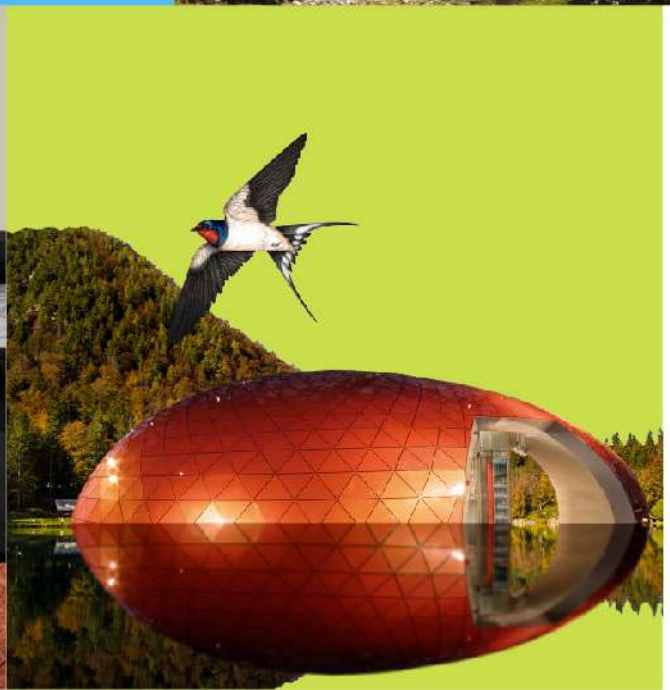
BIOEAST FORESIGHT EXERCISE

Sustainable Bioeconomies towards **2050**



MINISTRY OF AGRICULTURE

BIO east

The Central and Eastern European Initiative for Knowledge-based Agriculture, Forestry and Aquaculture in the Bioeconomy (BIOEAST) organised this special report by a group of independent experts. The views expressed are the collective work of the group, and do not necessarily reflect those of any individuals, of BIOEAST, of the Hungarian Ministry of Agriculture or of the European Commission.

In addition, the authors wish to thank for their assistance from the BIOEAST Foresight Task Force: Ákos Kristóf, Zsófia Kunya, Valéria Csonka, Krisztina Anett Szabó, Stanislav Hronček, Jana Hreňová, Argo Peepson, Marco Antonio Segovia Bifarini, Mario Plešej as well as to Barna Kovács, Secretary General of the BIOEAST Initiative.

A special thanks to numerous BIOEAST Foresight Exercise related national and international workshops participants and to the BIOEAST Governing Board, which have contributed and provided feedback at all stages of the work.

Design: Margarita Mitrovic

Proofreading: Justi Carey

Contacts:

Ministry of Agriculture of Hungary: Ákos Kristóf, akos.kristof@am.gov.hu

BIOEAST Initiative: Barna Kovács PhD, barna.kovacs@mfa.gov.hu

ISBN 978-615-5673-64-1

The report was financed by the European Commission's Horizon 2020 project Grant Agreement No. 862699, BIOEASTsUP.

BIOEAST Foresight Exercise

Sustainable Bioeconomies towards 2050

Ladeja Godina Košir MSc (Chair)

George Sakellaris PhD

József Popp PhD

Malgorzata Zimniewska PhD

Rando Värnik PhD

2021

Table of contents

Foreword

> ***"One only sees what one looks for. One only looks for what one knows."***
>
> — Goethe

2020 and 2021 have been exceptional years. Humanity has had a glimpse of disaster. It could have been avoided or at least mitigated, if knowledge which was readily available had been widely applied. These two years could also be seen as a demarcation point in time, for looking back 30 years and looking ahead 30 years. For someone who lived in Central and Eastern Europe 30 years ago, looking ahead towards 2050 can be especially challenging. It can be seen that in-depth systemic changes are needed once again. The sustainability transition will rewrite the current system; the global order should be rethought, and new structures must be developed. In these parts of Europe, the past 30 years have been spent on understanding the new political and socio-economic system in the making; 15 years ago a new policy context arose with EU accession, and now we are repeatedly facing enormous changes.

The past defines the present, leaving room for decisions which will influence the future. Looking back and ahead is not enough; we must have knowledge to be able to see. A foresight exercise can help decision-makers to choose viable paths for the way forward. It is important to emphasize that we can still develop foresight exercises; we can still think in terms of choices, we can still consider various pathways. However, it is also clear that the pathways offered by global foresight exercises 30 years ago as compared to those of today are significantly different, as the number of choices has shrunk and the urgency of decision-making is unquestionable.

Within the framework of the BIOEAST Initiative, the Central and Eastern European countries set up a government-level cooperation to develop sustainable bioeconomies and knowledge-based agriculture, forestry and fisheries. It is an extremely difficult process to design and implement systemic changes, when some parts of society have suffered from the previous transition and are still struggling to adapt to a rapidly altering environment. The sustainable transition of the BIOEAST countries requires special attention, and above all knowledge to see the available pathways.

The BIOEAST Foresight Exercise was developed in 2020-2021, on the edge of these challenging times. The task was to build on the ongoing European and global reports and to deliver new insights into possible reforms in the development of macro-regional economies. The aim is not only to give guidance to national policy makers, but also to identify special challenges that the macro-region might face, with the ultimate aim of contributing to the BIOEAST Strategic Research and Innovation Agenda. The Hungarian Ministry of Agriculture contracted five high-level independent experts within the framework of the Horizon 2020 coordination and support action BIOEASTsUP. The foresight exercise was driven by these experts.

It is my pleasure to present you with the results of this exercise. It was carried out during an unprecedentedly challenging time, when international travel was banned and lockdowns did not allow physical meetings. Despite these difficult circumstances, the dedicated group of experts from five different countries managed to engage relevant stakeholders from 11 BIOEAST countries, including among others a few European specialists, in a truly participatory process. The experts managed to bring together a common understanding of how to develop sustainable bioeconomies, identifying the priority needs for the countries of the BIOEAST macro-region. Their views will serve as a background to further discussions within the framework of the BIOEAST governance; the ministries will reflect on the findings of the report, and the Advisory Council of the BIOEAST Initiative will give its opinion. All these reflections should help to better prepare national and European policy decisions.

New insights are also offered by this exercise. Through developing different scenarios, the experts make current perceptions about the future tangible. Having in mind the targets for 2050, they look back from there to what the BIOEAST countries should do now. The aim was clearly not to guess or to predict the future, but to show what can be lost if we do not act in due time. Based on these insights, it becomes apparent that we do not have any more time to postpone decisions; the sustainable and circular bioeconomy should shape the new socio-economic paradigm. The political context, regardless of its ideological orientations, should consider stepping into the sustainable valorization of the available biomass. The biomass potential in the BIOEAST macro-region could open new opportunities for a sustainable future. The competitive advantages can only be exploited if the valorization process is based on education, research and innovation.

Substantial education, research and innovation investment through special bioeconomy programmes will be required to strengthen and support a dynamic rural-urban transformation and to promote responsible investments, having in mind the role of transformative approaches. The countries in the BIOEAST macro-region should shift the paradigm and foster multi-sectoral approaches. These should connect the use of biological resources, food system thinking, and new circular business models and their governance with the aim of building up national systems for the sustainable valorization of the available biomass, which in turn will benefit all society.

In the East, we have recent experience in adopting to major systemic changes, while in the West there is in-depth scientific knowledge, based on which one can see what one looks for. We should combine our forces for the benefit of future generations. European programmes have a major role to play in translating the knowledge and in bringing it closer to that which we wish to see.

Barna Kovács

Secretary General, BIOEAST Initiative

A message from the future (2050)

Dear Friends,

Here we are – in 2050. Our BIOEAST team still remembers our (mostly virtual) discussions with a variety of stakeholders back in 2021, in a year when both the climate crisis and the Covid crisis were high on the global agenda and greatly affecting our daily lives. Back then we were quite puzzled as how to connect the right dots and save not only our Planet Earth, but also our society. As team members, we are now looking back to those challenging times as retired seniors, grateful to enjoy most of our precious time with our grandchildren. Living and working in the BIOEAST countries for more than seven decades is giving us, the authors of this message, the opportunity for a unique "regional introspection".

Back in 2021 the European Green Deal, the Circular Economy Action Plan, the Bioeconomy Strategy, and other related strategies highlighted the importance of a sustainable, circular bioeconomy. The Green Recovery programme was considered as a kind of framework for decision-makers, while SDGs presented the global commitment to be respected and the goals to be achieved by 2030. "Build back better" was the motto of economic and social recovery, but in the subsequent years we realized that only radical systemic change can lead to a prosperous future. Mother Nature reminded us that we, humans, are nothing more than part of nature – we have experienced natural disasters, migrations, millions of deaths, shortages of water and food, diseases, extinction of animal species, loss of biodiversity, and more.

It was not an easy period for the Planet, nor for the BIOEAST region. The economic, environmental and social development that was achieved between 1990 and 2021 in our region was seriously challenged. We found ourselves at a crossroads back then – whether to accomplish a full bioeconomy by focusing on climate change, innovation, consumer behaviour, education and governance to co-create new development scenarios, or to continue business as usual, based on industries driven by fossil fuels. As you know, multinational companies were getting stronger every year and governance was more or less in their hands. National governments, as well as many other institutions, were losing their credibility and power.

Luckily, citizens around the globe strengthened their voices, and used the power of (primarily social) media and digitalization to turn the wheel. A bottom-up approach magically found a link with top-down management. A kind of "global network governance" took place and a growing number of states began to respect their commitments and adjust their laws and taxation systems in such a way as to protect natural and human capital, no longer prioritizing financial systems. Externalities were taken into account and "business as usual" was no longer profitable. A green, circular bioeconomy, based on the principle of "not leaving anyone behind" finally became our reality. But losses were severe and many species were lost forever; degraded land will need decades to recover; and health costs related to pollution and the dominance of the fossil fuel sector are still a burden on our national and global budgets. Jobs that we could not even imagine back in 2021 are flourishing, and many of those which were most respected have almost disappeared. Thanks to the reinvented education system, not only our grandchildren, but all generations have access to valuable knowledge via lifelong learning programmes and certifications, which enable us, as a society, to be creative and innovative, to co-create and transfer knowledge in the most effective way.

Back in 2021 we were aware of the potential a circular bioeconomy development direction could bring to our BIOEAST region. We understood it as a tool to achieve climate neutrality. For example, we questioned ourselves about how to use biomass for the production of renewable carbon to replace fossil carbon. Regardless of whether we had specialized producers of biomass in the country or not, we were in favour of the modernization of the primary sector to increase productivity. What we had been lacking was professional governance and a socio-economic ecosystem focused on value-added creation. We were challenged by the major question of how to use biomass: as renewable carbon for low or high value-added products, as a carbon sink in material, or as a provision for ecosystem services. Technologies were locked in, so new concepts of value-added production were also part of the story to be introduced to BIOEAST countries.

What we have been strongly promoting was radical collaboration between the BIOEAST countries, the sharing of knowledge and linked technological development, and the implementation of new, circular business models. Interestingly enough, at that time the reuse of waste was more costly than landfill, which mostly led to incineration instead of the recovery and reuse of valuable (waste) resources. We needed more than a decade to realize that less production and less consumption, as well as a focus on maintaining value for as long as possible, is the first step towards a thriving economy and society. Once investors began to go for green, circular biosolutions, recognizing the benefits of such decisions, serious economic transformation took place. Private-public partnerships began to flourish and the future began to look brighter. Attitudes towards nature have changed radically and more and more people have begun to learn how to grow their food in a sustainable way. We have managed to develop a resilient regional agricultural system in the past three decades, which is of crucial importance for our independence and wellbeing.

Today, cities and rural areas in the BIOEAST region are well connected and intergenerational collaboration is giving amazing results – people living purposeful lives in urban and in rural areas; a healthy environment contributing to a higher quality of life; digitalization and AI enabling better organization of value systems at the regional level, which adds value to products and services within the BIOEAST region, making it one of the leading regions in the EU and an example of “best practice” of regional governance at the global level. Due to our well-preserved, very diversified nature the region is becoming more and more attractive to live and work in.

For us, members of the BIOEAST team, there could be nothing more rewarding than looking at our grandchildren here and now, in 2050, growing up in this thriving environment. Who could have imagined the BIOEAST to be such a prosperous region while working on the Foresight Exercise during the pandemic times of 2021! We would like to thank you all for imagining the future in bright colours, and for courageously following our shared dreams.

With love and gratitude,

Expert Group, BIOEAST Foresight Exercise

Executive Summary

A foresight exercise involves future-oriented awareness and planning in order to respond quickly and effectively to future threats and opportunities. Basically, it is a qualitative, multiple holistic case study based on foundational investigation and opinion-based data collection and practice. The two major elements of a foresight exercise are the location and the domain, and in this particular case the foresight was carried out on the bioeconomy perspectives in the BIOEAST macro-region, in line with the implementation of the vision up to 2030, and aiming to support the Member States in developing their sustainable bioeconomies to benefit not only from their similarities, but also their differences, at all levels. At the same time, the broader EU and global context needs to be taken into consideration, investigating the special characteristics of the macro-regional deployment of the bioeconomy, specific needs, and potential through possible scenarios.

In order to set and analyze the perspectives of a sustainable bioeconomy in the region, the first steps of this document describe the current situation. Critical data are collected and the current situation is analyzed from the economic, environmental and social viewpoints. The report focuses on four main areas: 1) Sustainable natural resources, particularly soils and water; 2) A sharing economy in the context of the sustainable food system; 3) Renewable carbon use and decarbonization pathways; and 4) Governance in the context of circular and sustainable pathways.

The opportunities for the growth of a bioeconomy, including a circular bioeconomy, in the BIOEAST region are considered in context of the European Green Deal (EGD). Global climate action and the necessity to reduce greenhouse gas emissions to zero by 2050 is a big challenge for CEE countries, and requires a revision of the current approach of their policymakers and governments in order to implement the EGD principles. This can be achieved by developing national strategies and policies coherent with the EGD goals, and preparing BIOEAST countries for a new Common Agricultural Policy. The document also addresses the circularity of the bioeconomy, as well as the necessity for developing new value chains and biomass flow to create biobased products within a closed loop in the BIOEAST countries.

The methodology of this exercise was based on collecting views and opinions from key stakeholders in all the Member States of the region, and consequently developing scenarios based on them. The opinions were collected after two rounds of workshops, organized in most of the BIOEAST countries. During the workshops questions were raised on technological, economic, social and environmental matters related to the bioeconomy, and stakeholders were involved in constructive dialogues giving their feedback and viewpoints, which reflect not only each country's particularities, but also their potential and expectations.

Based on these outcomes, four scenarios were constructed, which could equally be applicable in the BIOEAST region in a 30-year perspective. These scenarios were: 1) The case for a fully circular bioeconomy; 2) The case for a linear bioeconomy keeping elements of business development as usual; 3) The case for a traditional fossil fuel based economy; and 4) The case for a new sustainable circular bioeconomy. The four scenarios considered current dynamics, and were compared on a performance basis for the implementation of technology and innovation, environmental consideration, social inclusion, economic impact and resilience. They were analyzed in terms of how sustainable and feasible they are and exhaustively investigated in each of the four areas of interest: natural resources, food systems, decarbonization and governance. Finally, a SWOT analysis was conducted for each scenario.

Balancing a bottom-up initiative and a top-down direction is imperative for developing a sustainable bioeconomy in the BIOEAST region. This can be achieved by applying multi-level governance principles. Due to the complexity of the sustainable bioeconomy, involving as many stakeholders as possible is a pivotal task. Policymakers at all levels must take a leading and directing role, with the help of researchers to ensure that the contributions of stakeholders are considered and policymaking is science-based.

Setting a vision for a sustainable bioeconomy in the BIOEAST region is the first task. Policymakers must direct the process of adopting national sustainable bioeconomy strategies with the help of researchers and stakeholders. As the sustainable bioeconomy is multilateral by nature, overcoming the barriers between disciplines is the first step in the process. Establishing a trans-institutional organization to develop and guide the sustainable bioeconomy could be the key to reaching a sustainable bioeconomy in the BIOEAST region.

Finally, this document offers a number of critical suggestions and recommendations to be taken into consideration by the policymakers of the BIOEAST countries. The BIOEAST region has a wide innovation and deployment gap between research knowledge and biobased products compared to the old Member States. Combining digitization with the biologization of industries is the vision of our research agenda. Invention needs to move up the scale of technology readiness levels. Education in the circular bioeconomy must be transdisciplinary, including complex systems thinking. The leading European universities in the field of bioeconomy must intensify their cooperation and join forces in research, teaching, education, and innovation. They have laid the cornerstone for a "European Bioeconomy University" consortium. Universities in the BIOEAST countries have no time to waste in getting ready to cooperate with the consortium.

The role of citizens is crucial in the social acceptance of the sustainable bioeconomy across the BIOEAST region. Particular emphasis will be given to networking and awareness raising in order to encourage a sustainable transition. Open communication between all the stakeholders of the sustainable bioeconomy is also essential. Studies on the social acceptance of the sustainable bioeconomy across the BIOEAST region can accelerate the transition. This study certainly provides food for thought: serving good food is not an option, it is an obligation. Furthermore, reliable databases involving all stakeholders are needed to measure the size of the bioeconomy (how and what to measure?), and research is required to give an objective answer to the widespread question: How do we manage the competitiveness issue between food and non-food outputs from biomass (by sustainable intensification, for example)?

Due to the high complexity and interdependence between the different sectors and stakeholders engaged in the circular bioeconomy transition, the government should primarily focus on inter-ministerial collaboration and harmonized regulation. Education of policymakers is a key area of intervention. The implementation of a successful circular bioeconomy transition is not possible without collaboration. In addition to a conventional public governance network, network governance is also essential. Environmental agencies and forestry chambers can contribute to a successful circular bioeconomy transition by boosting their role as communicators to the general public and the government. Businesses are crucial actors in the implementation of breakthrough technologies and other biobased solutions in biobased markets.

1 From foresight exercise to mindset shift

1.1 Bridging the gap on the path towards climate neutrality

Do you feel the gap between the bio- and circular economies? Too often we still view them as separate concepts, each having its own action plans, reports, guidelines, and so on. But the Green Deal is introducing the ambition for Europe to become the first climate-neutral continent by 2050, and this is not possible without a clear and aligned systemic approach towards the demanding transition needed to achieve this ambition. Climate neutrality is an ambitious objective, which requires fundamental changes to Europe's lifestyle, business operations, and societal habits overall. In this context, bridging the gap between the bio- and circular economies becomes unavoidable.

The focus of this BIOEAST Foresight Exercise report is therefore on the exploration of different scenarios that should be evaluated and elaborated further in a fruitful and constructive dialogue between decision-makers. As such, the document aims to assist and urge policymakers to shape national circular bioeconomy policies in the BIOEAST region. For this purpose, the authors of the report outline and define the parameters of the circular bioeconomy, its trends, obstacles, and potential areas of improvement. We have envisioned four circular bioeconomy development scenarios in the BIOEAST countries (BIOEAST is an interministrial initiative started by the Visegrad Group Countries: Czech Republic, Hungary, Poland, Slovakia, and joined by Bulgaria, Croatia, Latvia, Lithuania, Republic of Estonia, Romania, Slovenia) built on the already existing data and available information, and outline possible pathways which are worth further exploration.

These four scenarios form the core of this report and enable informed decision-making and the identification of prerequisite decision nodes. The scenario alternatives offer food for thought and scenario-specific notes, comments, and solutions, which can serve as the basis for developing national responses. In this way, the BIOEAST Foresight Exercise report serves as a kind of compass for politicians and public officers, but is equally informative for researchers and other relevant stakeholders. What we need for a successful green and circular transition is a radical shift in our collective mindset.

1.2 How to start connecting the dots to transform the CEE circular bioeconomy potentials into opportunities

The BIOEAST region holds a rich underlying potential for the development of an internationally competitive circular bioeconomy. But at the same time, the region is facing environmental, societal and economic challenges hindering the development of its sustainability and the fulfilment of the European targets and policies of the European Green Deal. Current ambitions are not enough – there is an urgency to push solutions and meet targets before it is too late.

According to the European Bioeconomy Strategy, the bioeconomy encompasses "the production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, feed, non-food products and bioenergy." The European Commission defines the circular economy as an economy "where the value of products, materials, and resources is maintained in the economy for as long as possible, and the generation of waste minimized, [it] is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource-efficient and competitive economy" [21]. We can see that the two concepts are aligned, and call for the creation of more synergies between them.

Climate change, in combination with the Covid crisis, is now more than ever a tangible trend that will challenge the resilience of the region, especially that of its agricultural systems. Most nations of the Western Hemisphere are currently developing circular and bioeconomy strategies, including as part of their post-pandemic green recovery programmes. Some of these strategies have constraining measures included in their structure, to regulate the bioeconomy and to address the circular economy at the same time. The Nordic countries lead by example.

What do we in the CEE countries lack? Too often we are still locked into a silo mentality, not collaborating between different ministries within government structures, and unable to establish long-term private-public partnerships to address the opportunities in an effective and impactful way. A lack of shared vision, governance, transparency, transfer of knowledge, smart use of data, research and innovation are just a few of the challenges to be properly addressed and solved. This foresight aims to offer a framework within which we can further explore how to get ready for the future by connecting the right dots.

1.3 Aim and mission – from project to action

The key activities of the BIOEAST Initiative are to develop ministerial level intergovernmental joint declarations, a common research and innovation agenda, position papers, and strategic policy advice.

The Foresight Exercise is a tool to face the challenges and to support the BIOEAST Member States in developing their bioeconomies (limited to agriculture, forestry and fresh water, and related waste management) through a macro-regional approach in the period 2030-2050. With this mission, it is not only a "project", it is actually supporting the BIOEAST Initiative to become a "moving force" of the systems transformation of CEE countries, based on the European Green Deal. While focusing on the region, we are at the same time keeping our eyes open to see what is happening around the world, and how to turn challenges into opportunities.

Because the differences in the economic growth rate, as well as in societal context, in the countries of Central-Eastern Europe and Western Europe are significant, it is necessary to adjust the policy and strategy of economic and social development to meet the European Green Deal targets for the BIOEAST countries. As a team of experts having lived and worked in these countries throughout our lives, we can share not only the outcome of the research and activities connected to this project, but also the experience gained through our careers and interactions with numerous stakeholders in the BIOEAST region.

The BIOEAST Foresight Exercise introduces scenarios for the bioeconomy to show the possible directions of change in the following areas:

- *Sustainable natural resources (mainly soil and water)*
- *Circular (sharing) economy in the context of the sustainable food system (biomass valorization)*
- *Renewable carbon use and decarbonisation*
- *Governance in the context of circular and sustainable pathways*

2 New elements of the circular bioeconomy are shaping the new socio-economic paradigm

2.1 An economic mindset fit for the 21st century

Today, we question the meaning of everything – what will our future socio-economic system look like? What are the values and metrics we want to follow? Is Gross Domestic Product (GDP) still the most relevant indicator of development? Having in mind 2050 as the year we are addressing with this exercise, we simply must leave the economic concepts created in the 1930s behind, and create new maps for navigating in the direction of sustainable, circular development.

Kate Raworth's Doughnut Economics proposes an economic mindset fit for the context and challenges of the 21st century. Rather than being a set of policies and institutions, it is a way of thinking that brings about the regenerative and distributive dynamics that this century requires. Drawing on insights from a variety of economic schools of thought – ecological, feminist, institutional, behavioural and complexity – it sets out seven ways to think like a 21st century economist to bring the world's economies into a safe and just space for humanity[8]. This is why we find this mindset "the one" to shape the future of the BIOEAST region. There are two important dimensions embedded in this model – ecological and social – and both must be considered at the global as well as the regional level (Fig 1).

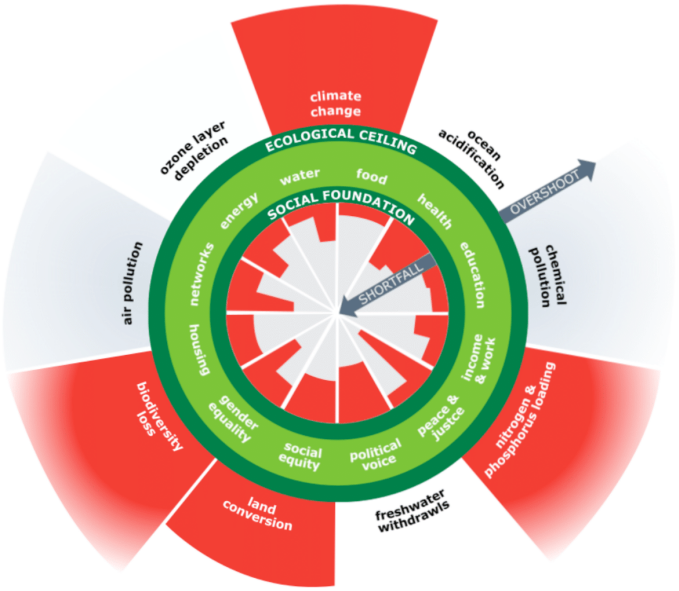


Figure 1: *Doughnut Economics model https://doughnuteconomics.org/about-doughnut-economic*

2.2 The bioeconomy and the circular economy – under the umbrella of the green economy

The green economy is generally considered to be an umbrella concept [7] and is understood to "result in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. A green economy can be defined as one which is low carbon, resource-efficient and socially inclusive" [44]. The production of food and animal feed usually involves the processing of agricultural goods and, therefore, fits into a bio-based economy.

The bioeconomy is understood as the part of the green economy (Figure 2). Generally, the bioeconomy is often more related to promoting global economic growth and technological development than purely focusing on limits to growth as a consequence of resource scarcity, depletion, and expected population growth [36]. The bioeconomy is being developed in a context where one of the main growing policy frameworks and development paradigms is the circular economy. One of the main building blocks of the European Green Deal is the Circular Economy Action Plan [17].

The BIOEAST Foresight Exercise identifies key product value chains, and maps the way for a sustainable and nurturing policy framework. Within this context it is of the utmost importance to consider the relationship between the bioeconomy and the circular economy, and the potential that lies in integrating both towards the sustainable development of the BIOEAST region, respecting the limits of growth presented in the Doughnut Economics model.

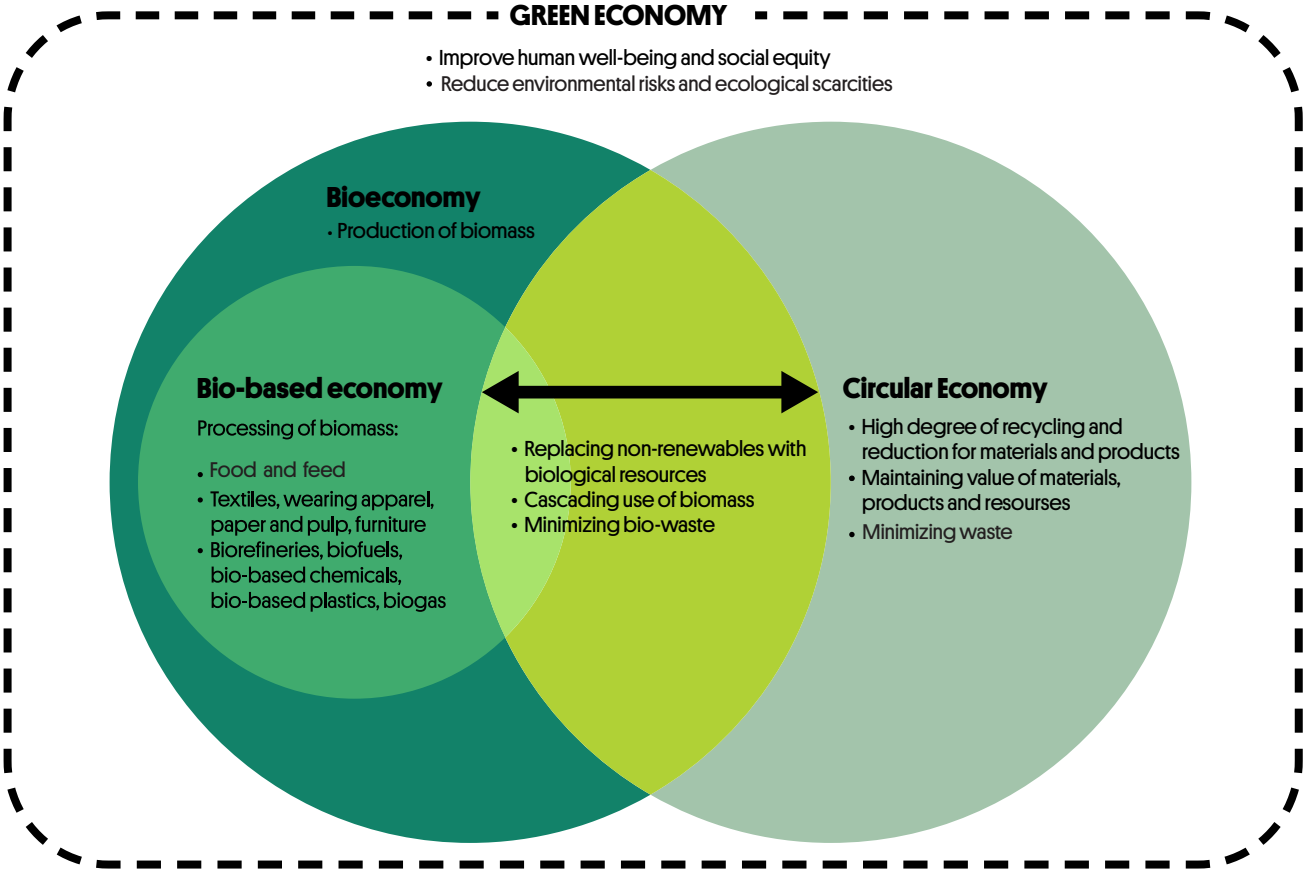


Figure 2: *Relationships between the bioeconomy,bio-based economy, green economy, and circular economy [27].*

These two narratives have both overlapping and non-inclusive areas. The bioeconomy and the circular economy are converging through time on certain paths. The bio-based economy is part of the bioeconomy and relates to the conversion of biological resources into products and materials (bio-based production). In some definitions of the bio-based economy, an emphasis is placed on innovative bio-based products such as biopolymers and bioplastics [7], while in others traditional bio-based products such as bio-based textiles, wood products, pulp, and paper are explicitly included as well [4].

The concept of circularity is not new and has been the foundation for economy-wide modelling dating back at least to the 18th century. The Ellen MacArthur Foundation (EMF), a strong supporter of the circular economy concept, defines it as "an industrial economy that is restorative or regenerative by intention and design" [9].

