (World Economic Forum, 2022).

“A business environment that is more accommodating to new start-ups and better supports the growth of existing enterprises is associated with a higher realization of youth potential in both education and employment” (United Nations, 2018). The youth interviewed for this study were not only asked what challenges they faced, but also which factors they think led to their success or supported them in moving forward with their entrepreneurial undertakings – externally (government, finance and education institutions, etc.) and internally (mindset, family and friends). Their answers are summarized here:

External factors of success

- ◆ Participation in a several-month-long incubation programme that was free for participants (paid for by the local government).
- ◆ Heightened interest from investors or other businesses in bioeconomy products and services due to their novelty.
- ◆ Support provided by universities to make connections and build initial networks.
- ◆ Being in an environment where biotechnology innovators are supported by the government, for instance through entrepreneur-investor matchmaking.

- ◆ Financial support, as young people often do not have savings.

Internal factors of success

- ◆ Making an effort to reach out to other actors to surround yourself with the right people who facilitate your access to knowledge and networks.
- ◆ Moral support from friends and family is essential.
- ◆ Collaborating with other initiatives and with other people on the same topic.

The interviews showed that external factors, such as start-up programmes, institutional support from universities and local government initiatives and financial support, were key to helping youth entrepreneurs move forward. Networking efforts, being part of a community of like-minded people, and moral support from loved ones were listed as crucial internal success factors. The experience of Hya Bioplastics described in Box 4 demonstrates that networking, public and private financial support and mentoring, as well as awareness raising among the general public, are all necessary to create the most supportive environment for young bioeconomy entrepreneurs.

The following actions are considered important for promoting innovation and developing bioentrepreneurship:

- ◆ Develop innovative instruments to facilitate interaction between the new bioeconomic enterprises (start-ups) and universities or research centres, especially to promote bioentrepreneurship among youth.
- ◆ Design financial and non-financial instruments to help new bioenterprises access bioeconomy markets and improve their capacity to respond and adapt to the speed of technological change.
- ◆ Promote public-private and regional-multilateral cooperation to strengthen the national infrastructure needed to comply with requirements in the countries that import bioproducts, either in terms of physical infrastructure (such as laboratories) or of quality-assurance certification.
- ◆ Foster a culture of enterprise that values freedom, creativity and innovation and that does not punish failure (ECLAC, FAO and IICA, 2019).

5.5 Findings from youth interviews and projects

Many youth are strongly motivated to be part of the bioeconomy. This section highlights the views and suggestions of the youth regarding the bioeconomy, including their advice to organizations working to include them in the bioeconomy and to other youth considering entering the sector. The section also presents several youth-led bioeconomy enterprises and the programmes and individuals who supported them along the way (See Annex 2 for list of bioeconomy project targeting youth).

During the interviews conducted with youth in the study, they were asked why they think the bioeconomy concept is interesting and relevant to them. Some of their responses are the following:¹⁴

It's the fact that there is a real emphasis on sustainability and circularity and something that is really urgently needed, when we think about biotech we think of really complex processes, bioeconomy includes also really low-tech simple and traditional processes (J. Kendzior, personal communication, 2022).

¹⁴ For the full list of interviewees and interview questions, see Annex 1.

Bioeconomy spans over many sectors, it encompasses many aspects of life, in your daily life, from sourdough, or buying wheels made of dandelion, to growing duckweed for your kitchen garden. Bioeconomy is systemic, you do not need to study to understand it, anyone can (J. Liebeton, personal communication, 2022).

Bioeconomy provides a change of paradigm; young people are looking for something new. Our generation has the power to change the situation around the world, not only can we tackle climate change but also food security and social issues (R. Vargas Carpintero, personal communication, 2022).

Bioeconomy is the need of the hour, if mankind has to stay longer, we have to take care of it from now on (N. Baliarsingh, personal communication, 2022).

I believe in my generation, and there are people who do amazing things to try to change this current reality that we are facing. I believe that the young people are changing and that change is possible, I would like to change my country and provide opportunities for the community through bioeconomy (M. Montoya Castrillón, personal communication, 2022).

During the interviews, youth were also asked what advice they would give to organizations aiming to scale their activities in promoting youth involvement in the bioeconomy. Below is a summary of their suggestions, grouped by information sharing, networking and the role of FAO.

Advice from youth to organizations that aim to promote youth involvement in the bioeconomy

Information and communication

- ◆ Make bioeconomy information and support accessible and communicate the concept of bioeconomy to the public, so that individuals who have bioeconomy projects or businesses recognize that they fall within the sector.
- ◆ Disseminate bioeconomy knowledge on a global scale.
- ◆ Support the development of a globally recognized definition of bioeconomy, while having different country-specific definitions. This would acknowledge that the understanding of bioeconomy varies from country to country. Different definitions and visions have an impact on sustainability. Find a way for the different visions of bioeconomy to coexist with aligned actions and measurements.
- ◆ Publish white papers and involve young people in preparing them.
- ◆ Provide support for making more data on the bioeconomy publicly available.

Youth networking

- ◆ Finance youth-led workshops and conferences.
- ◆ Establish a global bioeconomy youth alliance, with an active youth community, and foster cooperation with non-youth communities.
- ◆ Support existing youth groups such as iGem and Allbiotech, either financially or through publicity.
- ◆ Facilitate connections between youth and national and international regulatory and support institutions, as these connections are very difficult for individuals to make.

FAO's role

FAO is often seen as a seal of quality, and FAO's involvement can lend credibility to bioeconomy initiatives. When FAO reports positively about an initiative and shows how necessary it is, there is greater motivation to continue working on the topic. In this regard, the youth made the following recommendations for FAO:

- ◆ Further develop practical tools (such as sustainability monitoring frameworks for regional bioeconomies), suitable to different contexts and regions, which FAO could directly contribute to, in close cooperation with academic and non-academic actors working on sustainability assessment, standards and mechanisms.
- ◆ In Latin America, FAO accompanied the formulation of the bioeconomy strategy in Uruguay: Towards sustainable bioeconomy guidelines (FAO, 2019). This work serves as example and a source of best practices to replicate FAO support in the formulation of national and subnational bioeconomy strategies in other areas of the world, through co-creation and open dialogue that includes different stakeholders (youth, farmers, non-governmental organizations, companies, academic institutions, etc.).
- ◆ Provide technical assistance and capacity building to catalyse action around the use of biomass waste (some steps have been taken in different areas of Latin America with support from FAO), integrating the principles of bio-based value chains (such as sustainable production practices, integrated biomass utilization, circularity of material and energy flows, etc.) in existing agricultural systems and strengthening collective action and associativity.

An important aspect apparent in the youth's answers is that they were thinking beyond their own communities or countries. Many of their recommendations were on a global scale, such as global awareness-raising campaigns or the establishment of a global bioeconomy youth alliance. In terms of their recommendations regarding information and communication, they suggest that the focus in awareness raising should be on helping people realize what aspects of their work already fall within the bioeconomy. Youth also suggested that a globally accepted definition of bioeconomy should be developed, which recognizes the pluralism and complexity of the sector. They urge for more financial support for workshops and conferences related to bioeconomy awareness-raising and for operating existing bioeconomy youth networks. The youth also frequently mentioned the need for assistance to build connections with important support organizations, such as regulatory bodies. The youth provided concrete recommendations for FAO as well, including furthering the development of practical tools such as monitoring frameworks; continuing to support countries in the formulation of national and regional bioeconomy strategies through open dialogue; and focusing on capacity building in biomass waste utilization.

Some of the youth interviewed are young entrepreneurs. They were specifically asked about the advice they would give to other young people interested in becoming entrepreneurs in the bioeconomy. Policymakers, educators and other bioeconomy players can support youth in actions that enable them to step out of their comfort zone and believe in themselves. As shown by the youth's answers below, this support needs to go beyond supporting technological skills and providing financial and technological access. It should extend to building and nurturing the necessary soft skills such as creative thinking, networking, teamwork and self-confidence. These hard and soft skills should be combined with bioeconomy awareness-raising tailored to youth needs.

Advice from youth bioeconomy entrepreneurs to other youth

- ◆ Step out of your comfort zone and believe in yourself.
- ◆ Be proactive in contacting others who have similar experiences.

- ◆ Don't be shy about contacting others. Aim to build your network with the private sector and the local government. Look for organizations that support company creation.
- ◆ Become informed about what the bioeconomy includes and have a clear understanding of where you fit in it.
- ◆ Look around you; maybe there is a bioeconomy conference taking place near you.
- ◆ Avoid having a very narrow view of what bioeconomy is.
- ◆ Talk to other stakeholders who are not so obvious in your sector. They can share alternative incentives or insights.
- ◆ Believe that it's possible! It looks complicated, but we create the opportunities ourselves.
- ◆ Research the various subsidies and funding opportunities. Your only regret will be something that you haven't done. Take the risk, otherwise you will be thinking: that could have been me.
- ◆ No experience is ever a waste of time. What you learn helps you in life.
- ◆ We are young. We are learning. It is important to go to people who have experience, to get a mentor, someone who has been through the experience, in order to learn. There are many people who are open to doing this.
- ◆ Curiosity is very important in the entrepreneurship journey. As kids we are naturally curious. This curiosity should remain with us when we grow up. This helps us experiment with our ideas.
- ◆ Keep challenging yourself – a ship in the harbour is safe, but that's not what it's built for.

To complement the answers and suggestions of the youth highlighted above, three examples of youth-led bioeconomy enterprises are presented (see Box 5, Box 6 and Box 7). These provide a close-up look at what bioeconomy youth-led start-ups can look like and what similarities and differences can exist between them. All three enterprises have several aspects in common: they started very small (for instance, in their own kitchens, using them as improvised laboratories); they were able to grow through a mix of accelerator, incubator or mentoring programmes; and their founders are highly self-disciplined and dedicated.

◆ **BOX 5** Case study 1: Cano-ela, Kingdom of the Netherlands

Founder: Juliana Romero Guzmán

Year founded: 2020

Company website: www.cano-ela.com

About the company: Cano-ela proposes a new way to go from raw materials to final products. Seeds contain oil, proteins and carbohydrates, as well as micronutrients, that are stored in functional plant structures.

Cano-ela extracts these naturally present structures in canola seeds (and other oil-rich seeds) as building blocks to create foods. The process eliminates the need to create refined ingredients, while extracting the maximum functionality from the raw materials.



BOX 5 (cont.) Case study 1: Cano-ela, Kingdom of the Netherlands

Juliana was always curious about entrepreneurship. She likes the fact that, as an entrepreneur, one has more power to make one's own decisions – more revolutionary decisions – and the power to influence the supply chain. Last year, she joined the European Institute of Innovation and Technology, funded by the European Union, which supports young scientists to become entrepreneurs, organizing summer schools and hackathons for young entrepreneurs to meet and exchange ideas. Juliana also joined the Global Food Venture Programme in Madrid, which consists of 12 days of intense workshops during which participants receive guidance from the summer until end of the year, to build their companies. The participating start-ups are also assigned a mentor who meets with them once a month. Juliana also participated in the StartLife and StartHub programmes at Wageningen University and Research, which provide ideation, validation and acceleration support. Through StartHub, she was able to access a student loan (provided by the government and by the university). Together with the loan and her own savings she was able to buy her first equipment and begin experimenting with her ideas in her own kitchen.

The COVID-19 pandemic not only had no negative effect on her work, but Juliana took advantage of the many trade fairs that were organised online for free or for a very small fee. Therefore, being a small start-up, she was able to network with a lot of people from all around the world.

Juliana highlighted that there were different mentors (some of whom she met on LinkedIn) at different stages in the development of her start-up that were crucial, providing her with advice and with the necessary industry connections. Those mentors now make up her advisory board.

Through many video calls with her potential clients, represented by their R&D and innovation managers, she was able to understand their needs very well and tailor her product samples to those needs before sending them out.

Juliana also emphasized that it is not only important to talk a lot with the clients, but that talking directly to the farmers is crucial when aiming for your business to become a success. She explains that “There is a programme from the region of Gelderland which provides a subsidy for creating proof of concept products, and a part of the programme is to talk to farmers in the region. We therefore connected with a farmer who is connected with 70 percent of the farmers in the Kingdom of the Netherlands who grow canola. We want to spread our idea among farmers in the region, convince the farmer to switch to this crop, we can provide a fair payment and more of the material can be allocated in the food space.”

Source: Authors' own elaboration based on J. Romero Guzmán, personal communication, 2022.

◆ BOX 6 Case study 2: Alpha-Protein, Germany

Founder: Gia Tien Ngo

Year founded: 2020

Company website: www.alpha-protein.de

About the company: Alpha-Protein, a German start-up made up of an international team, aims to disrupt the food and feed industry by establishing cost-efficient and large-scale production of mealworms as a sustainable protein source.



©Alpha-Protein

Gia Tien Ngo, CEO and one of the founders of Alpha Protein, got the idea to use insect protein as a dietary supplement while living in a pescatarian household during his master's degree studies in Boston. As he could not afford seafood and fish as a student, he was looking for alternative and cheaper sources of protein. One day, while feeding the chickens that were kept in the backyard, he looked more closely at the fodder package and discovered the nutritional value of mealworms. With a protein content of over 55 percent, mealworms seemed to be the best and, by far, the cheapest solution to his problem. He started to experiment by mixing the dried mealworms into his morning smoothies. He experienced positive results in muscle growth relatively quickly. He also felt fit and full of energy. Upon his return to Germany he began developing his idea further and found three other young people who would support him to create a start-up.

The company's innovative and sustainable breeding system is based on a high rack system in which the mealworms are reared and water flows up. This space-saving technique enables the team to produce 1 000 times more protein per year on 1 square meter than would be produced through soy production. Proteins are produced by using waste streams, such as brewery waste. The system also consumes less water than traditional insect breeding systems. Although it can be used to produce black soldier flies, the team decided to go with mealworms, as black soldier flies in this system produce too much ammonia, which is not environmentally friendly.

The state of Baden-Württemberg has a Young Innovators programme through which the company won two large grants (EUR 150 000 each) to establish a demonstration plant.

Many young people cannot take the risk without having to deal with existential fears, as they usually haven't been able to save up enough money. What helped us was a combination of various grants, this allows us now to build the first industrial-scale and automated insect farm in Germany (G. Tien Ngo, personal communication, 2022).

Despite the success of securing these large grants, Gia Tien also mentions the challenges they faced, "Legal barriers for innovation are very high, especially in our area. It took many years until it was included in the law in October 2021 to allow insects as feed for animal meat production" (G. Tien Ngo, personal communication, 2022).

Despite the uncertainty, Gia Tien and his small team continued working on their dream, and eventually grew from being a three-person team in 2020 to a company with 25 employees today.

Source: Authors' own elaboration based on G.T. Ngo, personal communication, 2022.

◆ BOX 7 Case study 3: Nexus Power, India

Founders: Nikita and Nishita Baliarsingh

Year founded: 2019/2020

Company website: <https://nexuspower.in>

About the company: Nexus Power produces protein-based batteries from crop residue. The materials that are used are fully biodegradable and can be turned into manure after the life cycle is complete.



©NexusPower

Nexus Power was founded in Bhubaneswar,

Odisha, India by twin sisters Nikita and Nishita Baliarsingh. Nikita is a commerce manager and studied media and mass communication, with a focus on brand building, while Nishita is a financial expert. They started the company in 2019, and officially incorporated it in 2020. The sisters were always fascinated by sustainable vehicles, and since their college years, their initial plan was to make electric vehicles and create a new brand. But after researching the topic, they realized that the e-mobility space was already crowded and that there was no large-scale market in India for such vehicles as the supply was already too high and the demand too low. Further research led them to believe that e-cars are not yet a success, as charging time is too long and people are unwilling to compromise their time waiting for the battery to charge. This led them to think about creating a battery that is more dependable, charges faster and has a longer driving range. The sisters aim with their innovation to contribute to a sustainable future and a pollution-free battery market. The COVID-19 pandemic slowed the development of the company but also gave the founders with time to read and research more, and become better prepared.

An initial reality check that we had was that so many people are already working on these technologies, but we believed that it will take time and it will happen. One day, we stumbled across a book in our grandpas' library, where proteins can be used as electrolytes, we kept reading and found other research papers and it made us more confident about the entire undertaking (Nikita Baliarsingh, personal communication, 2022).

As raw material input, they are using paddy (husk) and wheat, which they are purchasing from 15 to 18 farmers, paying INR 12 (approximately USD 0.15) per kilo. They are able to extract fast generative nano-materials from the crop residues, which allow the charge to remain longer due to properties that make them sticky. Another property of the raw material, its light weight, provides the batteries with a considerable power to weight ratio.

Our battery, with a standard weight, delivers more power as compared to its conventional counterparts. The nexus battery is designed with voltage ranging from 5 volts to 800 volts to cater to the wide industry applications from mobile phones to commercial electric vehicles (Nikita Baliarsingh, personal communication, 2022).

The sisters were able to garner a lot of support, and managed to secure two grants from the Government of India, which promotes startups. However, there are still some challenges that hold them back.



BOX 7 (cont.) Case study 3: Nexus Power, India

We are in the process to get patented, but it's taking time and there are a lot of external factors that are hurdles, such as the pandemic, continuous lockdowns, during which we had to again and again shut down our lab, that delayed us a lot. I think it was not challenging to start, if there wouldn't have been the pandemic (Nikita Baliarsingh, personal communication, 2022).

Nikita shares the key lessons she learned as a co-founder:

1. You should not celebrate too early, nor should you punish yourself if something goes wrong. Just keep going.
2. Be emotionally stable. There will be a lot of highs and lows, because entrepreneurship is not about the right team, finances, and idea; it is more about the emotional state. It is the founder's responsibility to build the confidence, try to keep as calm as possible, talk things out. There are times you will get unhappy. Those are the days that you should take a break.
3. Have people with different specializations on board.

Source: Authors' own elaboration based on Nikita Baliarsingh, personal communication, 2022.

5.6 Creating impact at scale for youth in bioeconomy

Many great initiatives have been and are being implemented to involve youth more in the bioeconomy. However, most of them are small, regional or local initiatives or are initiatives that were not continued. The study included the full project analysis of a number of such initiatives, including a detailed selection of ongoing and past bioeconomy youth-related and monitoring projects and the identification of lessons learned, key goals addressed, funding sources and implementing partners. If decision-makers want to achieve higher impact, such youth-inclusive projects and other initiatives need to be scaled up. This section describes four types of initiatives from the study that have potential for scaling and creating large-scale impact:

1. support to youth clusters;
2. deliberate inclusion of youth and youth researchers in conferences and workshops;
3. structural inclusion of youth in policymaking processes;
4. support to programmes that highlight and accelerate youth entrepreneurship.

Support to youth clusters

Youth clusters, such as the Bioeconomy Youth Champions, Allbiotech and Green Africa Youth Organization (see Table 7), push for more youth inclusion in the bioeconomy space and make important inroads in raising awareness of the bioeconomy. Most of these groups are run by volunteers. Providing them with a supporting structure or hosting them under the flagship of FAO, could enable them to become stronger bodies, like the Young Professionals for Agricultural Development. Furthermore, including representatives of these youth groups in international advisory panels, such as the International Advisory Council on Global Bioeconomy, would also ensure better youth inclusion in the development arena.

◆ **TABLE 7** Bioeconomy youth groups, their geographic focus and main goal

Youth group	Geographic focus	Main goal
Green Africa Youth Organization	Africa	Youth-led, gender-balanced advocacy group that focuses largely on environmental sustainability and community development.
Bioeconomy Youth Champions	Worldwide	Youth around the globe elected by the International Advisory Council on Global Bioeconomy to act as ambassadors for the bioeconomy at the Global Bioeconomy Summit 2020 (GBS 2020) and beyond.
East-Africa Bioeconomy Youth Network	Burundi, Kenya, Rwanda, South Sudan, Uganda, United Republic of Tanzania	The East African Youth Network is a forum for youth which aims to facilitate holistic youth involvement by advocating for the firm entrenchment of youth issues in the agenda of the East African Community.
Allbiotech	Latin America	Promote biotechnology as a driver for competitiveness and economic growth in Latin America.
ReGeneration 2030	The Åland Islands, Denmark, Estonia, the Faroe Islands, Finland, Germany, Greenland, Iceland, Latvia, Lithuania, Norway, Poland, Russian Federation and Sweden. Welcoming youth from Belarus, Czechia, Slovakia and Ukraine.	Provide a common platform to gather initiatives, campaigns and organizations that work with sustainability and provide publicity. ReGeneration 2030 gathers young people from the Nordic and the Baltic Sea Regions, mainly focusing on teenagers and young adults between the ages of 15 and 30.
Bio-Entrepreneurship Action Movement (BEAM) – Malaysia	Malaysia	A non-profit, youth-led organization focusing on enabling youth to build their own bioenterprise.
Youth Climate Leaders	Worldwide	Global youth leadership network catalysing climate professionals.