Basic barriers to achieving a circular economy are the existing economic model, which does not value natural capital or internalize the externalities of measures taken (e.g. to tax negative externalities and reward positive social and environmental impacts), and the lack of incentives for companies to design more circular products and use secondary raw materials. Furthermore, products, materials and substances on the EU market contain banned substances of concern because:

- *they were introduced before being banned;*
- *information which does not travel with products and materials hampers circular practices like maintenance, reuse, repair and recycling;*
- *the overload or lack of information on products complicates consumers' ability to make sustainable choices;*
- *the misalignments in EU chemicals, product and waste legislation and the presence of certain chemicals hampers efforts to recycle and reuse products;*
- *there are insufficient quality criteria for secondary materials and lack of demand for recycled materials, like plastics;*
- *the lack of common definitions for waste, and hazardous waste, hinder shipments of waste across member states;*
- *there is illegal waste burning or shipments, different levels of ambition across the EU in reducing landfills and meeting the agreed recycling targets, and an overall underdeveloped waste management infrastructure;*
- *the global market and value chains complicate policy steering at the EU level.*

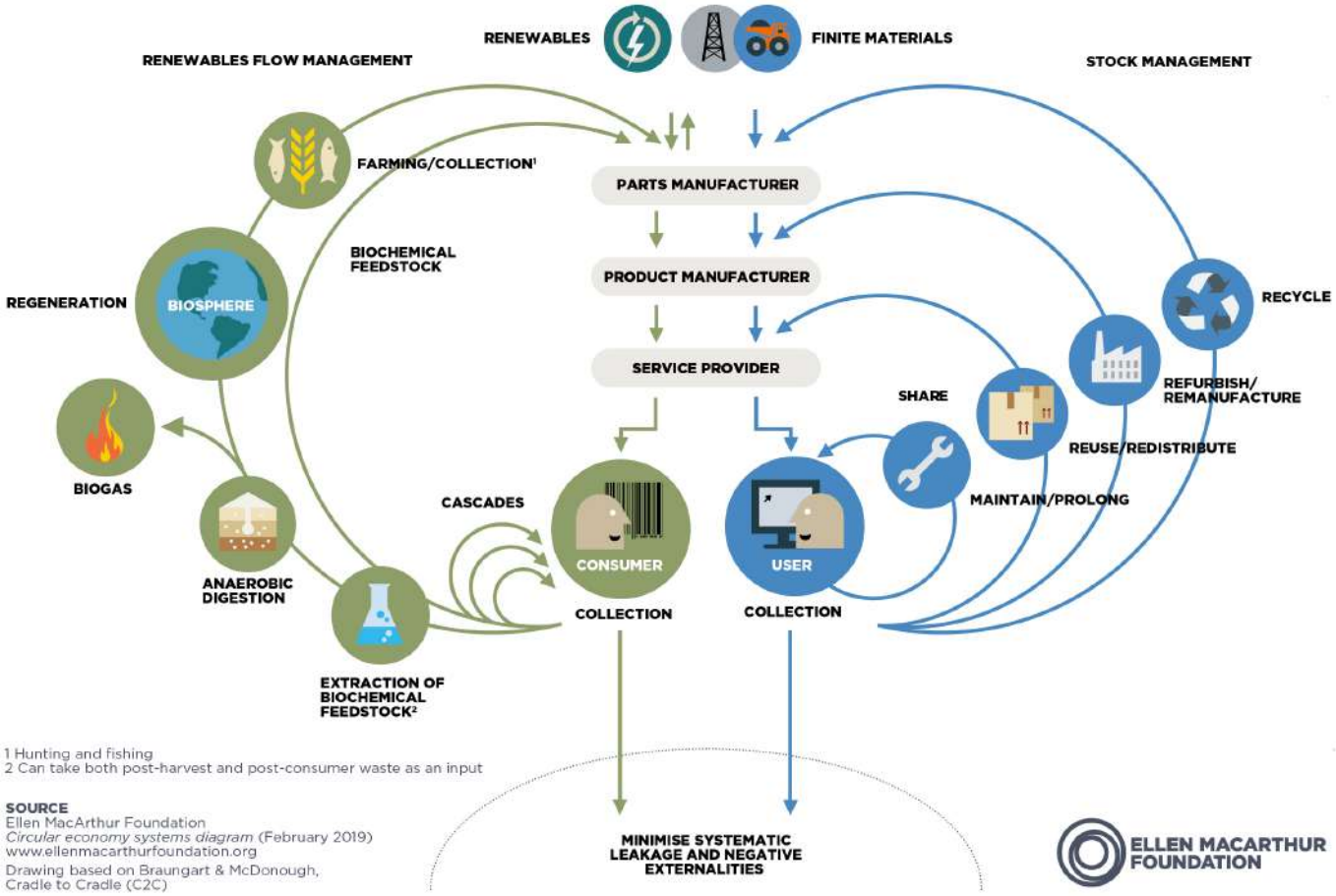


Figure 3: *Butterfly Diagram – https://www.ellenmacarthurfoundation.org/circular-economy/concept/infographic*

As the Butterfly Diagram of the EMF clearly shows, the bioeconomy corresponds to the left "wing" of the butterfly, which includes the cascade use of biomass and biorefineries, bioenergy production, and the restoration of the biosphere by returning carbon and nutrients to the soil with biobased fertilisers.

However, not all the bioeconomy is circular, since the latter also considers non-biological materials and sources, minerals and metals. Furthermore, one of the principles of the circular economy is maintaining the value of products, materials and resources in the economy for as long as possible. In certain cases, keeping the value of biobased products can be more challenging than that of metals and minerals. However, in order to be sustainable the bioeconomy should be circular [34], but there are difficulties in implementing circular value chains in some biobased sectors [4].

Their common ground lies in the following [4]:

- *Decarbonization and phase-out of fossil resources: Use of renewable sources of carbon and avoidance of fossil-based carbon with the aim of reducing GHG emissions and our carbon footprint;*
- *Valorization of waste and wastewater: This refers to biowaste and biotechnology associated with waste and wastewater treatment, which can allow the cycling of nutrients and carbon in the agrifood system and implement biorefineries;*
- *Cascading approaches and value chains: By using circular biorefineries;*
- *Resource efficiency;*
- *Nutrient cycling.*

The synergies between the bioeconomy and the circular economy concepts are significant. Several European industry associations such as CEPI (Confederation of European Paper Industries) and EuropaBio (The European Association for Bioindustries) use and support the concept of a 'circular bioeconomy', and promote greater integration of the two concepts instead of developing them in parallel [11]. The most recent effort towards bridging these two narratives was made by the EC when announcing that the Biobased Joint Undertaking Initiative will be substituted by the Circular Biobased Economy partnership.

New bioeconomy value chains have emerged, based on the increasing use of natural and renewable resources in non-food applications. A central link for these new value chains are bio-refineries, which integrate biomass conversion processes and equipment to produce transportation biofuels, power, and chemicals from biomass [26].

Can the circular bioeconomy slow down economic growth?

There are more narratives to be considered for the development of the bioeconomy, including the following [19, 45]:

- *Type 1 BE (Georgescu-Roegen) is defined as an ecological economy that is compatible with the biosphere and the economics of prudence and sharing; and is considered a strong sustainability approach.*

- *Type 2 BE (OECD (2009, 2017a, b, c) is defined as a science-based economy driven by industrial biotechnology. Here, a cell is considered as a factory and technology has the power to "correct God's mistakes". It is the economy of techno-scientific promises and is considered a very weak sustainability approach.*

- *Type 3 BE (Langeveld et al., 2010; EC, 2010, 2018) is defined as a biomass-based economy. It aims to replace fossil fuels and mining to produce energy and materials. Biorefining is at the heart of the ecological transition (multilevel perspective), but it is considered a weak sustainability approach, because the economy is working against nature. It would probably increase pressure on resources and land since it aims for the substitution of products and functions by new products (chemicals and materials).*

"The current EU narratives explicitly support the claim of the neoclassical economists that any limiting production factor can be substituted by technological innovation: "the world can, in effect, get along without natural resources" (Giampietro, 2019).

Giampietro (2019) identifies the fact that there is confusion around the conceptual definitions and interpretations of the term circular bioeconomy. More narratives are present, and the co-existence of diametrically opposite interpretations of the concept indicates a lack of serious discussion of its theoretical foundations. Using a biophysical and thermodynamic analysis, the required level of productivity of the production factors in contemporary developed economies (flows per hour of labour and per hectare of land use) are orders of magnitude larger than the pace and density of the supply and sink capacity of natural processes. This means that relying on nature to 'close the loop' will simply slow down the economic process. "Capturing this dissipated energy back into the economy inevitably slows it down, so again decoupling economic growth is impossible."

2.3 Merging elements of the circular bioeconomy into a system

We do not assume that the bioeconomy is sustainable per se; it must be developed in a sustainable way. Part of this pathway is the transition to a "circular bioeconomy". However, for this purpose its development should not advance as a separate sector, but should be mainstreamed across all sectors of the economy [1].

For better understanding of the circular bioeconomy that the BIOEAST Foresight Exercise envisions, we are introducing the Circular Bioeconomy Model (CBEM), which has been created based on the exchange of knowledge and expertise between the authors of this document, and includes the following principles and components:

PRINCIPLES OF THE CIRCULAR BIOECONOMY :

- Biomass that is derived from water and soil must be managed sustainably
- Closing the loops: circular flows should be established by harnessing the potential of biowaste and byproducts with high value from different industries
- Industrial symbiosis enhancing bio-circularity
- Fostering food security
- Implementing the use of the biomass cascade, reducing waste production
- Enhancing resilience in our economies
- Resource efficiency and value chain optimization

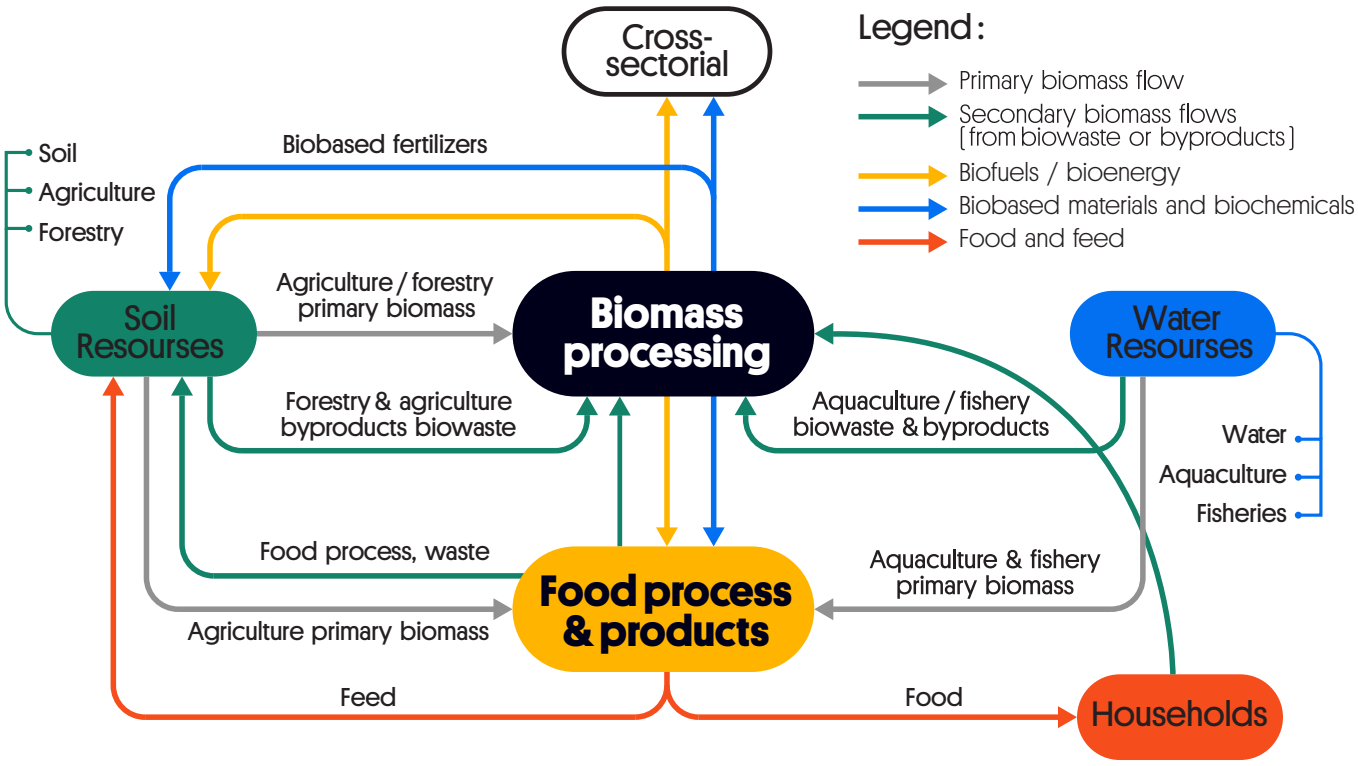


Figure 4: BIOEAST Circular Bioeconomy Model (CBEM) – the outcome of expert group interaction

The BIOEAST circular bioeconomy has two main bioresources with high potential – soil-based and water-based resources. The processing and use of the biomass delivered by water and soil creates waste biomass and byproducts which are still valuable and are crucial to the development of the circular bioeconomy.

Primary biomass resources

The soil provides us with crops and forests, while water gives us fish, algae and other water life. Primary biomass is utilized by agriculture and forestry from crops and forests, and by aquaculture and fisheries from water life. There is outstanding primary biomass potential in the region.

Agriculture, aquaculture and fisheries can add value to biomass in the form of food and feed. However, primary biomass from agriculture and forestry can be also used to produce non-food, bio-based, added value materials and energy/fuels.

Could we develop a kind of a "regional biomass network"?

This would strengthen the region and promote knowledge exchange, business, and research collaboration which could bring new ideas, projects, business models, and value chains.

Secondary biomass resources

Tapping the primary biomass potential is crucial for the development of the BIOEAST region.

However, in order to implement sustainability and circularity we must include secondary biomass flows and by doing so implement circular economy principles. Agricultural, forestry and aquaculture processes generate byproducts and biowaste. These streams should not be treated and considered as waste, but rather as valuable bioresources which can be used for different purposes:

- *Agricultural waste, manure, and waste from food and feed processing can be used to produce biobased fertiliser which cycles back the nutrients, or for further biomass processing to produce other added value biobased solutions (biobased chemicals and materials, bioenergy and biofuels);*

- *Circular aquaculture systems can use fish, algae and the biowaste from faeces to create circular biomass flows synergically;*

- *Forestry biowaste and byproducts can be exploited to make different added value products in biorefineries.*

Food waste which originates in households must also be sustainably managed; it can be used to produce biofertilizer and bioenergy/fuels.

The added value materials and energy/fuels produced by biomass processing can be used synergically by other industries, creating the potential for industrial symbiosis – a major building block of the circular bioeconomy.

Virtuous waste management practices are implemented in some BIOEAST countries, but for most of the BIOEAST countries waste management is still a challenge. In Czechia, nearly half of the waste ends up in landfill, which means lost value to the CBE. There is also a deep-rooted information asymmetry – for example, in the Estonian waste reporting system, data about biowaste as a stand-alone waste type is lacking, which hinders both research and policy-making.

Component analysis

1. Biomass resources

- *The soil gives: soil, crops, and forests*
- *Water gives: water, algae, fish and molluscs*
- *Biowaste and bio-byproducts: municipal biowaste, agrifood waste and losses, agricultural waste and losses, forestry biowaste, aquaculture biowaste, and other biowaste types generated in other sectors*

2. Transformation for adding value

- *Food and feed production*
- *Biotechnology and biorefineries*
- *Biomass processing*

3. Added value products

The biomass sources are used to produce added-value products such as:

- *Food and Feed*

  Food and feed should be sustainable and nutritious.

- *Biobased materials and biobased chemicals*

  Biomaterials have markets in a wide variety of sectors. This should be designed sustainably across the whole value chain and in agreement with the circular economy, so that they can be easily reusable, long-lasting, repairable, remanufactured and recycled, as shown in Figure 4.

  Most biomaterials are still in the early stage of product development for small niche markets. They are better than their fossil fuel counterparts not only in terms of CO_2 emission reductions, but also in terms of other relevant product qualities such as weight, toxicity and being recyclable. These include biobased polymers which are used in bioplastics and biofibres, chemicals, etc.

- *Bioenergy and biofuels*

  The production processes should also be sustainable and the resources renewable.

Within this model there are four main areas of the circular bioeconomy which the BIOEAST Foresight Exercise has focused on: the sustainable use of natural resources; a circular agrifood system; renewable carbon sources and decarbonization; and governance.

All these areas must be addressed in order to reach a circular bioeconomy that can bring resilience, added value and sustainability to the BIOEAST region. Throughout the document we map relevant trends and integrate them into the development of the foresight scenarios.

An institutional model for collaboration and innovation

In addition to the BIOEAST Circular Bioeconomy Model (CBEM), a BIOEAST institutional model that can work towards the implementation of a circular bioeconomy has been developed for this very study. It includes knowledge and collaboration exchange horizontally and vertically across the whole institutional system. Its guiding principles are connections and collaboration that can lead to synergic knowledge exchange, efficient financial flows, and policies.

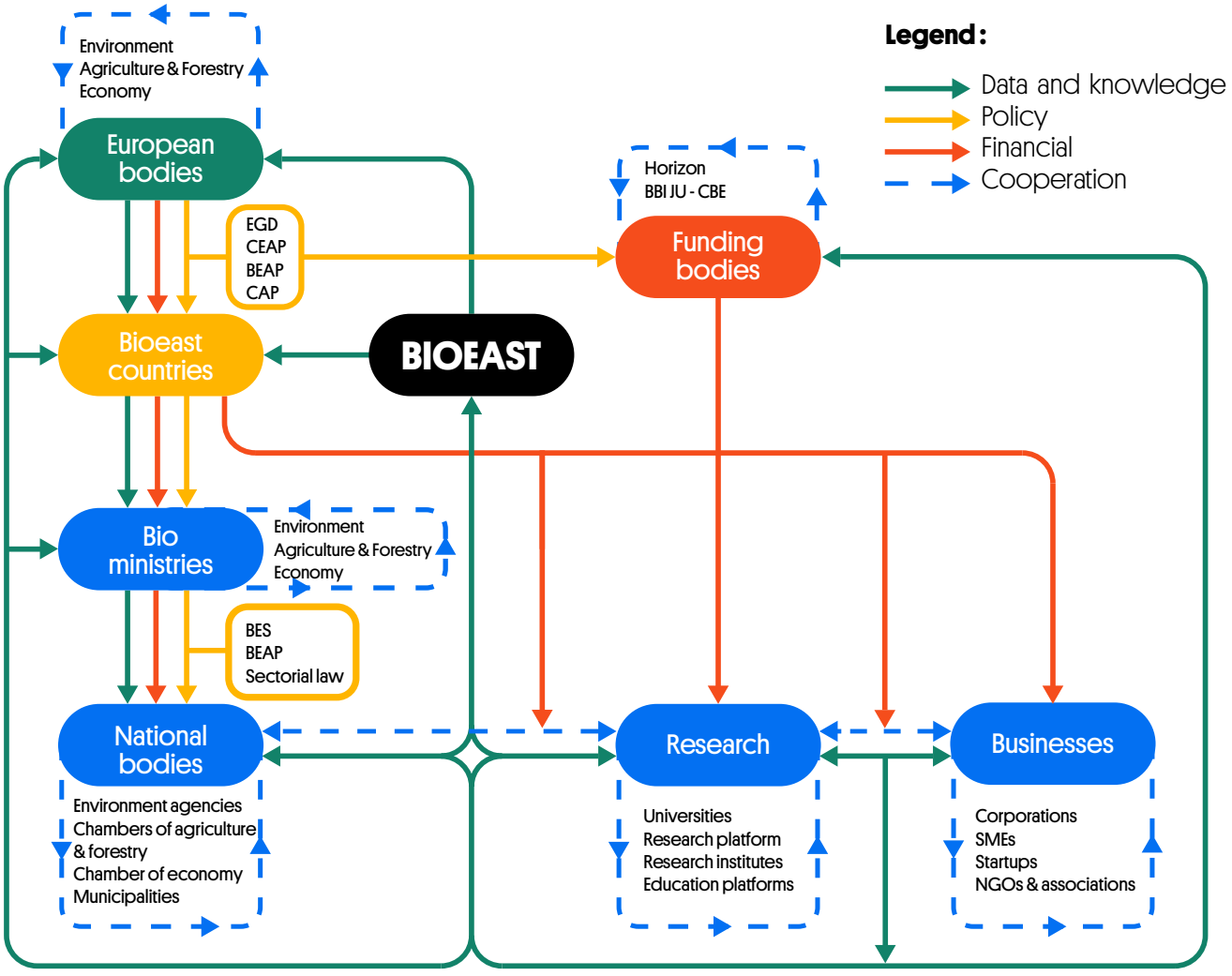


Figure 5: *BIOEAST institutional model (the outcome of BIOEAST workshops)*

Governance should connect research entities with businesses and public bodies, forming a synergic network that can help boost the circular bioeconomy. This type of ecosystem can work synergically to nurture appropriate policy-making and support the implementation of new business models as well as the so-much-needed funding frameworks. But this cannot happen without broader public interest in the issue.

Since the bioeconomy, as a part of a broader socio-economic system, is affected by different forces of change – economic, social, environmental, geopolitical, technology-related, policy-related, and crises-related (Fig 6) – only systemic thinking can lead to better understanding and management of these complex challenges. Key driving forces have different impacts on the bioeconomy. At the same time, the impact that the bioeconomy can have on these elements must also be considered.

The greater exchange and connection can help businesses identify opportunities, researchers produce more valuable research, and governments produce more effective policies.

Figure 6: *BIOEAST forces of change (the outcome of BIOEAST workshops)*

Through a two-dimensional materiality assessment based on the impact that drivers can have on the bioeconomy and the impact that the bioeconomy can have on drivers, the following classification of the driving forces of the CEE bioeconomy was developed:

1. Forces that are disruptive:

- **Loss of biological resources**
    1. *Low biodiversity*
    2. *Land consumption and land degradation*
    3. *Resource depletion and resource degradation*
    4. *Badly or unvalorized valorized biomass*
- **Climate change**
- **Macroeconomics and trends in the fossil market (including added value)**
- **Environmental, climate and bioeconomy policies and dedicated budget**
- **RDI**
    1. *Gaps in education*
    2. *Insufficient implementation of new practices and technologies in the bioeconomy areas*
- **Social**
    1. *Aging demographics of forestry and agrifood workers*
    2. *Low quality and low income bioeconomy jobs*
- **Trade, and the need for self sufficiency**

2. Forces to be observed and kept in mind: Health and well-being

3. Forces to adapt to: Digitalization and green funds from private or public (EGD and green recovery) sources

4. Other forces for the development of the BIOEAST circular bioeconomy: Shocks and pandemics, relative lack of resources compared to larger bioeconomy countries and competition, demographics and migration.

2.4 Wisely managing the “one and only” planet we have

Climate change is a particularly complex driving force in the production of biomass. On the one hand, it is a major challenge for the agricultural and forestry sectors, because climate change and more extreme weather events will affect forest and crop growth and wood production [4]. Climate change also increases the uncertainty in these sectors and can potentially cause market disruptions [2]. The development of the bioeconomy can help in phasing out fossil fuels and fossil-based products and reducing emissions, and in doing so help to meet the ambitious targets of the European Green Deal.

Furthermore, the bioeconomy offers an opportunity to develop new value chains, which could attract private and public investments in improved management practices; for example, in order to increase the resilience of forests to climate change [8], or to support the use of new breeding technologies that provide tools to develop crops that are suitable for a wide range of micro-agro climatic conditions much faster, thereby responding to climate change more effectively. Digitalization is an enabler of a more rapid transition to a circular bioeconomy.

According to how we develop and implement the bioeconomy, we can generate positive or negative environmental impacts. The areas of environmental concern of the bioeconomy have been mapped and analyzed by several studies [1,3,5]. The ones that the current study finds most relevant are the following (Fig 7):

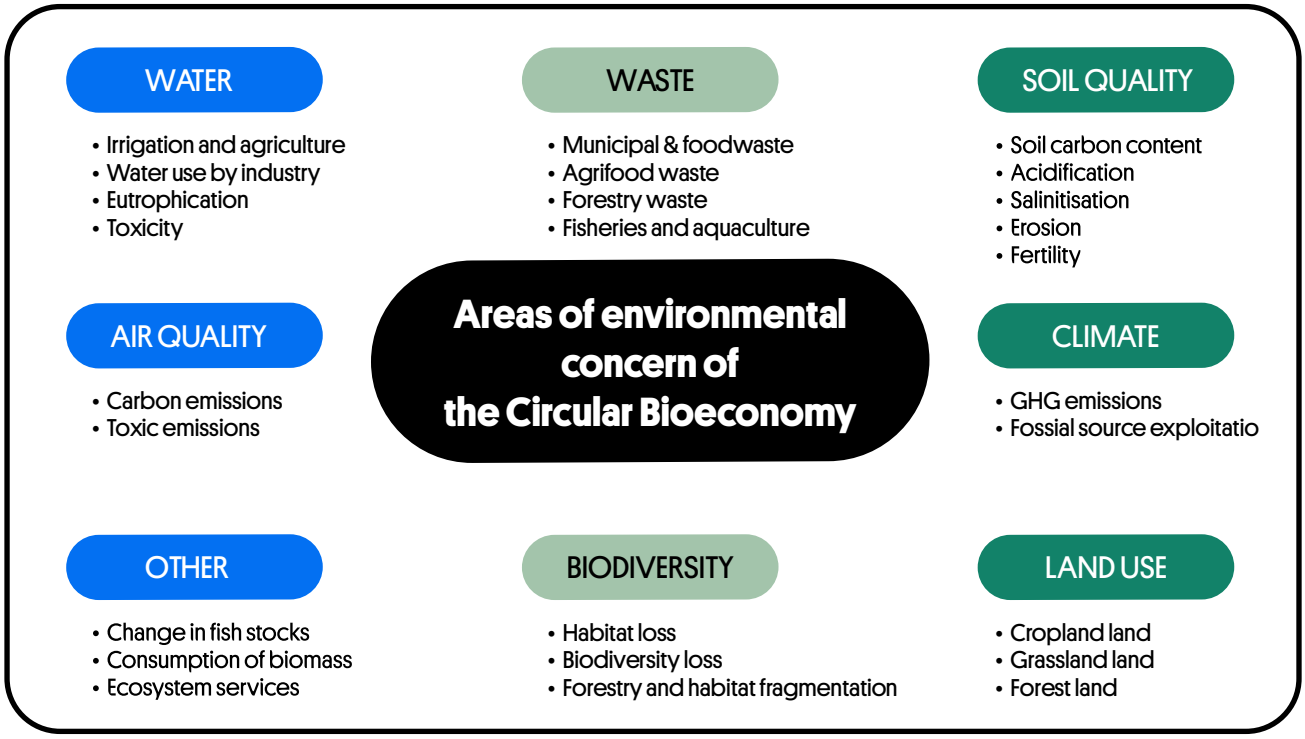


Figure 7: *Areas of environmental concern of the bioeconomy (own elaboration of Shaw and Lampen, 2020); [2]*

2.5 The underlying policy framework

The bioeconomy and the European policies

The EU's first bioeconomy strategy "Innovating for Sustainable Growth: A Bioeconomy for Europe" was adopted in 2012. It was later updated in 2018 under the title "A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment".

Eight EU Member States have adopted a national bioeconomy strategy, of which only one is a BIOEAST country (Latvia).

Latvia is currently developing a circular economy strategy in addition to its existing bioeconomy strategy. Each BIOEAST country should adopt its own strategy; however, at a national level it is crucial to coordinate circular and bioeconomy strategies for sustainable development, and to have an inter-ministerial approach to synchronize the two processes and make them efficient and effective.

The EU Bioeconomy Action Plan followed the strategy with the aim of developing local bioeconomies across Europe, and understanding the ecological boundaries of the bioeconomy. The action plan includes the following goals:

- *€2 trillion in annual turnover*
- *Over 18 million people employed in the EU Bioeconomy*
- *€621 billion added value*
- *4.2% of the EU's GDP to be biobased*
- *1 million new green jobs by 2030*

The Circular Bioeconomy is an enormous opportunity for the growth of the BIOEAST region, but to harness the potential we need a systemic approach. Policy-making in BIOEAST countries tends to be conservative, which hinders the transition to a contemporary bioeconomy. There is a widespread belief that the status quo is fine, as long as bioresource use – particularly the forests – is reduced. Perhaps overcoming this hurdle is the greatest issue for the CEE bioeconomy, because creating a truly sustainable bioeconomy requires the transformation of nearly all aspects of it.

The Bioeconomy and the European Green Deal

The European Green Deal (EGD) is one of the most recent and significant strategies guiding the present and future of the EU. "It aims to transform the EU into a modern, resource-efficient and competitive economy where climate and environmental challenges are addressed and turned into opportunities, while making the transition just and inclusive for all." [4]

The strategy confirms Europe's commitment to global climate action and to presenting a vision that can lead to achieving net-zero greenhouse gas emissions by 2050. The BIOEAST countries must develop national strategies and policies that create a bioeconomy that is coherent with the EGD goals.

A document of significant importance for the implementation of the Green Deal has been introduced by Systemiq and the Club of Rome: "A System Change Compass" offers valuable guidelines for a successful recovery and the much-needed systemic transition: "Without a clear compass steering the continent in the direction of a strong EGD, the ship will not be prepared for nor resilient to the expected turbulence from social, ecological and health shocks". Among the Compass Principles introduced can be found "Redefining natural resource use: prosperity decoupled from natural resource use" and "Redefining incentives: introducing the real value of social and natural capital", as well as other principles addressing the drivers and pressures of our economic system. Special attention is given to Healthy food – the ecosystem encompassing the whole lifespan of food – from its production to end of life.

Goals towards 2030 and 2050

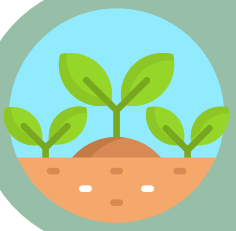
The EGD, together with the EU Biodiversity Strategy and the Circular Economy Action Plan, has set goals to reach by 2030. The latter, alongside the EU Farm to Fork Strategy, the EU Climate Pact and the EU Methane Strategy, has set goals to reach by 2050.

These goals are just the beginning. Fair, ambitious objectives and strategic steps will be made by the EU.