Source: Authors' own elaboration.

Deliberate inclusion of youth and youth researchers in conferences and workshops

At a European workshop on bioeconomy, held in Paris on 28 and 29 June 2017, a panel of young scientists was invited to express their reactions to the proposals and the issues discussed during the workshop. Specifically, they were invited to respond to three questions:

1. What are the priority research needs for the next 10 years?
2. Which tools for research and development are lacking today?
3. Which types of partnerships and which new stakeholders are needed for the development of bioeconomy?

Their spoken contributions during the round tables were followed-up by the preparation of a position paper called *Young Scientist Panel Position Paper* (Befort *et al.*, 2017). The paper presents the opinions of the young scientists on the current bioeconomy concept and what actions are needed to push a European bioeconomy transition forward.

Including youth in international fora and workshops, such as the International Bioeconomy Forum and the Global Bioeconomy Summit 2020 (GBS 2020), will provide youth a seat around the table with major decision-makers and ensure that their concerns and solutions are taken into account. Another example of this is the Talent4BBI project, which provides a unique opportunity for early-stage researchers to develop the key skills, competencies and experience required by bio-based industries through a targeted programme for future bioeconomy leaders.

Structural inclusion of youth in policymaking processes

Many youth groups, youth-centred literature, and each youth interviewed for this study, have highlighted that they perceive the lack of youth inclusion in policymaking processes as a significant gap. Many of the youth interviewed resented not being recognized as equal voices by older people in decision-making processes. One interviewee stated:

Young people often come in as an afterthought, as a checkbox that they have been consulted, actual inclusion on the ground is not happening, the level of inclusion and strategic investment is very limited, and unless this is in place I don't see that youth will become more included (J. Liebeton, personal communication, 2022).

The following three examples are about successful youth inclusion in the bioeconomy policymaking process in Finland and in non-bioeconomy youth-in-policy inclusion in Denmark and Sri Lanka. The two latter are good examples for bioeconomy policymaking and strategy development. As for specific youth-inclusion in bioeconomy governance processes, the only example of this identified during the study was Finland.

In the region of Satakunta, Finland, youth involvement is high on the bioeconomy policy agenda

Satakunta's regional strategic plan was prepared through a bottom-up process involving up to 2 000 participants, including the following methods: street polls, youth forums, interviews of unemployed people, children's crafts, internet inquiries and stakeholder/expert workshops. Similarly, the plan's implementation involved social and cultural societies and local and resident action groups. In addition, consultations with regional stakeholders and the public were part of the process of determining the strategic choices of the Regional Programme.

The Satakunta region, on the southwest coast of Finland (225 000 inhabitants), is an industrialized province with abundant forest resources. In the region there are established businesses in various sectors which are active in different parts of the bioeconomy. The main sectors associated with the bioeconomy are (i) agrifood production and processing and (ii) power generation, including the production and utilization of bioenergy, supported by a considerable amount of forest and agribased raw material. Research and development is undertaken on biorefineries, exploitation of forest resources, cleantech and environmental and energy technologies. The bioeconomy is extensively covered by major strategic documents developed by the Regional Council of Satakunta, which provides the general regional policy framework, articulates long-term development goals and coordinates regional strategies (Satakuntaliitto, 2022). These strategies aim to directly influence youth as the future main workforce of the new bioeconomy. Participatory approaches, such as the one happening in Satakunta, are excellent examples of how inclusive policy development can be carried out. Youth involvement in these processes should be supported and advocated for in all regions and countries around the world.

Danish Youth Climate Council

The Danish Youth Climate Council is an independent youth-led advisory board to the Minister for Climate and Energy. The Youth Climate Council provides concrete policy proposals to the Minister at least twice per year, with input from young people across the country. The Minister includes young people's ideas in the decision-making process. Meetings between the Youth Council and the Minister support accountability by including meaningful dialogue about why (or why not) the Minister will support the ideas put forth by the youth. The Youth Council also has the ability to add briefings to the Minister's briefing box and the ability to make official submissions to legislative proposals. Young people are also invited to take part in the implementation of policies, such as providing input for the establishment of guidelines on a healthy and sustainable diet (Borkowska-Waszak *et al.*, 2020).

Sri Lanka youth involvement in situation analysis through the Youth Parliament

Twice a month, the 335 members of the Sir Lankan Youth Parliament, representing 500 000 youth across the country, meet to debate relevant topics. Thirty youth ministers have a dedicated working space in national ministries. The national parliament has included the recommendations of the Youth Parliament in the National Youth Policy. This approach includes young people in national decision-making, through a representative process, and enjoys strong political support in Sri Lanka (OECD, 2017).

Support to programmes that highlight and accelerate youth entrepreneurship

Due to the timeframe and scope of this study, only three case studies on the success of youth bioeconomy entrepreneurs have been included in this report (see Box 5, Box 6 and Box 7 in Section 5.5). To inspire and motivate other youth to venture into the bioeconomy for employment and entrepreneurship, more such cases in the different bioeconomy sectors should be documented in-depth and widely disseminated. A good example of how this could be done are the 16 inspiring case studies produced under the BSR Youth for SDGs and Circular Bioeconomy (BeUBio) project. The BeUBio project ran from 2019 to 2021 and targeted youth in the Baltic Sea region. Box 8 provides a summarized version of one of the BeUBio case studies.

Other programmes that accelerate youth entrepreneurship in the bioeconomy and could be replicated in other countries and regions are Greenpreneurs, AfriLabs and the Bioeconomy and Production Development Programme of the Inter-American Institute for Cooperation on Agriculture (IICA).

Greenpreneurs is a 12-week global green entrepreneurship accelerator and competition open to youth between the ages of 17 and 35. Youth may submit their idea for a solution that positively impacts the future of sustainable energy, water and sanitation, sustainable landscapes (forestry and agriculture), or green city development. These priority themes reflect the urgent issues impeding growth in developing countries in the context of green growth, climate change and the SDGs. Its intentional broadness is expected to ensure maximum inclusion of creative and innovative ideas from around the world (Global Green Growth Institute, 2022).

AfriLabs is another good example of a programme that is already making a difference for thousands of young African tech entrepreneurs and that has potential for scaling. Founded in 2011 to build a community around rapidly emerging tech hubs, AfriLabs provides innovation spaces that serve as meeting points and communities for developers, entrepreneurs and investors. AfriLabs can now be found in every African country, and could be used as an entry point to support bioeconomy youth entrepreneurs.

◆ **BOX 8** Lessons from a bioeconomy youth start-up on the importance of identifying markets

In 2017, Amit Vaghasiya and Monika Gumbytė founded AgrocLEAR (www.agroclear.com), an independent marketplace helping farmers and buyers to trade online. The online platform is helping increase transparency and bringing buyers and sellers closer together by eliminating the need for middlemen. By improving the entire food system, through fair-trade, price discovery and transparency, AgrocLEAR is levelling the playing field for all producers. As a result, organic and certified ecological growers are seeing an emerging opportunity to become more competitive and promote their products directly. In turn, “organic growers contribute directly to health and the environment by producing food that is nutritional and poison free,” says Monika (Nordregio, 2023). In addition, Nextrade (www.nextrade.pro), the parent company founded by the same team, provides business management tools for agribusinesses. Bringing producers and consumers closer together makes sustainable products more competitive and empowers both consumers and producers. AgrocLEAR and Nextrade are currently operating from Lithuania, but the aim is to expand across Europe. Countries have different trading systems and challenges. Therefore, Amit sees a big opportunity in harmonizing systems at the European Union level. As stated on the AgrocLEAR website, “We want to be more than just a commodities exchange. We are on a journey to become the only platform you will ever need for all your business needs.”

Notes: Read the full story here: <https://nordregioprojects.org/beubio/amit-monika>. Find the other 15 stories here: <https://nordregioprojects.org/wp-content/uploads/2020/12/BeUBio-youth-stories-2020.pdf>

Source: Authors’ own elaboration, Swedish Institute, BeUBio, Young people leading the way to a sustainable economy, 2020.

The Bioeconomy and Production Development Programme is a multifaceted programme in Argentina, Belize, the Plurinational State of Bolivia, Costa Rica, Ecuador, Mexico and Uruguay. Its activities include: the incorporation of the youth employment dimension to support the identification of opportunities and design of strategies and policies for development of the bioeconomy; inspiring young people involved in agriculture and other rural economic activities; providing greater visibility to and improving the positioning of the bio-based enterprises of rural young people; facilitating collaboration, networking and interaction among young rural leaders and assisting public and private actors in the countries to formulate and implement support services that promote youth-based bio-businesses (see Annex 2).

Public and private support to these types of programmes can spur more innovation in the youth bioeconomy sphere, due to increased visibility and idea exchange on a global level. Existing bioeconomy projects have been scanned for successful activities that can be scaled and replicated. Before developing further plans, existing initiatives and projects worldwide should be considered. These existing projects provide insights into lessons learned and successful initiatives that might be applicable to other countries or situations. Furthermore, in terms of supporting awareness raising and networking among youth, building bioeconomy skills and knowledge, and improving access to information for youth entrepreneurs in the bioeconomy a number of resources already exist that can be leveraged:

Bioeconomy awareness raising and networking among youth

- ◆ Why pursuing career in bioeconomy? Video in English, Spanish and Polish (available at www.urbiofuture.eu/webinar).
- ◆ Map and visual youth stories of young entrepreneurs in the bioeconomy (available at <https://nordregioprojects.org/beubio>).
- ◆ Toolkits on bioeconomy explanations, education, communication and awareness-raising (available at www.transition2bio.eu/toolkits).
- ◆ Communication tools on awareness raising for the bioeconomy and bio-based products, communication material and enhancing collaboration (available at www.biobridges-project.eu/results).

Building bioeconomy skills and knowledge

- ◆ Connect students to real-life industry initiatives “From Bio-Trash to Cash, Sustainable Biowaste Management and Commercialization, Kenya” (available at www.pbl-bioafrica.net/post/from-bio-trash-to-cash).
- ◆ Youth engagement programme with the intent to tackle the challenges of youth participation in the Bioeconomy sector in inclusion and cooperation, peer learning and mentoring, network building (available at www.eusbsr.eu/news-room/news/591030-apply-for-the-baltic-leadership-programme-on-youth-bioeconomy).
- ◆ Think Bio-based Challenge (available at www.allthings.bio/biocanndo-announces-the-winners-of-the-think-bio-based-challenge). This initiative aimed to encourage the development of learning tools that draw students’ attention to learn more about the bio-based economy.

Improving access to information in the bioeconomy for youth entrepreneurs

- ◆ E-tool to explore good practices in bio-based business models and real-life inspiring examples (available at <https://balticbiomass4value.eu/explore-good-practice-bio-based-business-models-and-real-life-inspiring-examples>).
- ◆ Extensive list of bio-based technologies feasible in rural developing country communities and with high likelihood to create opportunities to diversify farmer incomes (available at www.bio4africa.eu/technologies/technology-catalogue).
- ◆ Catalogue of publications on in-country technologies and policy developments (available in Spanish at <http://biblioteca.iica.int/cgi-bin/koha/opac-search.pl?q=au:%22Programa%20Hemisf%C3%A9rico%20de%20Bioeconom%C3%ADa%20y%20Desarrollo%20Productivo%22>).
- ◆ Hub for innovation and entrepreneurship based on the bioeconomy (available in Spanish at <https://bio-emprender.iica.int>).
- ◆ Dynamic catalogue of technologies for the bioeconomy (available at <https://catalogo-bioeconomia.iica.int/en>).
- ◆ A selection of most promising success cases related to the bioeconomy from EU-funded Research and Innovation (available at www.urbiofuture.eu/success-cases).
- ◆ Map showcasing all existing open access pilot and demo-infrastructures across Europe, with the aim of creating one, very visible and easily accessible network for the European bioeconomy (available at <https://biopilots4u.eu/database>).



6 Conclusions and recommendations

Critical capacity gaps exist in countries and regions preventing them from tapping into bioeconomy opportunities and addressing barriers to improve youth engagement, employment and entrepreneurship. As a result, youth are unable to access or are unaware of many of the opportunities offered by the emerging bioeconomy sector. This is mainly due to policies that do not adequately address the push/pull factors that can foster youth inclusion in the bioeconomy. Currently, youth are not included in decision-making, and they do not have sufficient access to the knowledge and skills that are required to benefit from the bioeconomy.

However, there are considerable opportunities to improve youth engagement, employment and entrepreneurship in the bioeconomy at regional, country or even project level. This section presents initial conclusions and recommendations for this, based on the findings presented in this report.

The six push/pull factors for youth inclusion in the bioeconomy are: economic development (pull); education, vocational education and training (push); employment (pull); business development (push); land use (pull) and technology development (push).

Six policy goals were analysed that could improve youth engagement, entrepreneurship and employment in the bioeconomy in the future. Closely linked to and addressing the push and pull factors, these policy goals are: job creation; education, vocational education and training; start-up/incubation support; promoting innovation; transforming rural areas and consultation of youth in policymaking processes. It will be crucial to build on and scale existing successful measures and initiatives within these six policy goals, such as non-financial and financial support mechanisms for start-ups, youth-involvement processes (such as the one in Satakunta Finland), investing in integrated PBL methods and fostering ICT usage among youth.

From the review of the effect of the six policy goals on the six push/pull factors, four action areas were identified as particularly relevant and potentially impactful:

- 1. Investing in education, awareness building and innovation will have a positive influence on technology development (push factor).** One of the key barriers to youth employment and involvement in the bioeconomy is the insufficient development of bioeconomy-related skills. Policies aimed at developing skills for the bioeconomy must be refined. Bioeconomy education policies should focus on an interdisciplinary approach to all forms of education. This is essential to enable a sustainable bioeconomy transition. The bioeconomy itself is pluralistic and innovative. As such, people need skills in several fields in order to understand and nurture such a multifaceted system. All 34 bioeconomy strategies include the promotion of innovation as a policy goal.
- 2. Actions that foster job creation and rural transformation policy goals have a positive impact on youth employment (pull factor).** Although rural population growth is declining worldwide, rural areas are believed to be sustainable hubs for the bioeconomy. Locating biomass processing close to its production, offers the possibility to create more jobs in rural areas. Forty-six percent of the European bioeconomy strategies, 67 percent of the Asian strategies, 60 percent of the African strategies and only 20 percent of the Americas' strategies specifically address the transformation of rural areas. Proportionally, rural

areas provide more employment opportunities than urban areas. To transform rural areas, it will be key to provide attractive job opportunities to youth in the rural areas. Some countries address this in their bioeconomy strategies through the promotion of decentralised production models, educational programmes and knowledge sharing, green public procurement, bioprocessing of biowaste and setting up primary processing close to production sites. Job creation goals are closely related to each country's key bioeconomy-sector priorities, such as increased biomass processing, increased bioeconomy service provision or biochemical industry development. This emphasis will determine where the future job opportunities for youth are in each country.

3. **Scaling of existing bioeconomy start-up mechanisms will spur business development (push factor).** Young entrepreneurs in the bioeconomy face barriers that their counterparts in the traditional economy do not face. One of these additional barriers is problems in obtaining patents, as many innovative products and technologies in the bioeconomy are not yet defined or regulated. Despite this, young bioeconomy entrepreneurs and start-ups contribute to the needed sustainability transformation by commercializing innovative technologies and new business models. The three case studies presented in this report show that the entrepreneurs were able to grow their bioeconomy businesses through a mix of accelerator, incubator and mentoring programmes. Such initiatives need to be promoted, and an enabling policy environment can greatly contribute to this. Furthermore, SMEs play a significant role in global job creation. If start-up mechanisms target youth, this can have a ripple effect on youth employment, as youth are more likely to employ other youth.
4. **Youth involvement in decision-making is key to sustainably influence sustainable resource use (pull factor).** An increase in biomass production and biowaste utilization, will diversify each value chain, greatly increasing the potential for job creation for youth. However, this resource use must be managed sustainably. None of the 34 analysed bioeconomy strategies included youth groups in the policymaking and consultation process. If the current policy discourse focused on increasing primary biomass production continues, it is necessary to ensure that sustainability criteria are met. Otherwise, this could have detrimental effects, including further land degradation and insufficient food production. Youth must be included in policy discussions, as the decisions that are taken now will directly affect their future. In order to involve youth properly in the policymaking process, it is important to support youth beyond improving their technological skills and providing them with access to financial resources and technology. In order for them to navigate the political landscape and participate in policy discussions, it is necessary to develop their soft skills, such as networking, teamwork and self-confidence. Four activities that can be implemented immediately to create a more youth-inclusive bioeconomy at a large scale are: supporting youth clusters; structural inclusion of youth in policymaking processes; deliberate inclusion of youth researchers in conferences and workshops; and support programmes that highlight and accelerate youth entrepreneurship. These activities should be combined with bioeconomy awareness raising that is tailored to youth needs.

When designing these approaches, the challenges highlighted in this report must be taken into account. These include a decline in GDP growth, an inadequate educational system, and a lack of interest on the part of youth in the bioeconomy. Once these barriers are addressed, youth will have a better chance of participating in the bioeconomy and taking advantage of current and future job opportunities in bioeconomy sectors. At present, and at a global scale, the agriculture sector employs the largest part of the work force in the bioeconomy. Whether the majority of jobs are available in primary, secondary or tertiary sectors, strongly depends on the choice of bioeconomy priorities of the country where the

youth are based. For example, although the socioeconomic circumstances in the European countries are somewhat similar, each country has decided to place more emphasis on a specific aspect of the bioeconomy. In the Spanish bioeconomy, for example, the primary sector employs 17 percent of the workforce, while in Romania it employs 62 percent.

After the agriculture sector, the food and beverage sector in the European Union, South Africa and Latin America and the Caribbean, currently absorbs the largest share of the workforce in the bioeconomy. Specific youth employment data (but not bioeconomy-specific), show that the agriculture and manufacturing sectors currently provide the largest share of employment to youth worldwide.

In the European Union bioeconomy the steepest employment growth has been in the bio-based electricity and biofuel sectors, followed by the bio-based chemical industries (including pharmaceuticals, plastics and rubber), and the food and beverage sector. However, the largest employment numbers will be absorbed in bioeconomy sectors that have the most processing capacity and need the least biomass input, such as the biomaterial, engineered wood products and biochemical sectors. The European Union expects the trend of increasing employment in those three sectors to continue through 2030. These sectors could therefore potentially provide the most jobs for youth. In East Africa, experts see the rural biofuel, biopackaging and biomass waste briquette production sectors as the biggest potential generators of employment for youth. In Canada the biomaterials sector, with its ability to create three to ten jobs per 1 000 oven dried tons (ODT) of biomass, is considered to have the highest potential to create the most jobs.

Bio-based value chains are longer than traditional value chains, due to two additional intermediate value-creation stages. Bio-based value chains are strongly connected to rural areas and require decentralised management. Longer value chains, combined with the need for decentralised management, will likely create more employment opportunities. It is likely that youth will find the biggest number of employment opportunities in the biomass materials sector, which uses processing and biowaste utilization technologies.

6.1 Recommendations

The following short-, medium- and long-term concrete recommendations address the issue of more youth inclusion in the bioeconomy, as outlined in the aforementioned conclusions.

Short-term recommendations (to initiate in the next two years)

Conduct in-depth studies/analyses

- ♦ The issue of land-use rights should be investigated further, as availability of land for biomass production will be crucial in driving the bioeconomy forward, and structurally, youth have less access to and ownership of land. As such, mechanisms to enable their participation through improved access to land should be considered for further research.
- ♦ More case studies on successful youth enterprises in the bioeconomy should be conducted.

Increase communication and awareness-raising efforts

To close the current awareness and knowledge gap regarding the bioeconomy will require much investment and effort in educating and teaching the population about thinking and doing things differently. Raising awareness among youth and among the entire population can be achieved through mass media and campaigns. Specific recommendations to increase communication and awareness-raising efforts are:

- ♦ Work with youth groups to design and disseminate easily understood information on sustainable bioeconomy targeted towards youth. This could accelerate the development

of the bioeconomy more quickly than if the information is only circulated among experts in the various sectoral areas.