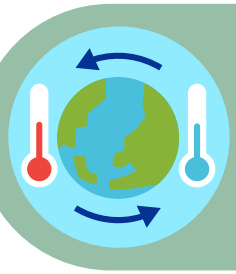
2030

- *Legally protect a minimum of 30% of the EU's land area and 30% of the EU's sea area*
- *Integrate ecological corridors, as part of a true Trans-European Nature Network*
- *Give 3-10% of the land area strict limits that leave "natural processes essentially undisturbed"*
- *Strictly protect at least 1/3 of the EU's protected areas, including primary and old-growth forests*
- *3 billion new trees to be planted in the EU, in full respect of ecological principles*
- *At least 25,000 km of free-flowing rivers to be restored*
- *A minimum of 10% of agricultural land under high-diversity landscape features*
- *A minimum of 25% of agricultural land under organic farming management*
- *Increased implementation of agroecological practices*

- *Food waste reduced by 50% by 2030*
- *All packaging to be reusable or recyclable in an economically viable way*
- *All plastic packaging recyclable by 2030*
- *Residual Municipal Solid Waste (MSW) reduced by 50%*
- *65% recycling of MSW*
- *70% recycling of packaging waste*
    1. *85% paper and cardboard*
    2. *55% plastics*
    3. *30% wood*
- *A maximum of 10% of MSW diverted to landfill (2035)*



- *50% reduction of use and risk of pesticides*
- *A minimum of 20% less fertilizer use*
- *50% reduction in sales of antimicrobials for agriculture and aquaculture*
- *25% of total farmland is organic*
- *Nutrient losses reduced by a minimum of 50%*



- *Climate neutrality*
- *GHG emissions reduced by 55%*

2050

- *CH4 emissions reduced by 50%*

The Bioeconomy and the Circular Economy Action Plan (CEAP)

The CEAP explicitly addresses the sourcing, labelling and use of biobased plastics.

Biobased materials are otherwise not mentioned; nonetheless, circularity must be integrated into their design and value chains. The CEAP clearly addresses key value chains where biobased products are being used or for which they can be developed in the future: electronics and ICT, packaging, plastics, textiles, construction and buildings.

The document also addresses "food, water and nutrients", a key element of the bioeconomy.

Two other guiding binaries are the decoupling of economic growth from resource use, and resource efficiency.

A key question for BIOEAST countries: How circular is our bioeconomy and our biobased products? How can we develop this?

The Bioeconomy and the new Common Agricultural Policy (CAP)

The future CAP that is being developed by the EC takes the bioeconomy into account in its structure, and establishes 9 common specific objectives: ensure a fair income for farmers; increase competitiveness; rebalance the power in the food chain; climate change action; environmental care; the preservation of landscapes and biodiversity; support for generational renewal; fostering of vibrant rural areas; and protection of food and health quality. The budget allocation of the new CAP for the period 2021-2027 will direct 40% of it to climate change objectives.

There will be a new delivery model that is more flexible and more coherent with the environmental legislation. A key question to drive policies: How are BIOEAST countries preparing for the new CAP?

The Bioeconomy and the changes in the BBI-JU/CBE-JU

In February 2021 the EC gave the green light to the succession of the BBI-JU programme by the new Circular Biobased Europe Partnership (CBE JU). As the name of the partnership announces, there will be a focus on circular biobased solutions and the delivery of the EGD objectives. This partnership will have the objective of increasing the environmental and economic benefits of the bioeconomy.

This represents a solid source of funding for CBE projects and initiatives in the BIOEAST region.

The CBE will focus more on deployment than the BBI, a Deployment Group will advise the Governing Board in the regional dimension, the participation of the primary sector and the investor. It will also be stronger on feedback to policy level (more coherence and stability).

A monitoring system will be placed to ensure sustainability. Specific objectives will be set on:

- *Biodiversity protection*
- *Mobilization of feedstock*
- *Land use and water management practices*
- *New crop protection systems*

3 Foresight Exercise

3.1 General assumptions and a common baseline for the scenarios

Following the current trends and policies, the development of the circular bioeconomy has been driven into a context where there are three prevalent dimensions that clearly identify the current and the future state of it – economic, environmental and social. However, the context of change is more complex, and while exploring the performance indicators with the participants attending the BIOEAST workshops, we came to the conclusion that technological and resiliency dimensions should also be included. Monitoring these five indicators is enabling us to better understand the impact of technology and the potential for resilience as two important transformative drivers, influencing the decisions and contributing to the transformative process at the economic and societal levels.

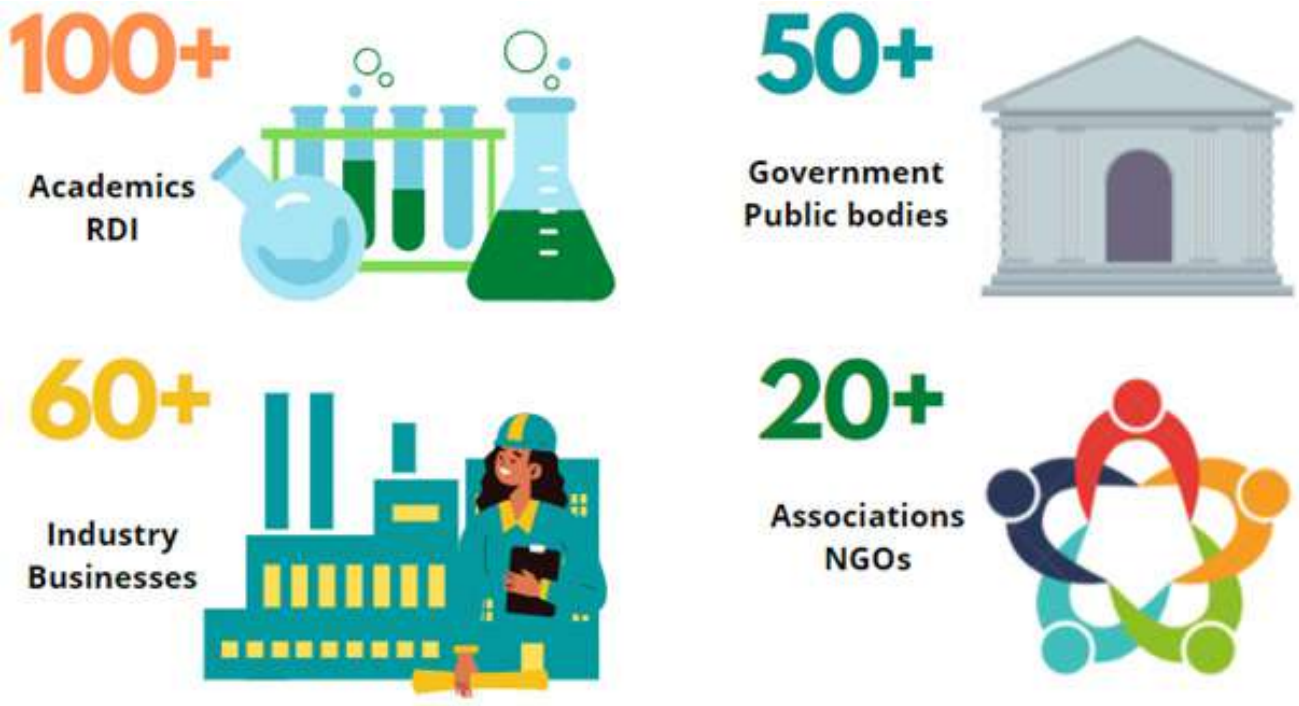
Once the performance indicators were in place, the scenario logic did not follow the 2x2 matrix often used for scenario building, but challenged us to develop a more holistic approach. Our focus has been on the areas that represent the core of this Foresight Exercise:

- *Sustainable natural resources*
- *Sustainable food systems*
- *Renewable carbon use & decarbonization*
- *Governance in the context of circular and sustainable pathways*

While exploring the drivers of change that are actually contributing to the shift towards a more sustainable, circular bioeconomy, the outcome of the workshops guided us to specify the following driving forces: the level of circularity, the bioeconomy, diversity (of business models), collaboration (among different stakeholders), and pace of change. All this affects our system in all the envisioned scenarios with a different degree of impact based on the particular principles of the dedicated scenario.

For the purpose of this Foresight Exercise, two rounds of virtual workshops were organized – altogether more than 250 participants from different backgrounds took part in Slovenia, Slovakia, Czechia, Hungary, Poland, Romania, Estonia and Croatia. The first round of workshops enabled the discussion of the current context of the national bioeconomies, their strengths, bottlenecks and leverage points, and ideas and opportunities for the future. Once the map had been laid down, the second round was used for scenario building with creative and dynamic discussions.

An additional workshop with international experts gave us the opportunity to better contextualize all the inputs collected in the previous interactive sessions, and build a regional picture.



The system that is addressed is complex and characterized by a high degree of uncertainty, which influences the assumptions that are taken into account in developing the future scenarios.

Although it is difficult to gauge how the political framework will shift after the current long-term strategy period ends in 2050, it is unlikely that the key objectives will undergo drastic changes. It is prudent to assume that the climate-neutrality objective will remain in place and even greater emphasis will be placed on efficiency in the use of resources.

3.2 Introduction to the scenarios

This foresight exercise identifies 4 different scenarios for the bioeconomy. The scenario narratives that were prepared are the fruit of an analysis of the literature, expert consultations, and stakeholder workshops and interviews. The uniqueness of this Foresight Exercise lies in the fact that it has been created by members of the BIOEAST region, based on the outputs of the workshops that engaged different stakeholders living and working in the BIOEAST region; it therefore represents the “original spirit” of the region.

The input and output parameters establishing the narratives of the scenarios are represented graphically in the scenario dashboards. Each scenario narrative is made up of a specific mix of input parameters; the percentage of circularity, biobased solutions, the diversity of the business models and actors involved, the state of collaboration, and the pace of change understood as a readiness for transformation. The values of these parameters are impacting the performance of scenarios, summarized in five dashboards, two of them capturing the level of resilience and technology, and three of them referring to the sustainability in sense of social, economic and environmental dimension.

The "most wanted" is Scenario 1, where we are experiencing a fully thriving circular bioeconomy. The other scenarios – Scenarios 2, 3, 4 – are envisioned as alternative but plausible realities evolving in the CEE region in the period from now to 2050.

All four scenarios are based on the outputs of workshops organized virtually in 7 countries (Estonia, Hungary, Slovenia, Croatia, Poland, Czechia and Slovakia), and at this stage present an overview of the visions shared.

These 4 scenarios introduce insights for the future of the circular bioeconomy in the BIOEAST region (and beyond), including a SWOT analysis presenting the strengths and weaknesses of each of them:

- ***Scenario 1:*** *A fully thriving circular bioeconomy – SUPERHEROES*
- ***Scenario 2:*** *A linear bioeconomy – PRETENDERS*
- ***Scenario 3:*** *Business as usual – UNCHANGEABLES*
- ***Scenario 4:*** *A nonprofit circular bioeconomy – CHANGE AGENTS*

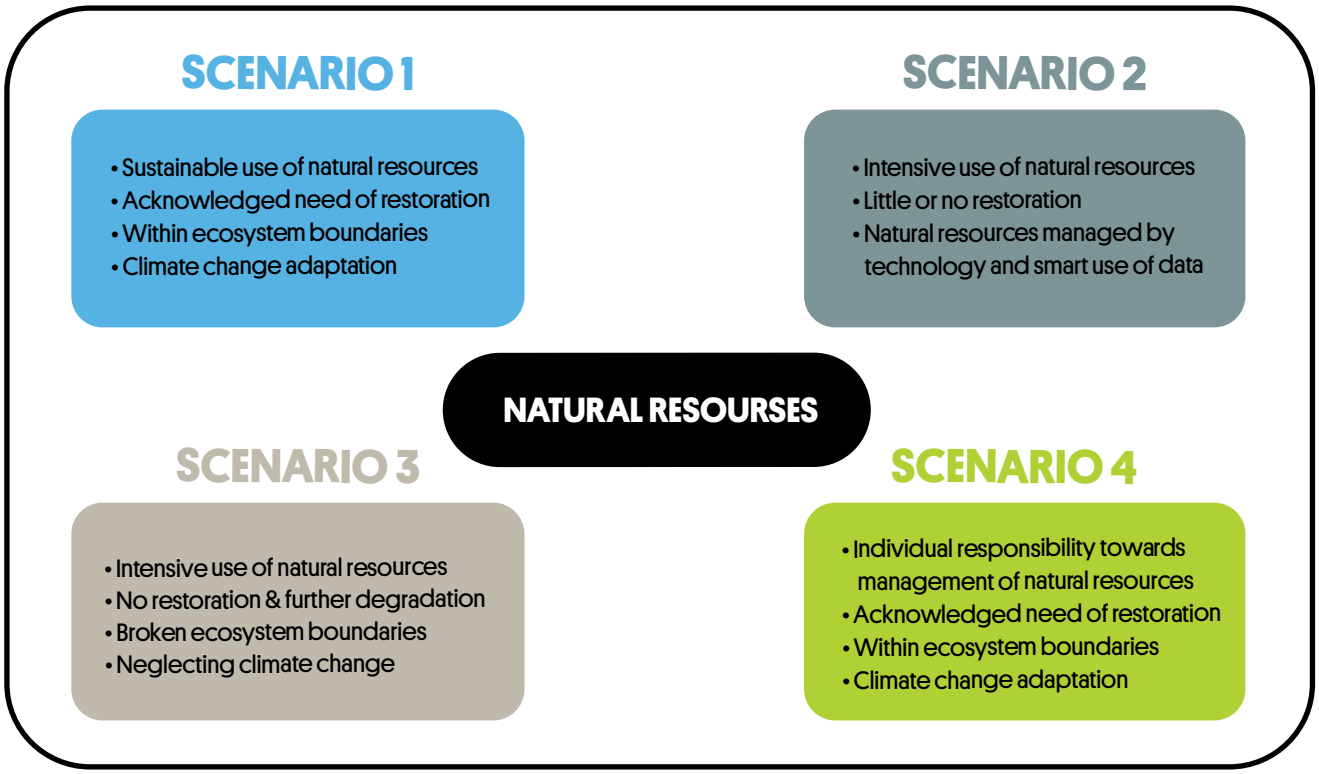
The first one – SUPERHEROES – is the most desirable. For this reason we present the gaps preventing the development of Scenario 1: What are the key missing links in each of the other three pathways preventing more circular and bioeconomy based solutions? What supportive measures are required to enable the transition towards Scenario 1? What are the key turning points for the circular and bioeconomy transition envisioned for each of other three scenarios – defining the triggers of change?

To foster imagination and make the scenarios a kind of "pitch" for further discussion, we are presenting 4 dashboards and 4 personas representing each of the presented visions. The personas are introduced to help the reader identify with the real-life story today and in 2050.

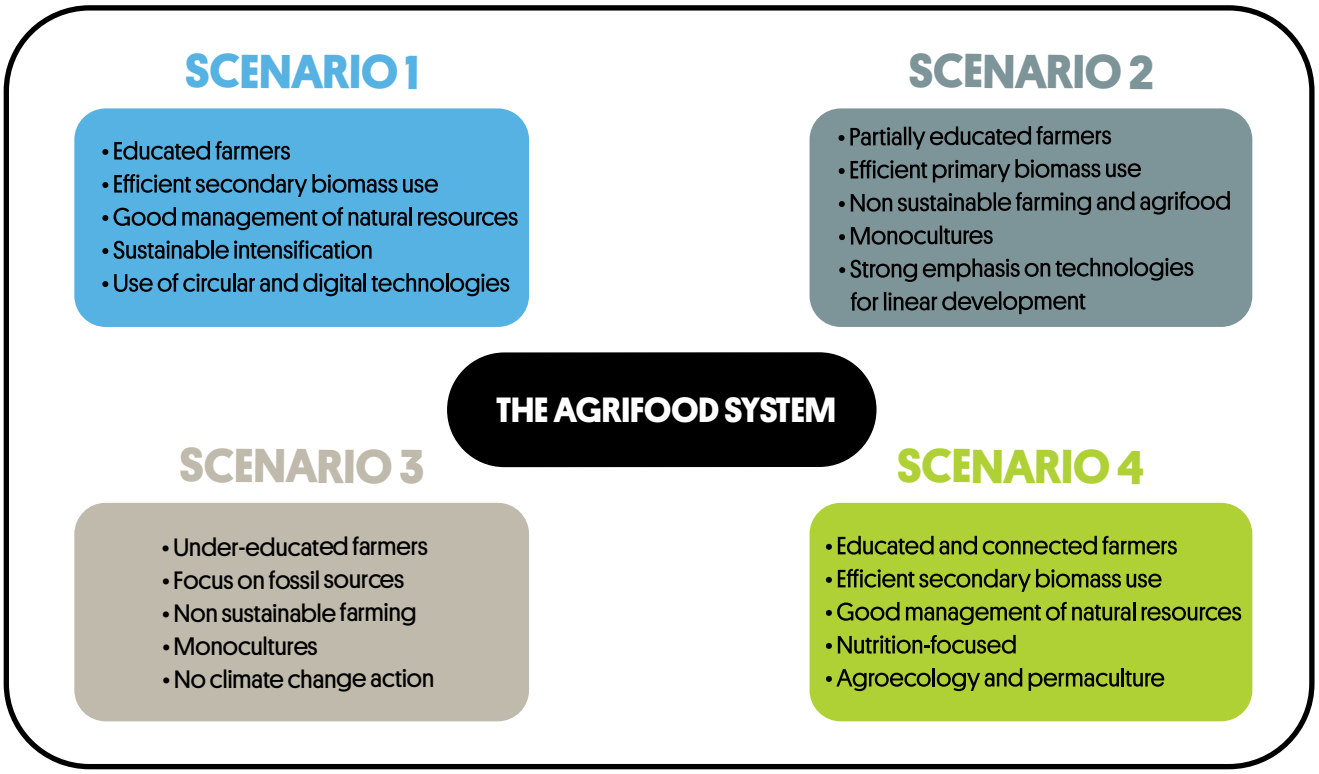
	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
SCENARIO 1	Political willingness Innovation Aspects	Level of awareness Social Attitudes	Lateral growth Inclusiveness	Lack of motivation Heterogeneity
SCENARIO 2	Social economy Known values chains	Lack of flexibility Low innovation	Slight adaptation Possible sustainability	Market change Competition
SCENARIO 3	Short-term investment Revenue increase	Limited perspectives Low competitiveness	Long-term investment Innovation	Market differentiation Regulatory barriers
SCENARIO 4	Sustainability Flexible economy	Lack of alternative funding	Alternative business EU allignement	Stakeholders reaction Economic impasse

A short overview of the key areas explored in the context of the 4 scenarios:

1. Sustainable natural resources



2. Sustainable food systems



3. Renewable carbon use and decarbonization

SCENARIO 1

- New business models
- Closing the loops
- Circular & sustainable based on economic decision making
- Circular RDI
- Old economic metrics

SCENARIO 2

- Adjusted business models
- Not closing the loops
- Non sustainable based on economic decision making
- Linear RDI
- Old economic metrics
- Traditional value chains

GENERAL PRINCIPLES

SCENARIO 3

- Traditional business models
- Not closing the loops
- Non sustainable based on economic decision making
- Fossil based prevailing
- Lack of RDI
- Old economic metrics
- Globalized value chains

SCENARIO 4

- New business models
- Closing the loops
- Social and environmental priorities
- Social innovation and strong collaboration
- New economic metrics
- Short value chains

4. Governance in the context of circular and sustainable pathways

SCENARIO 1

- Collaboration - Public governance
- Public-private partnerships
- Top down with some bottom up integration
- Developed RDI ecosystems

SCENARIO 2

- Coopetition
- Lack of vision and openness
- Top down
- Non synergic stakeholders

GOVERNANCE

SCENARIO 3

- Increased competition
- Short-term thinking
- Top down
- Non proactive and non-syneric stakeholders

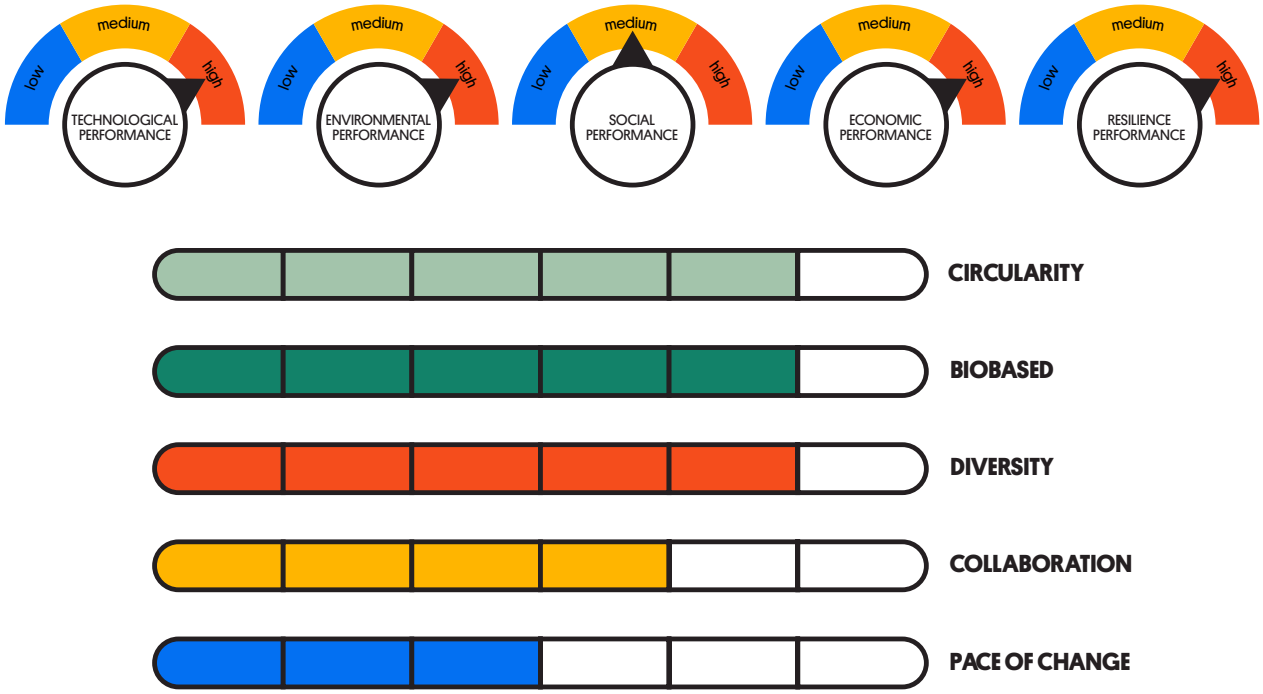
SCENARIO 4

- Collaboration - Network governance
- Public-private partnerships
- Strong bottom up influencing top down
- Strong educational system co-creating innovation-driven society

SCENARIO 1

A fully thriving circular bioeconomy - “Superheroes”

SCENARIO 1 - PARAMETERS
A Fully Circular Bioeconomy



Persona 1: Anna, 34, researcher

- *Enthusiastic about the opportunities bio and circular economy are offering.*
- *Internationally recognised researcher, devoted to teamwork and collaboration.*
- *Living a balanced life; engaged in highly demanding research projects, but at the same time finding time for family and friends.*
- *In love with nature, hiking and cycling are two of her favourite hobbies.*
- *Anna practises the "Zero waste" concept in her life, sharing her experiences via social media, where she has built a strong community of followers.*

Spotlight on 2050: Anna is still very active in the scientific community. The results of her research are well-recognized, and as one of the "Zero waste" Ambassadors, she advises governments on how to bridge the gap between science and technology to enable a faster transition to the circular bioeconomy. She is a member of the scientific committee of the regional BIOEAST circular bioeconomy HUB.

Adoption of a fully Sustainable and Circular Bioeconomy Model with added value for the Region

The adoption of the major bioeconomy principles, as set by the European Commission and other international institutions such as the UN, FAO and OECD, have succeeded. Specific projects by Research and Development and the European Green Deal implemented between 2021 and 2030 have paved a convincing path for growth and prosperity in a sustainable way in the BIOEAST region. Additionally, other economies which adopted a bioeconomy model as frontrunners (e.g. Finland or Ireland) acted like promoters for this direction for the BIOEAST countries. The priority of resilience, largely adopted by EU countries as part of the successfully implemented Green Recovery and Resilience programme, contributed to the positive change. Despite significant differences between the BIOEAST countries, there is a definite understanding within the BIOEAST countries' stakeholders that our joint vision and capacity for changing our mindset has been crucial in transforming opportunities into advantages. In 2050 the BIOEAST region is considered a "role model" for a thriving circular bioeconomy, and the citizens feel like "Superheroes", being enabled and empowered to contribute proactively to the sustainable lifestyle, society and economy.

Specific Frameworks

- ***Social:*** *Bioeconomy principles have been adopted at all levels of societal structure. Many of the operational schemes have been re-designed, and these changes have affected various societal structures. A multi-effective approach at the social level can be recognized.*

- ***Technological:*** *New methodologies and technological principles have been required. Technological innovation per se was not mandatory. Trends have not only been followed, but the BIOEAST region was quite often a trendsetter – its creative and innovative potential have been used extensively.*

- ***Environmental:*** *Substantial changes to the environmental impact have been challenging. Circularity principles and sustainable operations have been implemented at all levels. The environmental framework turned out to be very important for the effective applicability of this scenario.*

- ***Economic:*** *Economic principles have been adapted to the basic requirements for the development of this scenario. It was not easy to align the priorities recommended by the European Union, but targets were reached in 2030. It required a lot of adaptation at the level of planning and investment, as well as at the level of finances and taxation. After the pandemic recovery, the BIOEAST economy and society kept growing and fostering a competitive advantage in the EU and beyond.*

- ***Political:*** *Significant modifications were needed at the political level. Initially, we adopted National Strategies on the Bioeconomy in the BIOEAST countries, which served as a kind of push for better regional coordination and collaboration. Public administration became more operative, and inter-ministerial collaboration has strengthened and become more effective and efficient.*

- ***Values:*** *Basic values have been reconsidered in a new way. Circularity and sustainability became core elements in the development of this scenario. The values are reflected at both the societal and administrative levels.*

- ***Legal:*** *Significant adaptations were required at the level of the legislative and regulatory frameworks. The bioeconomy has introduced a novel concept and therefore the legal framework has been adapted accordingly. In addition, adaptation to the European recommendations and regulations is part of the transformative journey all the time.*

- ***Business methods:*** *Business models went through serious adaptation. The bioeconomy and circular economy paths required: (i) Adaptation to the current requirements in order to reach a high competitiveness; and (ii) The involvement of many paths in the existing production lines and the consideration of new and alternative value chains on a constant basis. The business models and practices adapted to a more sustainable and circular system, based on collaboration and biobased resources. Business in 2050 is based on new circular bioeconomy value systems.*

- ***Natural resources:*** *The use of natural resources, dominated by the principles of sustainability, is the most important element in this scenario.*

- ***Demographics:*** *Demographics did not play a major role in the realization of this scenario. However, given the regional character of the bioeconomy, specific applications and projects have been maximized or optimized according to the demographic distribution and planning.*

- ***Level of awareness:*** *The level of awareness and understanding are very important in the development of this scenario. A new concept has been introduced which requires the active participation of multiple players at all levels, including not only specific related stakeholders but also the general public. In fact, a continuous information flow is assured and, additionally, specific models for lifelong learning and training are in place.*

- ***Public perception:*** *The general public and related stakeholders are significant actors in the development of this scenario. Thanks to them, a supportive and consensual attitude for effective development has been adopted.*

3.3.1 Driving forces and their impact on the scenario's applicability – what is needed to make this scenario a reality?

- *The need to align with a European strategy for a sustainable bioeconomy, which convinces the audience that it is the main way to reach good economic growth and development in a sustainable way.*

- *The example of several EU member states, which after adopting a National Bioeconomy Strategy were capable of achieving their main socio-economic goals and establishing a better perspective.*

- *The persuasion that a sustainable circular bioeconomy provides a more concrete forecast for development in the long term, instead of focusing on traditional standards.*

- *The enhancement of awareness and understanding, allowing key stakeholders, policy makers, and also the general public to embrace the bioeconomy perspective.*

These driving forces are expressed and interpreted by specific stakeholder groups, and also by the public administration and specific authorities taking the responsibility for the implementation of the principles and interpreting them into specific actions. In these terms, key fundamental actions such as education, training, choice of value chains, development and economic priorities are reconsidered.

Impact on Economic Development and Growth Levels

In general, the adoption of bioeconomy principles will have a direct impact on economic development and growth in both the short and mid terms. Besides this, the potential investments will be observed, and an alignment to common European practices and an attempt at the synchronization of the BIOEAST countries are required. Direct impact will be achieved through various means of funding, exploration of specific investments, participation in related projects and consortia, and so on. Indirect economic impact will be achieved by adopting practices such as biomass valorization, enabling new value chains, circularity, sustainable production lines, and the cooperation of various sectors, among others.

Impact on Competitiveness

Given that sustainability is a key element in all bioeconomy practices, sustainable development will become a mandatory path and will support practices and actions involving it in all domains. Sustainability will make the regional economy more competitive by supporting not only bioeconomy-related pathways, but also lateral actions in totally different businesses and domains.

Another parameter influencing competitiveness is the regional character of the bioeconomy. New technologies and innovations are expected to have an applicability to the whole CEE macro-region, exploring the regional advantages such as natural resources, the size of the market, the alternativity of value chains, complementarity, competitiveness, and homogeneity of attitudes and perceptions, as well as development and growth. The opinion is that the CEE region should reach the standards of Northern and Western Europe in terms of competitiveness, market exploration, growth and attracting investments.

For the implementation of circular and bioeconomy business models, collaboration is essential. Instead of competing in the traditional way, radical collaboration must be encouraged. The goal of increasing know-how and knowledge of modern cooperation is a challenge. Cooperatives can be helpful in moving towards various circular bioeconomy objectives, especially when cooperatives themselves cooperate (policy measures aimed at cooperatives have the potential to reach a large proportion of agricultural producers, for example). But this is not a given – overcoming trust and transparency issues is problematic without appropriate know-how.

Impact on Societal Level

Job creation is one of the main societal impacts that a bioeconomy provides. Additionally, and in the same context, the bioeconomy will also enable investments and development in lateral or related domains, which will result in indirect job creation.

An additional aspect is an increase in awareness and understanding. Adoption of the circular bioeconomy requires a high level of awareness. Vocational education or case-by-case training are processes adding to this perspective.

Citizens are changing their behaviour patterns regarding purchasing and consumption, becoming more engaged in co creation of circular bioeconomy solutions and better connected. Sense of community and interdependency is getting stronger.

Environmental impact

A bioeconomy approach is based on sustainability, so the environmental impact of full implementation is definitely positive. The circular character of the process further enhances this positive impact.