- ◆ Document and promote successful youth cases (such as early adopters and start-ups) from the different bioeconomy sectors, working on innovative products and solutions, and disseminate them widely to inspire youth.
- ◆ Work together with universities to create and promote a massive open online course on bioeconomy and youth.
- ◆ Lead the organization of the next GBS, co-host other events, such as the International Bioeconomy Forum (moving from observer status to member status), or develop own bioeconomy events that specifically include and target youth.
- ◆ Work with private-sector companies that are promoting green jobs to showcase the possibilities of new types of jobs as well as the requisite skills.
- ◆ Promote sustainable bioeconomy-based products and build consumer awareness.

Increase existing collaboration efforts

- ◆ Align and strategize with the RYAP team and along the key points of the action plan (for example, linking to Pillar 2: Foster youth employment in an inclusive green economy).
- ◆ Connect the diverse youth groups that currently operate in their own countries by establishing one overall coordinating body, as was done with Young Professionals for Agricultural Development, and connect the groups with relevant private and public stakeholders.
- ◆ Support youth groups financially. (Most of the groups are run solely on a voluntary basis.)
- ◆ Build a global bioeconomy monitoring system, such as the European Union Bioeconomy Monitoring System (European Commission, 2022b), that collects age- and gender-disaggregated data. For this purpose, existing global monitoring efforts such as the conceptual framework and indicators developed by the OECD to monitor progress towards green growth (OECD, 2010) should be built upon. The available data will improve youth-inclusive decision-making. Currently, there is no internationally agreed data monitoring system to measure bioeconomy aspects.
- ◆ Support the development of policies and regulatory frameworks that are youth sensitive, by consistently incorporating youth groups into policymaking processes.
- ◆ There are already a number of development stakeholders actively promoting the bioeconomy. Connect with them and strengthen their existing programmes or revitalize past programmes, considering the following stakeholders and programmes:
 - Inter-American Development Bank and IICA: Bioeconomy and Production Development Programme (BE&PD).
 - Regional Universities Forum for Capacity Building in Agriculture (RUFORUM): Problem-based-learning bioeconomy entrepreneurship and capacity building programme in Africa (PBL-BioAfrica).
 - French Agricultural Research Centre for International Development (CIRAD): BIO4AFRICA project.
 - The Swedish International Development Cooperation Agency, the Stockholm Environment Institute and the East African Science and Technology Commission: BioInnovate Africa (BiSEA) Programme.
- ◆ Create stronger linkages with universities and other research institutions already active in this field, such as Wageningen University & Research, University of Hohenheim,

African Technology Policy Studies Network (ATPS), Tropical Agricultural Research and Higher Education Center, University of Zambia and University of Nairobi, to co-organise bioinnovation pitch events for youth, with mentors, coaches and seed funding.

- ◆ Expand and create communities of practice:
 - Build on platforms such as AgriSource – Open Innovation Platform and BECOTEPS – Bio-Economy Technology Platform
 - Use platforms to share outcomes of national pilot plants
- ◆ Connect with country-based bioeconomy innovation centres (for instance, in Italy, Malaysia, Thailand and the United Republic of Tanzania).

Promote youth-inclusive national policy development

Start to increase policy-development efforts by supporting countries to build on existing policies. Many countries have already adopted bioeconomy approaches in existing policies, but these are not explicitly mentioned. Ensure that the youth are consulted and their perspective is integrated.

Mid-term recommendations (to initiate in the next five years)

- ◆ To further develop the bioeconomy at the country level, promote and design programmes that prioritize specific skills essential for the adoption and sustainable integration of bioeconomy-related technologies by the youth. Increase the engagement of youth in the bioeconomy, promote the integration of ICTs into bio-based value chains. This should be further investigated and an implementation plan should be established.
- ◆ Raise awareness regarding the need to develop regulations, not only for youth bioeconomy entrepreneurs but for ensuring the sustainable development of the sector as a whole.
- ◆ Develop consensus on an internationally accepted definition of bioeconomy as a basis for a shared policy agenda among countries that enables monitoring.
- ◆ Collect further data on youth-specific country situations and requirements in rural areas and assess the maximum capacity of sustainable biomass production that does not conflict with food production nor with biodiversity protection, in order to forecast job creation for youth.
- ◆ Develop and strengthen South-South and South-North partnerships, to ensure access to the most up-to-date expertise and capital. Partnerships should draw strongly on Africa's strengths, such as available land, a large workforce and rapid economic growth.
- ◆ Several countries have established interministerial working groups and policy advisory bodies. Some countries have also established dedicated bioeconomy councils or panels, which include various stakeholders. The integration of youth in these bodies is crucial. FAO can play a strategic role in supporting the participation of youth groups. These strategies are encouraging and they should be disseminated so that other countries can learn from them.
- ◆ Focus policy and development efforts on advocating for bioeconomy-related interdisciplinary and entrepreneurial skills development on a wide scale and at all levels of education.

Long-term strategic direction recommendations (to initiate in five to ten years)

- ◆ Support the globally accepted use of a range of policy instruments that support youth inclusion in the bioeconomy, including policies that lower the burden for bioeconomy start-ups, the development of standards, and product labelling policies.

- ◆ Support the development of coalitions that support innovative pre-mature or early adopter youth-owed start-ups through incubation mechanisms, creating linkages to angel and venture investors, and promoting seed funding and investment support.

The bioeconomy presents great opportunities to “get it right this time”; that is, to create an economy that is sustainable and supports the health of our planet and the well-being of future generations. There is a wealth of knowledge on how the current economic and education systems impact resource and technology use and employment. Targeted investments in education, innovation, technology and the development of the bioeconomy industry will be crucial to counterbalance current socioeconomic threats such as unemployment, urbanization and the pressure on the environment and the effects of climate change. For youth – the next generation of leaders and inhabitants of our planet – overexploitation by the current economic system has a direct impact on their future.

As the bio-based industries and strategies are evolving further, it is crucial to take the above-listed factors into account and involve the youth in the bioeconomy development process. Youth will bear the impact of past and future policies and actions. As such, they must be included in decision-making over the coming decades in order to steer the transition to a sustainable bioeconomy, in the face of combined political, economic, ecological and health challenges.

Bibliography

- African Development Bank Group.** 2016. *Jobs for Youth in Africa Catalyzing youth opportunity across Africa*. Abidjan. https://www.afdb.org/fileadmin/uploads/afdb/Images/high_5s/Job_youth_Africa_Job_youth_Africa.pdf
- ATPS (African Technology Policy Studies Network).** 2020. *Developing an innovation-led bioeconomy strategy for Eastern Africa (BISEA) Foresight and Scenario Building Study Report*. Nairobi. <https://atpsnet.org/wp-content/uploads/2021/09/Bioeconomy-Strategy-for-Eastern-Africa-Foresight-Study-Report.pdf>
- AllThings.Bio.** 2021. *Jobs and Careers in the bioeconomy*. www.allthings.bio/wp-content/uploads/2021/04/JobsCareers_EN_2104.pdf
- Arujanan, M. & Singaram, M.** 2018. The biotechnology and bioeconomy landscape in Malaysia. *New Biotechnology*, 40(Part A): 52–59. <https://doi.org/10.1016/j.nbt.2017.06.004>
- Befort, N., de Fouchécour, F., de Rouffignac, A., Holt, C., Leclère, M., Loth, T., Moscoviz, R., Pion, F., Ruault, J. & Thierry, M.** 2020. Toward a European bioeconomic transition: is a soft shift enough to challenge hard socio-ecological issues? *Natures Sciences Sociétés*, 27(4): 438–444. <https://doi.org/10.1051/nss/2020004>
- Biocom.** 2022. Biocom. Berlin. [Cited 3 August 2022]. <https://biocom.de>
- Bio4Africa.** 2022. Conversion of agricultural waste fibers into biodegradable food packaging. In: *Bio4Africa*. [Cited 29 June 2022]. <https://www.bio4africa.eu/technologies/technology-catalogue/conversion-of-agricultural-waste-fibers-into-biodegradable-food-packaging>
- Borkowska-Waszak, S., Diamantopoulos, S.E., Lavelle, P. & Martinello, O.** 2021. *Youth for a just transition – Good practices of youth engagement*. Brussels, European Commission, Directorate-General for Regional and Urban Policy. https://ec.europa.eu/info/sites/default/files/eu_regional_and_urban_development/topics/documents/youth_for_a_just_transition_mid-term_deliverable_report_final.pdf
- Bracco, S., Tani, A., Çalicioğlu, O., Gomez San Juan, M. & Bogdanski, A.** 2019. *Indicators to monitor and evaluate the sustainability of bioeconomy: overview and a proposed way forward*. Rome, FAO. <http://www.fao.org/3/ca6048en/CA6048EN.pdf>
- Bresciani, F., Chalmers, T., Terzano, D., Gaiha, R. & Kaicker, N.** 2019. *An Outlook on Asia's Agricultural and Rural Transformation Prospects and options for making it an inclusive and sustainable one*. Rome, IFAD (International Fund for Agricultural Development). https://www.ifad.org/documents/38714170/41201480/apr_outlook.pdf/a1f8762e-ee0d-490a-cf3a-399241e34087?t=1561034540000
- Brugge, M.M., Hansen, T. & Klitkou, A.** 2016. What Is the Bioeconomy? A Review of the Literature. *Sustainability*, 8(7): 691. <https://doi.org/10.3390/SU8070691>
- Callo-Concha, D., Jaenicke, H., Schmitt, C.B. & Denich, M.** 2020. Food and Non-Food Biomass Production, Processing and Use in sub-Saharan Africa: Towards a Regional Bioeconomy. *Sustainability*, 12(5): 2013. <https://doi.org/10.3390/SU12052013>
- CIFOR (Center for International Forestry Research).** 2021. The hidden truth: Solutions for a youth-driven bioeconomy in Ghana – CIFOR Forests News. [Cited 27 June 2022]. <https://forestsnews.cifor.org/75113/the-hidden-truth-solutions-for-a-youth-driven-bioeconomy-in-ghana?fnl=en>

- Cruickshank, D., Grandelis, I., Barwitzki, S. & Bammann, H., eds.** 2022. *Youth-sensitive value chain analysis and development – Guidelines for practitioners*. Rome, FAO. <https://doi.org/10.4060/cb8489en>
- De Weerd, S.** 2021. Employment in the energy sector will dramatically expand as economies decarbonize. In: *Antropocene*. [Cited 27 December 2021]. <https://www.anthropocenemagazine.org/2021/07/one-consequence-of-climate-action-an-energy-jobs-boom>
- DST (Department of Science and Technology).** 2013. *The Bio-economy Strategy*. Pretoria. <https://www.dst.gov.za/images/ska/Bioeconomy%20Strategy.pdf>
- ECLAC (Economic Commission for Latin America and the Caribbean), FAO & IICA (Inter-American Institute for Cooperation on Agriculture).** 2019. *The Outlook for Agriculture and Rural Development in the Americas: A Perspective on Latin America and the Caribbean 2019–2020*. San Jose, ECLAC, FAO and IICA. <http://www.fao.org/3/cb3832en/cb3832en.pdf>
- European Bioeconomy Library.** 2019. Factsheet #2 Bioeconomy Education. https://www.bioeconomy-library.eu/wp-content/uploads/2020/03/02_LIFT_FactSheets_education.pdf
- European Bioeconomy Network.** 2022. Let's get kids on board the bioeconomy. In: *European Bioeconomy Network*. [Cited 2 October 2022]. <https://eubionet.eu/lets-get-kids-on-board-the-bioeconomy>
- European Commission.** 2018. *A sustainable bioeconomy for Europe - Strengthening the connection between economy, society and the environment: updated bioeconomy strategy*. Brussels, Directorate-General for Research and Innovation. <https://data.europa.eu/doi/10.2777/478385>
- European Commission.** 2020. *Brief on jobs and growth of the EU bioeconomy 2008–2017*. Brussels. https://knowledge4policy.ec.europa.eu/sites/default/files/KCB_Brief_bioeconomics_2008-2017.pdf
- European Commission.** 2021. Bioeconomy strategy. In: *European Commission*. [Cited 28 August 2022]. https://ec.europa.eu/info/research-and-innovation/research-area/environment/bioeconomy/bioeconomy-strategy_en
- European Commission.** 2022a. The bioeconomy in different countries | Knowledge for policy. In: *European Commission*. [Cited 27 August 2022]. https://knowledge4policy.ec.europa.eu/visualisation/bioeconomy-different-countries_en
- European Commission.** 2022b. Knowledge Centre for Bioeconomy. In: *European Commission*. [Cited 20 June 2022]. https://knowledge4policy.ec.europa.eu/bioeconomy/monitoring_en
- European Commission.** 2023. Jobs and Wealth in the European Union Bioeconomy (Biomass producing and converting sectors). In: *European Commission*. [Cited 11 May 2023]. <https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html>
- Fachagentur Nachhaltige Rohstoffe.** 2020. Land Use in Germany. In: *Fachagentur Nachhaltige Rohstoffe*. [Cited 14 August 2022]. <https://mediathek.fnr.de/flachennutzung-in-deutschland.html>
- FAO.** 2014. *Developing sustainable food value chains – Guiding principles*. Rome. <https://www.fao.org/3/i3953e/i3953e.pdf>
- FAO.** 2016. *State of the World's Forests 2016: Forests and Agriculture – Land use challenges and opportunities*. Rome. <http://www.fao.org/3/a-mq442e.pdf>
- FAO.** 2018. *Assessing the contribution of bioeconomy to countries' economy*. Rome, FAO. <https://www.fao.org/3/I9580EN/i9580en.pdf>

- FAO. 2019. *Towards sustainable bioeconomy guidelines*. Rome. <https://www.fao.org/3/ca5145en/ca5145en.pdf>
- FAO. 2021a. *Aspirational Principles and Criteria for a Sustainable Bioeconomy*. Rome. <https://www.fao.org/3/cb3706en/cb3706en.pdf>
- FAO. 2021b. *Guidance note on monitoring the sustainability of the bioeconomy at a country or macro-regional level*. Rome. <https://www.fao.org/3/cb7437en/cb7437en.pdf>
- FAO. 2022a. Sustainable and circular bioeconomy for food systems transformation. In: *FAO*. [Cited 3 October 2022]. <https://www.fao.org/in-action/sustainable-and-circular-bioeconomy>
- FAO. 2022b. Youth employment | Decent Rural Employment. In: *FAO*. [Cited 27 June 2022]. <https://www.fao.org/rural-employment/work-areas/youth-employment>
- FAO. 2022c. *Rural Youth Action Plan*. Rome. <https://doi.org/10.4060/cc0583en>
- FAO. 2022d. Ecosystem Services & Biodiversity (ESB). In: *FAO*. [Cited 1 November 2022]. <https://www.fao.org/ecosystem-services-biodiversity>
- FAO Regional Office for Latin America and the Caribbean. 2018. FAO/OECD: Latin America and the Caribbean will account for 25 % of global agricultural and fisheries exports by 2028. In: *FAO*. [Cited 10 December 2022]. <https://www.fao.org/americas/noticias/ver/en/c/1200912>
- GBS (Global Bioeconomy Summit). 2018. *Global Bioeconomy Summit Conference Report Innovation in the Global Bioeconomy for Sustainable and Inclusive Transformation and Wellbeing*. Berlin, Office of the Bioeconomy Council. https://gbs2020.net/wp-content/uploads/2021/10/GBS_2018_Report_web.pdf
- Gomez San Juan, M., Bogdanski, A. & Dubois, O. 2019. *Towards sustainable bioeconomy – Lessons learned from case studies*. Rome, FAO. <http://www.fao.org/3/ca4352en/ca4352en.pdf>
- Government of British Columbia. 2022. Bioeconomy and Jobs Creation. In: *British Columbia*. [Cited: 28 June 2022]. www2.gov.bc.ca/gov/content/industry/forestry/supporting-innovation/bio-economy/bioeconomy-jobs
- Global Green Growth Institute. 2022. Greenpreneurs. In: Global Green Growth Institute. <https://gggi.org/global-program/greenpreneurs>
- Hodgson, A., Alper, J. & Maxon, M.E. 2022. *The U.S. Bioeconomy: Charting a Course for a Resilient and Competitive Future*. New York, USA, Schmidt Futures. <https://doi.org/10.55879/d2hrs7zwc>
- ICCA (International Culture Communication Association). 2019. *Bioeconomy and Production Development Program Conceptual and methodological approaches for technical cooperation*. San Jose. <https://repositorio.iica.int/bitstream/handle/11324/7909/BVE19040201i.pdf?sequence=2>
- Lachman, J., Bisang, R., de Obschatko, E. & Trigo, E. 2020. *Bioeconomía: Una estrategia de desarrollo para la Argentina del Siglo XXI Impulsando a la bioeconomía como modelo de desarrollo sustentable: entre las políticas públicas y las estrategias privadas*. Buenos Aires, IICA. <https://repositorio.iica.int/bitstream/handle/11324/12478/BVE20108164e.pdf?sequence=1&isAllowed=y>
- International Advisory Council on Global Bioeconomy. 2020. *Expanding the Sustainable Bioeconomy Vision and Way Forward. Communiqué of the Global Bioeconomy Summit 2020*. Berlin. https://gbs2020.net/wp-content/uploads/2020/11/GBS2020_IACGB-Communique.pdf

- ILO (International Labour Office).** 2018. *World Employment Social Outlook Trends 2018*. Geneva, Switzerland. www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_615594.pdf
- ILO.** 2020. *Global Employment Policy Review 2020: Employment policies for inclusive structural transformation*. Geneva, Switzerland. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---ifp_skills/documents/publication/wcms_734489.pdf
- ILO.** 2015a. *Key Indicators of the Labour Market, Ninth edition*. Geneva, Switzerland. https://www.ilo.org/wcmsp5/groups/public/---dgreports/---stat/documents/publication/wcms_498929.pdf
- ILO.** 2015b. Decent work. In: *ILO*. [Cited 29 June 2022]. <https://www.ilo.org/global/topics/decent-work/lang--en/index.htm>
- Kircher, M.** 2021. Bioeconomy – present status and future needs of industrial value chains. *New Biotechnology*, 60: 96–104. <https://doi.org/10.1016/J.NBT.2020.09.005>
- Kuckertz, A.** 2020. Bioeconomy Transformation Strategies Worldwide Require Stronger Focus on Entrepreneurship. *Sustainability*, 12(7):2911. <https://doi.org/10.3390/SU12072911>
- Kuosmanen, T., Kuosmanen, N., El-Meligli, A., Ronzon, T., Gurria, P., Lost, S. & M'Barek, R.** 2020. *How Big is the Bioeconomy? Reflections from an economic perspective*. Luxembourg, European Union. <https://doi.org/10.2760/144526>
- Lange, L., Connor, K.O., Arason, S., Bundgård-Jørgensen, U., Canalis, A., Carrez, D., Gallagher, J. et al.** 2021. Developing a sustainable and circular bio-based economy in EU: by partnering across sectors, upscaling and using new knowledge faster, and for the benefit of climate, environment & biodiversity, and people & business. *Frontiers in Bioengineering and Biotechnology*, 8: 1456. <https://doi.org/10.3389/fbioe.2020.619066>
- LatAm Investor.** 2021. Why Latin America is the Middle East of Biofuel. In: *LatAm INVESTOR*. [Cited 11 December 2021]. <https://latam-investor.com/2021/04/latin-america-becomes-biofuel-superpower>
- Malaysian Bioeconomy Development Corporation.** 2017. The Influences of Bioeconomy and its structural changes in Malaysia: 2005–2015. In: *Issuu*. [Cited 10 October 2022]. https://issuu.com/ahmadnazmiidrus/docs/bioeconomy_structural_changes_53c159e7770dcd
- McLeod, E., Bruton-Adams, M., Förster, J., Franco, C., Gaines, G., Gorong, B., James, R. et al.** 2019. Lessons from the Pacific Islands – Adapting to climate change by supporting social and ecological resilience. *Frontiers in Marine Science*, 6: 289. <https://doi.org/10.3389/FMARS.2019.00289>
- Ministry of Business, Innovation and Employment.** 2022. A Nation of Curious Minds – He Whenua Hihiri i te Mahara. In: *Ministry of Business, Innovation and Employment Hikina Whakatutuki*. [Cited 27 March 2022]. <https://www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/curious-minds/a-nation-of-curious-minds-he-whenua-hihiri-i-te-mahara>
- NACI (National Advisory Council on Innovation).** 2022. *Audit of the south African bioeconomy sector*. Pretoria. https://www.naci.org.za/wp-content/uploads/2022/02/Bioeconomy-Audit-NACI-Presentation_-Dr-Mziwandile-Madikizela.pdf
- Nordic Council of Ministers.** 2018. *Nordic Bioeconomy Programme: 15 action points for sustainable change*. Copenhagen. <https://doi.org/10.6027/ANP2018-785>
- OECD (Organisation for Economic Co-operation and Development).** 2010. *Monitoring progress towards green growth: indicators for the OECD green growth strategy*. New York, United Nations. <https://unstats.un.org/unsd/envaccounting/ceea/meetings/UNCEEA-5-16.pdf>