Main constraints and obstacles

- *Level of awareness can be a constraining parameter at times. Competence in the specific topics is a must in order to understand and adopt specific methodologies. An asynchronous level (or lack) of awareness can result in misunderstandings and inefficiency.*

- *Public perception and support are mandatory. The lack of a convincing communication strategy can result in societal reactions which would inhibit the development of the project.*

- *Stakeholders and public attitudes differ between the various regions, sectors, education and social backgrounds, economics and many other factors. Lack of adaptation to these specific attitudes is therefore a potential inhibitor.*

- *The availability of funding is a substantial parameter. It is necessary to guarantee the funding either as an investment, as a loan or as a contribution form. Knowledge of these mechanisms is mandatory and without it efficiency is limited.*

- *The knowledge of finance (financial literacy) of the market actors should be improved while considering sustainability, in addition to implementing robust life cycle assessment protocols.*

- *Finally, "corruption" at any level is definitely an obstacle and a limiting factor in all cases.*

SWOT Analysis

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
SCENARIO 1	Political willingness Innovation Aspects	Level of awareness Social Attitudes	Lateral growth Inclusiveness	Lack of motivation Heterogeneity

3.3.2 Reflection of the Scenario 1 in particular aspects

A. Sustainable natural resources – mainly soil and water

The BIOEAST region in general has a rich availability of resources and concrete national plans for using them for the benefit of rural development, economic growth and societal prosperity. This background can be an optimal basis for the development of a scenario involving fully sustainable use of the natural resources, based on bioeconomy principles with added economic value.

In this scenario a rational use of water for both urban and rural needs will be achieved, while soil productivity will be enhanced by the use of primary biomass, as well as agricultural residues and wastes. In this way the improvement in efficiency in the use of natural resources based on EC regulations and recommendations will be achieved.

The whole system will have the challenge of satisfying the needs of a diversified spectrum of end-users, and therefore all planning should be based on a carefully designed knowledge-based platform by analyzing and monitoring the process.

In this scenario the possibility of sustainable intensification on a case-by-case basis will be available by considering other environmental parameters based on modern technologies, methodologies and measures for the protection of cultivation (production, manufacture) and the quality of the resulting products. Specific indicators related to quality and health standards will be established.

The system will be sustainable and adaptable to various climatic conditions and also fully monitored, while it will be as free as possible from toxic substances, pollutants and additives, reducing the risk to human safety and environmental security. Food safety should be essential at every step of the value chain.

In this way technological improvement and economic benefit will be achieved in sustainable conditions.

Mandatory Conditions for the effective realization of the scenario - recommendations

- *Establishing and implementing strategy and policy for the development of the bioeconomy, including sustainable use of natural resources and systems of incentives and actions to encourage the application of the principles of the bioeconomy and circular economy.*

- *Convergence of digital technologies with circular bioeconomy research, covering life sciences and bio sciences and technologies to create enablers of bio-based innovation, including bioinformatics or nanobiotechnologies, aiming to improve bioengineering and build novel biological systems prospecting, understanding and sustainably exploiting natural resources.*

- *Creating a research programme to develop a model for the transformation of agriculture and the economy into a circular bioeconomy, and the adaptation of farms and business entities to the changes. In this case, digitalization tends to be essential for establishing a monitoring system. >>*

- *Creating a multidisciplinary education system, multi-level education of specialists in the bioeconomy and circular economy, and a systemic programme to raise the environmental awareness of society.*
- *Creating programmes for financing research on innovative solutions for the sustainable use of natural resources.*
- *Developing resource-saving and low-cost technologies.*
- *Biologization.*
- *Strengthening ecosystems.*

B. The circular economy in the context of a sustainable food system (valorization of biomass)

The BIOEAST region has a very competitive infrastructure for the development of both primary and secondary sectors in agriculture, aquaculture, forestry and food. The region is highly industrialized in these sectors and in general is adopting the implementation of the EU recommendations and regulations.

It seems that the necessary condition for adopting a fully sustainable scenario for a circular bioeconomy in this domain is political willingness and the positive perception of the related stakeholders. Such scenarios would involve, of course, all the production stems from crop cultivation to final food processing in agricultural systems, livestock farming, aquaculture units, fisheries and forestry.

In this scenario key parameters would be taken into consideration, namely waste-free production; collection and reuse of by-products where possible; implementation of high-level technology and practices like precision farming; modern surveillance and monitoring systems; data collection and analysis; and extensive attention to the reduction of GHG emissions at all stages and processes.

Based on the collected data, new and alternative value chains and supply-chains would be analyzed and adopted when possible.

It is obvious that this scenario cannot be effectively applicable at a limited scale or in a fragmented way, so the implementation of a broader plan at a macro-regional or national scale is mandatory, while the optimal condition would be the adoption of national strategies on the circular bioeconomy by the BIOEAST countries. It is therefore essential to have good governance.

Finally, implementing such a scenario requires a satisfactory level of education and training for the involved actors, the stakeholders concerned, and society in general, with the involvement of those actors in the specific programmes and training initiatives.

It is also important to mention that special attention would be given to the incorporation of small businesses in such a sustainable system of development.

Mandatory Conditions for the effective realization of the scenario - recommendations

- *Need to establish long-term support mechanisms for a sustainable economy, and their implementation over immediate short-term benefits.*

- *Legal system supporting transformation towards a sustainable food production system and circular economy.*

- *Improvement in and consequently use of a comprehensive system to incentivize the use of the circular economy and sustainable food system, including, among other things, subsidies, surcharges and fee/tax allowances.*

- *Support for small farms influencing the diversification of crops and food.*

- *Support for the development of technology for the manufacture of biobased products and the recovery of active substances from food waste biomass.*

- *A programme of scientific research focused on the identified needs of a sustainable food system and circular economy, new technologies and innovative products.*

- *A comprehensive system of education and training of specialists in the field of sustainable food systems and the circular economy.*

- *Legal principles and research programmes designed for cooperation based on the identified needs of consumers and food producers. The importance of acknowledging the leading role of cooperatives as the frontrunners of rural society is crucial for policymaking and economic logic alike.*

- *Promotional activities supporting the position of bio-products on the markets by introducing food certification. For example, implementing specific labels for food produced in a sustainable way or without the use of fossil fuels.*

- *Increasing public awareness of the need to reduce food waste and use by-products made from waste biomass.*

- *Digitization: the agrifood value chain needs specific data and information management systems to ensure advances in quality, traceability and food safety; the development of the agroindustry and healthy food will be supported by new digital tools and methods.*

C. The renewable carbon and decarbonization perspective

The whole energy supply and use system in the region will be designed anew. Carbon dioxide emissions in the atmosphere will be substantially cut by reducing the use of fossil fuels, increasing energy intensity, using renewable energy sources including bioenergy

and biofuels, and introducing low-emission technologies. The public administration will align policy and regulation according to the directives established by the European Commission. A new research agenda will include the priority of all decarbonization innovations. A financial support system will be introduced for entities implementing a circular economy and reducing greenhouse gas emissions, structured according to investments coming from both the public and the private sectors. A new education and training system will be implemented, leading to a knowledge-based transformation economically justified for the circular bioeconomy.

Digitization will facilitate the transformation in agriculture, industrial production, transport and in the field of marketing activities. These types of structural change will have a tremendous impact not only on basic economic and production lines, but also on lateral vital activities such as tourism, while substantially improving the quality of citizens' lives.

Mandatory Conditions for the effective realization of the scenario - recommendations

- *Effective implementation of policies and strategies for sustainable development in the BIOEAST countries.*
- *State policy aimed at creating favourable conditions for reducing greenhouse gas emissions, including the transformation of the education system.*
- *Substantial support of the industrial and energy sectors to direct them towards the use of more sustainable energy sources is vital, while also adapting new resource-efficient technologies.*
- *Effective use of tools to control greenhouse gas emissions.*
- *More effective legal regulations and economic incentives for the use of renewable energy sources and the reduction of greenhouse gas emissions.*
- *Guaranteeing funds for the development of renewable energy sources – for agriculture, business entities and local governments.*
- *Establishing research programmes and increasing research expenditure on reducing greenhouse gas emissions and developing renewable energy sources.*
- *Changes in consumer awareness of the growing threat and effects of climate change, increasing the environmental awareness of society in general.*
- *Substantive and technical support for enterprises implementing low-emission technologies, producing bioenergy and using renewable energy.*
- *Introduction of new professional digital technologies addressed to decarbonization processes management and integration of digital industries, with renewable energy resources allowing the efficient control of GHGs emissions.*

D. Governance in the context of circular and sustainable paths of bioeconomy

Adoption and development of a long-term National Strategy on the bioeconomy is vital. The adoption of a clear regulatory framework will provide specific guidance for economic and societal incentives, which is addressed to all related actors and stakeholders and takes into consideration lateral parameters such as the sustainable use of natural resources, a guarantee of the preservation of biodiversity, the achievement of carbon neutrality and so on.

In parallel, these strategies are developed and incorporated into the operational mechanisms. Efficient and comprehensive management and surveillance monitoring systems, considering the multidisciplinary and multi-sectoral dimension of the whole context, are required. In the same perspective, other regulatory frameworks and legislation are adapted according to the newly introduced context of the bioeconomy.

New educational and training programmes are adopted ready to train the new generation of experts who will manage the operation. At the same time the educational system remains updated by continuous development and training. In addition, there is the specific training organized for the educators. Much more attention must be paid to strengthening knowledge transfer programmes that could be used to help train advisers and enterprises. A strong connection between businesses and education allows improvements to the education system and showcases sustainable business management and best practice. Research institutions and SMEs form clusters and partnerships that accelerate the implementation of circular biobased solutions and new business models.

The importance of the concept of centres of competencies (or centres of excellence) should be emphasized. These help to disseminate know-how and information in general about the circular bioeconomy. Finally, alongside education, an information platform is developed aiming to provide material to enhance the awareness of specific stakeholder groups and the general public.

Mandatory Conditions for the Effective Realization of the scenario - recommendations

- *DDetermining appropriate IT/digitization tools for closed-loop bioeconomy management at various levels of target achievement.*
- *Increasing investment in research including basic research.*
- *Promotion of bioproducts on domestic, European and world markets.*
- *Promotion of economic entities implementing the principles of low emissions.*
- *Launching research programmes for projects focused on the bioeconomy.*
- *The development of "Bioeconomy Champions". Similar as EU Member States appoint "Digital Champions", who help everyone get digital, "Bioeconomy Champions" would promote bioeconomy.*
- *Development of a system of interactive consultations: society – stakeholders – decision-makers – a "one stop shop" in the form of a centre of excellence.>>*

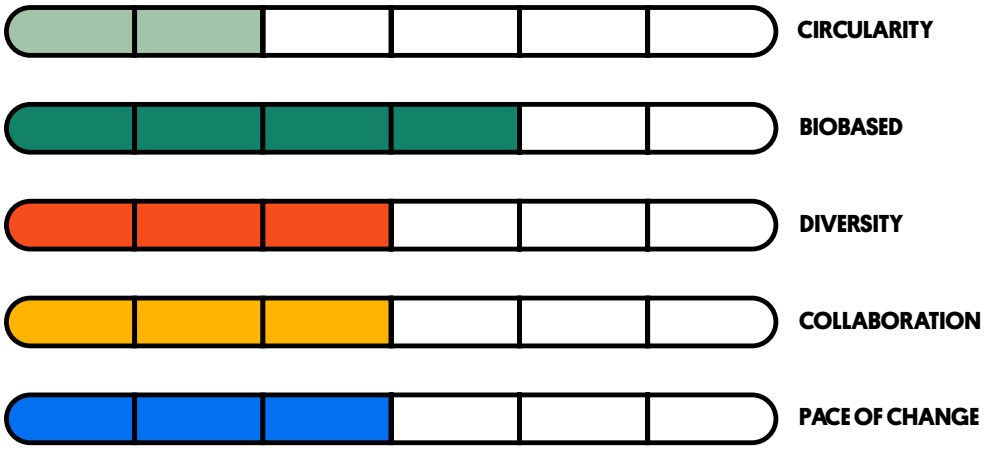
- *Digitization – digital research and technologies will be addressed to ensure the transparent and effective implementation of the principles of the circular bioeconomy.*

- *New educational courses and curricular changes will be designed, aiming at the integration of digital tools and methods into circular bioeconomy sectors, and ensuring the education of qualified staff able to work productively at the interface of multidirectional sustainable growth.*

SCENARIO 2

A linear bioeconomy - “Pretenders”

SCENARIO 2 - PARAMETERS
A linear bioeconomy



Persona 2: Pavel, 55, CEO

- *Has an understanding of biobased solutions as an opportunity to become more competitive on the domestic as well as on global markets.*
- *Diverse portfolio of investments, including "green business", but not satisfied with the return on investment.*
- *Hedonist, divorced, two grown-up children, used to travel a lot, owns a speedboat.*
- *Enjoys international cuisine – has a licence as a sommelier. Cannot resist smoking a good cigar*
- *As a member of the Lions Club, he combines his business and charity activities.*

Spotlight on 2050: Pavel is retired, enjoying time in the countryside. He lost quite some money while investing in cryptocurrencies back in 2030. His advice to his grandchildren: invest in new technologies. He is still enthusiastic about the innovation potential of the BIOEAST region, but sceptic about circular solutions. What he values is entrepreneurial spirit and material wealth.

A linear bioeconomy – a kind of "fake change" with a focus on competitiveness, neglecting the need for a systemic change.

Overview

Competitiveness is "glorified" in this scenario. The BIOEAST region is proud of its GDP, which in 2050 is comparable to the Scandinavian countries that were used as the "benchmark" when designing the development guidelines for the region. Only minimum effort has been invested in the adaptation of measures to fight the climate crisis and the pandemic. SDGs were respected at a declarative level, but in practice not much has been done. Business models from 2020 were just slightly adjusted; the involved actors are familiar and very much "profit driven". For the majority of the BIOEAST countries the socio-economic uncertainty resulting from the post-Covid era is very much present. Quite some investments have been made based on the Green Recovery and Resilience programme, and FDI has also been supported. Innovations in the bioeconomy sector are contributing to the competitiveness of the region, but most solutions are not aligned with circular economy principles.

Specific frameworks

- ***Social:*** *No need for specific social adaptation. Society is operating in a conventional way adopting linear practices and aiming for the maximization of turnover and revenue.*

- ***Technological:*** *Technological adaptation is focused on following the current trends of technology and innovation and adapting the technological infrastructure to them.*

- ***Environmental:*** *Development is based on fossil-based energy use with a negative impact on the environment. Limited adaptations in a bioeconomy are mostly related to the administrative and infrastructure levels, with no significant impact on the environment.*

- ***Economic:*** *The economy is already adapted to the operational mode of this scenario, so it is stable and growing. However, some challenges due to the increasing competition of more circular-oriented economies are recognized, and lack of adaptation is becoming a hurdle.*

- ***Political:*** *Political support is provided in this scenario, since the economy is still competitive at the international level.*

- ***Values:*** *A substantial reconsideration of values has not been the case so far.*

- ***Legal:*** *The legislative and regulatory frameworks are well-established and operating, already adapted into a valid operational frame. Adaptation to the European regulations is mandatory but fundamental changes have not been implemented.*

- ***Business methods:*** *Business models are adapted to market requirements and societal expectations, but most of them are still linear. Digitalization is embedded in highly competitive businesses.*

- ***Natural resources:*** *The use of natural resources is quite exhaustive and lacks even the basic elements of sustainability.*

- ***Demographics:*** *Demographics do not significantly affect the realization of this scenario. Reduced "brain drain" is a positive consequence of more investments in innovation and digitalization.*

- ***Level of awareness:*** *Awareness and level of understating are not of major importance but the information flow plays an important role at all levels.*

- ***Public perception:*** *Full support by the public is an essential part of this scenario.*

3.4.1 Driving forces and their impact on the scenario's applicability – what is needed to make this scenario a reality?

1. *The tendency to maintain a relatively solid economy and increase its potential in Europe in general.*

2. *One driving force will be the efforts towards recovery, rebuilding competitive socio-economic structures and resilience, particularly in the post-pandemic period.*

3. *A slight tendency to adapt the social, economic and educational background to the principles of the bioeconomy, which seems to be a priority in Europe and worldwide*

These driving forces, expressed by various stakeholder groups, are sound. It is important to state that the stakeholders implicated are not only those who are directly involved in bioeconomy issues, but a broader spectrum, including politicians and decision-makers, and stakeholders from the financial, investment and industrial sectors currently implicated in the present status quo.

Impact on economic development and growth levels

The well-established production lines will offer the BIOEAST countries maintenance of their channels of cash flow and the continued building of business in the traditional way. However, the European priorities in funding are changing to more bioeconomy-oriented actions and projects, while investments are also focusing on more viable and sustainable business proposals.

Impact on competitiveness

The current business structure will be able to guarantee a certain competitiveness thanks to the established background and networks. However, in the long term, these structures will tend to be substituted by more sustainable ones, so the competitive advantage will be lost.

Impact at the societal level

In this particular period a societal benefit seems to overlap with growth and employment. The advantage of the relatively low unemployment rate of the BIOEAST countries compared to the European average seems to be neutralized due to the situation caused by the pandemic, while vital lateral activities like tourism have been seriously affected. For this reason, models that are not highly sustainable cannot offer substantial societal benefits like they used to. In the current situation the increasing unemployment seems to become a potential threat to regional growth and citizen prosperity.

Environmental impact

This scenario is mainly based on fossil-based energy use with no positive impact on the environment. Additionally, the linear model of this scenario and the limitation of circularity have a negative environmental impact.

Main constraints and obstacles

- *Preference for certain domains and sectors can encourage discrepancies and disputes.*

- *The availability of funding is a substantial parameter. It is necessary to guarantee funding either as an investment, as a loan or as a co-financing form. The knowledge of these mechanisms is crucial and without it efficiency is limited.*

- *Public perception and support are mandatory. The lack of a convincing communication strategy can result in societal reactions which would inhibit the development of the project. The level of awareness can be a constraining parameter at times.*

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
SCENARIO 2	Social economy Known values chains	Lack of flexibility Low innovation	Slight adaptation Possible sustainability	Market change Competition

3.4.2 Reflection on particular aspects of Scenario 2

A. Sustainable natural resources – mainly soil and water

In this scenario, recommended practice for the sustainable use of natural resources will not be neglected; however, standard procedures will not be abandoned, due either to certain financial constraints or to developmental security. Therefore, the development of non-waste technologies using primary and waste biomass, optimization of water use, increase in soil fertility using biological nitrogen fixation, reduction in the use of phosphorus and pesticides, and other pro-environmental activities will be implemented to a certain level, but not as the mainstream direction. On the other hand, due to the lack of a state policy supporting the rational use of resources in a way that brings economic benefits, and the absence of promotional action for the preferential use of sustainable systems, the interest of both end-users and entrepreneurs will be attracted by the most cost-efficient, but not the most sustainable, pathway.

In these circumstances the improvement of soil productivity through the use of economically beneficial chemicals, nitrogen, phosphorus, pesticides, the optimization of water consumption only within economically justified limits, the limited use of closed water systems without recovery, and the limited use of sludge and fragmented use of biomass will be possible but only in areas of high economic profitability not compatible with the cascade principle.

In this scenario a platform for enhancing innovation in the various stakeholders' groups and citizens will also be established, and specific instruments for educating the experts will also be invented. However, this knowledge will not be implemented unless the financial parameters permit.

B. The circular economy in the context of a sustainable food system (valorization of biomass)

New production lines and the developed technologies based on digitalization will be used in all stages of production guaranteeing the maximum turnover and revenue; however, most of the available biomass will remain unexplored and economically ineffective. The production lines will remain steady, but additional beneficial factors such as food diversification, food safety, process efficiency, and alternative value chains will be limited or minimized. No specific precautionary measures will be taken with regard to the reduction of greenhouse emissions. Finally, the implementation of new technologies for risk assessment and management will be limited.

Briefly, this scenario will implement some basic measures of sustainability, but fundamentally it will stick to the market demand and supply framework. This action may result in certain short or medium-term economic benefits; however, it will not guarantee sufficient food security nor economic viability in the long-term, since a totally sustainable food system in a circular economy will not be achieved.

Two additional parameters (described below) include the economic weakness of the BIOEAST region compared to the competitive Member States, and the loss of benefits from the support programmes of the European Commission.

C. Renewable carbon and decarbonization perspective

Energy needs in the BIOEAST region are based mainly on fossil fuel carbon, which is primarily imported. The government adopts policies and strategies enhancing the circular bioeconomy with all its principles, but energy use remains untouched because there is a steady economic path for revenue and growth for both the public and the private sectors. There are attempts to restructure and convert the energy mix; however, the economic interests are strong and many related businesses were built on this initial scheme. There is no convincing plan for a transition to a non-fossil fuel energy pathway, and neither the political will nor societal forces push in this direction. Therefore, national economies remain to a large extent on the track of the existing old model, which offers a certain stability and security. The inability to finance any transition will be the main reason for the continuous use of fossil fuels, so economically unattractive bio-sequestration systems will not be developed. The funding will only include projects with a clear beneficial perspective and minimal risk. In this situation, an asynchronous development in various sectors and domains will result in a non-homogenous growth perspective involving both sustainable and unsustainable paths. This model can be viable in the short term, but it will fail in the long term because it is unable to satisfy all the terms and requirements.

At the societal level there will be ongoing actions aiming to enhance the level of awareness and participation, and new research programmes will be established, resulting in innovations in the field of decarbonization, developed education and training systems, and increasing social responsibility for environmental quality and climate change. Initiatives will form, taking measures for a reduction in greenhouse gas emissions and developing renewable energy sources.

However, the non-effective financial support systems including subsidies, tax breaks and other economic factors motivating agricultural and economic entities to develop and use renewable energy sources and to reduce greenhouse gas emissions will limit the achievement of circular bioeconomy objectives.

D. Governance in the context of circular and sustainable paths of bioeconomy

There is an adoption of the bioeconomy principle, mainly as an alignment to the European directions coming from the European Commission and related services. However, the main national priority is maximizing turnover based on conventional production lines, without considering alternative pathways, new value chains and novel potential. Parallel activities such as restructuring the educational framework, establishing an effective information system, and involving stakeholders in a holistic decision-making mechanism remain incomplete and superficial. This approach has two sub-scenarios: Sub-scenario A In the short term development and growth will develop sufficiently by using the advantage of the pro-existing structures, but in the long term this direction will collapse due to the weak background and will not be able to compete with competitors. Sub-scenario B Partial investment will be sufficient to motivate stakeholders so they will undertake initiatives to complete the infrastructure during the first period of prosperity and then to align with the new sustainable circular bioeconomy principles.

SCENARIO 3

Business as usual - “Unchangeables”

SCENARIO 3 - PARAMETERS
Business as usual Fossil & linear

Persona 3: Markus, 65, Trade Union Leader

- *Hard worker, being loyal to his company for almost 40 years.*
- *Grandfather, proud of his grandchildren and a big fan of motorbikes.*
- *Very conservative and traditional in his mindset.*
- *Stands up for the rights of workers and worries about the negative impacts digitalization and new concepts like bio and circular economy might have on the labour market.*
- *Still remembers the times of communism in Central Eastern Europe.*
- *Sharing economy, biorefineries and similar "innovations" are not what he is going to support*

The flash on 2050: Markus is a role model of longevity. In his local community he is highly respected and his home has become a kind of "museum" of vintage products, including his collection of motorbikes. He is extremely sceptical about "western countries" promoting a circular economy and demanding highly circular solutions from partners in their value chains. He finds the reaction of the EU towards the traditional and unsustainable way of doing business in BIOEAST countries unacceptable.

Business as usual – fossil fuels and linear paths protecting the status quo

Overview

It is hard to believe that in the period between 2020 and 2050 so little has changed in the BIOEAST countries. Back in 2030 it looked as if the Green Recovery and Resilience programme and the money allocated for the green transition would contribute to a shift towards a more green and sustainable region, but unfortunately most of the money has been spent, not invested. Given the growing dominant role of regulations imposed by international institutions, at least a certain minimum of requirements have been adopted. In these terms the implementation of the 17 Sustainable Development Goals, proposed by the United Nations, and the European Green Deal adopted by the European Commission, made the possibility of completely neglecting environmental principles or specific objectives such as biodiversity-related policies at least a bit narrower. This scenario occurred because the economic aspects became an indispensable priority and were supported by a policy ignoring the international regulations. In 2050 we are realizing that the way chosen by our politicians is not feasible in the long term. Our overall competitiveness is seriously threatened. The way we do business in BIOEAST region is no longer supported by any European institutions.

Specific frameworks

- *Social: Society is operating in a conventional way, adopting linear practices and aiming for the maximization of turnover and revenue. Economic success is the main priority and environmental concerns are neglected.*

- *Technological: There is no investment in technological development; thes main focus is on technological adaptation and the maintenance of existing facilities.*

- *Environmental: Development is based on fossil-based energy use, with a negative impact on the environment. The limited adaptations to a bioeconomy mostly take place at the administrative and infrastructure levels, with no significant impact on the environment.*

- *Economic: Economic success is the main priority, based on existing practices, structures and know-how. Fiscal and taxation systems are already adapted in the operation of this scenario. Lack of adaptation to international trends, based on circular bioeconomy solutions, is already causing problems and diminishing our competitive position within the EU.*

- *Political: Political support is being challenged, since the socio-economic situation is becoming less stable.*

- *Values: A conservative mindset prevails, and creative, out-of-the-box thinking is not supported. Even worse, those in favour of values that contribute to a more coherent society and the wellbeing of every citizen are not welcome.*

- *Legal: The legislative and regulatory frameworks are well-established and operating on traditional "top down" principles. The gap between EU governance and the BIOEAST way of regulatory development is getting larger every year.*

- *Business methods: Business models are adapted to market requirements and the expectations of leading structures. No big changes or alternatives are welcomed or supported.*

- *Natural resources: The use of natural resources is exhaustive and lacks the basic elements of sustainability, which is becoming a serious threat.*

- *Demographics: Demographics do not significantly affect the realization of this scenario. A brain-drain is apparent and the lack of young, educated people is becoming a threat to further economic development and societal consensus.*

- *Level of awareness: Lack of information and access to knowledge is a problem. Those willing to contribute to positive, sustainable change must find reliable sources of information outside the BIOEAST region.*

- *Public perception: On the surface there is a consensus on the status quo, but several indicators are signalling that the situation in BIOEAST countries is just about to "explode".*

3.5.1 Driving forces and their impact on the scenario's applicability – what is needed to make this scenario a reality?

1. *The tendency to maintain a relatively solid economy to maximize its impact and to increase its potential within the region and in Europe in general.*

2. *The aim is to adapt and implement any current recommendation imposed externally with the least compromise to its main priority.*

3. *A guarantee of societal neutrality, taking care of basic expectations and requirements (employment, quality of life).*

Impact on economic development and growth levels

The well-established production lines will offer the BIOEAST countries the possibility of maintaining their channels of cash flow and continuing to build business in the traditional way. However, European priorities in funding are changing to more bioeconomy-oriented actions and projects, while investments are also focusing on more viable and sustainable business proposals.

Impact on competitiveness

The current business structure will be able to guarantee a certain competitiveness thanks to the established background and networks. In the long term, these structures will tend to be substituted by more sustainable ones, so the competitive advantage will be lost.

Impact at the societal level

A societal benefit seems to overlap with growth and employment. The advantage of the relatively low unemployment rate of the BIOEAST countries compared to the European average seems to be neutralized due to the situation caused by the pandemic, while vital lateral activities like tourism have been seriously affected. For this reason, models which

are not highly sustainable cannot offer substantial societal benefits like they used to. In the current situation the increasing unemployment seems to be a potential threat for regional growth and citizen prosperity.

Environmental impact

This scenario is mainly based on fossil-based energy use with no positive impact on the environment. The linear model and the limitation of circularity of this scenario drives an unsustainable and compromised bioeconomy.

Main constraints and obstacles

- *The availability of funding is a substantial parameter. It is necessary to guarantee funding either as an investment, as a loan or as a co-financing form. Knowledge of these mechanisms is crucial and without it efficiency is limited.*

- *Public perception and support are mandatory. The lack of a convincing communication strategy can result in societal reactions which would inhibit the development of the project.*

- *Stakeholders and public attitudes differ between various regions, sectors, education and social backgrounds, and between economic and many other factors. Lack of adaptation to these specific attitudes is therefore a potential inhibitor.*

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
SCENARIO 3	Short-term investment Revenue increase	Limited perspectives Low competitiveness	Long-term investment Innovation	Market differentiation Regulatory barriers

3.5.2 Reflection on particular aspects of Scenario 3

A. Sustainable natural resources – mainly soil and water

The biomass-based economy will continue to grow in the traditional way without taking into consideration the principles of the bioeconomy and the circular economy. These principles, such as rational water use and soil utilization, will be adopted in a fragmented and non-systematic way. We will observe a lack of coordination, with a wide diversification in agricultural practices affecting the final quality and homogeneity of end products. Economy and productivity will grow based on market demand and supply only. In the long term this direction will affect exporting capacity and reduce competitiveness.

From the regulatory viewpoint, the lack of an effective regulatory framework will make the adoption of a homogenous policy of natural resources management impossible, with a final impact at both the economic and societal levels.

B. The circular economy in the context of a sustainable food system (valorization of biomass)

In this scenario a lack of National Strategies for a bioeconomy in various BIOEAST countries will be observed. This lack includes the sustainable food system, which will eventually result in a lack of particular measures and initiatives in any domain or in the primary and secondary sector (agriculture, forestry, aquaculture food processing etc.). In parallel, the absence of any infrastructure for awareness training and education will deprive the related audience of interests and innovative initiatives. Briefly, all the related actors will stick to the existing situation as their only possibility for generating turnover and revenue.

As a matter of fact, this is a scenario especially for economies with a strong and promising infrastructure and potential in bioeconomy. Considering it objectively, this scenario is most unlikely to occur.

C. Renewable carbon and decarbonization perspective

The development of this scenario is mainly based on fossil fuel carbon, which is primarily imported. The economic interests are strong and many lateral businesses were built on this initial scheme. There is no convincing plan for a transition to a renewable and biobased energy pathway, and neither political will nor societal forces push in this direction, so national economies remain in the existing old model, which offers a certain stability and security. However, in the long term the consequences will be disastrous because of increasing competitiveness, deterioration in the quality of life standards, and the negative impact on lateral domains (e.g. tourism). Additionally, the region may face liability consequences and penalties due to the updated European regulatory frameworks.