- OECD.** 2017. *Evidence-based Policy Making for Youth Well-being: A Toolkit. OECD Development Policy Tools*. Paris. <http://dx.doi.org/10.1787/9789264283923-en>
- OECD.** 2022. Green growth and sustainable development. In: *OECD*. [Cited 22 June 2022]. <https://www.oecd.org/greengrowth>
- OECD & European Commission.** 2020. *Policy brief on recent developments in youth entrepreneurship*. Paris, OECD Publishing. <https://doi.org/10.1787/5f5c9b4e-en>
- Oxford Business Group.** 2021. *Agriculture in Africa 2021*. London. https://catalogue.unccd.int/1701_OCP_Agriculture_Africa_Report_2021.pdf
- SEI (Stockholm Environment Institute), Scinnovent Centre, ICIPE (International Centre of Insect Physiology and Ecology), BioInnovate Africa & EASTECO (East African Science and Technology Commission).** 2020. Bioeconomy growth Prospects for Eastern Africa. Proceedings from the first Eastern Africa Bioeconomy Conference, 21–22 October 2020. <https://bioinnovate-africa.org/wp-content/uploads/2021/11/Conference-PROCEEDINGS-J-web.pdf>
- Razak, M.** 2021. *Malaysia – A thriving bioeconomy destination in APAC*. BioSpectrum Asia. [Cited 10 October 2022]. <https://www.pressreader.com/india/biospectrum-asia/9gut/20211115/281822877033393>
- Ricker-Gilbert, J., Jumbe, C. & Chamberlin, J.** 2014. How does population density influence agricultural intensification and productivity? Evidence from Malawi. *Food Policy*, 48: 114–128. <https://doi.org/10.1016/J.FOODPOL.2014.02.006>
- Saget, C., Vogt-Schilb, A. & Luu, T.** 2020. *Jobs in a Net-Zero Emissions Future in Latin America and the Caribbean*. Washington, DC, Inter-American Development Bank and Geneva, Switzerland, ILO. https://www.ilo.org/wcmsp5/groups/public/---americas/---ro-lima/documents/publication/wcms_752069.pdf
- Sakellaris, G.** 2021. Bioeconomy Education. In: E. Koukios & A. Sacio-Szymańska, eds. *Bio#Futures: Foreseeing and Exploring the Bioeconomy*, pp. 489–506. Cham, Switzerland, Springer Nature Switzerland. <https://doi.org/10.1007/978-3-030-64969-2>
- Satakuntaliitto.** 2022. *Satakunta region's Smart Specialisation Strategy for 2021–2027*. Satakunta, Finland. https://satakunta.fi/wp-content/uploads/2022/05/S3_enpowerpoint.pdf
- Scarlat, N., Dallemand, J., Taylor, N. & Banja, M.** 2019. *Brief on biomass for energy in the European Union*. Luxembourg, Publications Office of the European Union. <https://doi.org/10.2760/49052>
- Stockholm Resilience Centre.** 2022. *Planetary boundaries*. In: *Stockholm Resilience Centre*. [Cited 10 October 2022]. <https://www.stockholmresilience.org/research/planetary-boundaries.html>
- Tiron-Tudor, A., Ștefănescu, C. & Nistor, C.S.** 2018. The Role of Universities in Consolidating Intellectual Capital and Generating New Knowledge for a Sustainable Bio-Economy. *Amfiteatru Economic*, 20(49): 599–615. <https://www.cceol.com/search/viewpdf?id=699933>
- Trigo, E., Chavarria, H., Pray, C., Smyth, S.J., Wesseler, J., Zilberman, D. & Mar, J.F.** 2021. *Food Systems Summit Brief: The Bioeconomy and Food Systems Transformation*. https://sc-fss2021.org/wp-content/uploads/2021/03/FSS_Brief_Bioeconomy_and_Food_Systems_Transformation.pdf
- United Nations.** 2003. *World Youth Report – The global situation of young people*. New York, USA. <https://www.un.org/esa/socdev/unyin/documents/worldyouthreport.pdf>

- United Nations.** 2018. *World Youth Report – Youth and the 2030 agenda for sustainable development*. New York, USA. <https://www.un.org/development/desa/youth/wp-content/uploads/sites/21/2018/12/WorldYouthReport-2030Agenda.pdf>
- United Nations.** 2020. *World Youth Report – Youth social entrepreneurship and the 2030 Agenda*. New York, USA. <https://www.un.org/development/desa/youth/wp-content/uploads/sites/21/2020/07/2020-World-Youth-Report-FULL-FINAL.pdf>
- UNCTAD (United Nations Conference on Trade and Development).** 2017. *Harnessing Youth Entrepreneurship: Key to a better Future*. In: *UNCTAD*. [Cited 28 March 2022]. <https://unctad.org/news/harnessing-youth-entrepreneurship-key-better-future>
- UNEP (United Nations Environment Programme), ILO, IOE (International Organisation of Employers) & ITUC (International Trade Union Confederation).** 2008. *Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World*. Nairobi, UNEP. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_158727.pdf
- USAID (United States Agency for International Development).** 2015. *A framework for a push/pull approach to inclusive market systems development*. Washington, DC. https://www.marketlinks.org/sites/default/files/resource/files/LEO_Framework_for_a_Push_Pull_Approach_to_Inclusive_Market_Systems_Devel....pdf
- Virgin, I., Diaz-Chavez, R., Morris, E.J., Haileselassie, T., Tesfaye, K., De Cliff, S., Njau, K., Munganyinka, E., Muyambi, F. & Otim, M.O.** 2022. *The State of the Bioeconomy in Eastern Africa: 2022*. Stockholm, SEI, The East African Science and Technology Commission and BioInnovate Africa. <https://easteco.org/wp-content/uploads/2022/06/Status-of-the-East-African-Bioeconomy-report-2022-1.pdf>
- World Bank.** 2005. *Children and youth: a resource guide for World Bank staff (English)*. Human Development Network children and youth series, no.2. Washington, DC. <http://documents.worldbank.org/curated/en/283471468158987596/Children-and-youth-a-resource-guide-for-World-Bank-staff>
- World Bank.** 2021. *World Bank Group to Discontinue Doing Business Report*. In: *World Bank*. [Cited 26 June 2022]. <https://www.worldbank.org/en/news/statement/2021/09/16/world-bank-group-to-discontinue-doing-business-report>
- World Bank.** 2022. *World Development Indicators*. In: *World Bank*. [Cited 26 June 2022]. <https://datacatalog.worldbank.org/search/dataset/0037712>
- World Economic Forum.** 2022. *Why young entrepreneurs are so important*. In: *World Economic Forum*. [Cited 28 March 2022]. <https://www.weforum.org/agenda/2015/10/why-young-entrepreneurs-are-so-important>
- WIPO (World Intellectual Property Organization).** 2022. *Patentscope*. In: *WIPO*. [Cited 26 June 2022]. <https://patentscope.wipo.int/search/en/search.jsf>
- YABT Young Americas Business Trust.** 2022. *Young Americas Forum*. In: *YABT Young Americas Business Trust*. [Cited 28 June 2022]. <https://yabt.net/foro/en>
- Zicklin Center & World Bank.** 2018. *Ideas For Action, Financing and Implementing Sustainable Development Goals*. Washington, DC. <https://thedocs.worldbank.org/en/doc/720611539785849721-0270022018/original/IdeasforActionfinal91018web.pdf>

Bioeconomy strategies references

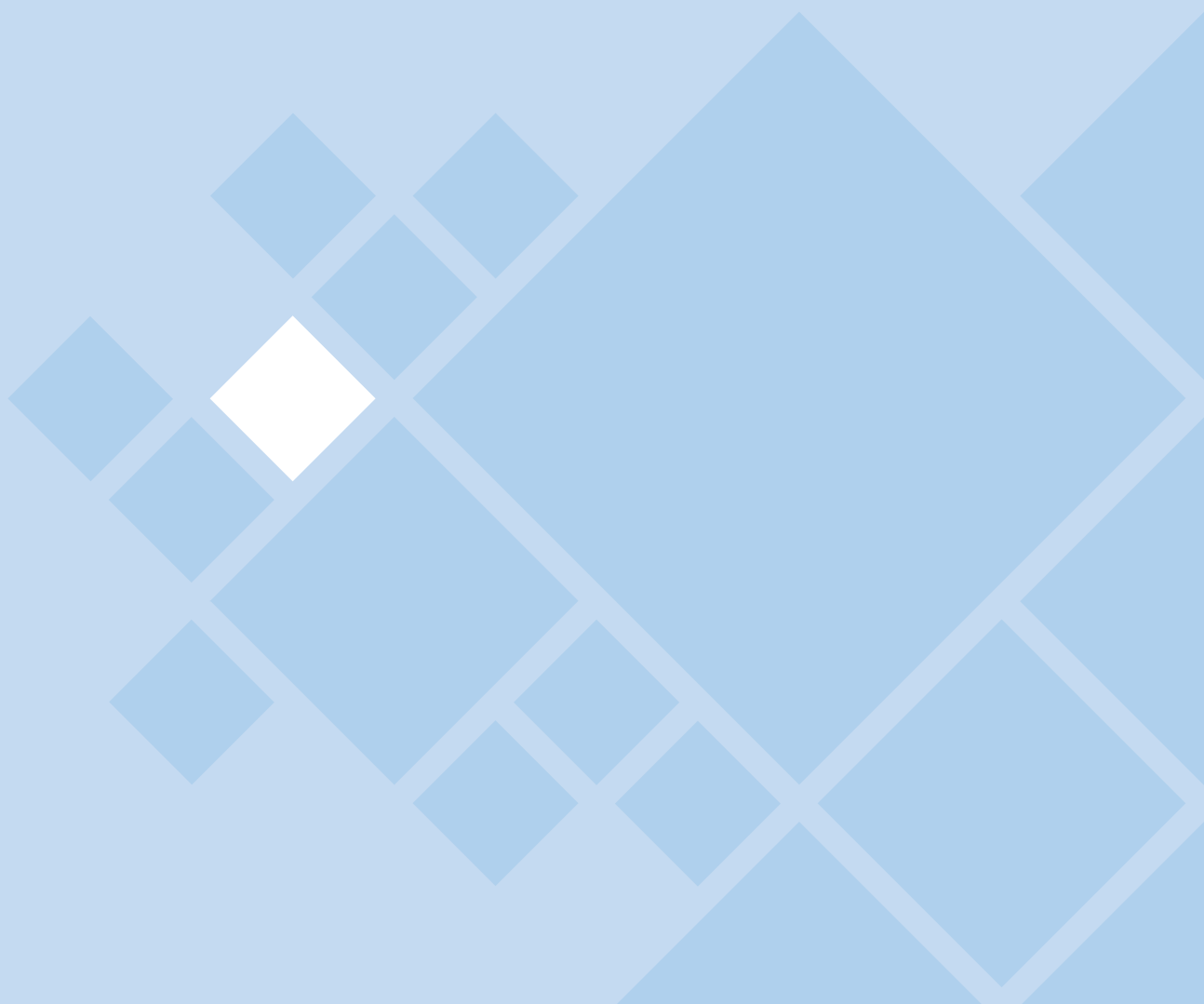
- Biotechnology Industry Research Assistance Council.** 2020. *India Bioeconomy Report 2020*. New Delhi. https://birac.nic.in/webcontent/1594624763_india_bioeconomy_rep.pdf
- Bundesministerium für Bildung und Forschung & Bundesministerium für Ernährung und Landwirtschaft.** 2020. *Nationale Bioökonomiestrategie*. Berlin. https://www.bmel.de/SharedDocs/Downloads/DE/Broschueren/nationale-biooekonomiestrategie-langfassung.pdf?__blob=publicationFile&v=5
- Carbonell, S.A.M., Cortez, L.A.B., Madi, L.F.C., Anefalos, L.C.V., Baldassin Junior, R. & Leal, R.L.V.** 2021. *Tropical Bioeconomy – Roadmaps and Guidelines for Bioeconomy Development in Brazil*. Santo André, Agropolo Campinas-Brasil, FARESP and Áttema. https://www.iac.sp.gov.br/media/publicacoes/agropolo_bioeconomia_tropical_eng.pdf
- Delbrück, S., Griestop, L., & Hamm, U.** 2018. *Future Opportunities and Developments in the Bioeconomy – a Global Expert Survey*. Berlin, Office of the German Bioeconomy Council. <https://www.biooekonomierat.de/media/pdf/archiv/international-gbs-expert-survey.pdf?m=1637834861&>
- Department of Business, Energy and Industrial Strategy.** 2021. *UK Innovation Strategy – Leading the future by creating it*. London. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1009577/uk-innovation-strategy.pdf
- Dieckhoff, P., El-Cichakli, B. & Patermann, C.** 2015. *Bioeconomy Policy Synopsis and Analysis of Strategies in the G7*. Berlin, Office of the Bioeconomy Council. <https://www.biooekonomierat.de/media/pdf/archiv/international-bioeconomy-policy-part-I.pdf?m=1637834917&>
- Dubois, O. & Gomez San Juan, M.** 2016. *How sustainability is addressed in official bioeconomy strategies at international, national and regional levels – An overview*. Rome, FAO. <https://www.fao.org/3/i5998e/i5998e.pdf>
- EASTECO.** 2020. *The Eastern African Regional Bioeconomy Strategy – A Summary*. Kigali. <https://bioeconomy.easteco.org/wp-content/uploads/2020/10/EXECUTIVE-SUMMARY-BIOECONOMY-STRATEGY.pdf>
- EASTECO, ECLAC & IICA.** 2019. *The Outlook for Agriculture and Rural Development in the Americas: A Perspective on Latin America and the Caribbean 2019–2020*. San Jose, IICA. <https://www.fao.org/3/cb3832en/cb3832en.pdf>
- European Commission.** 2018. *A sustainable bioeconomy for Europe – Strengthening the connection between economy, society and the environment: updated bioeconomy strategy*. Brussels. <https://data.europa.eu/doi/10.2777/792130>.
- Federal Ministry for Sustainability and Tourism & Federal Ministry for Transport, Innovation and Technology.** 2019. *Bioeconomy – A Strategy for Austria*. Vienna. https://www.bmk.gv.at/themen/klima_umwelt/klimaschutz/biooekonomie/strategie.html
- Fund, C., El-Chichakli, B. & Patermann C.** 2018. *Bioeconomy Policy (Part III) Update Report of National Strategies around the World*. Berlin, German Bioeconomy Council. <https://www.biooekonomierat.de/media/pdf/archiv/international-bioeconomy-policy-part-III.pdf?m=1637834907&>
- Fund, C., El-Chichakli, B., Patermann, C. & Dieckhoff, P.** 2015. *Bioeconomy Policy (Part II) Synopsis of National Strategies around the world*. Berlin, German Bioeconomy Council. https://www.sureaqua.no/Sureaqua/library/Bioeconomy-Policy_Part-II%20-%20Synopsis%20of%20National%20Strategies%20around%20the%20World,%202015.pdf

- German Embassy Tokyo.** 2020. *Bio-strategy 2020 (translation)*. Tokyo. https://www.dwih-tokyo.org/files/2020/10/bio2020_honbun_en_rev-1.pdf
- Government of Ireland.** 2018. *National Policy Statement on the Bioeconomy*. Dublin. <https://assets.gov.ie/2244/241018115730-41d795e366bf4000a6bc0b69a136bda4.pdf>
- Inter-ministerial Bioeconomy Committee.** 2022. *National Bioeconomy Strategy Costa Rica 2020–2030*. <https://thedocs.worldbank.org/en/doc/de734572ac8e6b503423b40811d096c1-0350012021/related/The-Costa-Rica-Bioeconomy-Strategy.pdf>
- International Advisory Council on Global Bioeconomy.** 2020. *Expanding the Sustainable Bioeconomy – Vision and Way Forward. Communiqué of the Global Bioeconomy Summit 2020*. Berlin, Secretariat of the Global Bioeconomy Summit 2020. https://gbs2020.net/wp-content/uploads/2020/11/GBS2020_IACGB-Communique.pdf
- Ministerio de Economía y Competitividad.** 2022. *Estrategia Española de Bioeconomía Horizonte 2030*. Madrid. https://www.mapa.gob.es/ca/desarrollo-rural/temas/innovacion-medio-rural/estrategiaenbioeconomia23_12_15_tcm34-560119.pdf
- Ministry of Agriculture.** 2018. *Informative Report – Latvian Bioeconomy Strategy 2030*. Riga. <https://www.zm.gov.lv/lv/media/1023/download?attachment>
- Ministry of Agriculture and Food.** 2018. *A Bioeconomy Strategy for France 2018–2020 Action Plan*. Paris. <https://agriculture.gouv.fr/bioeconomy-strategy-france-2018-2020-action-plan>
- Ministry of Agriculture of the Republic of Lithuania.** 2019. *Lithuanian Bioeconomy Strategy*. Riga. https://scar-europe.org/images/CASA/Events/Baltic_Riga_4-5April2019/presentations/3-2_Dalia-Miniataite_Bioeconomy%20Lithuanian.pdf
- Ministry of Economic Affairs and Climate Policy.** 2018. *The position of the bioeconomy in the Netherlands*. The Hague, Netherlands (Kingdom of the). https://knowledge4policy.ec.europa.eu/sites/default/files/NL%20BE%20Position%20Paper_en.pdf
- Ministry of Employment and the Economy.** 2014. *Sustainable growth from bioeconomy – The Finnish Bioeconomy Strategy*. Helsinki. https://biotalous.fi/wp-content/uploads/2014/08/The_Finnish_Bioeconomy_Strategy_110620141.pdf
- Ministry of Science, Technology and Innovation.** 2015. *Bioeconomy Transformation Programme – Enriching the Nation, Securing the Future*. Kuala Lumpur, Malaysian Biotechnology Corporation SDN BHD. https://www.bioeconomycorporation.my/wp-content/uploads/2011/11/publications/BTP_AR_2015.pdf
- Ministry of Trade, Industry and Fisheries.** 2016. *Familiar resources – undreamt of possibilities – The Government’s Bioeconomy Strategy*. Oslo. https://www.regjeringen.no/contentassets/5b2dc02e8dd047adba138d7aa8b4dcc1/nfd_biokonomi_strategi_engelsk_uu.pdf
- National Bioeconomy Task Force.** 2017. *BIT II – Bioeconomy in Italy – A new Bioeconomy strategy for a sustainable Italy*. Rome. https://cnbbsv.palazzochigi.it/media/1774/bit_en_2019_02.pdf
- Nordic Council of Ministers.** 2018. *Nordic bioeconomy programme 15 action points for sustainable change*. Copenhagen. <https://doi.org/10.6027/ANP2018-785>
- Republic of Estonia.** 2019. *Bioeconomy strategies: Estonia – context and scope*. Tallinn. https://scar-europe.org/images/CASA/Events/Baltic_Riga_4-5April2019/presentations/3-3_Helena-Parensen_Bioeconomy_Estonia.pdf
- Rodríguez, A.G., Rodrigues, M. & Sotomayor, O.** 2019. *Towards a sustainable bioeconomy in Latin America and the Caribbean: elements for a regional vision*. Santiago, Economic Commission for United Nations. https://repositorio.cepal.org/bitstream/handle/11362/44994/1/S1901014_en.pdf

- Science and Technology Department, Republic of South Africa.** 2013. *The bio-economy Strategy*. Cape Town. https://www.gov.za/sites/default/files/gcis_document/201409/bioeconomy-strategya.pdf
- SEI.** 2021. *Colombia's National Bioeconomy Strategy*. Stockholm. <https://www.ksla.se/wp-content/uploads/2021/05/2021-06-08-Monica-Trujillo-Colombia-Bioeconomy-Strategy.pdf>
- Teitelbaum, L., Boldt, C. & Patermann, C.** 2020. *Global Bioeconomy Policy Report (IV): A decade of bioeconomy policy development around the world*. Berlin, Secretariat of the Global Bioeconomy Summit 2020. https://knowledge4policy.ec.europa.eu/sites/default/files/gbs-2020_global-bioeconomy-policy-report_iv_web.pdf
- The White House.** 2012. *National bioeconomy blueprint*. Washington, DC. https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/national_bioeconomy_blueprint_april_2012.pdf



Annexes



Annexes

Annex 1. Methodology

◆ **TABLE A1** Push/pull factors and indicators analysed with corresponding FAO principles and criteria and SDG targets and indicators



1. Economic development	
Indicator analysed: Gross domestic product growth (annual %).	
<p>Principle 3: Sustainable bioeconomy should support competitive and inclusive economic growth.</p> <ul style="list-style-type: none"> ◆ Criterion 3.1: Economic development is fostered. <ul style="list-style-type: none"> – Impact category: 3.1.a Economic development. ◆ Indicator SDG 8.1.1: Annual growth rate of real growth domestic product per capita. 	
<p>Target 8.1: Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7% gross domestic product growth per annum in the least developed countries.</p> <ul style="list-style-type: none"> ◆ Indicator SDG 8.1.1: Annual growth rate of real growth domestic product per capita. 	
2. Employment	
Indicator analysed: Rural and urban youth employment rate of youth at ages 15 to 29 by region between 2015 and 2020: rural employment rate female youth (%), male youth (%); urban employment rate male youth (%), female youth (%). Youth unemployment rate of youth at ages 15 – 29 in different sectors by region between 2015–2020: rural unemployment rate female youth (%), male youth (%). Urban unemployment rate male youth (%), female youth (%). Employment rate of youth at ages 15 – 29 in different sectors related with the bioeconomy, by region between 2015–2020: employment rate of female/male youth in agriculture/education/energy/manufacturing/water and waste.	
<p>Principle 3</p> <ul style="list-style-type: none"> ◆ Criterion 3.2: Inclusive economic growth is strengthened. <ul style="list-style-type: none"> – Impact category: 3.2.a Employment. <ul style="list-style-type: none"> – Indicator: Number of employed persons in rural and urban areas. ◆ Impact categories: 3.2.e Equality, 3.2.f Gender equality, 3.2.g Inclusiveness. 	
<p>Target 8.5: By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value.</p> <ul style="list-style-type: none"> ◆ Indicator: 8.5.2 Unemployment rate, by sex, age and persons with disabilities. <p>Target 8.6: By 2020, substantially reduce the proportion of youth not in employment, education or training.</p> <ul style="list-style-type: none"> ◆ Indicator: 8.6.1 Proportion of youth (aged 15 to 24 years) not in education, employment or training. 	



TABLE A1 (cont.) Push/pull factors and indicators analysed with corresponding FAO principles and criteria and SDG targets and indicators






3. Business development	
Indicator analysed: Starting a business cost for men and women (as of percent of income per capita) and required procedures by men and women (in numbers) between 2015–2020: starting a business: cost – men (% of income per capita), women (% of income per capita); starting a business: procedures required – men (number), women (number).	
Principle 3	
<ul style="list-style-type: none"> ◆ Criterion 3.3: Resilience of the rural and urban economy is enhanced. <ul style="list-style-type: none"> – Impact category: 3.3.a Rural income diversification. – Impact category: 3.3.d Financial stability. 	
<p>Target 8.3: Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services.</p> <p>Target 8.10: Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all.</p>	
4. Sustainable resource use	
Indicator analysed: Land use change per region between 2015 and 2020: agricultural land (% of land area), forest area (% of land area), permanent cropland (% of land area), population density (people per km ² of land area), surface area (km ²).	
Principle 1: Sustainable bioeconomy development should support food security and nutrition at all levels.	
<ul style="list-style-type: none"> ◆ Criterion 1.2: Sustainable intensification of biomass production is promoted. <ul style="list-style-type: none"> – Impact category: 1.2.c Land for biomass production. – Indicator: Total area of land for bioeconomy feedstock production, and as compared to total national surface. – Indicator: Land use (forestry; agricultural and horticultural land as % of total land area). 	
Principle 2: Sustainable bioeconomy should ensure that natural resources are conserved, protected and enhanced.	
<ul style="list-style-type: none"> ◆ Criterion 2.1: Biodiversity conservation is ensured. ◆ Criterion 2.2: Climate change mitigation and adaptation are pursued. ◆ Criterion 2.3: Water quality and quantity are maintained, and, as much as possible, enhanced. ◆ Criterion 2.4: The degradation of land, soil, forests and marine environments is prevented, stopped or reversed. <ul style="list-style-type: none"> – Impact category: 2.4.a Land use change. <ul style="list-style-type: none"> – Indicator: Change in cropland area, grassland area, non-arable land use. – Impact category: 2.4.e Forest quantity. <ul style="list-style-type: none"> – Indicator: Change in forest area. – Indicator: SDG 15.1.1 Forest area as a proportion of total land area. 	
Principle 5: Sustainable bioeconomy should rely on improved efficiency in the use of resources and biomass.	
<ul style="list-style-type: none"> ◆ Criterion 5.1: Resource use efficiency, waste prevention and waste re-use along the whole bioeconomy value chain are improved. ◆ Criterion 5.2: Food loss and waste is minimized and, when unavoidable, its biomass is reused or recycled. 	



TABLE A1 (cont.) Push/pull factors and indicators analysed with corresponding FAO principles and criteria and SDG targets and indicators

<p>Target 8.4: Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead.</p> <p>Target 9.2: Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities.</p>	 
<p>6. Education, vocational education, training</p>	
<p>Indicator analysed: Gross enrolment ratios for tertiary education worldwide by region between 2015–2020: gross enrolment ratio for tertiary education, both sexes (%); female (%) and male (%). Enrolment in bachelor, master, vocational and doctorates by gender by region between 2015–2020: enrolment vocational rate, female (%), male (%); enrolment Bachelor rate, female (%), male (%); enrolment master rate, female (%), male (%); enrolment doctorate rate, female (%), male (%).</p>	
<p>Principle 7</p>	
<ul style="list-style-type: none"> ◆ Criterion 7.2: Knowledge generation and innovation are promoted. <ul style="list-style-type: none"> – Impact category: 7.2.a Knowledge generation / (high level) education. – Indicator: SDG 4.3.1 Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, by sex. – Indicator: Intellectual property rights (IPRs) (patent, trademark, design) applications in bioeconomy subsectors. – Indicator: Quality of workforce (secondary and tertiary education (% of total population)). 	
<p>Principle 10</p>	
<ul style="list-style-type: none"> ◆ Criterion 10.1: Cooperation, collaboration and sharing of resources, skills and technologies are enhanced when and where appropriate. <ul style="list-style-type: none"> – Criterion 6.2: Inclusion and engagement / information. 	
<p>Target 4.3: By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university.</p> <ul style="list-style-type: none"> – Indicator: 4.3.1 Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, by sex. 	
<p>Target 4.4: By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship.</p>	
<p>Target 4.5: By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations.</p>	
<ul style="list-style-type: none"> – Indicator: 4.5.1 Parity indices (female/male, rural/urban, bottom/top wealth quintile and others such as disability status, indigenous peoples and conflict-affected, as data become available) for all education indicators on this list that can be disaggregated. 	
<p>Target 8.6: By 2020, substantially reduce the proportion of youth not in employment, education or training.</p> <ul style="list-style-type: none"> – Indicator: 8.6.1 Proportion of youth (aged 15 to 24 years) not in education, employment or training. 	

Sources: Authors' elaboration based on: FAO. 2021a. *Aspirational Principles and Criteria for a Sustainable Bioeconomy*. Rome. United Nations. 2022; United Nations. n.d. The 17 Goals. In: *United Nations*. [Cited 22 June 2022]. <https://sdgs.un.org/goals>; FAO. 2022c. *Rural Youth Action Plan*. Rome. <https://doi.org/10.4060/cc0583en>

◆ **TABLE A2** Countries in each region

Region	Country name
Central Europe and Baltics	Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia
East Africa bio-strategy	Burundi, Ethiopia, Kenya, Rwanda, South Sudan, Uganda, United Republic of Tanzania
Eastern and Southern Africa	Comoros, Djibouti, Madagascar, Malawi, Mauritius, Mozambique, Nigeria, Sao Tome and Principe, Seychelles, Somalia, Zambia, Zimbabwe
East Asia and the Pacific	Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Mongolia, Myanmar, Philippines, Republic of Korea, Thailand, Timor-Leste
Europe and Central Asia	Armenia, Belarus, Bosnia and Herzegovina, Georgia, Iceland, Montenegro, Republic of Moldova, Russian Federation, Serbia, Switzerland, Ukraine, United Kingdom of Great Britain and Northern Ireland
European Union	Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands (Kingdom of the), Norway, Poland, Portugal, Romania, Slovakia, Slovenia
Latin America and the Caribbean	Belize, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Honduras, Jamaica, Mexico, Panama, Paraguay, Peru, Uruguay
Near East and North Africa	Egypt, Jordan, Liberia, Occupied Palestinian Territory, Tunisia
North America	United States of America
Pacific Island Small States	Fiji, Kiribati, Marshall Islands, Samoa, Tonga, Vanuatu
South Asia	Afghanistan, Bangladesh, India, Nepal, Pakistan, Sri Lanka, Viet Nam
Sub-Saharan Africa	Angola, Botswana, Cameroon, Central African Republic, Chad, Congo, Democratic Republic of the Congo, Equatorial Guinea, Eswatini, Gabon, Lesotho, Namibia, South Africa, Sudan
Western and Central Africa	Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Eritrea, Gambia, Ghana, Guinea, Guinea-Bissau, Mali, Mauritania, Niger, Senegal, Sierra Leone, Togo

Source: Authors' own elaboration.

◆ **TABLE A3 Youth interviewees**

	Name	Role	Occupation	Country
1	Johann Liebeton	Ambassador for the bioeconomy at the Global Bioeconomy Summit 2020 (GBS 2020)	Student	Germany, Denmark
2	Tokelo Shai	Bioeconomy Youth Champion at GBS 2020 and agriculture analyst at GreenCape	Young professional	South Africa
3	Saskia Purbojo	Biotechnology student	Student	Indonesia, Sweden
4	Manuela Montoya Castrillón	Cofounder of Conexbi	Entrepreneur	Colombia
5	Christin Boldt	GBS 2020 Secretariat	PhD candidate	Germany
6	Jennifer Kendzior	Microbiome Specialist at FAO and founder of Vegetal Vivant	Entrepreneur	France
7	Juan Fernando Martínez	Public servant, Ministerio de Ciencia, Tecnología e Innovación	Policymaker	Colombia
8	Juliana Romero Guzmán	Founder of Cano-ela	Entrepreneur	Mexico, Netherlands (Kingdom of the)
9	Ricardo Vargas Carpintero	PhD candidate bio-based value chains, Research Associate, University of Hohenheim	PhD candidate	Colombia, Germany
10	Natalia Rodriguez Muxica	Biotech consultant at Inter-American Development Bank Co-founder of LabNettings Director at Allbiotech	Entrepreneur	Chile
11	Gia Tien Ngo	Founder, Alpha Protein	Entrepreneur	Germany
12	Nikita Baliarsingh	Cofounder, Nexus Power	Entrepreneur	India

Source: Authors' own elaboration.

Youth interviews – guiding questions:

Can you tell me a bit about yourself?

- ◆ What aspect of bioeconomy sparked your interest so that you would become more interested?

Why is the bioeconomy concept interesting for youth/you and your work?

- ◆ What do you think the bioeconomy can offer to youth?
- ◆ What challenges related to bioeconomy are youth facing in your country?

What can organizations and institutions do to support youth to venture into bioeconomy?

- ◆ How do you see that youth (groups) are currently involved into policymaking?
- ◆ What can policymakers do to support young people to become agripreneurs?
- ◆ What major opportunities/challenges do you see lying ahead of the sector?
- ◆ What recommendations would you give to other young people to enter into bioeconomy?

For entrepreneurs:

Can you tell me about your business?

- ◆ What entry challenges did you face?
- ◆ What access did you have to which support organizations?
- ◆ How did you access financing/funding?
- ◆ What are the main lessons learned in establishing your business? What would you tell other young people?
- ◆ What would you do differently if you were starting your business now?

Annex 2. List of bioeconomy projects targeting youth

- ◆ BIO4AFRICA (<https://www.bio4africa.eu>)
- ◆ Problem-Based Learning PBL-BioAfrica (<https://www.pbl-bioafrica.net>)
- ◆ Talent4BBI project (<https://biorbic.com/talent4bbi>)
- ◆ Baltic Leadership Programme on Youth & Bioeconomy (<https://northerndimension.info/baltic-leadership-programme-on-youth-and-bioeconomy>)
- ◆ BioBaltic (<https://nordregioprojects.org/biobaltic/#/home>)
- ◆ Transition2Bio (<https://www.transition2bio.eu>)
- ◆ Bioeconomy and Production Development Program (<https://repositorio.iica.int/bitstream/11324/7909/2/BVE19040201i.pdf>)
- ◆ UrBIOfuture (<https://www.urbiofuture.eu>)
- ◆ BSR Youth for SDGs and Circular Bioeconomy (BeUBio) (<https://nordregioprojects.org/beubio/#/home>)
- ◆ ALCUE KBBE (http://alcuenet.eu/ALCUE_KBBE.php)
- ◆ Bioeconomy Awareness and Discourse Project (BioCannDo) (<https://www.allthings.bio/about>)
- ◆ Bioeconomy Cluster: Meeting policy challenges for a responsible biodiversity based bio-economy in Colombia (Bioeconomy Cluster: Meeting policy challenges for a responsible biodiversity based bio-economy in Colombia)
- ◆ Pilots4U (<https://biopilots4u.eu>)
- ◆ Bloom (<https://bloom-bioeconomy.eu>)
- ◆ AllThings.BioPRO (<https://www.allthings.bio>)

Annex 3. Data analysis of socioeconomic, biophysical and technological push/pull factors affecting youth employment in the bioeconomy

Analysis of annual gross domestic product growth and rural-urban population dynamics and implications for bioeconomy development

Complete data was not available to determine the exact contribution of bioeconomy sectors to gross domestic product (GDP). Also, currently there is no standard methodology established that enables international comparison of bioeconomy contribution to GDP. Only a few countries provide estimates for the contribution of bioeconomy to GDP. Two such countries are South Africa, where bioeconomy is estimated to contribute 8 percent to the GDP (ICIPE *et al.*, 2020) and Argentina, where the bioeconomy contributes 16.1 percent to GDP (IICA, 2020). Another argument for looking at GDP growth in this report is that there is a strong negative correlation between youth unemployment and GDP per capita (United Nations, 2018). The outcome of this analysis provides only an indication, rather than the full picture, as GDP growth does not provide a complete sustainability measure. Other socioeconomic factors that are often used to measure bioeconomy, such as employment, resource use (for instance, land), and primary production of biomass in the country (through agriculture and forestry, for instance) are analysed further below.

Before COVID-19, economies were growing at different rates, with annual GDP growth between 1 and 10 percent. The COVID-19 pandemic caused a decline in GDP in 2020 in all compared world regions, except for the East Africa biostrategy region,¹ which displays surprising a 1 percent growth. In contrast, the Pacific Island Countries' (PICs) GDP shrank by more than 10 percent (see Figure A1).

Population growth (annual percent): There are currently 1.2 billion youth in the world, the majority of whom live in rural areas in developing countries. In general, the total population growth has a negative tendency in all the regions. Africa has the highest population growth rate among all regions, at 2 percent, evidencing the world's largest expected youth workforce. This is confirmed by current numbers: In Africa, 65 percent of the population is under 35 years old and 10 to 12 million youth enter the workforce each year (Chari *et al.*, 2017). Also, the PICs have a positive population growth tendency with rates close to 1.5 percent per year. This is not the case in North America, where the population growth rates dropped from 2015 to 2020 (see Figure A1).

Rural and urban population (percent of total population and annual population growth): When looking at the rural population growth between 2015 and 2020 (see Figure A1), all regions show a decrease in the population growth rate, except Central Europe and the Baltics (which are stable). In general, rural areas are facing the effects of the emigration by young people to cities and the ageing of the wider population. If, in the future, rural areas do not have enough young labour, this will likely have a negative impact on countries' capacities to realize their full bioeconomy potential. This is especially the case in regions such as Central Asia, North America and Latin America, which have large surface areas and high biomass production potential. Additionally, Latin America is expected to have an average annual growth rate of 1.5 percent for agriculture, and account for 25 percent of the global agriculture supply. This is in conflict with the high share of population of African countries, where agriculture will have the same growth rates as Latin America, but a much larger population to provide food for (Oxford Business Group, 2021).

¹ East Africa biostrategy countries: Burundi, Ethiopia, Kenya, Rwanda, South Sudan, United Republic of Tanzania, Uganda.

FIGURE A1 Economic status, population growth and share of rural and urban population

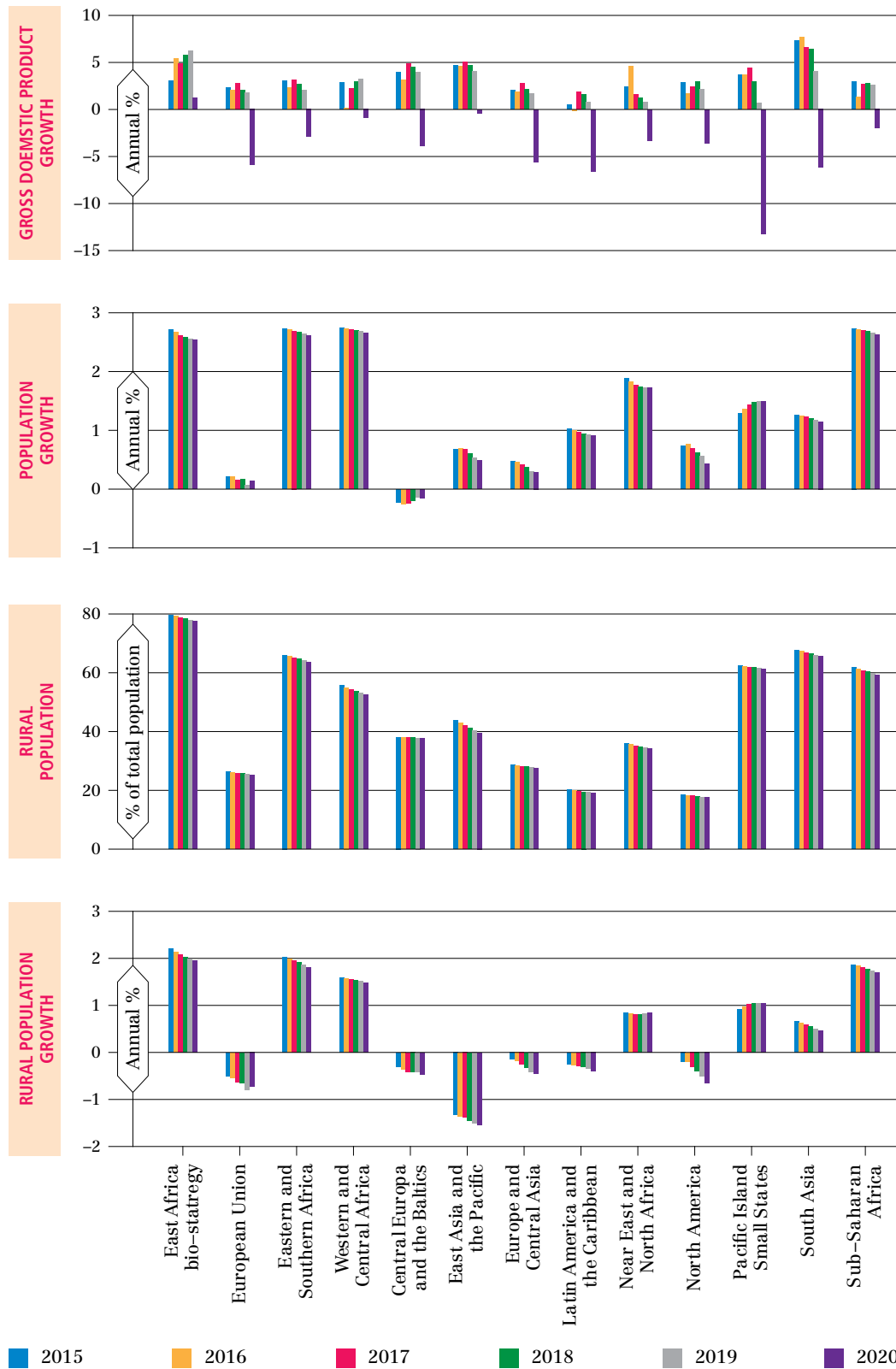
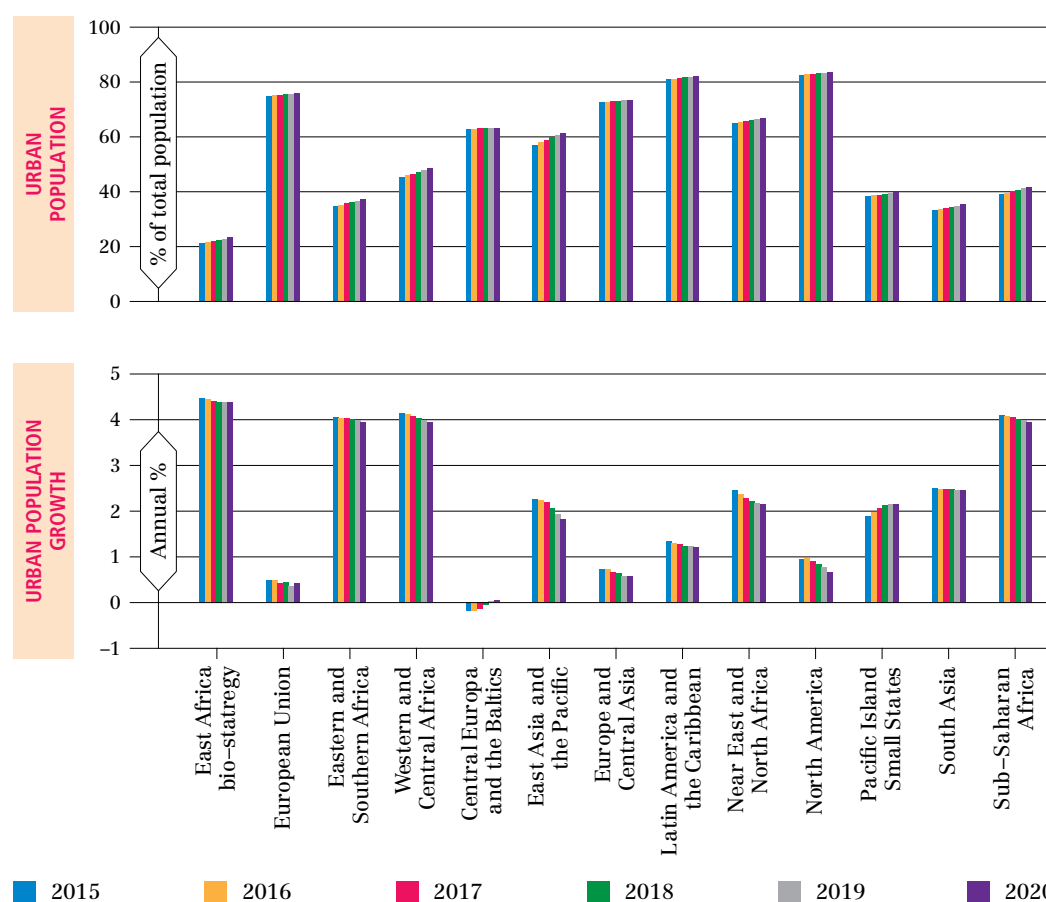