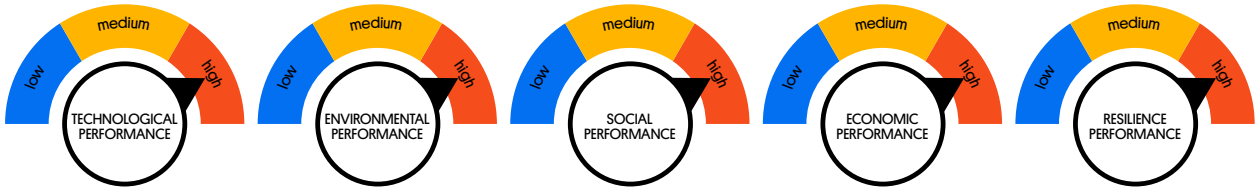
D. Governance in the context of circular and sustainable paths of bioeconomy

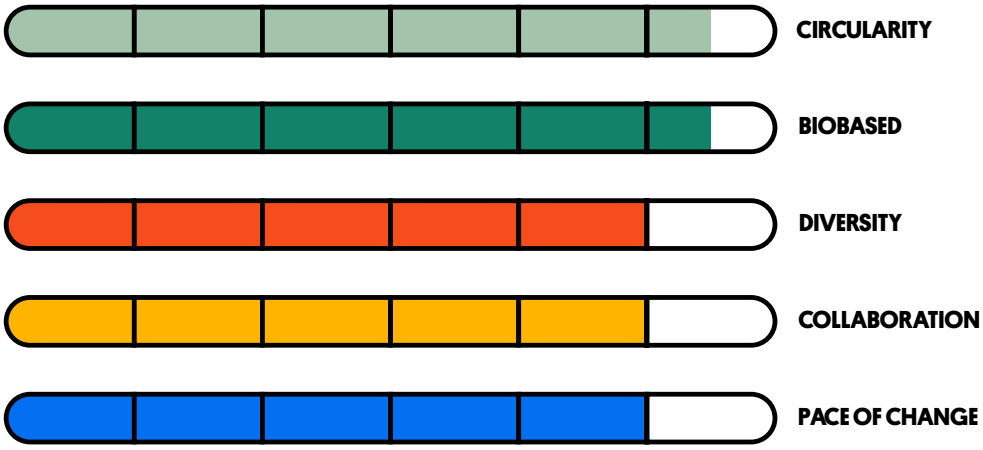
There is a delayed reaction or even an absence of willingness from governments to adopt a national strategy, resulting in a more general deficiency of the related legislation and specific regulations. In this situation, the interest not only in primary initiatives such as new value chains and production lines, but also lateral activities such as education, public awareness, training and communication will fade away, and the overall business development towards a sustainable bioeconomy will fail. From this perspective the advantage of the country in competitiveness, growth and attraction of investments will be lost, and the consequences could be disastrous both in economic and societal terms.

SCENARIO 4

A “non profit” Circular Bioeconomy - “Change Agents”

SCENARIO 4 - PARAMETERS
A "non profit" Circular Bioeconomy





Persona 4: Zofia, 23, owner of a local shop

- *Runs her own business and enjoys being an active player in her local community*
- *Earns enough money to live on, with no ambitions to "get rich".*
- *Purpose-driven person, with a lot of friends willing to support her ideas on how to build a thriving society.*
- *Married to a freelance photographer, spends a lot of time in nature, exploring hidden places in her country.*
- *Optimistic about the future and committed to contributing to the positive change in society and the economy.*

Spotlight on 2050: Zofia keeps improving the socioeconomic background she has built in the last 30 years, always adapting her priorities to the forthcoming opportunities and challenges. Her first business adventure did not work out and she switched careers to join her husband, managing his creative agency. They are supporting young creatives in the BIOEAST region, educating them on how to shape a new narrative and promote sustainable solutions.

A "non profit" Circular Bioeconomy

Overview

New circular biobased business models are emerging. Purpose-driven actions are becoming mainstream. The opportunities enabled by the Green Recovery programme back in 2030 have empowered other change agents to explore alternative scenarios for the development of a circular bioeconomy in the BIOEAST region. In areas and domains where environmental sustainability is independent and does not affect value chains and production lines, a large number of new companies have emerged. These activities (e.g. Red Biotech sector or ICT-related initiatives) have created additional value, generated export revenue, and offered employment in the macro-region. The focus of socio-economic development is shifting entirely to environmental sustainability. Young entrepreneurs and creatives are setting new trends, core values have been redefined in a sustainable way, and profit is not the main motivation or driving force in 2050.

Specific Frameworks

- ***Social:*** *Society is entering a compromise state, with basic societal standards becoming adaptable to new priorities and business models, while environmental standards and sustainability are not open to compromise.*

- ***Technological:*** *Innovation and the implementation of technology become a top priority in order to be adaptable to the new business models and value chains proposed for various sectors. The trends of technology and innovation are followed and implemented continuously.*

- ***Environmental:*** *Sustainability is the basic priority for all environmental standards, and is not affected by various business models or sectoral priorities.*

- ***Economic:*** *A flexible economy is required in order to accommodate the economic and fiscal particularities of this scenario. A strong economic background stabilizes unpredictable consequences.*

- ***Political:*** *Political support is present, and strong engagement of all stakeholders in the co-creation of policymaking is a well-established practice. Substantial flexibility is expected.*

- ***Values:*** *Environmental sustainability is becoming a priority. Purpose-driven decision-making is accepted as part of new circular bioeconomy culture.*

- ***Legal:*** *The legislative and regulatory frameworks are well-established in a valid operational framework. Slight adaptations are expected in order to accommodate the requirements of the guidance given by international institutions.*

- ***Business Methods:*** *New circular bioeconomy business models are developed and tested. The pluralism in business models is one of the key issues of this scenario.*

- ***Natural Resources:*** *The use of natural resources is calculated following the sustainability principles.*

- ***Demographics:*** *The BIOEAST region is "rejuvenating" due to the interest of young people in establishing their businesses and living their family lives in the region.*

- ***Level of Awareness:*** *Awareness is very high. Key stakeholders and the public in general are well-informed about the impacts of environmental sustainability in all domains. Information flow and transparency are also important.*

- ***Public Perception:*** *The public have adopted sustainability goals and principles, and are not only supportive but also proactive in setting new sustainable standards.*

3.6.1 Driving forces and their impact on the scenario's applicability – what is needed to make this scenario a reality?

1. *The tendency to align with environmental principles and the sustainability goals are the main driving forces. This tendency is not only a decision made by the policymakers, since it requires a bottom-up action conducted mainly by specialized institutions, NGOs and the general public.*

2. *The certainty adopted by financial institutions and the investment of government in a long-term plan of resilience after the pandemic crisis, being aligned with institutional and administrative directives, has priority over a more financially aggressive but more fragile strategy.*

3. *The reassurance that the economy and business development can more easily become competitive in a period when all economies worldwide are equally weak and in a rebuilding phase.*

These driving forces are expressed by a very broad spectrum of stakeholder groups. It is important to reach a consensus for the viability and feasibility of this scenario based on four pre-requirements: 1. Political will; 2. Well aware and informed public and stakeholders; 3. A relatively solid economy; and 4. A realistic strategic plan including deviating paths and alternatives.

Impact on economic development and growth levels

Economy and finance are the domains facing the greatest risks in this scenario. Often, environmental restrictions have an inhibiting effect on economic growth, and this may raise implications such as decreasing interest from foreign investments and other conflicts of interest. On the other hand, the alignment with the EC directives enhances the possibilities for financial support and minimizes the risk of penalties. Additionally, the economy has the option to invest in businesses requiring environmental sustainability, such as tourism.

Impact on competitiveness

The new business models and the alternatives will guarantee competitiveness, enhancing potential. However, strong competitiveness alone is not enough to ensure financial viability. High turnovers and attractive conditions for investment are also a must.

Impact at the societal level

The BIOEAST region has by tradition had a low unemployment rate; however, this situation has worsened during the COVID-19 pandemic. It is uncertain whether the business models proposed in this scenario will create many new jobs. Other societal impacts occur due to environmental sustainability and its consequences.

Environmental impact

This scenario is based on the condition of environmental sustainability, so a positive impact will be reached in all domains.

Main constraints and obstacles

- *Unbalanced priorities in various domains and sectors can mean that discrepancies and disputes ensue.*

- *Public perception and support are mandatory. The lack of a convincing communication strategy can result into societal reactions which would inhibit the development of the project.*

- *Stakeholders and public attitudes from various regions, sectors, education and social backgrounds, and economic and many other factors differ. Lack of adaptation to these specific attitudes is therefore a potential inhibitor.*

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
SCENARIO 4	Sustainability Flexible economy	Lack of alternative funding	Alternative business EU alignement	Stakeholders reaction Economic impasse

3.6.2 Reflection on particular aspects of Scenario 4

A. Sustainable natural resources – mainly soil and water

In this particular domain priority will be given to the development of limited or non-waste technologies, the use of primary and waste biomass, the optimization of water use, smart-choice of the water cycle and use, an increase in soil fertility by using biological nitrogen fixing, a reduction in the use of phosphorus and pesticides, the preservation of the biodiversity of crops, and finally the precautionary actions taken for a healthy ecosystem and environment.

Objectively, there is a contradiction in a state policy supporting the rational use of resources and also operating in a way that brings economic benefits. In economic terms, there is no preferential support system for environmental sustainability at the micro-economic level, no tax breaks or other supportive financial incentives. Due to the lack of economic efficiency, there is increasing indebtedness of farms and entrepreneurs.

On the other hand, there will be possible improving soil productivity through the use of economically beneficial chemicals, nitrogen, phosphorus, pesticides. Optimization of water consumption based only within economically justified limits, without closing the loops of water systems, recovery and use of sludge is taking place. Fragmented use of biomass is present, but only in areas of high economic profitability not compatible with the cascade principle. Economic incentive systems linking the environmental effects of agricultural and economic activity with financial benefits are not really effective.

The environmental awareness of society and a multidisciplinary education system for specialists leads towards the sustainable use of resources and contributes to a reduction in greenhouse gas emissions.

B. The circular economy in the context of a sustainable food system (valorization of biomass)

In the various domains where food systems are involved, the emphasis should be put on new, smart technologies and the existence of the necessary state subsidies to implement them. Other relevant practices are organic farming, small-scale production, family enterprises, and vertically integrated enterprises sometimes linked to complementary activities such as eco-tourism. This would be a costly endeavour, because the focus would be put entirely on environmental sustainability.

In parallel, new value chains should be considered, such as micro-algae development, which is a great source of biomass or technologies based on the Blue Bioeconomy. These methodologies have the potential to significantly improve the environmental sustainability of the bioeconomy.

In general, actions preserving economic and financial stability should be the top priority in a context where environmental sustainability is not compromised. These actions should focus on cost-effective original processes to provide the advantage of competitiveness based on synergies at all levels.

C. Renewable carbon and decarbonization perspective

This scenario could see the rise of various technologies and practices for capturing carbon. This goal could be achieved by sequestering carbon in soil, and locking it into plants (for example, increasing forest biomass) or ecosystems such as bogs. As a result, less biomass would be used for bioenergy production, which could lead to higher added-value activities in the future.

Due to political reasons for the achievement of environmental sustainability, the use of fossil fuels will not be promoted, and economically unattractive bio-sequestration systems will not be developed. New technologies will be implemented carefully, taking into account the risks associated with highly innovative solutions.

The increased environmental awareness of society, new research programmes resulting in innovations in the field of decarbonization, the developed education and training systems, increasing social responsibility for the quality of the natural environment, and the need to mitigate the effects of climate change grant an incentive to take measures to reduce greenhouse gas emissions, develop renewable energy sources, and replace fossil fuels.

However, the non-effective financial support systems including subsidies, tax breaks, and other economic factors motivating agricultural and economic entities to develop and use renewable energy sources and reduce greenhouse gas emissions will limit the achievement of bioeconomy objectives.

D. Governance in the context of circular and sustainable paths of bioeconomy

Due to the priority given to environmental sustainability, specific measures should be taken in order to support the economy in any of the alternative scenarios. The state must implement clear subsidies and distinctions for peripheral areas to ensure income for the local residents. This will be a rather expensive measure, but it will benefit regional development and perhaps even build the foundation for an economically feasible circular bioeconomy in the long term. The regional character of the bioeconomy should be further supported by co-financing synergies and regional initiatives.

At a microeconomic level, domestic income could be increased by enhancing the product development and marketing performance of small producers, supporting sectors with a strong orientation towards export, and sectors with activities in line with the environmental sustainability principles. All of these actions could shift the economic burden away from the bioeconomy and enable it to achieve true environmental sustainability.

	Driving Forces	Social Impact	Economic Impact	Environmental Impact	Constraints and Obstacles
SCENARIO 1	Alignment with EU	Substantial changes at many levels	Long-term growth	Sustainability Circularity	Asynchronous development
SCENARIO 2	Solid economic recovery	Conventional adaptation	Preserving funding channels	Fossil use Slight adaptation	Market changes Strong competition
SCENARIO 3	Tendency to maintain solid economy	Societal neutrality	Revenue-oriented	Compromised sustainability	Restrictive regulation
SCENARIO 4	Long-term investments	Working positions	Flexible economy	Sustainability priority	Lack of funding

4 Feet on the ground, head in the clouds

4.1 Biomass supply – what we have and what we value

In the EU, total biomass supply accounted for 1.1 billion tons of dry matter in 2015, amounting to roughly 9% of global biomass production. The main source of biomass is agriculture, which supplies about 6% of the overall biomass input to the economy, including crops (47%), grazed biomass (11%) and crop residues (9%). Forestry makes up most of the remaining 33%, with a negligible 0.2% being contributions from fisheries and aquaculture. The aquatic sectors contribute less than 2 million tons of dry matter annually, i.e. a negligible amount of total biomass supply; the relative importance of the marine-based sectors in the bioeconomy is higher than expected given their extremely low share of total biomass [1].

Poland and Romania are the BIOEAST countries in the top 10 EU27 countries with the highest potential of forest wood-based biomass in terms of the size of the forest area and the availability of the wood supply. In Poland the forest area available for wood supply is 8.19 million ha, and the proportion of the total forest area available for wood supply is 87.2%. In Romania the area is 4.84 million ha and the proportion of the total forest area available for wood supply is 71.9% [2].

The main destination for agricultural biomass is feed and bedding, including animal-based food (49%), plant-based food (10%), liquid biofuels feedstocks (4%) and energy (4%). Wood biomass is used as solid wood product and wood pulp for biomaterials (20%), and as heat and power for bioenergy production (13%). With regard to the share of biomaterial and bioenergy uses, roughly two-thirds of the primary and secondary sources of wood are used for materials, while the remaining third is used for energy. Energy and pellet use of wood biomass has been increasing in the last two decades. The biomass flows show that 67% is used in the feed and food sector, followed by biomaterials at 20%, and bioenergy at 13% [2]. Bioenergy includes biofuels produced from energy crops of about 30 million tons of dry matter (4% of biomass from agriculture).

Poland and Romania are the biggest agricultural biomass producers in the BIOEAST macroregion by attribute (economic/residue production), crop group (cereals, vegetables, etc.) and crop. They deliver, respectively, 9.2% and 7.2% of the total agricultural biomass produced in the 28 EU countries each year, and are counted among the top 5 biomass producers [2]. Hungary delivers 4.3%, Bulgaria 3.0%, Czechia 2.7%, Lithuania 1.6%, and Slovakia 1.2% of EU biomass. The volume of biomass produced by the other BIOEAST countries is much lower, less than 1% of the total European agricultural biomass.

This diversity in biomass production in the BIOEAST region indicates differences in the prioritization of the directions of bioeconomy development in different countries.

Diversity of biomass production should be a driver to create a BIOEAST biomass network for cooperation, aiming at the development of new biomass processing, biorefination, new direction of biomass use for added value biomaterials, and channels for biomass delivery to countries which do not produce it.

Biomass from residues is generated at different stages of production and consumption. In 2010 there were approximately 52 million cubic metres (m^3) of post-consumer wood waste, of which some 36 million m^3 were recovered. This was a smaller volume than forestry residues and production waste, which amounted to ~178.7 million m^3 [4].

Within agriculture, more than half of the global harvest's dry mass consists of agricultural residues and inedible biomass. Approximately 121 million tonnes of agricultural crop residues (mainly straw) can be produced annually in Europe, together with 46 million tonnes of forestry residues and 31 million tonnes of grass [3]. To ensure the sustainability of biomass use it is necessary to apply multipurpose crop use and valorisation of biomass.

4.2 The economic context of biobased solutions

For a better understanding of the status of the bioeconomy in the BIOEAST countries we are introducing some key numbers, enabling us to recognize the potential for further development of the circular bioeconomy in the coming decades.

Trends show that the turnover of the bioeconomy in the BIOEAST countries is increasing, making up 10.71% of the total turnover of the BIOEAST countries in 2017. The growing importance of food production can be observed in the EU countries in addition to increasing bio-based chemical manufacture highlighting the focus towards more value-adding activities. Based on this turnover data, the trend is expected to continue beyond 2020, while the sectors of primary production are expected to continue to diminish in importance.

Compared to the EU27, BIOEAST countries have a higher share of total turnover coming from the agriculture, wood products and furniture sectors. However, the BIOEAST countries also have a comparatively smaller share of food, beverage and tobacco, as well as bio-based chemicals, pharmaceuticals, plastics and rubber manufacture (excluding biofuels) (Fig.8).

While the share of the bioeconomy within the overall economy of the BIOEAST countries is greater, it is more focused into processing sectors than biomass production sectors when compared to the EU27. Nevertheless, between 2008 and 2017 the proportion of agriculture in the bioeconomy has decreased at a higher rate in the BIOEAST region, signalling an inclination towards more value-added activities in the BIOEAST countries.

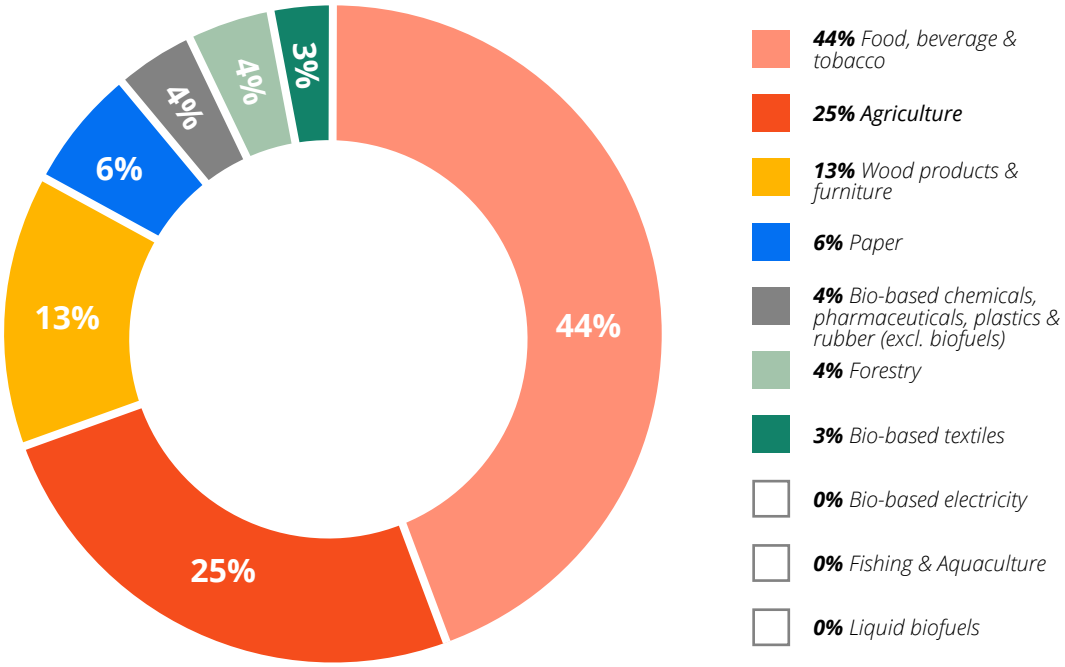


Figure 9: *Turnover in the BIOEAST bioeconomy by sector in 2017 [1]*

An interesting trend can be observed concerning employment. In 2008, 20.12 million people were employed in the bioeconomy in the EU27 [1]. In 2017, in the EU post-Brexit, the outlook shifted to 17.5 million people. The agrifood sector employed three quarters of them (53% in agriculture, and 25% in the food, beverages, and tobacco industries, indicating a reduction of 13% compared to 2008 [1]. However, compared to the EU27, employment in agriculture in the BIOEAST countries was significantly higher – by 13 percentage points – in 2008. By 2017, the difference had decreased by just by a single percentage point. Employment emphasises the dominant position of agriculture in the BIOEAST countries (Fig 10).

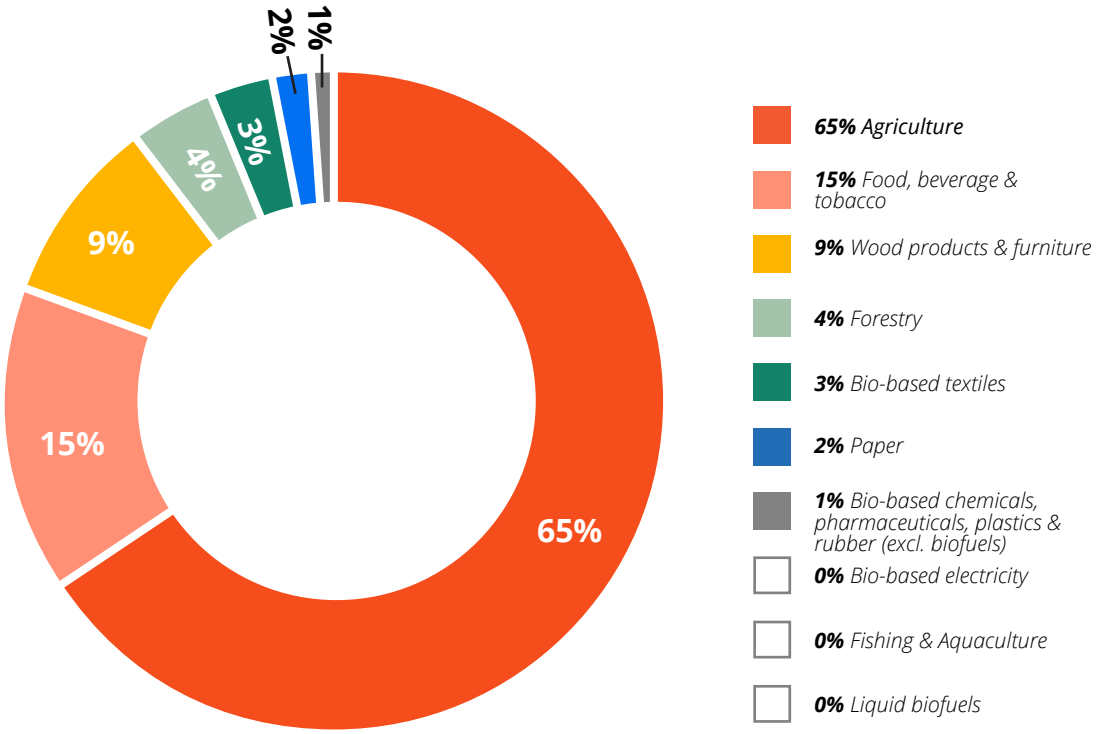


Figure 10: *Employment in the BIOEAST bioeconomy by sector in 2017 [1]*

Much like the EU27, employment in the BIOEAST countries' agriculture decreased in 2008-2017. Consequently, employment in food, beverage and tobacco production has increased. Similarly to the EU27, the total number of people employed in the BIOEAST countries' bioeconomy decreased in the observation period, from 9.32 million to 7.41 million.

Value added is the most important indicator in the economy. Value added in the EU27 and BIOEAST bioeconomy in 2017 was 614 billion and 85 billion euros respectively [1]. This makes up 4.2% of the total GDP in the EU27 and 7.4% of the total GDP in the BIOEAST countries. The bioeconomy generated a higher share of value added in the BIOEAST countries compared to the average of the EU27; however, in the total value-added production of the EU27 the BIOEAST countries achieved a share of only 13.8%.

4.3 Social trends and the power of educated citizens

The bioeconomy can have positive impacts and trade-offs in the social sphere of the BIOEAST region. Food security, employment, work safety, sanitation and wellbeing, household income, land access and quality of life are areas that have been addressed by participants at the BIOEAST workshops as those of significant importance for the implementation of the circular bioeconomy (Figure 11).

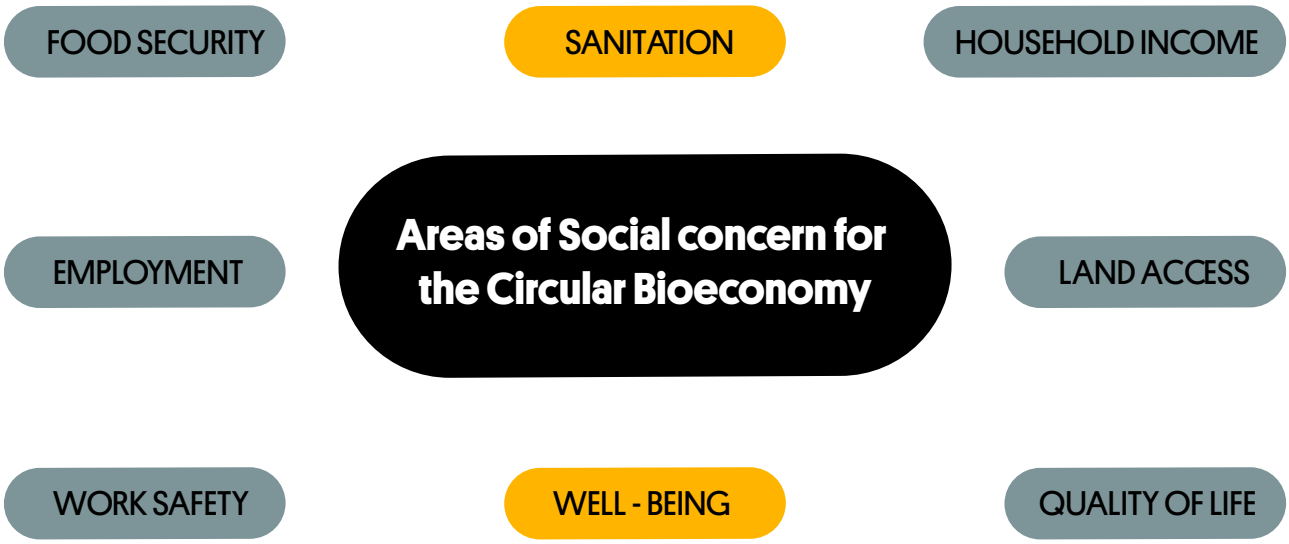


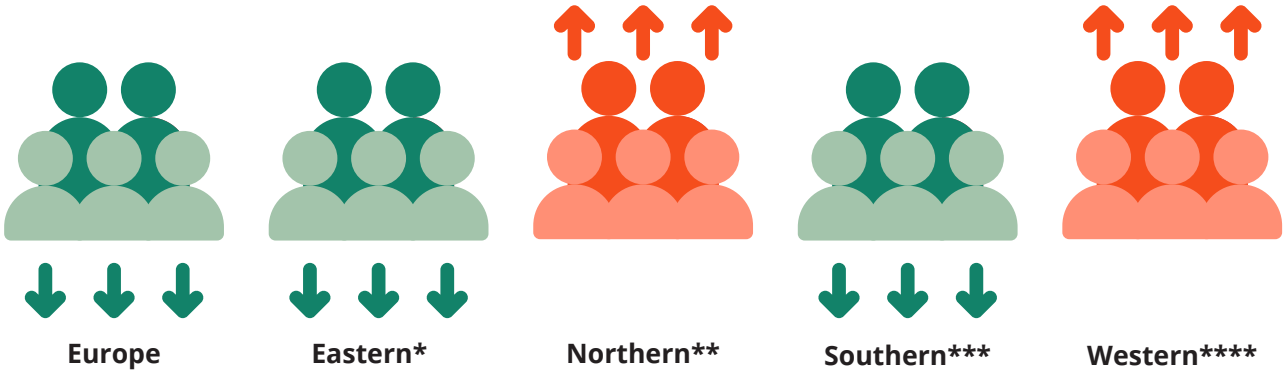
Figure 11: *Social sphere of circular bioeconomy in BIOEAST countries*

Since citizens play an important part in the co-creation of decisions that directly affect their wellbeing, their role in the circular transition should not be overlooked. Citizens as consumers create demand for food, feed and non-food biobased products and ecosystem services. The expected behaviour of consumers depends on societal awareness, which should be modelled by the new education system. The attitude of citizens towards sustainability may force the government to find solutions that the circular bioeconomy strategy requires. For this reason, responsive governance and an adaptive and interactive administration need to ensure that many change actors are considered as a matter of basic justice in various processes of the bioeconomy transition. Key aspects of change, such as citizens' values, interests, know-how and environmental entitlements need to be considered. For example, the key challenge of a responsive forest-based bioeconomy will be the empowerment of ordinary citizens, forest owners and small and medium business actors to provide a counterweight to the private sector and forest authorities in the forest policy [9].

An ageing population is a common trend in the EU27 and BIOEAST countries. About 30% of the EU27 population will be aged 65 or more in 2060, and all the member states will be affected by this phenomenon [3]. This is especially relevant to the agrifood sector of the bioeconomy. Only 5.6% of all European farms are run by farmers younger than 35, while more than 31% of all farmers are older than 65. The same occurs in the BIOEAST countries. Eight of the eleven countries will have passed 50% in the old-age dependency ratio by

2050 [7]. A decrease in the working age population forces businesses and governments to seek new, less labour-intensive solutions and processes. The current projections tell us that the old-age dependency ratio will be higher than 60% in Bulgaria, Czechia, Latvia, Lithuania, Poland, Romania, Slovenia and Slovakia by 2050. Immigration, strongly dependent on persistent asymmetries in economic situations and in demography, can be viewed as a threat (as currently perceived by a large share of Europeans) or as an opportunity: a larger and younger workforce to sustain an ageing population.

Demographic imbalances between developed countries and developing countries are set to deepen by 2050. Rapid population growth is concentrated in Sub-Saharan Africa and other developing countries, while population numbers in the majority of developed countries are expected to stall or even shrink [1]. This leads to the increasing significance of migration as a means to bolster the workforce in the EU27 and BIOEAST countries. Increasing migration should balance the estimated decrease in the population in CEE countries in 2050.