FIGURE A1 (cont.) Economic status, population growth and share of rural and urban population



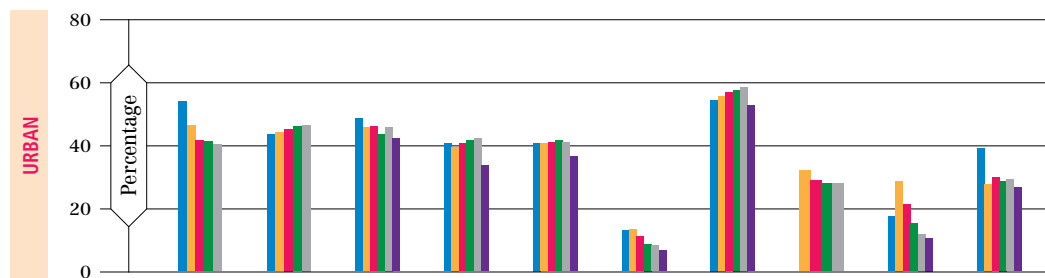
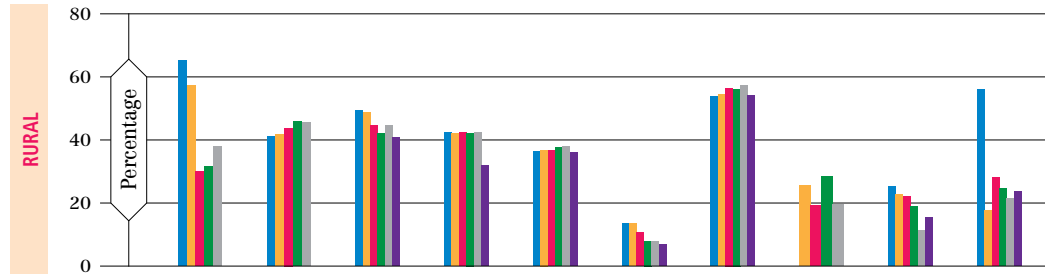
Source: Authors' elaboration based on data from World Bank. 2022. World Development Indicators. In: *World Bank*. Washington, DC. [Cited 22 June 2022]. <https://databank.worldbank.org/source/world-development-indicators>

Analysis of employment indicators

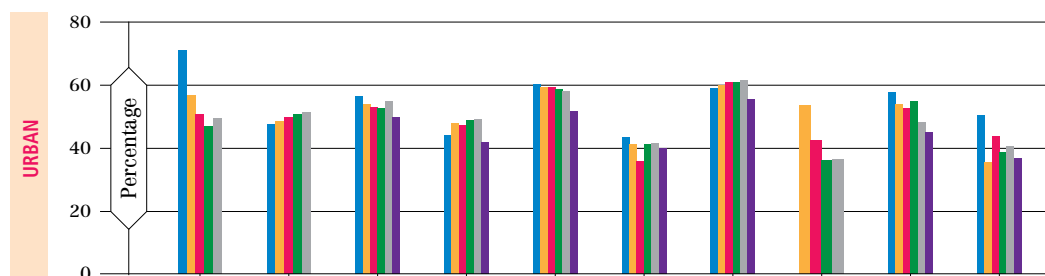
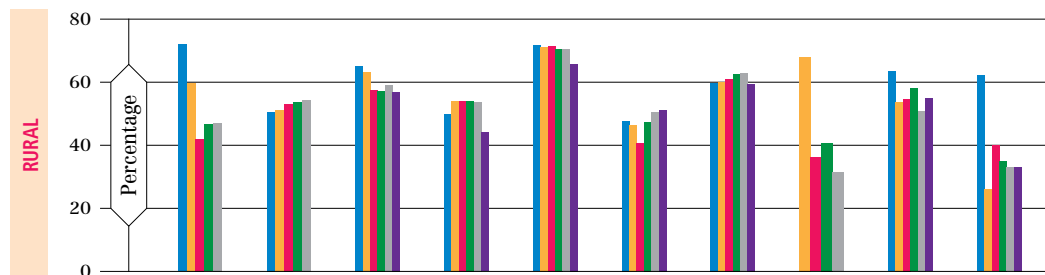
As with economic development, the employment factor strongly relates to FAO Principle 3 and SDG 8. The related indicators include the number of employed persons in rural and urban areas and unemployment rate, by sex and age, for which data has been analysed. Youth employment and unemployment rates were compared between female and male youth living in rural and urban areas, in the agricultural sector, as well as overall (in all sectors). When looking at the data (see Figure A2 and Figure A3), it is clear that in 2020, the COVID-19 pandemic had a significant negative impact on youth employment in agriculture around the world (where data was available). Youth employment in the informal economy of the agricultural sector is high, with a worldwide average of 77.1 percent (see Table A4). The majority is found in Africa (94.9 percent), Arab states (85.1 percent), Asia and the Pacific (86.3 percent) (ILO, 2020). Twenty-four percent of the working poor are youth, and the situation is especially dire for youth in Africa, with 70 percent of youth having to live on USD 2 or less per day (FAO, 2022b).

FIGURE A2 Employment rate of rural and urban youth (15 to 29 years) by region, 2015–2020

A. FEMALE



B. MALE

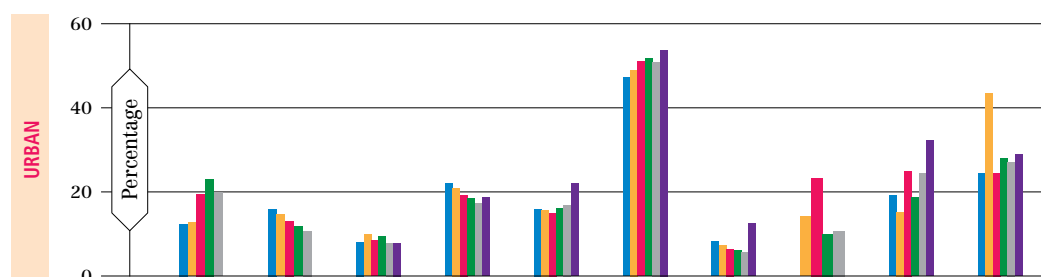
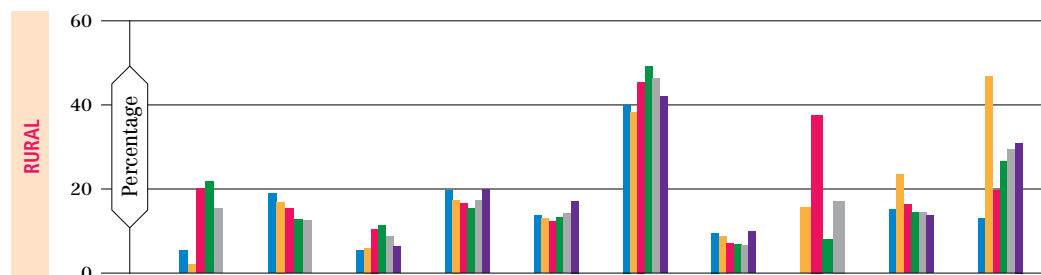


2015 2016 2017 2018 2019 2020

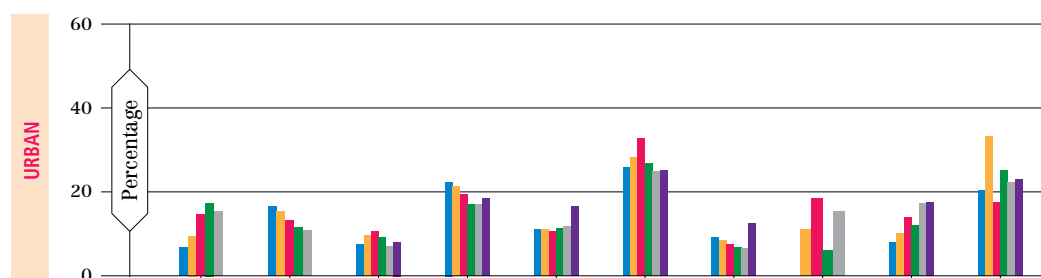
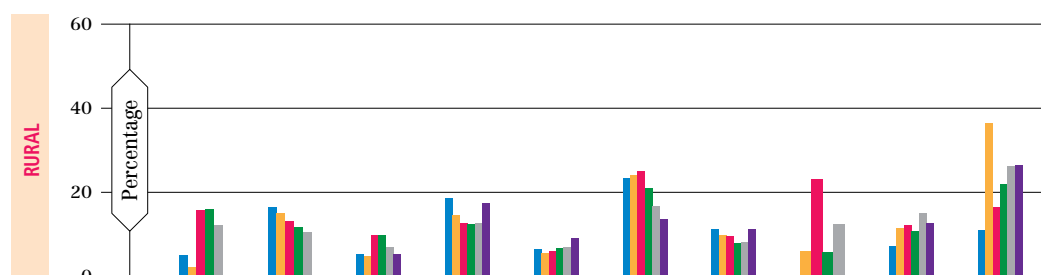
Source: Authors' elaboration based on data from ILO. 2022. Statistics on Youth. In: *ILOSTAT*. [Cited 22 June 2022]. <https://ilostat.ilo.org/topics/youth>

FIGURE A3 Unemployment rate of youth (15 to 29 years) by sector and region, 2015–2020

A. FEMALE



B. MALE



2015 2016 2017 2018 2019 2020

Source: Authors' elaboration based on data from ILO. 2022. Statistics on Youth. In: *ILOSTAT*. [Cited 22 June 2022]. <https://ilostat.ilo.org/topics/youth>

◆ **TABLE A4** Total informal unemployment of youth (15 to 24 years), 2016

World	North America (United States of America and Canada)	Europe and Central Asia	Latin America and the Caribbean	Asia and the Pacific	Arab States	Africa
(percentage)						
77.1	12.8	35.7	62.4	86.3	85.1	94.9

Source: Authors' elaboration based on data from ILO. 2022. Statistics on employment. In: *ILOSTAT*. [Cited 22 June 2022]. <https://ilostat.ilo.org/topics/employment>

Data confirms (Figure A2) that the overall average employment rate for male youth is higher compared to the female employment rate around the globe. Surprisingly, when comparing youth employment between urban and rural areas, rural youth employment is slightly higher compared to urban youth employment in all regions. The European Union is the only region where the employment rates of youth in both rural and urban regions are growing in the last years, although no data was available yet for 2020, which could provide another picture due to the COVID-19 pandemic and its negative impact on economic growth. The only other region in the world where youth employment is increasing is in the Near East and North Africa, but for males only.

In South Asia and the Near East and North Africa, female employment (both rural and urban) is decreasing significantly. Female unemployment in the Near East and North Africa is at 50 percent, and in sub-Saharan Africa it is around 30 percent in both urban and rural areas. Both regions are the only ones where employment among young males is almost double the employment among young females.

The African regions have no clear trend in employment rates during the past years for either female or male youth, although in rural areas the fluctuations from year to year are high compared to urban areas. In Latin America, male youth employment in rural and urban areas is decreasing significantly in the last years, but female employment remains more or less stable.

In the regions of Europe and Central Asia, the European Union and North America the unemployment rate has decreased in recent years. However, when comparing this to Figure A3, it is apparent that this does not mean that more opportunities are being created. This could be interpreted as youth emigrating to other countries.

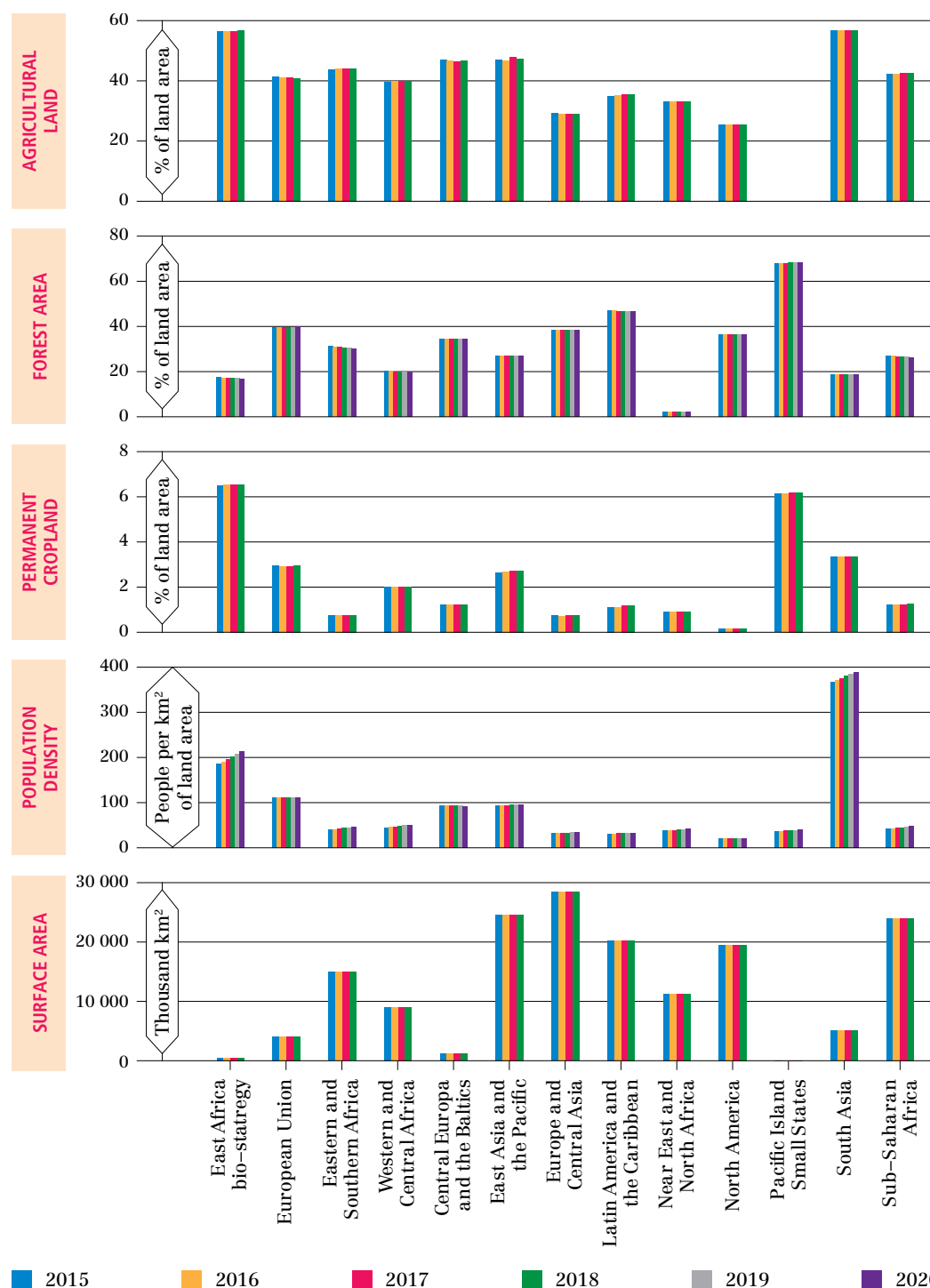
In general, for all regions, unemployment is higher in the urban areas than in rural areas. This is in line with the growing population in the urban areas, which is followed by an increase in unemployment, as the labour markets cannot absorb all the increasing population. The East Africa Biostrategy and sub-Saharan African regions show high unemployment rates but also high growth population rates. This means that more youth will be at risk of being unemployed in the coming years. Therefore, the development of the bioeconomy industry in those regions could be a crucial solution to counter the socioeconomic threats such as a potential increase of unemployment, outmigration to urban areas and the impact of depleting ecosystems and increasing adverse weather events on human health.

Analysis of sustainable resource use

Indicators for sustainable resource use have been used in this report as data was consistently available for all regions and from 2015 to 2020 (see Figure A4). Indicators looked at in this report are SDG 15.1.1 – Change in forest area (as a proportion of total land area), and FAO's indicators for impact category 1.2.c and 2.4.a – Total area of land for bioeconomy

feedstock production, as compared to total national surface; land use (forestry; agricultural and horticultural land as percent of total land area), and Change in area of the listed land uses. Data on land use per region, surface area and population density have been analysed for comparison and data interpretation and are explained in the following paragraphs under agricultural land, arable land and forest area.

◆ **FIGURE A4 Land use by region, 2015–2020**



Source: Authors' elaboration based on data from World Bank. 2022. World Development Indicators. In: *World Bank*. Washington, DC. [Cited 22 June 2022]. <http://wdi.worldbank.org/table/3.1>

Land use rights are not addressed in this report, despite the fact that in many countries, access to land for youth and especially young women is restricted due to inheritance systems, unfavourable laws and local customs, which also adversely affect youth employment. However, it is suggested that further research be conducted on this aspect as it will also influence future interventions that aim to support sustainable and socially equitable bioeconomy development. The focus here is on showing the current and potential land use types per analysed region in order to provide a basis for further analysis on the development potential of the bioeconomy in these regions.

Agricultural land (percent of land area):² South Asia and Africa have the highest percent of agricultural land available. South Asia has higher GDP percent growth per year and a higher rural population share of the total population than Africa (except for the East Africa biostrategy region). This could be interpreted as a good condition for a faster biomass production and processing potential and, thus, a higher job creation rate in the near future. Nonetheless, South Asia has a low surface area and high population density associated with smaller farm sizes and lower real agricultural wage rates (Ricker-Gilbert, Jumbe and Chamberlin, 2014). In countries with small surface areas and a high population density, increased urbanization and infrastructure development can lead to highly negative environmental effects, due to increased conversion of forest into land for agriculture or construction (Bresciani *et al.*, 2019).

Arable land (percent land area):³ South Asia, the East Africa biostrategy cluster countries and Central Europe and the Baltics have the highest share of arable land related to their total surface area. For both forest and arable land, the expansion of biomass production for the bioeconomy should be urgently addressed in a sustainable way. The large availability of agricultural, forestry and breeding residues, as well as side and waste streams with underexploited potential, need to be fully harnessed first, before increasing biomass production.

Despite the large surface area of the sub-Saharan African region, with a high share of agricultural land, the countries in the region have a relatively small amount of arable land and forest area.

The countries of the East Africa biostrategy, South Asia and PIC regions with small surface areas might find challenges in bioeconomy development, as a focus on increasing primary biomass production (thus increasing permanent cropland) will strongly compete with other land uses and the needs related to high population density. Reconversion of abandoned industrial and urban sites, conversion of former oil refineries and industrial sites into biorefineries, valorization of brownfields rather than virgin land, and upstream valorisation, are strategies that can support a more sustainable bioeconomy development in these regions.

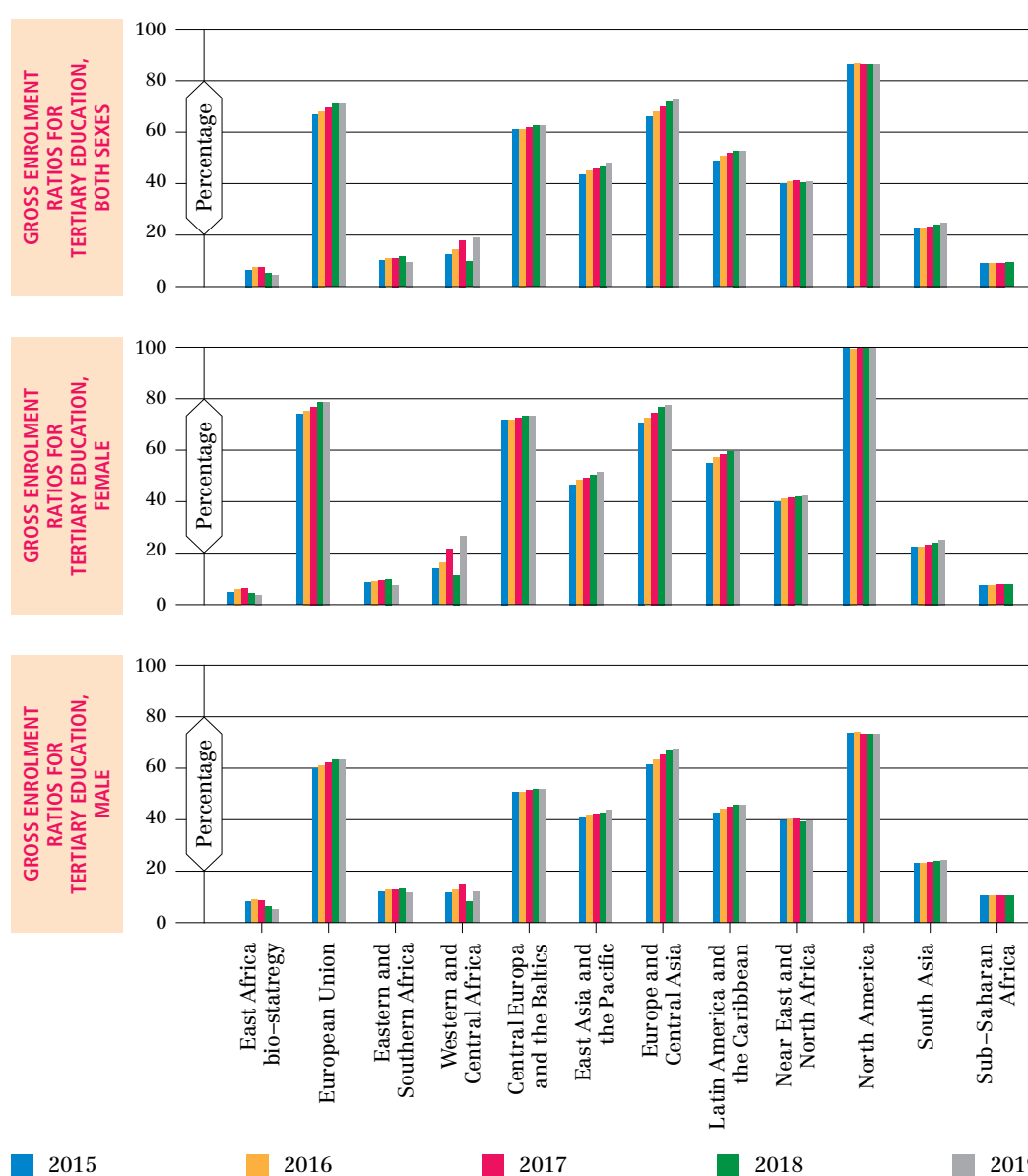
Forest area (percent of land area): PICs have more than 60 percent of their land area covered by forest, followed by Latin America and the Caribbean, with about 45 percent. If bioeconomy transition strategies are designed in a way that they are largely based on biomass production from annual and perennial crops, this could compete directly with forest area and could lead to deforestation, due to an increase in arable cropland. Expansion in agriculture decreases the net forest areas in countries with middle to low income ratings, where agriculture provides the main share of the economy (FAO, 2016).

² Agricultural land is defined as the share of land area that is arable, under permanent crops or under permanent pastures.

³ Arable land, is defined as land under temporary crops, temporary meadows, land under market or kitchen gardens and land temporarily fallow.

Figure A5a, b and c, present data for the gross enrolment ratio for males and females. The ratio is calculated as the number of persons enrolled in any tertiary studies over the total population, within five years after graduation from secondary school. Tertiary studies are those after secondary school, including universities, vocational studies, trade schools and colleges. North America has the highest enrolment rate for youth around the world. Consequently, the gender difference is not as big as in other regions. Furthermore, in North America, the percentage of female enrolment in such programmes rose to 100 percent in the past two years. Figure A6 shows the enrolment rate for females and males for the different levels of tertiary education per region. The enrolment rate is defined as the number of enrolments per level over the total amount of enrolments per year.

FIGURE A5 Gross enrolment ratios for tertiary education by region, 2015–2020



Source: Authors' elaboration based on data from World Bank. 2022. World Development Indicators. In: *World Bank*. Washington, DC. [Cited 22 June 2022]. <https://datacatalog.worldbank.org/search/dataset/0037712>

Analysis of current enrolment rates as indicator for bioeconomy development

While the bioeconomy is projected to create more and new types of jobs in selected sectors, education systems that have the capacity to respond early on (preferably from primary and high schools) to avoid skill gaps, will be essential. As data for this group was not available for this analysis, the focus is on providing insights at secondary and tertiary education (see Figure A6). However, it is important to mention that innovative thinking and critical thinking should be nurtured at an early age in schools, where children can be taught to be curious and ask questions. Natural sciences, especially biology, starting from early education are important for the bioeconomy. For societies to develop innovators for bioeconomy solutions some level of analysis and investment ought to be taught in early childhood. One good example is the Curious Minds fund in New Zealand, which aims to encourage and enable better engagement with science and technology in all sectors.

FIGURE A6 Enrolment in bachelor's, master's, vocation and doctorate programmes, by region and gender, 2015–2020

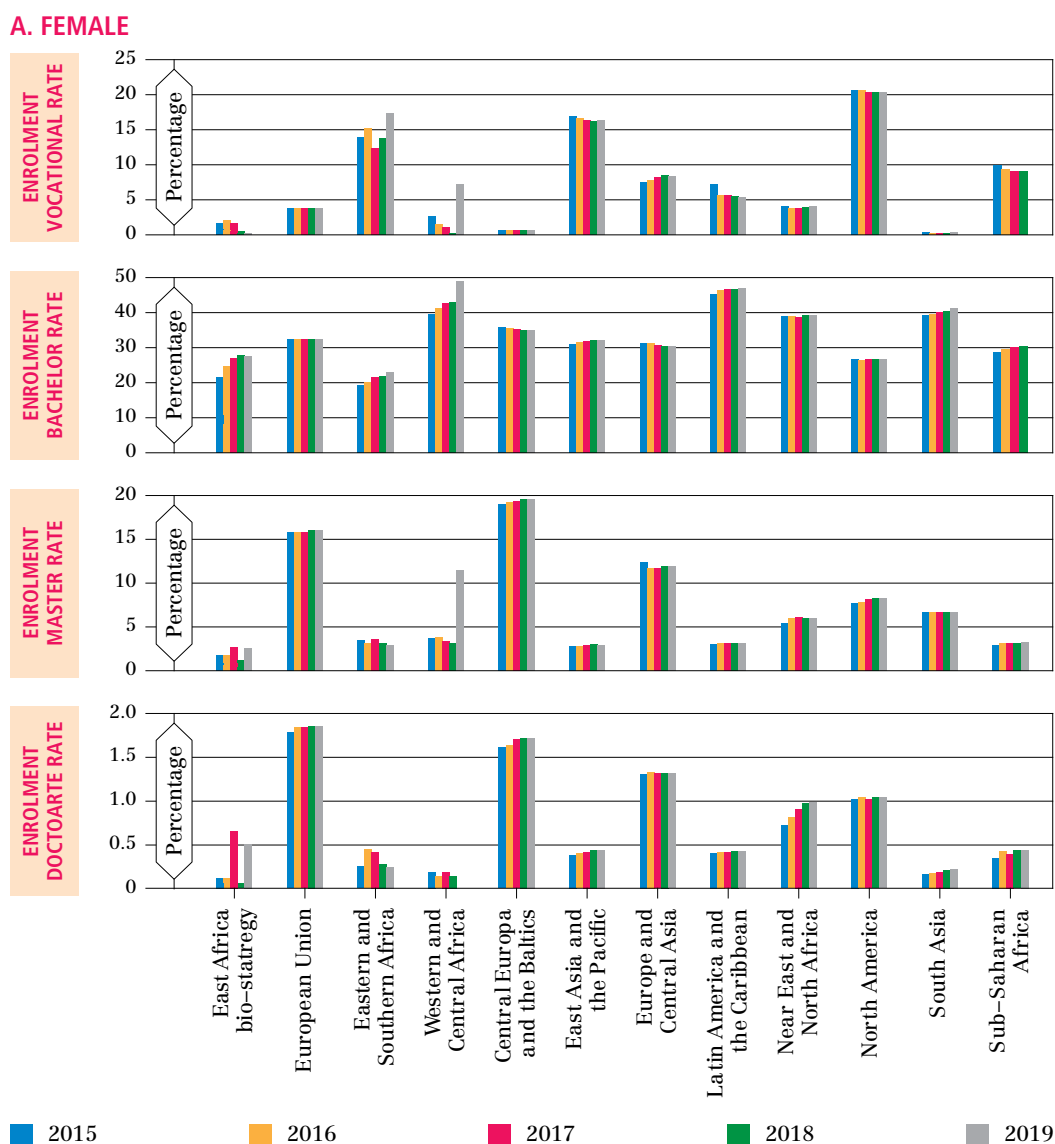
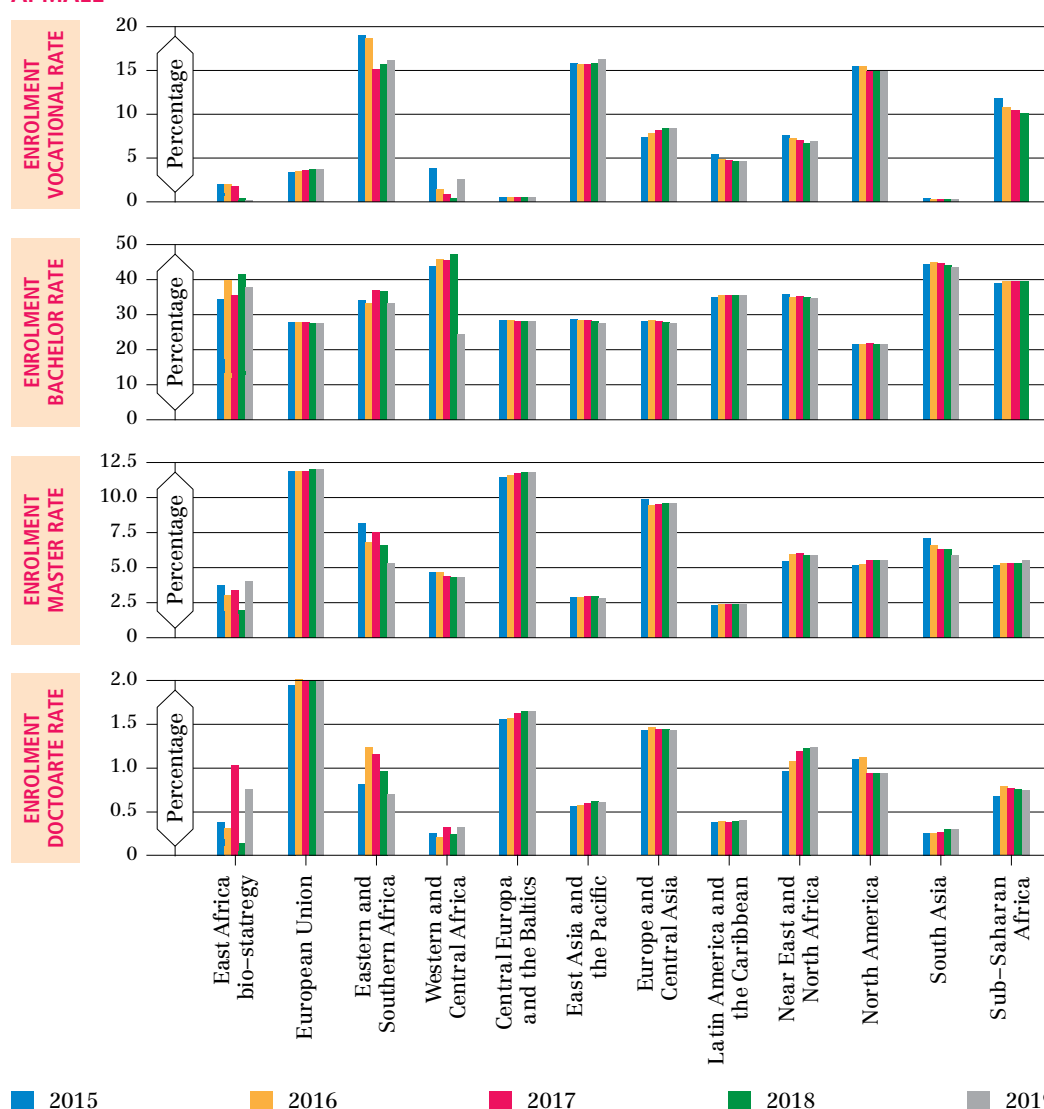


FIGURE A6 (cont.) Enrolment in bachelor's, master's, vocation and doctorate programmes, by region and gender, 2015–2020

A. MALE



Source: Authors' elaboration based on data from World Bank. 2022. World Development Indicators. In: *World Bank*. Washington, DC. [Cited 22 June 2022]. <https://datacatalog.worldbank.org/search/dataset/0037712>

Worldwide, the enrolment rate at tertiary education for each gender is increasing, except in East and West Africa (where it is declining) and North America (where it is stable). In all the African regions, enrolment is below 25 percent compared to Latin America and the Caribbean, for example, where enrolment is at about 50 percent. In general (not surprisingly), the percentage of female enrolment is lower than that of males.

Sub-Saharan Africa has an increase in the rate of bachelor's programme enrolment for both genders. In contrast, enrolment for vocational training for both genders has declined in the past five years. The tendency is the same for the Africa Eastern and Southern, Africa Western and Central and East Africa biostrategy regions. This difference in the enrolment rates in the first two levels of tertiary education could result in a shortage in the technical youth workforce in the long term due to the different approaches in each level of education. While

persons graduating from bachelor's programmes can do technical work at an operational level, the focus of bachelor's programmes in most countries is towards supporting students to be entrepreneurs or managers, while vocational programmes provide the operational-level technical skills (Sakellaris, 2021).

Latin America and the Caribbean has quite a high enrolment rate in bachelor's programmes, for both sexes, but the enrolment rate in master's programmes is low compared with the other regions – having approximately the same rate as that of African regions, (although the Latin American economies are stronger than the African economies). The principal reason for this is the inequality in the region, where access to higher education remains a privilege for the wealthier sectors of society (UNESCO and IESALC, 2020).

In the case of doctoral programmes, enrolment rates for both sexes are significantly lower in African, Latin American, East Asian and South Asian regions compared to the rest of the regions. This could lead to less technology development in these regions, as this level of education usually prepares students to develop innovations and new technologies.

Next to insights into education, vocational education and skills training, information on intellectual capital⁴ can provide indications around the successful development of the bioeconomy in the different countries. Intellectual capital is critical for the evolution of bioeconomy (Tiron-Tudor and Nistor, 2018). Africa has a high potential to move towards bioeconomy, with ongoing successful initiatives already underway. Yet, it will likely not be able to develop the knowledge, skills and local technological solutions needed to transition towards bioeconomy at the necessary scale. This is a gap and presents great opportunities for investment into educational system across Africa, not just in formal studies but also in new training centres and innovation hubs which target solutions for the bioeconomy. South Africa for example, considers training and education for scientists, engineers and technicians along bioeconomy value-chains to be of the highest priority. The country aims to develop technopreneurs who will convert technologies into innovative bio-based products. To achieve this, the combined entrepreneurial and technological mindsets need to be nurtured through the education system early on. In Denmark, employment in the bioeconomy benefits mainly individuals who have completed a vocational training (United Federation of Danish Workers, 2015).

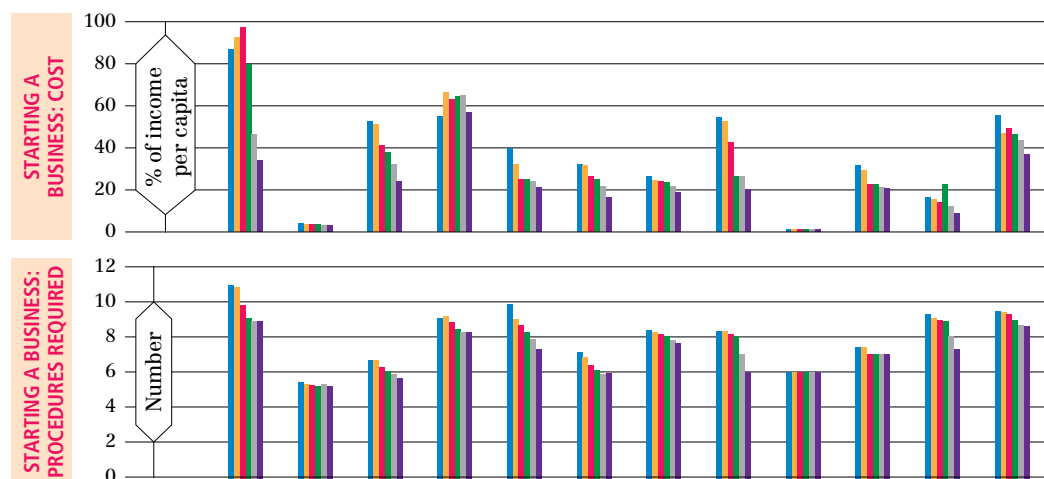
Analysis of business development indicators

For this part of the report, data on business start-up costs (per gender, as a percentage of per capita income) and the number of procedures required (in total numbers), for all the defined regions, have been analysed (see Figure A7). Here it is important to mention that the data used originates from the World Bank. The World Bank decided, in September 2021, to discontinue their Doing Business report (World Bank, 2021). However, the data can still provide a rough estimation of the current situation, as cost and procedures, next to regulations and laws, are the main barriers to doing business. Especially for start-ups, a significant portion of which are created by youth, high costs, unfavourable loan conditions and slow return rates are significant barriers.

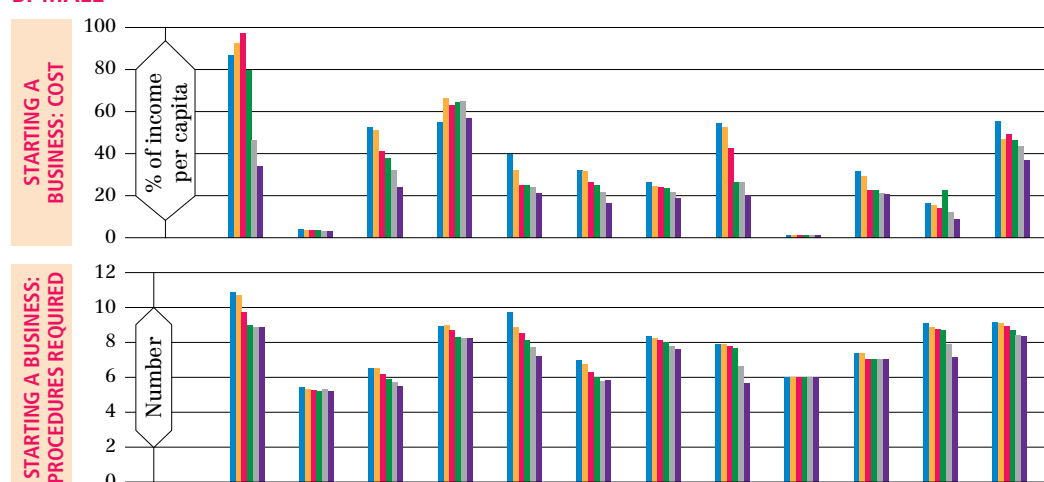
⁴ Intellectual capital comprises the knowledge, wisdom, capability and expertise that provide countries with a competitive advantage over other countries and determine a country's potential for future growth.