Population growth in Europe up to 2050 by sub-region:

***Eastern Europe:** Belarus, Bulgaria, Czechia, Hungary, Poland, Republic of Moldova, Romania, the Russian Federation, Slovakia and Ukraine.*

****Northern Europe:** the Channel Islands, Denmark, Estonia, the Faroe Islands, Finland, Iceland, Ireland, Isle of Man, Latvia, Lithuania, Norway, Sweden, the United Kingdom.*

*****Southern Europe:** Albania, Andorra, Bosnia and Herzegovina, Croatia, Gibraltar, Greece, the Holy See, Italy, Malta, Montenegro, Portugal, San Marino, Serbia, Slovenia, Spain, North Macedonia.*

******Western Europe:** Austria, Belgium, France, Germany, Liechtenstein, Luxembourg, Monaco, Netherlands, Switzerland.*

Another trend to note is gender balance. In the EU27, population projections indicate that the proportion of women in the population will remain at 51.1% throughout 2020-2050[8]. As for the BIOEAST countries, the proportion of women in the population is projected to decrease – in 2020, eight BIOEAST countries have a female population above the EU27 average of 51.1%, but by 2050, three BIOEAST countries will have a female population above the EU27 average [8].

New working trends are emerging. Due to the increased old-age dependency ratio in 2050 and beyond, older people are expected to be part of the workforce for longer. Coupled with innovations in technology and practices, establishing a robust lifelong learning system is a must to avoid alienating older members of the workforce. The nature of work itself is changing, as new generations enter the workforce and older generations work for longer [2]. These factors change employment, career models, and organizational structures [2]. In combination with automation and other technological advancements, therein lies potential to negate the decrease in the workforce.

In line with the above notion, education and learning are going to become more diversified. New generations, demographic changes and hyperconnectivity are transforming both educational needs and modes of delivery [4]. Developments in cognitive sciences, the availability of information, novel pedagogical approaches and an emphasis on lifelong learning are increasing the diversity of interests and ways of learning, not to mention access to education[4].

Another major trend is that income equality between different countries is decreasing, while that within them is increasing [5]. This is in line with the observation that inequalities pertaining to socio-economic background have persisted in Europe [5]. Low social mobility may have spillover effects on developing the bioeconomy, primarily via restricting access to the workforce.

Urbanization in Europe is on the rise, and its level of urbanization is expected to increase to 83.7% in 2050 [6]. The proportion of rural population in the total population of the EU27 has steadily declined from 1961 to 2018, while the population of urban areas has steadily increased[6]. This is one of the factors driving the abandonment of agricultural land, which is expected to reach 3% of total agricultural land by 2030 [6].

Estonia is the most urbanized country in the region, with nearly 61% of its population living in cities. Large cities are present in Poland, Romania, Hungary, and Czechia.

It is important to develop the CBE in the urban environment in a sustainable way too. In this biowaste as a biomass source, green gardens, urban farming and ecosystem services are important measures to be considered.

Additionally, building a synergic link between urban and rural development is key to ensuring inclusiveness and developing value chains.

The social acceptability of biobased solutions and facilities is an important aspect that needs to be addressed in order to successfully implement a circular bioeconomy. This includes:

- *Local communities accepting the presence of biogas plants and biorefineries, especially with the use of biowaste biomass;*
- *Local communities accepting the shutdown of coal mines, and being ready for labour retraining;*
- *Scepticism towards bioenergy and biofuels plants;*
- *Accepting the use of forestry biomass - informing citizens about sustainable forestry management;*
- *Green products markets, despite their appeal, face high prices and thus a lack of preference from customers, especially in low income households.*

Nutrition and nutrition inequality is also an important topic. An efficient nutrient cycle is a critical issue for a sustainable circular bioeconomy. Nutrient shortages reduce soil fertility and impede healthy plant growth, while nutrient excesses cause environmental problems due to evaporation to the air or releases to ground and surface water [Circular Economy and Bioeconomy: Partners in Sustainability, EEA European Environment Agency, 2018].

In most of the BIOEAST countries it will be necessary to create a new education system dedicated to the bioeconomy and circular economy. Education and awareness raising is key, not just for the young; the first step towards change is understanding the need for it. Diversification in education and learning requires the development of special programmes at each level of learning, from primary schools up to universities, and training and knowledge communication to public audiences. Lifelong learning must become a trend. The new system should cover the inter-sectoral approach of the education of specialists in the bioeconomy and circular economy. New systemic educational programmes are needed at the academic level to produce highly educated researchers, teachers and industrial specialists in the field of the bioeconomy and circular economy. The system should ensure the inflow of competent staff to local government and state administration bodies, extension agronomy institutions, farmers and entrepreneurs. The new education system must correspond to a new model of knowledge delivery. The concept should be characterized by openness involving citizen participation, removing barriers to entrance for new enterprises, and the circulation of knowledge (including between businesses).

Based on the knowledge gained and the experiences shared between citizens, self-sufficiency/resource dependency can also influence the lowering of the risk of Covid-19 epidemic dissemination, since shorter value chains mean that less actors (potentials transmitters of the virus) are involved.

4.4 UN Sustainable Development Goals – the need for more resilient societies and economies

Implementing the UN's 2030 Agenda by pursuing the UN Sustainable Development Goals (SDGs) is an integral part of the European Green Deal, as well as of the Green Recovery programme in these pandemic times. The goals 1, 2, 3, 7, 8, 9, 11, 12, 13, 14, 15 are relevant in terms of the impact that the bioeconomy can have on them. Goals 16 and 17 are relevant in terms governance (Fig 12).

Sustainable use of natural resources	A circular agrifood system
	
Renewable carbon & decarbonization	**Governance for sustainable pathways**
	

The agrifood sector directly influences the life on land, life on water, zero hunger and climate action goals. The use of renewable carbon and the decarbonization of fuels and materials directly tackles the climate action goal, and indirectly the life on land and life on water goals. When energy cultures or other types of culture are used for biobased purposes it has competitive interaction with the goal of zero hunger. Through the production of biofuels and of renewable energy, this bioeconomy sector also influences Goal 7, affordable and clean energy.

Generally, Goal 10 (reduced inequalities) and Goal 11 (sustainable cities and communities) are not included in other studies, however they must be considered. Goal 10 is important in terms of nutrition and food equality, and horizontally across all the bioeconomy sectors. Goal 11 is relevant to the development of rural communities and for improving the connection between rural and urban ecosystems. Cities can be enablers of the urban circular bioeconomy, especially with the use of a systemic decarbonization approach in the region.

Horizontally, the bioeconomy can impact the decent work and economic growth, industry innovation and infrastructure, responsible consumption and production, quality education, good health and well-being, and no poverty goals. The clean water and sanitation goal is also impacted directly by the consumption of water and the production of wastewater.

What is the real progress? Most BIOEAST countries have made strong progress in their struggle for multifaceted bioeconomy development, but several of them are still in the stage of mild progress or even regression (Fig 12):

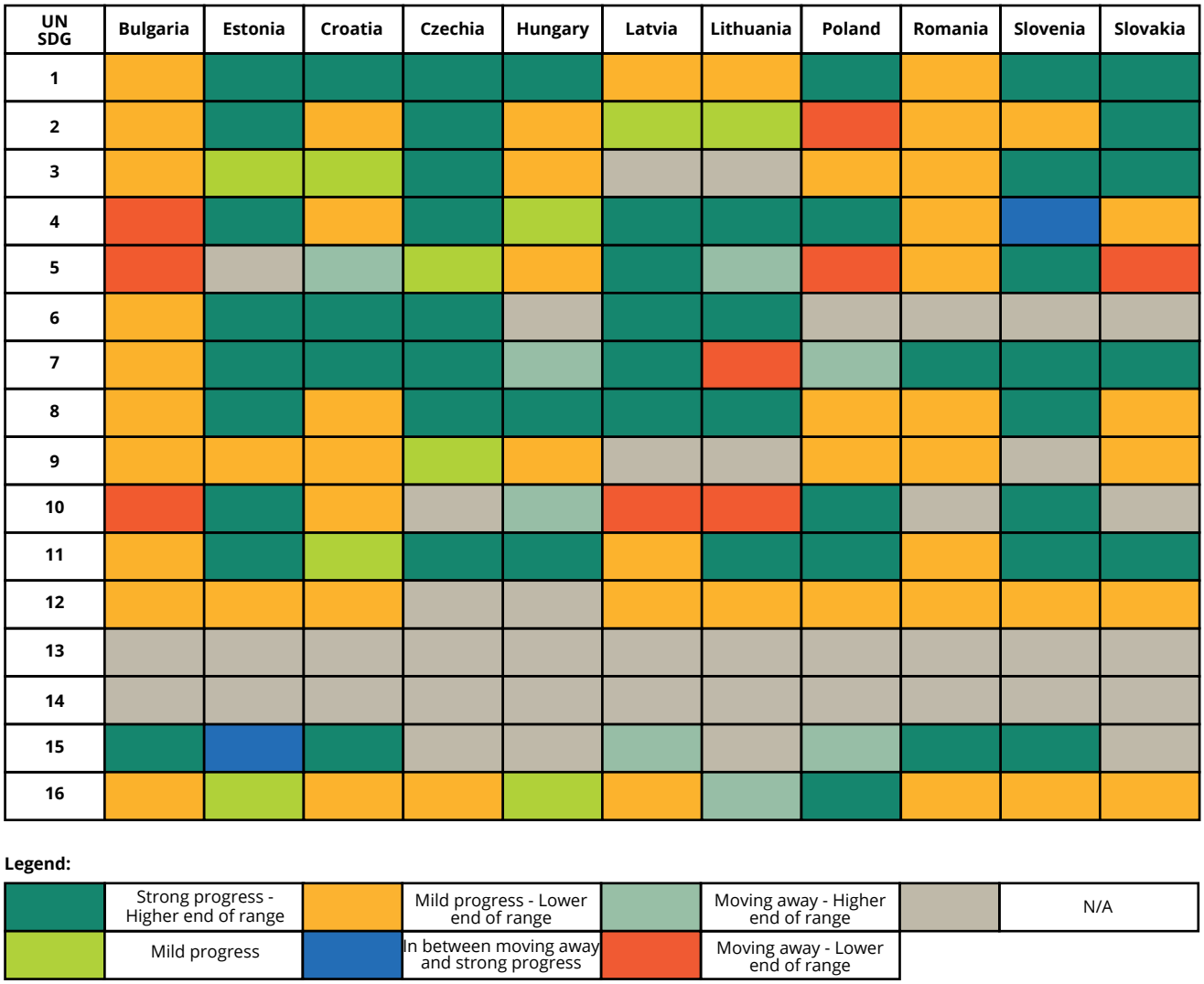


Figure 13: *Own elaboration of Eurostat data (Monitoring Report on Progress towards the SDGs in an EU Context) [2,3]*

SDGs 1, 7, 11 and 8 are the most advanced of the SDGs in the BIOEAST countries. Changes in agriculture, food production and off-farm economies support the elimination of hunger in rural areas, giving people the chance to feed their families and live a decent life. The BIOEAST countries can develop modern energy services in food systems by improving energy efficiency and increasing the use of renewable energy. They apply a multifaceted approach to urban resilience, and more coherent and inclusive food security.

The development of farm and non-farm employment opportunities in agriculture and beyond – in agrifood chains linked to sustainable agriculture, agri-business development and related support services – leads to SDG 8.

Work still needs to be done in order to improve the trends towards responsible consumption and production (Goal 12), improving our industry, and infrastructure (Goal 9) and governance through peace, justice and strong institutions (Goal 16).

4.5 Resilience for our future – the lesson of Covid-19

The Covid-19 crisis has introduced multilevel changes in the directions of the economy and bioeconomy development, and forced a focus on human health and safety. The new approach to governance covers the pursuit of greater local self-sufficiency and diversity, which is less related to globalization and uniformity. There is tendency to create supply chains closer to home and filled with redundancies to protect against future disruption.

Covid-19 has had a mixed impact on bio-based sectors and the bioeconomy. Relatively little data is available to make profound conclusions about the lasting effects of the pandemic. Production, demand and international trade in agriculture and food products have been relatively unaffected, compared to many other manufacturing and service industries [4]. As the OECD put it "enough food is available globally, but Covid-19 is disrupting supply and demand in complex ways" [2].

The IMF estimate for global decline in GDP in 2020 is 4.6% in absolute terms [2].

The pandemic crisis demonstrates the need for structural changes that make the BIOEAST economies more resilient to future shocks. The crisis has changed patterns of food buying, diet, and nutrition, but also improved digital tools, nutritional education, and social solidarity. Structural changes may be triggered by new trends in the demand for biobased products. Demand for biodegradable packaging has surged due to the increase in online shopping and the need to reduce interpersonal contacts [3].

The forces that affect investment and capital stock can develop in two plausible directions; making some capital obsolete, and encouraging increased investment in other areas. The utilization of the pre-pandemic capacity of both capital and labour will bounce back significantly post-pandemic, but to a highly uncertain degree.

A circular, sustainable bioeconomy can be a core instrument in the European Green Deal in the post-Covid era, making the BIOEAST macroregion more resilient and competitive. Sustainable biomass is available from sources in the BIOEAST region in the long term, meeting demands for existing and emerging uses (e.g. biobased material) by 2030. There is enough sustainable biomass to contribute to all sectors by 2030, and probably beyond, as well as to bring organic carbon back to the soil. Nevertheless, in addition to residues and wastes, sustainable biomass supply includes sustainably sourced agricultural and forestry feedstocks, and feedstocks from recovering and restoring marginal and degraded land. The bioeconomy includes sustainable food systems which can increase resilience. The BIOEAST countries have no reason not to dream big.

5 Sustainable use of the natural resources of the bioeconomy

5.1 Resource management in the BIOEAST countries

Soil and water are the main resources that the bioeconomy depends on; if these two are not treated accordingly, biomass quality and quantity will suffer the consequences.

Rethinking resources

- *Avoid overuse and overharvest*
- *Boost resource efficiency*
- *Sustainable management*
- *Closing the loops*

Interventions that lead us toward the sustainable soil management within the planetary boundaries:

Sustainable soil management covers climate mitigation actions with evidence of mitigation potential on agricultural land in the EU [2].

- *Conversion of arable land to grassland to sequester carbon in the soil*
- *Agroforestry*
- *Wetland/peat bog conservation and restoration*
- *Woodland planting*
- *Preventing deforestation and removal of farmland trees*
- *Management of existing woodland*

Crop production systems

- *Reduced tillage*
- *Zero tillage*
- *Leaving crop residues on the soil surface*
- *Ceasing the burning of crop residues and vegetation*
- *Use of cover/catch crops*

Livestock production systems

- *Livestock disease management*
- *Use of sexed semen for breeding dairy replacements*
- *Breeding lower methane emissions in ruminants*
- *Feed additives for ruminant diets*
- *Optimized feeding strategies for livestock*

Manure, fertilizer and soil management

- *Soil and nutrient management plans*
- *Use of nitrification inhibitors*
- *Improved nitrogen efficiency*
- *Biological N fixing in rotations and in grass mixes*

Land and Soil

Land quality degradation, loss of organic matter, and soil erosion are the remarkable results of "industrial agriculture", with negative consequences for the factors that fuelled it (cheap energy, neglect of the environment, large investments, privatization of genetic resources). Nitrogen (N) applied to croplands causes soil erosion; 15% of used N has a negative effect on soil quality; approximately half of the N is incorporated into plant biomass, while the rest is lost mainly through leaching (16%), and gaseous emission (14%) [7].

Soil degradation is not well monitored, and intensive land management leads to negative impacts on soil biodiversity, which is the key driver of terrestrial ecosystems' carbon and nutrient cycling. Different forms of soil degradation (soil organic carbon loss, tillage, pollution, compaction and erosion) negatively impact the habitat available for soil

organisms. In all regions across Europe, the species richness of earthworms, springtails and mites has been negatively affected by the increased intensity of land use. Healthy soils contain active microbial (bacteria and fungi) and animal (micro to macro fauna) communities, of which bacteria and fungi are mainly responsible for nutrient cycling, which is essential for plant growth [11]. The food system is a major driver of biodiversity loss, land and soil degradation and GHG emissions, and is a polluter of air, freshwater and oceans through eutrophication. Progress in the remediation of polluted soils is slow. Europe is not on track to protect its soil resources based on existing strategies. Europe continues to consume more resources and contribute more to environmental degradation than other world regions. The BIOEAST countries need to develop their own strategy to protect soil against degradation.

Managing our forests – Slovenia and Estonia are highly forested; 58% and 50% of their land is covered by forests! These large shares suggest that sustainable forest management is key to ensuring the land is properly managed. Spatial planning strategies should be coherent with this. Each country should address their situation locally, targeting their specific needs.

The BIOEAST macroregion is characterized by a high diversity of landscape fragmentation. The fragmentation is at a stable level and the greatest is observed in Lithuania, Hungary and Czechia, and the lowest in Bulgaria, Slovenia and Slovakia [8].

Land management – land-system change: cropland (12% of land surface) and pastures (28%) together represent the largest share of land use, except Antarctica and Greenland. Future expansion, at least in the tropics/subtropics, in response to increased food/feed demands is expected. Agricultural expansion is expected to exacerbate other impacts (CO_2, CH_4, NO_2), in particular if climate changes will reduce the productivity of land under cultivation today. Forest surface is increasing in the north, and decreasing in the tropics/subtropics [9]. In the face of increasing demand for land-intensive crops and livestock, around 20% of the Earth's vegetated land surface showed persistent declining trends in productivity between 1998 and 2013 (20% of cropland, 16% of forests, 19% of grassland, 27% of rangeland). This is particularly worrying as further intensification (albeit under the "sustainability" label) is advocated to meet increasing food and feed demands.

Sustainable agriculture of the future implies [2]:

- *1. Increasing agricultural production per unit land area, per unit fertilizer input, and per unit water consumed (resource efficiency);*
- *2. Maintaining and increasing soil organic matter in croplands, which is a key to water holding capacity, nutrient availability, and carbon sequestration;*
- *3. Employing agroforestry practices that provide food and fibre yet maintain habitats for threatened species;*
- *4. Maintaining local biodiversity and associated ecosystem services such as pollination and pest control.*

Sustainable management and protection of water resources, ensuring access to fresh water for citizens and the economy, protection of lands, improving soil quality, and reduction in emissions of greenhouse gases are key targets of the national bioeconomy strategies in the BIOEAST countries. In Poland this principle is covered by the "Ecological State Policy 2030 – Development Strategy in the Field of Environment and Water Economy" established in 2019, and the "Strategy for Responsible Development to 2020 with a Perspective to 2030".

Water management: the EU Water Framework Directive (WFD) establishes a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater. It aims to prevent and reduce pollution, promote sustainable water use, protect and improve the aquatic environment, and mitigate the effects of floods and droughts. The overall objective is to achieve good environmental status for all waters. The WFD is supported by more targeted directives.

The Urban Wastewater Treatment Directive aims to protect the environment from the adverse effects of urban wastewater discharges and discharges from industry. The directive sets minimum standards and timetables for the collection, treatment and discharge of urban wastewater, introduces controls on the disposal of sewage sludge, and requires the dumping of sewage sludge at sea to be phased out. The Commission is intending to update this directive, to better tackle water scarcity by facilitating the reuse of treated wastewater for agricultural irrigation.

The Nitrates Directive aims to protect waters from nitrates from agricultural sources. Whereas the reform of the Common Agricultural Policy set out in the Commission's green paper "Perspectives for the Common Agricultural Policy" indicated that the use of nitrogen-containing fertilizers and manures is necessary for Community agriculture, it also stated that excessive use of fertilizers constitutes an environmental risk, that common action is needed to control the problem arising from intensive livestock production, and that agricultural policy must take greater account of environmental policy. It stated that, in order to protect human health, living resources and aquatic ecosystems and to safeguard other legitimate uses of water, it is therefore necessary to reduce water pollution caused or induced by nitrates from agricultural sources and to prevent further such pollution, and that it is important to take measures concerning the storage and the application on land of all nitrogen compounds, and concerning certain land management practices.

The trend of water abstraction in the BIOEAST region is diversified. In countries like Czechia, Hungary, Lithuania, Poland, Romania, Slovakia and Slovenia there has been a reduction over the 10 years to 2018. The countries where this has been most evident are Lithuania and Czechia. Poland, Hungary and Croatia are the only countries with available data for non-freshwater extraction. On the other hand, the average rate of water consumption change in the region is that of an increase towards 2050. By 2030 and 2050 water consumption will have increased by 28% and 65% respectively [4].

Agricultural practices in the BIOEAST countries show the following results:

- *Resource productivity has been increasing in Poland and now it has the highest growth rate in the Baltic region (+20% 2011-2015) [2];*
- *Estonia and Latvia have a high land use intensity (km2/GDP) when compared to other Baltic countries;*
- *Poland has the highest reduction in land footprint and water footprint of the Baltic countries from 2011 to 2015;*
- *Land footprint has increased in Estonia during the last years.*

Resources and RDI – Developing digital technologies and their convergence with life sciences supports understanding and the sustainable use of natural resources. The multidimensional approach to digitalization introduces innovations related to water and soil use to all sectors of the economy. The growth in digitalization is based on research, development and implementation, and covers bioinformatics, artificial intelligence and automation. The needs of new professional competencies, qualifications and skills will be developed thanks to new courses, curricula and education programmes. A good sample of digitalization supporting soil and water use is Global Land Surface Phenology organized by the European Commission, Joint Research Centre, with data produced by BOKU University of Vienna. In order to develop digitalization it is necessary to have established an action plan or strategy in CEE countries.

5.2 Climate change risks and trends to be considered

There are several ways climate scenarios can develop; however, the consequences of climate change that can have a greater impact on the bioeconomy are those that affect the sources of the circular bioeconomy model (water, soil for crops) and agricultural feasibility:

- *Alternating droughts and water excess periods in some regions*
- *Water scarcity*
- *Floods*
- *Sea level rise*
- *Increasing temperatures and pests*
- *Low temperature extremes*

A period of sufficiently prolonged, abnormally dry weather, resulting from climatic changes, can cause a lack of water and therefore a serious hydrologic imbalance and drought. The climatic water balance in Poland used for the evaluation of the drought scale indicates that Wielkopolska is a region particularly sensitive to climate change due to long-term drought.

The highest concentration of air polluting substances is registered in the central and southern regions: Gornoslaski, Krakowski, Rybnicko-jastrzebski, Lodzki and Warszawski. The implementation of the principles of the energy policy of Poland up to 2040 should significantly improve the situation.

Other countries such as Slovenia and Estonia also have regions that are highly sensitive to climate change. In Slovenia the main issue for certain areas like the Alpine region which is sensible to climate change effects and in the karst will be dealing with water management due to water scarcity, and in some areas due to floods. The Pandivere Upland region of Estonia is similar to the karst region of Slovenia, and coastal areas in Western and Northern Estonia could become more vulnerable to coastal flooding.

This makes regional BIOEAST farmers sensitive to climate change – they therefore need support and education.

6 The circular agrifood system

6.1 Agricultural productivity

The UN Food and Agriculture Organization (FAO) estimates that global food supply must increase by 70% by 2050. In order to meet global food challenges, we will have to grow more with less: less land, less input, less water and less energy. The adoption of these goals creates a serious dilemma in Europe: having a target of reducing the impact of agriculture would risk making European agriculture less productive. To meet increasing food demands on the available agricultural land in the EU would have to be compensated by increasing the agricultural area at the expense of nature, whether this be within or – more likely – outside the EU. Fortunately, producing more with less is possible if the EU allows an enabling toolbox of technologies and approaches to further improve agriculture. Compared to the European average, the countries of the BIOEAST macroregion seem to be more susceptible to embracing modern technologies both at the level of regulation and at the level of public and stakeholders perception. Further enhancing this attitude will certainly be beneficial for the agricultural productivity of the region.

On the other hand, greenhouse gas emissions from the agricultural sector declined by 20% between 1990 and 2015, according to Eurostat-2, and in the same period EU agriculture increased its overall productivity by 25%. The respective numbers for the BIOEAST region were an 11% reduction in greenhouse gas emissions and a 14% increase in productivity,

far behind the European average. This is partly due to the fact that these countries adopted fewer innovative solutions and practices, and they delayed in implementing the EU regulations and suggestions (e.g. eco-friendly practices, integrated crop or agriculture management, more efficient pesticides, and solutions enabled by biotechnology). In recent years this situation has seemed to improve and the governments of the BIOEAST countries seem to be persuaded that making agriculture even more eco-friendly is a good idea, and they encourage all these innovative solutions and practices.

The amount of agricultural land is very high in the BIOEAST region compared to the Western EU countries. Hungary is the country with the highest percentage, 59.6%, Romania is second with 58.1%, and Lithuania is third with 50.7%. The lowest shares are Estonia at 25.7% and Slovenia at 27.7%. Nevertheless, agriculture is an important economic sector for the entire region.

The agrifood context is quite diverse in the region, and country diversification needs to be addressed. Czechia is characterized by large farms, while Slovenia has small, fragmented farms with less than 10 ha.

In some cases small farms with outdated methods lead to a high environmental impact per hectare.

6.2 Digital transformation of the agrifood system

In many ways agricultural engineering is already completely digitized. However, there is still progress to be made in digital cropping and smart (or precision) farming. Technical challenges involve the manipulation of a machine through electronic control systems, while parallel sensors are being developed to record the data upon which process control can be based. After 20 years of research in “precision agriculture” there are today many types of sensors for recording agronomically relevant parameters, as well as many farm management systems. However, it still cannot be claimed that precision agriculture has been widely established in crop production.

Today, many farmers are already using digital technologies such as smartphones, tablets, in-field sensors, drones and satellites. These technologies provide a range of farming solutions such as remote measurement of soil conditions, better water management, and livestock and crop monitoring. By analyzing the data collected, farmers can, for example, gain insight into likely future crop patterns or animal health and welfare. This enables them to plan more effectively and be more efficient. Digitization can increase profitability, improve working conditions for farmers, and reduce the environmental impacts of agriculture.

Some of the digital methodologies in agriculture are already in use in several BIOEAST countries, such as robotics and precision farming, while in others they still need to be further enhanced (decision support tools, digital marketing, digital innovation hubs). Specific data analysis tools, including those with a special focus on cost-benefits, can help farm advisers to play a critical role in informing farmers on digital technologies.

The introduction and uptake of technologies requires new skills and knowledge for farmers and advisers. Raising awareness and organizing training at a regional/local level is essential, especially to reach small and medium-sized farms where the use of digital technologies is not always thought of as profitable. Agricultural Knowledge and Innovation Systems (AKIS) has played an important role in promoting mutual learning, to generate, share and use knowledge and information related to digitization in agriculture. This example could also be adopted in the BIOEAST region.

While there is already a lot of literature from a natural or technical sciences perspective on different forms of digitalization in agriculture, social science researchers have only recently begun to investigate different aspects of digital agriculture in relation to farm production systems, value chains and food systems. There is, therefore, a lack of overview on how this field of study is developing, and what are established, emerging, and new themes and topics. Specific issues can be raised in this domain:

- *Adoption, uses and adaptation of digital technologies on farms;*
- *The effects of digitalization on farmer identity, farmer skills, and farm work;*
- *Power, ownership, privacy and ethics in digitizing agricultural production systems and value chains;*
- *The economics and management of digitalized agricultural production systems and value chains.*

These issues raise questions that will need to be addressed in the future. What will the impact on farm profitability be, for instance? How will digitization affect employment? Can it be a means to reconnect consumers with farmers? What is the environmental impact? Which types of farming will or will not benefit? These issues, and other questions like data ownership, data use and re-use, must be explicitly analyzed and presented in specialized workshops. Several BIOEAST countries are already quite active in this.

6.3 Sustainable agriculture and the agrifood system

The Oxford University's Future of Food project defines the food system as a complex web of activities involving the production, processing, transport, and consumption. Issues concerning the food system include the governance and economics of food production, its sustainability, the degree to which we waste food, how food production affects the natural environment and the impact of food on individual and population health. The EU FOOD2030 initiative emphasize three main aspect of the system: to be sustainable including circularity, healthy and to provide nutritious food.

Without further detailing the definitions and concepts it must be stated that as soon as we start discussing sustainability, healthy and nutritious aspects there is no other way than to tackle the whole system in its integrity. The partial approaches trying to make the different parts: production, processing, logistics and waste separately sustainable, could not reach to long-term solutions. The new systemic approach towards food systems is crucial.

Thus, the biggest challenge of the BIOEAST countries to start to think out of the box, and to leave behind the conventional approaches. Today in most of the countries still do have a disrupted approach not just in policymaking, but also in building up strategic thinking along the value chain. The traditional sectors based approach is prevailing. Sustainable and circular solutions are planned to be developed separately in agriculture, or in food processing or in waste streams management, and it is not common to have a complex systemic and cross-sectorial approach. The negative externalities, which do derive from the disrupted approaches like health of society, less nutritious food, problems with natural resources (air, soil, water) are going to be left untacked. This is not anymore an option.

One of the key reluctances towards bioeconomy deployment is the fear of biomass scarcity for feed and food productions. The policy makers do need to overcome this fear and recognize the opportunity in value added processes to the biomass and in the new business models, which are built on systemic approaches to solve the societal problems. On one hand, a sustainable, healthy and nutritious food system cannot be built without having in mind the sustainable bioeconomy, thus the sustainable valorisation of the available bioresources. Policy makers should develop national level strategy and action plan for the whole bioeconomy including a food system.

Some elements of the system do require special attention in the BIOEAST countries:

- *Productivity*
- *Digital transformation*
- *Scarcity of natural resources*
- *New business model for food production*
- *Reducing pollution*
- *The food culture in the context of nutritious and healthy diets*

A sustainable food system has become a universal requirement. In part, this is due to the increasing demand for food worldwide in parallel with the rising global population and the changing diet. In addition, there are other challenges to consider such as behavioural change needed in food choice and alternative food sources, and the competition for the land use with non-food biomass feedstocks. Furthermore, food systems significantly contribute to GHG emissions and have multiple other environmental impacts. Nowadays, these systems are also characterised by large water footprint and intensive use of synthetic fertilizers and pesticides, at the same time they are threatened by soil impoverishment and climate change.

Today, the food systems in our region are still unsustainable to a large extent due to the complex economic, social and environmental components of the food chains. In order to transform our systems into sustainable and resilient ones we need radical transformations. To meet this demand, sustainable intensification of biomass production is required. Furthermore, the food system and its value chains must transition from linear to circular ones. This can only be achieved by using a holistic and transversal approach and considering the food system as a whole, including all its value chain and avoiding compartmentalized reasoning.

The United Nations and FAO are closely cooperating with National and Regional organizations aiming to put in action specific regulations. In the European Union this domain has been characterized as a "domain of priority". The BIOEAST countries are aligned with the EU directives and special emphasis is put in this direction, since the agrifood production and processing is a crucial sector of the regional economy.