FIGURE A7 Business start-up costs and procedures for men and women, 2015–2020

A. FEMALE



B. MALE



Notes: Start-up costs are presented as a percentage of per capita income. Procedures required are presented as the number of procedures required.

Source: Authors' elaboration based on data from World Bank. 2022. World Development Indicators. In: *World Bank*. Washington, DC. [Cited 22 June 2022]. <https://datacatalog.worldbank.org/search/dataset/0037712>

The analysed data shows that for all world regions, except for Latin America and the Caribbean and Africa Western and Central, the costs associated with creating a new business, for women and men, have been reduced in recent years. There is no significant difference between genders in the amount of the costs involved in creating a new business. For North America and Europe and Central Asia, the cost is less than 10 percent (of per

capita income), which is linked to the small amount of procedures necessary to start a business. In Latin America and the Caribbean and Africa Western and Central, the costs have remained relatively constant in recent years, but the costs in Latin America and the Caribbean are around 50 percent less than in Africa Western and Central.). Also, around the world, the number of procedures needed to start a business has dropped in recent years. The African regions have improved the business start-up process by reducing the number of procedures required and the associated costs. However, at 25 to 55 percent of per capita income, these costs are still high and constitute a barrier, especially for young people who do not have enough starting capital. Two interesting regions with increasing opportunities for new business development are the PICs and South Asia, where business start-up costs are dropping faster than in other regions and are below 25 percent of per capita income.

Analysis of technology development indicators

Analysed indicators for technology development and exports of goods for the different regions between 2015 and 2020 (see Figure A8): PIC economies depend on the exports of agricultural raw materials; therefore, this region has a lot of potential to develop bioeconomy-based biomass production. In contrast, the investment and amount of technology development in this region is low. Additionally, this region has the potential to have risks in terms of agricultural land management and irreversible effects of climate change (McLeod *et al.*, 2019). In the East Africa bioeconomy region, agricultural raw materials are at the same level as in other regions, but food exports are quite high, at around 45 percent. There is more processing of agricultural raw materials in this region compared to other African regions. The number of patents and investment in R&D is extremely low, which could mean that processing of the raw materials is conducted in traditional manner.

The region of Latin America and the Caribbean shows a growing tendency in exporting foods and agricultural material with relatively good patent tendency, but with a decrease in R&D expenditure. This could be crucial for a region with a large surface and tropical forest area, as this positive tendency in agriculture can continue, but with a traditional focus, without the inclusion of bioeconomy innovations and sustainable development moving the countries forward towards high-income economies. Another key aspect of the Latin American and the Caribbean economies, especially in South America, is that they are highly dependent on fossil fuel production. First, the transition from fossil fuels to clean energies currently focuses on the production of biofuels. As such, biomass production for this industry will be relevant in this region (LatAm Investor, 2021). Secondly, the bioeconomy could end dependency on oil and support the transition towards a more sustainable economy.

FIGURE A8 Technology development and exports of goods by region, 2015–2020

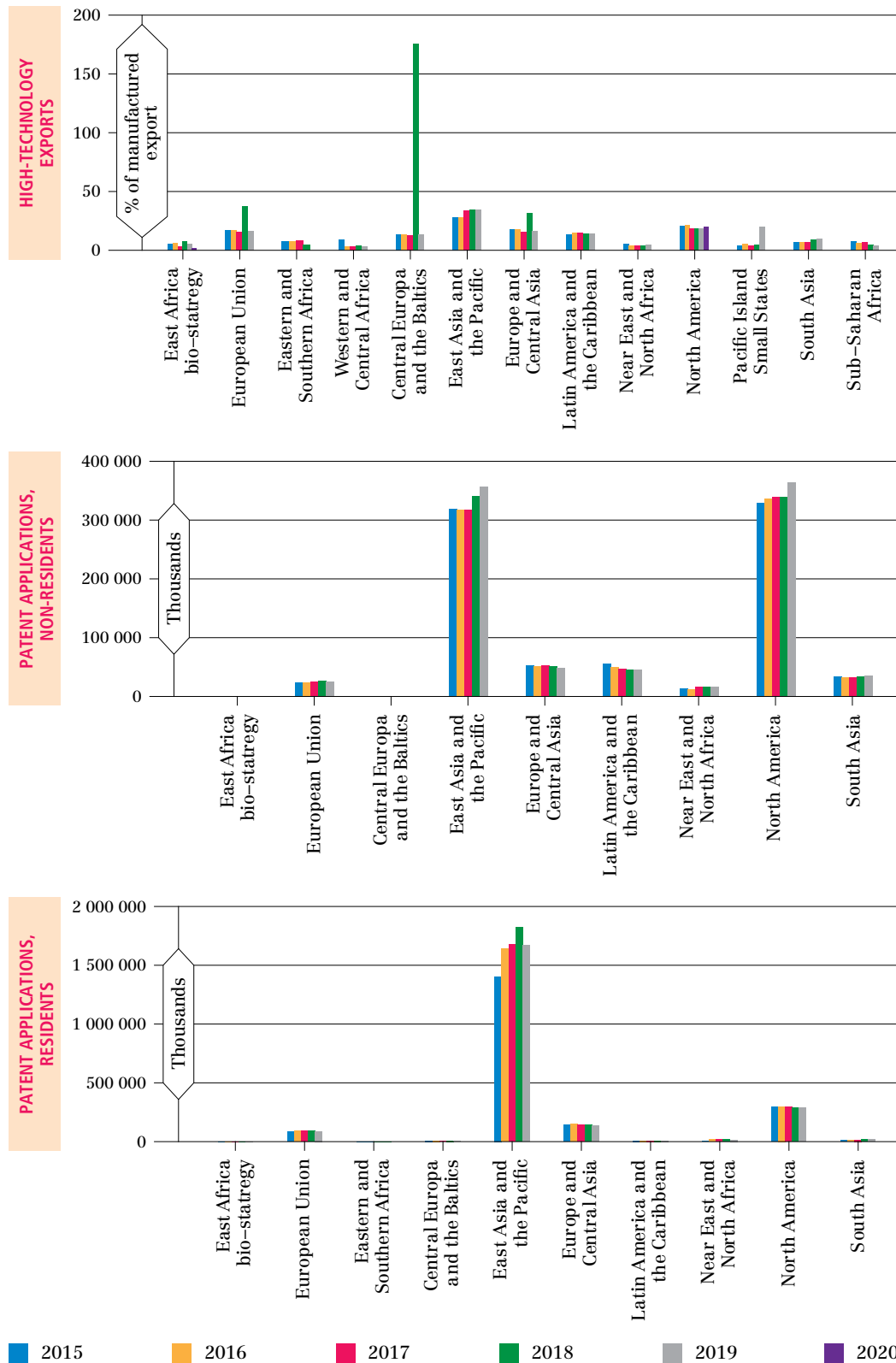
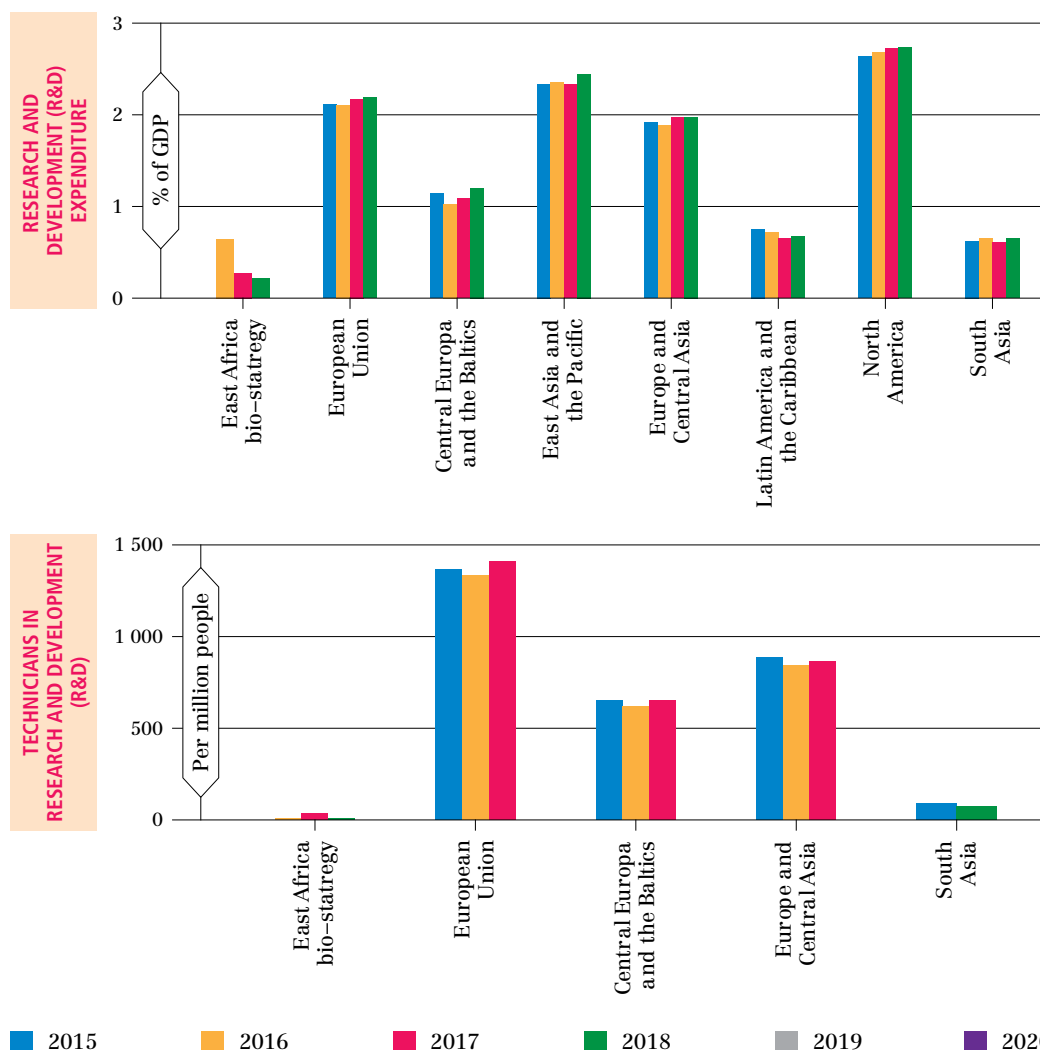


FIGURE A8 (cont.) Technology development and exports of goods by region, 2015–2020



Source: Authors' elaboration based on data from World Bank. 2022. World Development Indicators. In: *World Bank*. Washington, DC. [Cited 22 June 2022]. <https://datacatalog.worldbank.org/search/dataset/0037712>

Analysed indicators on patents, R&D expenditure and employment: The greatest barrier to innovation development exists in countries where the scientific capacity is weak. In order to promote innovations, it is recommended to substantially and purposefully strengthen the capacity of national scientific institutions in the production of bioeconomy products. Table A5 shows a comparison of various countries and the relation of their gross domestic expenditure on research and development to bioeconomy-related publications and employment of researchers (DST South Africa, 2013). There is a direct relationship with higher gross domestic expenditure on research and development and new knowledge creation efficiency, this is important as transitioning to a bioeconomy is knowledge intensive and requires a high level of research and technical skills as well as non-scientific skills, such as business skills, legal and regulatory expertise, and knowledge of financing and patenting, which are equally important in equipping the growing youth workforce with the needed skills for the bioeconomy (see Table A5).

◆ **TABLE A5** Indicators relevant to bioeconomy technology development potential (selected countries)

Indicator	Australia	Brazil	Cuba	India	Malaysia	Singapore	South Africa
Total full-time employment researchers (per million)	73 173 (4 224)	133 266 (694)	5 525 (493)	154 827 (137)	9 694 (372)	27 301 (6 088)	19 320 (393)
Bioeconomy-related publications	17 813	17 792	451	14 674	1 128	2 411	3 306
Gross domestic expenditure on research and development as a percentage of gross domestic product (%)	2.06	1.1	0.44	0.8	0.64	2.52	0.93

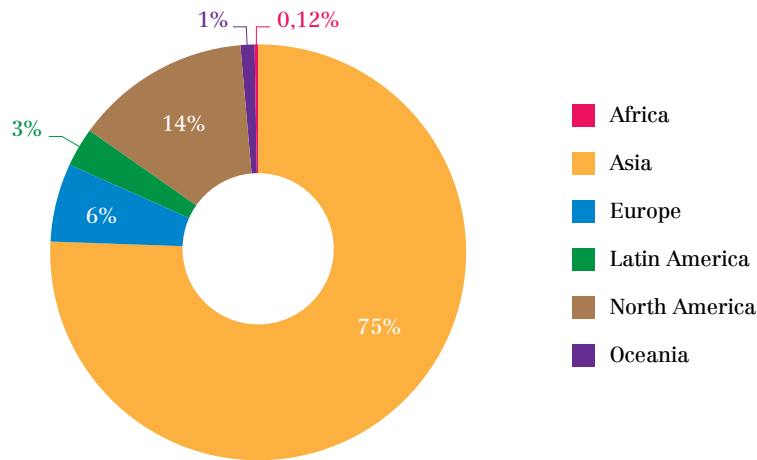
Source: Authors' elaboration based on data from DST (Department of Science and Technology). 2013. *The Bio-economy Strategy*. Johannesburg. [Cited 24 June 2022]. www.dst.gov.za

Figure A9 shows the share of each world zone regarding the number of published patents related to bioeconomy between 2015 and 2020.⁵ By far, Asia leads in the number of patents related to bioeconomy, with 75 percent of the global total. In contrast, Africa has the lowest amount in the world, despite the potential population and land-related advantages.

In Asia, Europe and North America the biggest proportion of patents are in the energy field, with approximately 45 percent (see Figure A10). In contrast, in Africa and Latin America, fine organic chemistry (which focuses on the use of deoxyribonucleic acid, ribonucleic acid sugars, natural products, proteins and steroids, among others) is the predominant technology. This is particularly interesting for these regions due their own biodiversity, giving them the capability to develop new bioeconomy technologies. In Oceania, another region with huge biodiversity, the focus is on developing new genetic-modification technologies, based on different plants, insects and microorganisms or using natural microorganisms and complex microbial communities. Food chemistry patents, which include agricultural developments and processed food, are in 3rd or 4th place in all the regions (WIPO, 2022).

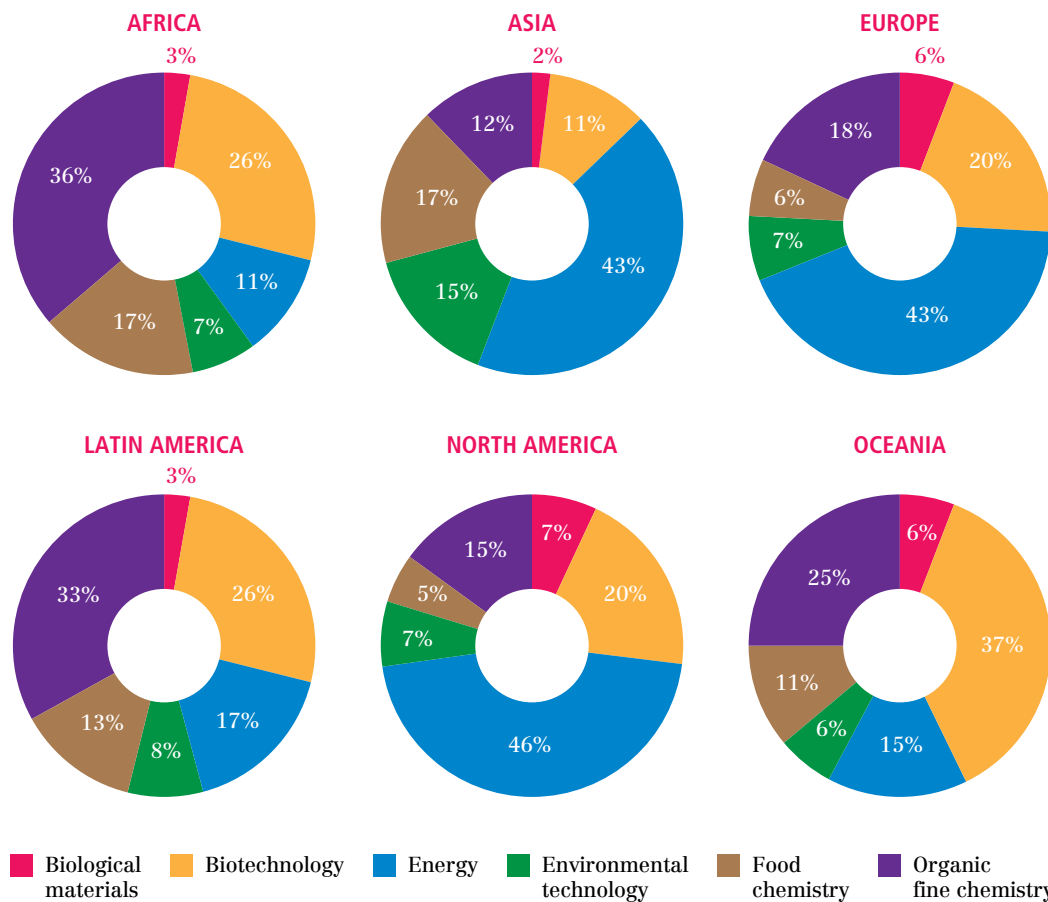
⁵ The percentage of shares is calculated by adding the number of published patents in the fields of biological materials, biotechnology, energy, environmental technology, food chemistry and fine organic chemistry in the time window from 2015 to 2020 per zone and dividing by the total number of patents.

◆ **FIGURE A9** Percentage of bioeconomy-related patents by region, 2015–2020



Source: Authors' elaboration based on data from PATENTSCOPE. In: *World Intellectual Property Organization*. [Cited 26 June 2022]. <https://patentscope.wipo.int/search/en/search.jsf>

◆ **FIGURE A10** Percentage of patents by bioeconomy-related technology by region, 2015–2020



Source: Authors' elaboration based on data from PATENTSCOPE. In: *World Intellectual Property Organization*. [Cited 26 June 2022]. <https://patentscope.wipo.int/search/en/search.jsf>

Increased competition between food, energy and the environment, which could result from an accelerating bioeconomy, can be an opportunity to further push innovations for more efficient use of land, biomass and other resources. However, such competition can also increase imports of biomass, especially raw materials, and can have environmental costs, something which is already occurring in some countries such as Japan and the Kingdom of the Netherlands. This highlights the importance of critical and comprehensive sustainability assessments in any bioeconomy-related innovation.

In order to foster youth employment in the first place, educational systems must encourage innovation – consistently, throughout all levels of education, beginning at preschool, and must provide access to other resources that would support students’ innovation capacity (United Nations, 2020). Only when local youth capacity is supported, can relevant, affordable, accessible and sustainable technological developments be made – and, ultimately, youth job development encouraged.

This report provides a comprehensive analysis of key challenges and barriers to achieving greater youth inclusion in the bioeconomy. The analysis covers key factors (push/pull factors) that impact youth employment and entrepreneurship opportunities, such as education, vocational training, skills building, technology and business development. It also underscores the significance of considering economic development opportunities, rural–urban dynamics, and sustainable resource management, when implementing policies.

The study assesses the youth inclusiveness of current bioeconomy strategies and related policies and identifies six policy goals and how they need to be addressed for greater youth inclusion. Additionally, the report assesses specific youth employment opportunities and challenges in different sectors of the bioeconomy and provides a specific set of recommendations to support youth participation in the bioeconomy.

Finally, the report provides generic recommendations for better youth inclusion and support in the bioeconomy. Overall, the report concludes that the bioeconomy offers considerable opportunities and is attractive to youth, but more needs to be done to support youth entrepreneurship and employment in the sector.

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