Sustainable agriculture and agrifood systems offer a wide spectrum of benefits and opportunities for further development. It is possible to indicate the following:

- *Soil protection and improvement;*
- *Lower losses and higher yields; focus on innovation, e.g. use of new technologies and digital solutions;*
- *Reduced food loss and waste: biobased innovation can help to reduce both food loss and waste at different parts of the value chain: in food production/manufacturing and by consumers, e.g. through bio-preservatives and antioxidants to improve shelf life;*
- *Enhanced feed conversion rate: innovative feed solutions, including feed additives produced using biotechnology, will enable livestock to retain more nutrients and nitrogen from less high-protein animal feed. This helps to increase the efficiency by which animals convert feed into protein and can contribute to reducing the EU's dependency on the import of soybeans and soybean meal high protein feedstocks;*
- *Water protection: non-tilled soils trap moisture better, reducing run-off into streams and rivers and contributing to more efficient water use;*
- *Reduced spraying: crop biotechnology has reduced pesticide spraying;*
- *Partially replacing pesticides: microbials work as biological crop protection products or biocontrols that can help farmers to protect plants from pests and diseases, including weeds;*
- *Thanks to technology and innovation, farmers can now use natural resources more efficiently. Sustainable land use and management enable both high yields and biodiversity. This reduces the pressure to convert more land to farming, helping to preserve natural habitats and their wildlife.*

In this perspective our countries should consider a mix of different measures aiming to maximize effectiveness. These actions should include:

- *Valuable food: Delivering affordable, nutritionally adequate, safe and healthy (and even culturally acceptable) food*
- *Implementation of circular transition:*
    1. *Reducing food waste and food losses and minimizing the impacts on the environment and society*
    2. *Value the resource potential present in biowaste and wastewater streams*
    3. *Cycle the nutrients and carbon back to the soil*
- *Systemic approach: Applying the sustainability principles throughout the whole value chain (pre-production, production, supply chain, consumption)*
- *Balancing between agro-ecosystems integrity and social well-being*
- *Tailored and specific solutions: Considering the specificity of each region and case, since each case needs its own tailored solution. The one-size-fits-all doesn't work here.*

It is important to mention that implementing Sustainable Food Systems is not only to help guide food systems toward an equitable and sustainable future, but also to cultivate health and wellbeing, biodiversity, resilience, and equity at all levels. This goal can be achieved by developing specific validation tests for sustainability, thorough life cycle assessments, upgrading the processes, and developing tools and methods for food systems analyses including spatial decision support tools, ex-ante evaluation/foresight, and modelling of the interdependence between changes in food system and impact on consumers or the environment at different scales.

6.4 Sustainable food production

A key priority is to make food production more sustainable. From this perspective, it is important to encourage the use of biobased alternatives for sustainable crop cultivation, as well as innovation in plant breeding. Biotechnology supports sustainable crop cultivation through bio stimulants and biocontrols that provide an alternative to fossil-fuel derived products. It can also provide the tools to create more sustainable food processing and more sustainable, safe, healthy and nutritional end products. The BIOEAST countries should adopt concrete and pragmatic measures to support the uptake and use of such bio-based products. Innovation in plant breeding has the potential to bring several thousand new plant varieties to the market each year. Many of them are stronger and less dependent on inputs than older varieties and can increase yields, thereby ensuring efficient land use and carbon capture in soils. Likewise, climate change is beginning to result in new pests and more extreme weather conditions, and new genomic techniques can provide much of the required acceleration of plant breeding innovation for disease and insect resistant varieties. In addition, genome edited plants can bring important health and nutritional benefits.

6.5 Reducing pollution

The EU has made an important commitment to make substantial progress towards the ambition of zero pollution, including from excess nutrients, to reduce the pressure of pollutants on ecosystem function and biodiversity. This decision will facilitate the placing on the market of sustainable and innovative feed additives that help reduce the associated greenhouse gas (GHG) footprint and water and air pollution, as indicated in the Bioeconomy Strategy (2018). The biobased industries and industries of the agrifood sector can contribute to such ambitions by reducing the amount of nitrogen and phosphorous burden of agriculture and water consumption in animal farming by using innovative feed additives such as amino acids and enzymes, contributing to less eutrophication of marine waters and reduced GHG emissions. The majority of the BIOEAST countries have also adopted this EU commitment and they are proceeding with its implementation by adopting related national legislation.

6.6 The added value of food

Agriculture is important and so is a sustainable agrifood value chain, but we cannot forget about food. Food can be the added value that the BIOEAST region needs to develop. Most attention usually goes to other biomass and its added value, but we often forget the importance of food. Food can be industrial, plain and lacking in value, but it can also be developed with quality value chains, quality ingredients, quality techniques and be organic. It can become regionally and internationally distinguished. This brings added value and recognition to the region of origin, in our case to the BIOEAST countries

We want to improve our primary biomass added value and quality. Why not do the same with food?

Opportunities in the region:

1. Collaboration within the value chain by building consortia that work on product quality and RDI. An inspiring example is the Grana Padano and Parmigiano consortia in Italy, which engage in strengthening the value chain and even RDI.

2. Examples from other markets to be considered in the development of agricultural practices and agrifood techniques able to produce quality-distinguished and well branded products in the BIOEAST region:

- ***Pata Negra ham from Spain*** *[A]*
- ***Virgin olive oil from Italy*** *[B]*
- ***AOP cheese from France*** *[C]*

The BIOEAST region is rich in soil and land and culture, and we also have the potential to develop the best products. The BIOEAST region's diversity can only help in this direction. Crucial steps are rethinking the food system, collaborating in agrifood value chains, and changing the mindset from plain aliment to quality, nutritious and valuable food.

3. Food waste value is being lost and not taken advantage of while keeping us from our goals of waste collection and recycling and of restoring the quality of the soil.

We need two important components to ensure a holistic and sustainable food and nutrition system; a nutrition-positive agrifood system and engaged citizens.

Towards a nutrition-positive agrifood system: agricultural practices and natural resources management, as well as the management of waste and wastewaters, impact the quality of the soil and water and thus the quality of food.

It is important that we avoid polluting our food. The quality of our food will impact the health of society, which in return can then impact the costs of the healthcare system and the development of the economy.

The habits of BIOEAST citizens impact the development of the whole bioeconomy. Our current habits and diets are not sustainable. Among alternatives to be considered, we can address new and alternative sources of protein that provide nutrition but are environmentally and socially sustainable (insects, vegetarian/vegan proteins, lab-grown meat, etc.). Urban agriculture can also improve the efficiency of food production in urban areas.

7 Renewable carbon and decarbonization

7.1 The competition for bio-based carbon

Renewable or bio-based carbon can replace fossil carbon in many products as a natural substitute for fossil fuels. There are three sources of renewable carbon: recycling of existing plastics (mechanical and chemical recycling), utilization of biomass as a resource, and direct CO_2 utilization of waste gas from the fossil-based and cement industries, biogenous sources such as biogas, and the air. The traditional fossil fuel derived carbon can be successfully replaced by bio-carbon products often used as adsorption materials, soil amendments or improvements for agriculture. Bio-carbon used as a soil enhancement is a carbon sink, thanks to its stability. The competition for bio-based carbon will be decided by the finished products with high added value. Contrary to the renewable carbon use, the decarbonisation affects mainly the energy sector, to withdraw from the market the fossil-based GHG emissions, the intensive use of fossil-based carbon, and to replace it with renewable energy sources. Massive decarbonisation plans should be put in place to be able to reach the GHG emission targets by 2050

If the BIOEAST countries do not address the prioritization of bio-based carbon, the macroregion will remain an assembly economy, lag behind in international competitiveness, and fail to meet the goals of the European Green Deal and a sustainability transition. A very rapid change in the decarbonization process and renewable carbon market is expected, and the BIOEAST countries can no longer wait to be part of these markets. Decarbonization is a key term used to describe the phasing out of carbon dioxide emissions from the use of fossil fuels by the substitution of the fossil fuels themselves or by producing a climate-friendly, sustainable alternative to fossil resources by using biogreen technologies (the pyrolysis process) or producing other renewable energy (solar, wind etc.). Removing CO_2 from the atmosphere is also related to decarbonization.

The implementation of the European Union Climate and Energy Policy, including its long-term vision of striving for EU climate neutrality by 2050, is a huge challenge for the BIOEAST countries. The "Energy Policy of Poland until 2040" establishes the framework for energy transformation in Poland. It contains strategic decisions concerning the selection of technologies for building a low-emission energy system. The policy takes into account the scale of the challenges related to the adaptation of the national economy to the EU regulatory conditions of the 2030 climate and energy targets, the European Green Deal and the efforts to achieve climate neutrality.

7.2 Energy systems and renewables

About 80% of the EU energy system relies on fossil fuels and nuclear energy. The proportion of renewables is growing but their role still remains limited (20%). The transport sector is the biggest driver of oil demand at the EU level – two-thirds of the final demand for oil comes from transport. Non-energetic or material use of fossil fuels (e.g. asphalt, lubricants, solvents, waxes, fertilizers, tars) now amounts to 8% of its overall use, but this figure could grow to 30% by 2050 if no additional measures were taken.

Fossil fuels will still provide about half of the EU's energy in 2030, due to the substantial reduction in the use of coal, which has a high pollution intensity. Decreasing oil and gas imports is expected between 2030 and 2050. The import of natural gas as a transition fuel in the EU is likely to increase in the future. The EU imports significantly more carbon than it exports, and the issue of carbon leakage cannot be ignored. The challenge for the EU is to design a carbon border tax to prevent carbon leakage by incentivizing other countries across the world to decarbonize [16].

Reducing energy dependency from imports is possible. Hungary has done so by introducing energy efficiency and renewable energy sources in the existing biobased industries and emerging value added chain (two good examples are the Pannonia Bio Zrt. and Hungrana Ltd biorefineries).

Decarbonization can also create new energy security risks, mainly from the imports of products and raw materials that serve as inputs for clean energy and clean technologies (for example, rare-earth elements). Renewable electricity is expected to decarbonize a large proportion of the energy system by 2050, and hydrogen is seen as a way to decarbonize parts of the energy system electricity cannot reach (including industrial processes such as steel and cement production, and transport sectors such as trucking, shipping, and aviation). As fossil fuel resources gradually phase out, crops cultivated for bioenergy (including biofuels) and for the production of biobased materials could affect food security (taking away land and calories from human nutrition), with the risk of increasing food prices.

7.3 New added value in the bioeconomy

The bioeconomy can contribute to the defossilization of major industries, such as the energy and transport sectors, the chemical industry (e.g. plastics) and the construction sector (use of wood as a substitute for non-renewable building materials). In fact, the biobased sector can also help to sequestrate carbon through its long-term storage e.g. in wooden and woody biomass-based products. Moreover, the circularity and defossilization of major economic sectors, including the agriculture and food sector, the chemical industry and the wooden construction sector, offer possibilities for long-term carbon sequestration and the implementation of the low carbon economy. In the construction sector, greater use of wood as a substitute for more energy-intensive non-renewable building materials can reduce greenhouse gas emissions. The technologies also enable biowaste and residues from farms and forest-based sectors, from cities or from the food sector to be transformed into bio-based products such as chemicals, organic fertilizers, biofuels and eventually heat and power, if a more circular use is not possible. Removing CO_2 from the atmosphere through both nature-based (afforestation and reforestation) and technological solutions (carbon capture and storage) will be necessary to reach climate neutrality and achieve net negative emissions by 2050 [16].

Multi-product biorefineries can improve the efficiency of biomass utilization by increasingly parallel exploitation of sideflows, and reducing and/or recovering waste and residues, thereby boosting recycling and circularity. As biomass is bulky and hence expensive to transport, these new transformation processes should ideally be located close to the primary production sites, thus bringing new added value generation into rural areas. The development and deployment of biorefineries will depend heavily on the profit margin of biobased products and the successful development and commercialization of new technologies, availability of local and/or regional feedstock at competitive prices, suitable infrastructure, and fostering by a regulatory enabling environment.

The current risk to the security of the supply of crude oil is high in the BIOEAST countries (mainly in Poland, Slovakia, Hungary, and Czechia) due to their high dependence on oil supplied by pipeline from one single supplier (Russia), except for Romania and Estonia which have an energy dependence of 24% and 1% respectively. By implementing a strong decarbonization strategy for transport the BIOEAST countries can address energy insecurity and gain climate, environmental and economic benefits for the long-term. The BIOEAST countries are expected to continue to import fossil fuels at more or less unchanged volumes for another decade. The BIOEAST region will remain a major net importer of green energy, such as solar and wind electricity, and green hydrogen. On the other hand, carbon farming initiatives could encourage the BIOEAST region to establish (on a voluntary basis) a fund to buy carbon credits from farmers and forest owners who implement specific on-farm projects aimed at increasing soil/biomass carbon sequestration and/or reducing emissions in the livestock sector or related to fertilizer use.

Replacing non-renewable resources (e.g. construction, plastics, textiles), increasing waste recovery of biobased materials, the creation of biorefineries, and enhancing investments in new infrastructure, research, innovation, education and training will contribute to greater renewable carbon use and decarbonization in the BIOEAST region.

7.4 Technological trends

In 2018 the Joint Research Centre (JRC) mapped 803 biorefineries in the EU producing biobased chemicals, liquid biofuels, and composites and fibres; 177 of them were integrated biorefineries [18]. The highest density of integrated biorefineries can be found in the Netherlands and Belgium. Of the 314 biobased facilities located in the BIOEAST region, 97% were commercial biorefineries and the remaining part pilot and demo facilities. These facilities produce liquid biofuels, pulp and paper, timber, starch and sugar, chemicals, composites and biomethane. Most of the facilities use forestry and agriculture feedstock, and 16% of them use bio-waste feedstock. Most of the facilities (25%) produce timber and pulp and paper; however, timber is produced with minimum added value and the regional forestry potential could be harnessed in a better way. In terms of biofuels production, liquid biofuels dominate the scene with 85 facilities, while only two facilities produce biomethane (Hungary). Liquid biofuels are produced in almost all the region, except for Slovenia and Croatia. The facilities that produce biobased materials and chemicals have a larger presence in Czechia and Slovakia. Starch and sugar are also produced in the macroregion by dozens of facilities. There are only a few facilities in the whole region producing either macroalgae or microalgae (Estonia and Hungary).

Some countries, e.g. Poland, Hungary, and Czechia, have developed biorefineries; however, they are lacking in Latvia, Lithuania, Slovenia, and Croatia. In these countries, the density of integrated biorefineries is among the lowest in the EU27.

The number of Polish biorefineries is large compared to the other BIOEAST countries, but not considering its size; the density of integrated biorefineries in Poland is among the lowest in the EU.

Countries lacking biorefineries need to be addressed in the right way, while the others need to improve and develop them towards high added value circular biorefineries.

Hungary has the largest biorefinery in Central Europe. Pannonia Bio operates a multi-product biorefinery in Dunaföldvár, Hungary, which uses state-of-the-art production processes. The sustainable production of raw materials for such a refinery will very much influence the future competitiveness and long-term sustainability.

Focuses:

The role of the chemical industry:

- *Global chemical sales expanded three times in value between 1998 and 2018, while the relative share of the EU chemicals market halved due to increased competition from other regions; however, the chemical sector still has a positive trade balance [3]. Investment in biochemical production capacity is starting to increase from a very low base. Biobased surfactants and solvents are the most important biobased products utilized in chemistry; however, the production of biopolymers and biobased plastics is expected to grow at a greater pace.*

- *In the EU, 10% of the total volume of organic chemicals raw materials/feedstock used for chemicals production is biobased. The biomass demand for biochemicals in 2030 is still projected to be much lower than the demand for bioenergy or biofuels [15, 17].*

- *The EU biobased chemicals market is diverse and large differences can be found between product categories. For example, solvents and platform chemicals have a very small biobased percentage, while on the other hand, surfactants and cosmetics already enjoy a large biobased share. Biobased platform chemicals are expected to grow rapidly, while biobased solvents are expected to grow much less.*

- *Biobased surfactants and solvents (mostly based on vegetable oils/animal fats, sugar or starch) are currently the most important biobased applications in chemistry. Biopolymer demand in the EU by 2030 is estimated to be in the range of 2-3 million tonnes. Forecasts indicate that more than half of the EU composite production (of 2.4 million tonnes per year) could be bio-composites by 2030.*

Bioenergy:

- *Energy plays a central role as it is responsible for 75% of emissions in the EU. The ratio between net imports and gross available energy indicates the import dependency for energy. The import dependency for all fossil fuels is about 50% in the EU [13].*

- *Bioenergy is the EU's largest renewable energy source (RES), and it is expected to remain a key component of the energy mix in 2030. The use of biomass for energy will become less attractive, as it is not able to compete on production costs with wind and solar energy.*

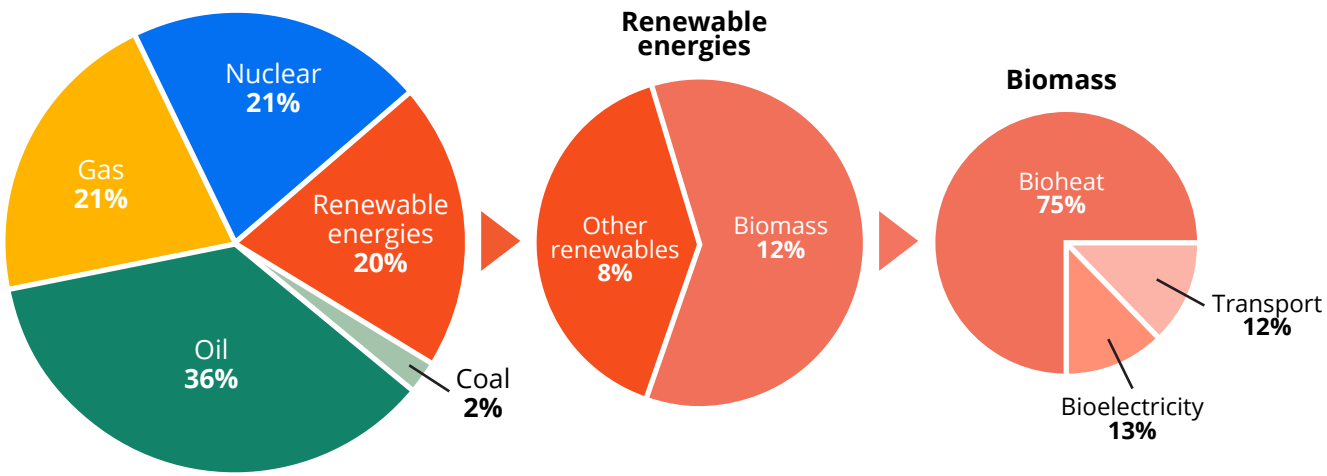


Figure 14: *Gross final energy consumption by fuel in the EU27 in 2019 (%) (Eurostat (2021a) [13]; Eurostat (2021b) [14])*

- *The EU target for RES energy use (20%) was met by 2020; however, the target set for most of the BIOEAST countries was lower than the average target of the EU. With 41% of energy from renewable sources in its gross final consumption of energy, Latvia had by far the highest share among the BIOEAST countries, followed by the others with a share in the range of 12-28%.*

- *At the opposite end of the scale, the lowest proportions of renewables were registered in Hungary (12.6%) and Poland (12.2%). When looking at the national targets, most BIOEAST countries have already surpassed their targets for 2020, except for Slovenia, Poland and Hungary. [13, 14]*

- *The BIOEAST region must find different ways to replace the fossil fuels themselves by producing or importing sustainable alternative energy to fossil fuel resources. Solar and wind power will cover an increasing share of energy demand and the proportion of electric cars powered by non-fossil fuel electricity will increase rapidly. Biorefineries will produce biofuels, among several other bio-based products, but the future of biofuels will depend on the policies towards energy production and the electrification of mobility.*

Several BIOEAST countries are embracing the potential for industrial hemp, as it has the potential to become the strategic renewable biological feedstock. In the past decade, hemp has been used for textiles, construction (concrete), facades, insulation and car production materials. Hemp biomass is also a source of bioenergy.

It is important to investigate further the possibilities and to invest in multiple raw material based refineries. The modern biorefinery concept should be applied to have multi product outputs. The new business models should be ideal for large and small-scale processes. Most of the applications are not yet market ready but it is important to turn towards research and innovation investments, de-risking the pilot and demo projects, which in few years could become the biorefineris of the future, the main pillars of sustainable and competitive processing of available biomass.

8 Technological trends for a 4.0 circular bioeconomy

Understanding the impact of the potential opportunities of new technologies, societal changes, and economic dynamics, as well as many other external factors, is a vital part of a concrete analysis. Today, these parameters are dominated by specific technological trends covering the whole spectrum of innovation: from big-data storage and management to Artificial Intelligence; from data visualization techniques to 3D printing; from IT technologies to total digitalization; from drones to robotics and so on.

Therefore, while building the roadmap, it is important to identify lateral opportunities created by these technological advancements. Future technological trends just show the future and so, they cannot be ignored, but they are indispensable for any strategic decision.

Digitalization is one of the major driving forces in a plurality of sectors of the European and CEE economies. The developments in digital technologies can be synergic to the acceleration of both the circular economy and the bioeconomy. In recent years the bioeconomy has taken major steps driven by digital solutions [5].

What is the connection between biobased, circular and digital?

The combination of digital and biological transformation can be synergic in many areas. As visualized below:

IT, Tech, Developments	Measure, observe & predict	Optimizing	Connect and empower	Communicate and educate	Secure
Artificial Intelligence & Machine Learning	○	○			
Big data	○	○			
Blockchain					○
Cloud Services	○				
Social Platforms			○	○	
3D printing		●			
Drones		○			
Apps			●	●	
Data visualization			●		
Internet of Things (IoT)	●	●	●		

○ • *Biomass optimization* • *Resource optimization*	○ • *Connect small producers* • *Connect producers with consumers*
○ • *Quantify biomass flows* • *Geospatial data for soil, water and resource mapping* • *Satellite imagery analysis*	● • *3D bioprinting* • *3D printing of microorganisms Environmental biosensors* • *Complex production manufacturing*
○ • *Precision agriculture*	● • *Communicate with farmers and foresters*
● • *Decision support systems*	● • *Real time systemic data*
○ • *Protect sensitive information* • *Secure and record transactions* • *Prevention of bio-piracy*	○ • *Predict outputs and trends* • *Identify leverage points* • *Identify weaknesses*
○ • *Data storage* • *Complex data analysis*	● • *Connect value chains* • *Connect biobased producers*
○ • *Raise awareness* • *Communicate with farmers and forester*	● • *Understand the relations between value chains* • *Real-time data*

A wide range of new digital technologies have emerged that are affecting all economic activities (agriculture, manufacturing, transportation, trade, energy, health, public administration). The potential productivity benefits of these new technologies are urgently needed (multi-factor productivity growth), although today, many firms find it difficult to turn new technology into productivity growth. The productivity gap between the globally most productive firms and other firms has widened. Strong, fixed broadband subscriptions are required and mobile infrastructure is essential to the Internet of Things. Effective use of digital technologies varies and small firms in the BIOEAST region lag behind large firms in engaging in e-commerce. The BIOEAST region's innovation performance is not robust, and a handful of other countries in the EU lead in artificial intelligence research.

Many jobs will be affected by digital transformation: mainly jobs with high and medium potential for automation (jobs between 50-70% of substitutable tasks). But history suggests new jobs will also emerge, complementary to new technology. A range of new (and old) skills will be needed, as well as societal trust in digital transformation. Digital divides need to be addressed, together with broader well-being. A huge gap in internet use by educational attainment can be recognized.

Governments also need to go digital by improving efficiency and targeting of existing policies (monitoring of imperfectly observable outcomes, monitoring of dynamic phenomena and emerging risks, compliance and enforcement); improving policies of design and impact (broaden suite of policy instruments, feedback to final users, policy experimentation and evaluation); and expanding stakeholder engagement (data collection, participation in design and implementation) including with respect to open data (open government data availability and accessibility). We must therefore understand the digital transformation and its impacts on the economy and society, provide policymakers with the tools needed to develop a forward-looking, whole-of-government policy response, and help overcome the gap between technology and policy development.

The vectors of digital transformation are scale, scope and speed; ownership, assets and economic value (sharing economy); and relationships, markets and ecosystems. Mark-ups are consistently steady and higher in digitally intensive industries.

Europe is currently in the midst of two transitions: the creation of a more circular bioeconomy and the digital revolution. These two major developments have the power to transform the economy and society. Major efforts are currently being made by the European Union and national policymakers to promote both transitions; however, these efforts are rarely aligned. The ultimate goal should be to ensure that they contribute to long-term sustainable economic, social and environmental prosperity, in alignment with the United Nation's Sustainable Development Agenda and the Paris Agreement.

Data and digitally-enabled solutions such as digital platforms, smart devices, Artificial Intelligence, the Internet of Things and blockchain are already contributing to the circular bioeconomy. It is important to recognize that digitalization will not automatically lead to greater sustainability. In fact, there is a risk that if it is not guided well, it will result in unwanted rebound effects, such as an overdrive of a linear 'take-make-dispose' economy, and increases in GHG emissions.

To get this transition right, the EU must think systemically, define a vision and act. Maximizing the synergies between digitalization and the circular bioeconomy and preventing negative externalities will provide an adequate governance framework and economic incentives for a (digital) transition to a (digital) circular bioeconomy.

It is important to recognize that this expands far beyond the traditional digital and environmental agendas; measures will need to be aligned with climate action and the wider sustainability agenda, and be supported by single market tools, the industrial agenda, research and development, and social and consumer policy. The main task is to encourage collaboration across European society and economy as well as globally, and empower the citizens to contribute to the transition.

Becoming more consistent in aligning the digital and circular economy agendas must start with a digital review of the circular economy transition and a sustainability review of the digital transition. We must encourage the use of data and digitally-enabled solutions to improve policy-making and implementation, with the aim of creating a more circular economy at the EU, national and sub-national levels. In addition, conditions must be created for the European economy, society, industry and public sector to become more sustainable and circular via digitalization. Incentivization is needed in the development and deployment of sustainable digitally-enabled solutions (e.g. AI, blockchain, IoT) in alignment with a more sustainable, circular economy by ensuring that digital and data-related legislation (e.g. on the free flow of data and data protection), investments, and public procurement support the transition. We must set up conditions and drivers for the digital/ICT industry to become more sustainable and circular, thus reducing its negative externalities on the environment, climate and natural resources (e.g. with the help of financial tools).

Smart (digital) farming such as innovative precision farming uses ICTs extensively, contributing to the development of sustainable agriculture [4]. The biosciences, and especially genome sequencing and analyses produce significant amounts of data. Data storage and information analysis tools are vital for bioeconomy innovations such as phenotyping, smart breeding, medical diagnostics, genome discovery and exploration, and therapy development.

ICTs also move agriculture, forestry, and fishery management forward. The use of Blockchain technologies, for instance via a distributed database of records structured in encrypted smaller datasets, promise to improve agrifood supply chains [1]. Blockchains can provide a higher level of transparency and efficiency, and guarantee traceability for all kinds of products such as coffee, fish, or milk.

As ICTs improve, many technologies become more affordable, and their use spreads globally, including in developing countries. New developments allow the detection of biobased material content in consumer goods, supporting labelling as well as the tracking and tracing of biobased materials along the supply chain. Their impacts on the bioeconomy and, therefore, on society, will gain in importance.

9 Governance towards a sustainable bioeconomy

9.1 Fundamentals of governance, policymaking, institutions, and sustainability

There are strong geographic patterns in how people view religion, national identity, minorities and key social issues. Particularly sharp differences emerge when comparing attitudes in countries historically associated with Eastern vs. Western Europe. However, major changes are underway in the regional and global economies, with quite significant implications for the BIOEAST countries.

The fact that foreign firms play such an important role in the BIOEAST region adds an extra complication: faced with demographic decline and worsening institutions, these firms may simply decide to pack up and leave. Many people from the region, including some of the best educated, may continue to reach similar conclusions. However, while it is easy to paint quite a negative picture for the future of the BIOEAST region, all is certainly not lost, and there are several reasons for optimism about the future:

- *First, there is a reasonable chance that labour shortages in the region will drive productivity-enhancing improvements, leading to per capita GDP increases, further wage convergence with Western Europe, and better living standards. A key lesson from economic history is that it is oftentimes when labour is relatively scarce/expensive that innovation and progress happens.*

- *Second, automation of services could also release quite significant labour reserves. The fact that Western firms dominate many industries in the BIOEAST countries creates an additional element of doubt, but there are big incentives for these firms to stay and invest rather than leave.*

- *Third, the new digital economy represents a decent opportunity for this region. Although most of the region is behind Western Europe in terms of infrastructure, education, training and the legal aspects of ICT, the gap is not always that large. Moreover, all of this is quite new, so the 'lock in' of other industries is not as relevant here – the BIOEAST region could feasibly catch up quite quickly with a strong circular bioeconomy strategy.*

R&DI is a key component of a circular bioeconomy, yet it is meaningless without direction. Identifying opportunities and coping with challenges is inevitable in building a sustainable circular economy. All the hurdles on this path can be overcome by governance, "the process through which the rules systems in place in any social setting are adapted to the needs of those who live under them"[16].

Governance is an incessant process of adoption, which has three dimensions: substantial (what are the rules?); procedural (how are the rules developed?); and structural (how are the rules implemented and enforced, and how are conflicts over the rules resolved?) [4]. The aim of governance is to coordinate collective action among stakeholders through rules and institutions, going beyond technical and scientific matters to consider social, political, cultural, environmental, and economic influences [3].

The ownership of any entity can be defined by asking three questions:

Who owns?

Who controls?

Who benefits?

Answers to these questions are critical when dealing with public goods.

The development of the bioeconomy in BIOEAST countries is characterized by a sense of alienation. Because the bioeconomy feels foreign, irrelevant, and unclear to a large portion of society, members of society act indifferently. This hinders governance, as a general lack of interest offers little incentive for policymakers to create, amend or update bioeconomy-related policies.

What society fails to realize is that they are not enforcing their ownership rights. A circular bioeconomy is essentially the practice of using natural resources as sustainably and efficiently as possible. An inability to properly enact ownership rights is fatal to the sustainability and longevity of businesses, and the same applies to societies.

The sense of ownership is one of the prerequisites of moving towards a circular bioeconomy. Invoking this sense by governance is an important, albeit equally sensitive issue. Enlisting the help of stakeholders is a difficult task, even in matters immeasurably less complex than the bioeconomy.

Assigning the bioeconomy to a single institution could please the public, but a holistic solution incorporating various actors would be more effective. After all, unlocking the most sustainable pathways for the future requires negotiating, compromising, and reaching a consensus between stakeholders. Thus, reaching a balanced combination of different actors is necessary – this is where a multi-level governance (MLG) approach comes handy.

MLG is characterized by cooperative intergovernmental relations between sub-national and national authorities, or between national and supranational organs [15]. The framework enables the involvement of a variety of stakeholders to ensure that policymaking is inclusive and democratic. MLG is effectively unavoidable in governing the bioeconomy because it spans the competencies of several institutions.

Successful governance of the bioeconomy requires implementing and upholding certain principles.

Good governance principle	To enforce a disciplinary effect in the bioeconomy, governing actors must answer to the public, institutional stakeholders, and those that their activities, decisions, and actions affect.
Accountability	To enforce a disciplinary effect in the bioeconomy, governing actors must answer to the public, institutional stakeholders, and those that their activities, decisions, and actions affect.
Transparency	The governing structure of organizations and processes must be accessible to all interested stakeholders. Information about the bioeconomy must be understandable and freely available to all those that are affected by organizational decisions.
Effectiveness/ efficiency	The outcomes and activities of the bioeconomy must meet the needs of society in a way that best utilizes the available resources and does not cause harm to the environment. The cascading principle should guide stakeholder activity, which good governance of the bioeconomy should ensure.
Participation	Men, women, and vulnerable and emerging groups, including those without a traditionally strong voice in economic development matters, must be allowed to participate equitably. Involving all actors in decision-making processes is essential, from producers to consumers.
Fairness	Rules, standards, and common law must be abided by, and bioeconomy power, resources and outcomes must be distributed fairly and impartially. Commonly accepted standards, labelling and criteria for biobased goods, not to mention the overarching bioeconomy principles (a la those proposed by SCAR 2015) may help to guarantee fairness in the development of the bioeconomy.

Even though the BIOEAST countries share a non-democratic past, it is possible to achieve democratic governance of the bioeconomy. From the perspective of creating a sustainable circular bioeconomy, two principles are especially important: accountability and participation [3]. The issue of accountability is particularly critical, as attempts to maximize participation could lead to accountability becoming unclear.

One of the foremost solutions to ensuring good governance of the bioeconomy is establishing national bioeconomy councils, as suggested by Devaney et al. (2017). By selecting a representative board that includes members from many sectors of the bioeconomy, ensuring participation and consistency in approach, as well as reducing competition and conflicts between sectors is possible. The council could also fulfil supervisory duties, making sure that good governance principles are followed.

As far as accountability is concerned, establishing a national bioeconomy creates a clear line of accountability, yet at the same time guarantees that all sectors of the bioeconomy share a part of it. What makes the task difficult is finding the right balance – no sector or party should have an excessive or disproportionate influence on the council's work. National bioeconomy councils could maximize the support of national and EU measures, and cooperation between national councils in the BIOEAST framework could take the development of the bioeconomy in the CEE region to a new level.

Although the EU is at the forefront of developing the bioeconomy, as its bioeconomy strategy was adopted in 2012 and is now in its second iteration, there is a regional divide [5,6]. CEE countries are lagging in circular bioeconomy policymaking, and of the eight EU member states that have adopted a dedicated national bioeconomy strategy, only one, Latvia, is in the CEE region[7].

Governance can be conducted top-down or bottom-up. While using either approach depends on exact circumstances, bottom-up governance is preferable. Simply because it fosters grassroot movements and enables garnering comprehensive support.

This is known as vertical governance. To ensure that the quality of bioeconomy policies is as good as possible, horizontal governance is in order. That is, involving many stakeholders without creating hierarchical barriers.

Fortunately, the BIOEAST countries' policy initiatives are supported by the EU's clear bioeconomy definition and the presence of both a bioeconomy strategy and an action plan. The EU enables countries to overcome other major hurdles that hinder the BIOEAST countries – R&D funding and public-private partnerships. For example, the EU has contributed 3.85 billion euros to Horizon 2020 and has proposed to invest 9 billion euros into Horizon Europe.

Shortcomings in dedicated strategies are alleviated by incorporating elements of the circular bioeconomy in other strategic documents. As of the 1st of July 2020, 15 EU countries have submitted their national long-term strategy to the Commission (including one draft) [10]. Six BIOEAST countries (Latvia, Poland, Czechia, Slovakia, Croatia, and Lithuania) have developed and submitted their national long-term strategy (including one draft) [10].

National long-term strategies encompass elements of the circular bioeconomy, but comprehensible circular bioeconomy strategies must follow suit. Good governance guarantees that drafting strategies will not be the final step in developing the bioeconomy in the BIOEAST region.

National and local policymakers have a pivotal role in creating a national bioeconomy strategy. While the UN SDGs and the European Green Deal serve as guides, more direct international intervention is undesirable, at least in the beginning. Initiating the strategy development process is where the top-down approach of policymakers is unavoidable, because the bioeconomies of the BIOEAST countries are not yet advanced enough to initiate strategic governance bottom-up.

Despite the top-down approach in developing the bioeconomy strategy, its complementary action plan and other policies must happen bottom-up. R&DI is the key, as only then is it possible to involve the necessary stakeholders and motivate them to participate in creating the bioeconomy strategy. Research efforts help to structure the process and support policymakers in managing the process.

One of the key areas where research institutions can help policymakers is in systems thinking. Policymakers in the BIOEAST countries are competent in addressing all sectors of the bioeconomy. However, they do not yet have the experience or competence of thinking about the sectors holistically, as a cluster of interdependent areas of activity.

Researchers can help policymakers make this leap at nearly every step of the process: defining the characteristics and needs of the bioeconomy, assisting with developing policy measures, and identifying and involving stakeholders to provide a neutral space to co-create. As a result, policymakers should be able to overcome their reservations with regard to the bioeconomy, foster its development, and ultimately ask researchers even more specific questions to improve bioeconomy policies.

Multi-level governance (MLG) of the circular bioeconomy relies on crucial prerequisites:

- *A transdisciplinary institution that facilitates systematic and comprehensive management of the bioeconomy;*
- *Strategic and financial tools to foster the development of a bioeconomy strategy;*
- *R&D initiatives that foster innovation and facilitate the achievement of circular bioeconomy goals.*

Establishing a robust circular bioeconomy RDI presence can be achieved by implementing these actions:

- *Creating a dedicated RDI unit within each Ministry of Agriculture in the BIOEAST region, which would in collaboration with other Ministries: 1) launch and coordinate research programmes for sustainable agricultural growth 2) develop industrial synergies between universities and businesses; and 3) exploit the capacity of students to think outside the box; >>*

- *Building platforms of collaboration and communication that have tangible commercial and practical impact;*

- *Creating multi-stakeholder and multi-sector clusters and platforms for exchanging knowledge.*

To achieve what is outlined above, developing incentives is vital. For example:

- *Subsidies to businesses of the bioeconomy for contracting R&D work;*

- *Reduced red tape to economic entities that participate in R&D;*

- *Tax exemptions for engaging in R&D efforts;*

- *Sustainability certification for businesses that implement good circular economy practices;*

- *Support for fostering the creation of bioeconomic clusters.*

By successfully implementing these measures, the governance process of the circular bioeconomy will become increasingly self-sufficient.

Development of bioeconomy policies does not necessarily follow the same route, but globally there are some commonalities. For example, regulatory governance measures included in bioeconomy strategies include [4]:

- *State regulation of the bioeconomy*

- *Governmental development of positive incentives (e.g. payments for environmental services)*

- *Government support for private standards and certifications*

- *International cooperation (through international organizations and regimes)*

It is important to understand that some aspects of the bioeconomy have a diversified impact on the UN SDGs. There are trade-offs that can be minimized, and synergies can be promoted by constraining governance tools. The foremost mechanisms used to implement the bioeconomy enhance the competitiveness of biobased products through subsidies, implementing awareness-raising campaigns, and a biobased research and development strategy.

Finland is deemed one of the forerunners of the bioeconomy in the EU and across the world. However, its case highlights that even conventional, top-down governance methods can be used to achieve excellent results, as Bosman & Rotmans (2016) illustrate in their comparison of Dutch and Finnish bioeconomy transitions.

	Dutch biobased economy	Finnish bioeconomy
Transition	Fossil to biobased	Bulk to specialty
Drivers	Chemistry sector/government	Bioeconomy and innovation in genes
Urgency	Rather high	Average
Phase	Pre-development	Just before take-off
Regime	Economic top-sectors	Powerful silo structure
Niches	Systematic experimentation	Many unconnected pilots
Vision	Co-created vision for 2050	Government-led vision for 2025
Governance	Transition governance	Traditional top-down
Scale	Regional	National
Approach	Conceptual, network-based	Practical, sector-based
Focus	Radical innovation	Incremental innovation
Government	Facilitator	Director

For reference, the transition management (or transition governance) process involves the following:

1. *Structuring the problem in question, developing a long-term sustainability vision, and establishing and organizing the transition arena;*

2. *Developing future images and a transition agenda, and deriving the necessary transition paths;*

3. *Establishing and implementing transition experiments and mobilizing the resulting transition networks;*

4. *Monitoring, evaluating, and learning from the transition experiments and adjusting the vision, agenda, and coalitions based on the revealed information [14].*

Despite taking a more conventional path, Finland managed to adapt its bioeconomy strategy in 2014, four years before the Netherlands. Both countries started from different positions and different aims, but both managed to reach their goals. Given how the starting position of Finland is more similar to that of the BIOEAST countries due to their traditional bioindustries, the country serves as a fine example that the top-down approach can yield results, if there is enough governance capacity.

9.2 The impact of foreign direct investment (FDI) on the Bioeast region

The BIOEAST countries have attracted billions of EUR since their accession to the EU. Foreign investment has also contributed significantly to exports, employment, and productivity growth, albeit with cross-country variation. Relative wages in the BIOEAST region are still very favourable compared to Western European Member States, even taking into account productivity and skills differences. There are also strong advantages in terms of their geographic proximity to the main markets of Europe and a cluster of well-established suppliers. However, rising labour shortages and projected workforce/ population ageing may influence investors' decisions on new investment.

Labour has remained a key attraction for investors. To attract investors, the BIOEAST countries have provided generous financial incentives, particularly in the form of tax holidays and investment credits. Gross exports have seen a tremendous increase over time, but domestic value-added in total exports declined, reflecting high import contents, particularly for assembly plants, which have seen an increase over time. This may also reflect profit repatriation by foreign firms and pressures to keep costs down by a declining share of labour income in manufacturing.

The automotive industry is a case in point. Large-scale foreign investment has transformed the automotive industry in many Central European countries where the industry counts for a significant share of total merchandise exports. Per capita car production in these countries and the automotive sector's share in industrial employment rank among the highest in the world.

In recent years, a number of BIOEAST countries have seen a notable increase in FDI outflows relative to inflows. This could indicate industrial upgrading by companies headquartered in these countries who are outsourcing parts of production to pursue cost efficiency.

Much of the FDI inflows to the BIOEAST region in the last two decades have come from EU countries, with larger countries attracting the lion's share of total flows. The BIOEAST countries continue to depend heavily on financial incentives and competitive wages to attract investors. The factors which would matter most in scaling up foreign investment are better institutions and labour skills, and improved quality of infrastructure [12].

State policies to attract foreign investment would need to balance the goals of short-term investor interest and long-term sustainability. In terms of financial incentives, relying on cost-based as opposed to profit-based measures would better serve countries.

To sustain economic growth in the BIOEAST countries, but also to reproduce the growth potential in the region for the long term, a first step for the governments would be to rethink their role in the development of human capital, and invest in it. As the coming decades must combine better living conditions for all with higher productivity growth, new investments are necessary in education, health and social inclusion, where the emphasis – until now – has tended to be on cutbacks. >>

The great human capital challenge in the BIOEAST region is well illustrated by data on workers' participation in lifelong learning, where a far lower percentage of workers or unemployed people participate in training and education (5-10%) compared to old Member States. The major question for the next stage is whether the BIOEAST region can continue to catch up without the internal socio-economic polarization observed thus far, and how exactly the latter process could in fact be reversed. Whether EU membership has been positive for the BIOEAST countries is something that cannot be measured only in terms of GDP. The quality of economic development and the changes in society are at least as important, if not more important. This makes the overall picture uneven [12].

9.3 Intra-EU mobility

Eastern enlargements have doubled the volumes of intra-EU labour mobility. This mobility is likely to be sustained as long as income disparities between Member States persist. According to estimates, around 5% of the Polish labour force now resides in other EU Member States, while this number has exceeded 10% for Romania and Lithuania. Given the fact that young people are over-represented among Eastern EU-migrants, these labour outflows tend to generate and sustain population decline, especially in regions with lower than average fertility and higher than average mortality. The real risks of labour mobility from the BIOEAST region to Western Europe are not in the recipient countries, but in the sending countries. A large percentage of workers who migrate from the BIOEAST countries to the old Member States are overqualified for the jobs in which they find themselves. In certain sectors of employment, particularly healthcare, we can speak of a 'brain drain' which leads to serious problems in the sending countries.

Intra-EU mobility is an important political, economic and demographic phenomenon for the EU, especially when it comes to young people. Several EU initiatives, most notably the Erasmus+ programme, facilitate the temporary mobility of students and young workers within the EU. These aim to open new educational opportunities for young people, foster the circulation of knowledge, improve knowledge of the EU and its languages and educational systems, and strengthen the EU's identity.

In the medium and long term EU mobility also has an impact on the demographic structure of the population. Particularly in the case of the BIOEAST region, free movement can contribute to population decline and a shrinking of the labour force. Western European countries would experience further population growth from the continuation of current migration trends, and Eastern European countries would see smaller population sizes. Generally, mobility within the EU is likely to reduce the size of the population in the BIOEAST region and will accelerate the ageing population of those countries, with the highest gain in the proportion of over-65s caused by migration. International migration would rejuvenate and increase the populations of the economically attractive European countries [13].

10 From where we stand to where we rise

10.1 Regional challenges

A shift from substitution logic towards circularity and sustainability requires a significant shift in mindset. Governing the sustainability of the bioeconomy, for which the SDGs are the normative framework, means being ready to constantly monitor the relations between different segments and stakeholders, while orchestrating the process of transformation.

For example:

- *Weak integration of the sustainability governance of forests into EU policies (and vis-à-vis non-EU countries) is one hindrance to achieving the objectives of a circular, sustainable bioeconomy (a forest strategy is needed).*
- *Farmers and foresters are at the forefront of the bioeconomy, and their activities condition most of the value chains and consequently the output of the regional bioeconomies, but they lack knowledge and they are detached from the research and technology world. Farmers need appropriate knowledge and support for the upcoming challenges related to climate change effects, which may require job change adaptation, better water management practices, protecting biodiversity, and becoming more resilient.*
- *The importance of technology – farmers are reluctant to accept new technologies, but they are often also difficult to access due to financial matters. There is a need for education and communication about the benefits of digital practices and technologies.*
- *Difficulty implementing organic and sustainable certification schemes is another barrier farmers are facing when considering more sustainable practices.*

To support the much-needed shift from a mostly linear to a circular bioeconomy, we must address the challenges and barriers summarized below:

WHAT IS LACKING IN OUR REGION?

GOVERNANCE AND CONNECTIVITY

- Fragmentation of the political framework - Lack of interministerial and cross-sectorial coordination
- Lack of national bioeconomy AND circulareconomy strategies
- Lack of political willingness and trust in intitutions
- Unclear roles and guidelines
- Low connectivity and public-private partnetships

RESOURCES AND TECHNOLOGY

- Unused biomass potential
- Lack of biorefineries
- Lack of dedicated funding and additional funding sources
- Low productivity and added value
- Addressing climte change
- Inadequate education of farmers
- Respurce efficiency
- Water and soil management

BEATING THE THREATS

- Climate change adaptation and mitigation
- Shocks and lack of resiliency
- Fossil-based industries

INDUSTRY AND WORKFORCE

- Jobs are lacking in the high-value levels of the CBE
- Loss of workforce and manpower to other countries

KNOWLEDGE

- Insufficient awareness of the bioeconomy as a concept
- Cross-sectorial knowledge difficulty
- Inadequate education of farmers
- Unclear vision and understanding by policy-makers
- Lack of indicators, robust and appropriate data

10.2 Dilemmas and necessary balance in future choices – conflicting priorities

Through the process of mapping key dilemmas in the BIOEAST region when setting the compass for the much-needed transition towards a circular bioeconomy and implementation of the European Green Deal, the following topics were recognized as those that need to be addressed at the regional as well as at the national level:

Finding a balance between sustainability and economic development

- *Rebalance the relationship between nature, climate and economy.*
- *A balanced approach is required, which looks neither towards environmentalist nor ideological extremes. The sustainability that businesses need to reach must meet economic, environmental and societal criteria.*
- *Small farmers are part of the local tradition and their farms are part of the local cultural landscape, which forms the historical culture of the region. This needs to be preserved, but for this to happen small farmers need to be protected and empowered.*
- *It is important to create a synergic new knowledge built upon new science, but with a revision of old knowledge integrated at its core, if we want to find the right balance between traditional and technology driven food production.*

Reshaping the economic system and way of making business

- *A paradigm shift towards more resilient and sustainable economy and society is required;*
- *Financial profit should not be the only criteria when evaluating biobased practices. Externalities have to be considered as well.*

- *A change in our lifestyles – from maximizing quantity to maximizing quality – leads to more balanced diet and stronger demand for local and more nutritious food as well as towards higher demand for sustainable biobased products.*

- *Inclusion of climate change projections in business strategies and feasibility studies: in food processing, agrifood, in the real practices. Businesses need simulations for long-term sustainability*

Productivity and diversity

- *Productivity as an economic criteria should be improved to a level that activities benefits farmers, but it is necessary to avoid conflict with environmental and social aspects. There is a concept that warrants consideration – sustainable intensification [12].*

- *Changes brought about by the concept of the bioeconomy have impacted land use management practices (LUMPs). This is why different aspects of land use management practices must be considered in terms of resource efficiency, agroecology practices, and the potential use of biotechnology and innovation. Considering the importance of productivity and diversity demands new know-how and R&D in the BIOEAST countries.*

- *Agricultural intensification which focuses on increasing productivity per hectare or per unit input is the main driver of biodiversity loss. Next to biodiversity loss due to habitat destruction by the conversion of natural lands into agriculture, intensification of agriculture has led to a strong decline in specific farmland biodiversity.*

- *Many agricultural landscapes face pollution by pesticides and fertilizers, and encounter depleted soils and erosion due to unsustainable farming practices. This is threatening not only biodiversity but also complete ecosystems and the ecosystem services on which agriculture itself depends.*

- *The pressure of feeding an increasing number of people in combination with a change in diet towards more animal protein puts a lot of additional pressure on the currently available agricultural lands and nature areas.*

- *The risks in intensive agriculture are managed by risk control models based on externalities, with important side effects such as risks of social costs and decreased function of natural processes. Sustainable intensification and adaptive risk management of biodiversity is the most successful measure to improve productivity in the agricultural system, alongside sustainability and decreasing risk of production loss. By managing (bio)diversity in agriculture, sustainable agriculture can contribute to reaching several Sustainable Development Goals.*

A paradigm shift is needed in agriculture to stop the large-scale loss of biodiversity in the agricultural landscape and soil, but even more than that, to rethink the use of the role of soil life, landscape elements and biodiversity in the context of sustainable production and agricultures of biomass. In the EU, most species are in decline. But, for example, in the Netherlands, policies have been implemented to improve the situation (manure policy, nitrate directive, air quality, nature protection etc.).

Primary biomass or bio-waste biomass

- *Primary biomass includes all terrestrial plants such as trees, bushes and grass, while waste biomass is produced as a low value by-product of various industrial sectors such as agriculture (corn stover, sugarcane bagasse, straw etc.) and forestry (saw mill and paper mill discards);*

- *The current limited uptake of secondary raw materials is partly due to the downgrading of material after recycling and the need for quality standards for secondary raw materials and end of waste criteria;*

- *We must redefine the content of waste and losses – these are not a problem but a part of a solution. Considering waste and losses as goods is a prudent approach, to maximise their value via the circular economy.*

Scale of biorefineries

- *Small-scale, specialized biorefineries as against large-scale, multi-purpose biorefineries*

- *In some local realities large-scale biorefineries may not be the most appropriate solution, which is why policy-makers should build solutions corresponding to the context.*

Market direction and priorities

- *Keeping products in the local market or exporting them? Preferentially local due to sustainability and national bioeconomy potential.*

- *National logistics should look towards clean green energy with a low carbon footprint.*

- *The Farm to Fork strategy must be implemented but opportunities to get added value from the export of agricultural produce (or preferably agrifood products) must also be taken into account.*

Decarbonization as the main solution to climate change

- *Emerging new technologies are helping to grow renewables, develop new energy carriers, improve energy efficiency, reduce GHG emissions, and create new markets for carbon;*

- *Steps to decarbonization include increased and competitive electrification, increasing use of renewable energy, and intensifying energy efficiency measures;*

- *Decarbonization itself is not the main solution to climate change – decarbonization of electricity, energy efficiency, and integrating/storing green energy combined have the power to limit global warming;*

- *Decarbonization of power generation can be achieved by increasing the proportion of low-carbon energy sources, particularly renewables, and reducing the use of fossil fuels;*

- *Electricity progressively becomes a low-carbon fuel and with lower generation cost it is also increasingly competitive – the wider adoption of other low-carbon energy carriers such as liquid biofuels, hydrogen, e-gas and e-liquids can be expected; >>*

- *Electrification plays a key role in the energy transition by replacing technologies that run on fossil fuels with alternatives that run on electricity – a further push is required to electrify the energy-consuming sectors;*

- *Transport is one of the crucial sectors that has shown a very low degree of electrification so far, but this situation is likely to change soon thanks to the rapid development of electric vehicles and the expected uptake of electricity-derived synthetic fuels;*

- *Increasing energy efficiency in buildings, transportation and industrial sectors help save energy and reduce consumption – the switch from inefficient fossil fuel technologies to more-efficient electric ones provide efficiency gains;*

- *New technologies make it possible to use CO_2 as a feedstock for chemicals, and plastics- waste-to-hydrogen plants are being built;*

- *A paradigm shift that could transform waste from a problem to a solution could be experienced – in the medium-term companies may view everything they produce, including emissions, by-products and end-products, as a resource to create economic value.*

Policy approaches

- *Stakeholders have a split opinion, where nearly half of them think policy should be from local to local, while the remaining half thinks more interconnection is required.*

Governance approaches

- *Bottom up vs top down. From a business perspective, stakeholders believe that we are missing clear guidelines from the government and cooperatives. There is a negative experience with the effectiveness of top-down approaches but at the same time a lack of proactivity from the bottom levels can be experienced.*

- *Should the bottom-up approach begin to build success stories, interdisciplinary and cross-sectoral collaboration platforms, clusters and projects to be the frontrunners of the bioeconomy in the region?*

- *From this perspective, the bioeconomy is a big step, and for this purpose the government should still take a central leading role with clear decisions and directions and specific roles for ministries and governing bodies.*

- *Could the bottom-up approach not work, since there is not a high enough level of understanding in business actors? This type of approach could not manage the big shift that is required with the implementation of a sustainable bioeconomy, and thus a top-down approach is better, but with a clear leading role of the upper governing levels that from the top stimulate businesses and associations to implement the bioeconomy in small strategic steps. With the top leading then the bottom will follow even if we consider the lack of knowledge of policy-makers.*

- *A synergic approach might be the solution. The top level should mobilize academia and business with policy tools. Knowledgeable actors on the ground should stimulate the top level leaders to foster collaboration with stakeholders on the ground to better understand their issues and needs. They also should continue initiatives from the bottom, for communication and dissemination and the development of circular biobased projects, business models and value chains.*

11 Fields of change – our vision and recommendations

The recommendations introduced in this chapter are the result of the outcomes of the workshops in which over 200 participants from eight BIOEAST countries have been engaged, as well as of consultations and interviews with different stakeholders from the EU.

To empower the transition towards biocircular economy in the BIOEAST region we are suggesting the following shifts:

- *Silos mindset to systemic mindset*
- *Linear business models to circular business models*
- *Resource waste to resource efficiency*
- *Fossil-driven to biobased economy*
- *Long value chains to resilient value systems*
- *Competition to collaboration*
- *Traditional education to lifelong learning*
- *Job losses to job creation*
- *Passive citizens to proactive changemakers*
- *Public governance to network governance*

The ecosystem model consists of four main groups (Businesses, Government, Citizens and RDI) engaged in the Foresight Exercise process.

At the heart of the ecosystem, the Circular Bioeconomy is nourished by these four groups. Each of them provides essential components and in return the Circular Bioeconomy is contributing to the sustainable, resilient, thriving and regenerative future of our BIOEAST region.

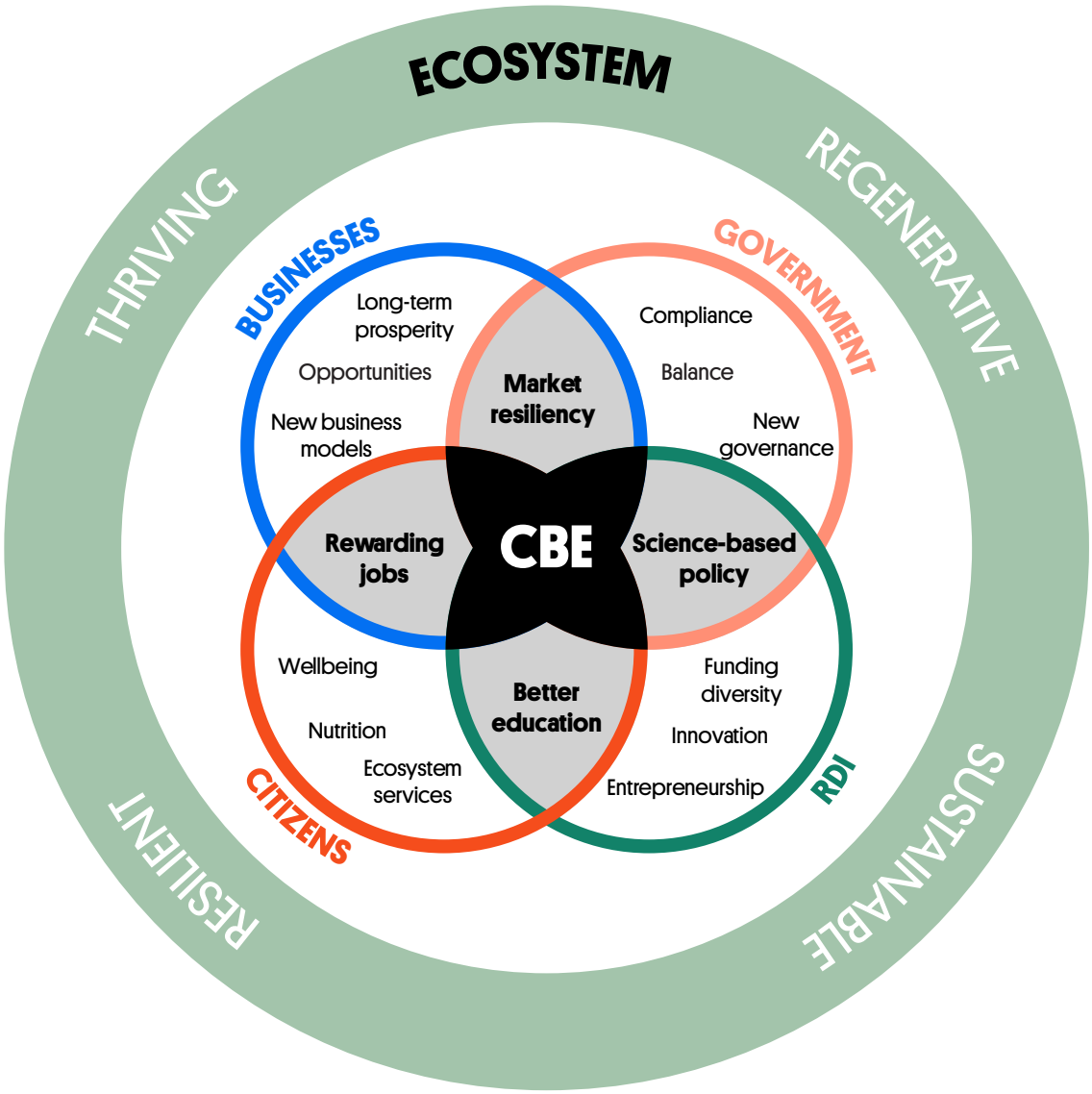


Figure 15: *Ecosystem Model emerged as a result throughout Bioeast Forsight journey*

11.1 The role of the government and policy-makers

Due to the high complexity and interdependence of different sectors and stakeholders engaged in the circular bioeconomy transition, the government should primarily focus on inter-ministerial collaboration and harmonized regulation. Enabling the optimal conditions for an effective systemic change is of the utmost importance. For this purpose it is key to identify the overlapping responsibilities, activities and investments between different institutions.

Could an interdisciplinary, interdepartmental unit/hub for comprehensive, systemic circular bioeconomy management be an option?

An overarching initiative such as the Knowledge Centre for Bioeconomy may prove to be an outstanding solution to overcoming the boundaries of different institutions and organisations. Due to the multilateral nature of bioeconomy, overcoming the barriers between disciplines is the first step.

Additional recommendations for policy-makers:

- *Establish clear roles and responsibilities for circular bioeconomy stakeholders;*
- *Bring leadership and direction;*
- *Enable systemic governance;*
- *Consistently implement long-term strategies for the development of the bioeconomy and the principles of the circular economy – these should be followed by clear action plans;*
- *Promote the development of hubs, universities and other governance and collaboration platforms;*
- *Define clear objectives that can be carried out by incremental, achievable milestones that will add up to a significant step forward;*
- *Revitalize the education system;*
- *Promote guidelines for bioethical, environmentally conscious behaviour in our society;*
- *Develop and implement Green Public Procurement including circular biobased products and services;*
- *Establish an RDI and implementation taskforce that launches and coordinates research programmes for sustainable bioeconomy development;*
- *Include regional and local governments in the implementation of the biobased economy – support bottom-up collaboration.*
- *Education of policy-makers and science-based policy*

Education of policy-makers is a key area of intervention. The top level decision-makers need to better understand the reality of the legislation they are proposing. This can be enhanced by the involvement of research, businesses and other relevant stakeholders. Initiatives like these can help policy-makers identify priority areas and give them a more holistic view and understanding of the circular bioeconomy.

11.2 The role of network governance

Implementation of the European Green Deal, including a successful circular bioeconomy transition, is not possible without radical collaboration. Different stakeholders from different sectors must work hand in hand to address this complex transformative process, which is not an easy task. While the variables of the governance process can be changed independently, governance of the circular bioeconomy is holistic. No actor operates in isolation, and all actors influence each other either implicitly or explicitly. Acknowledging that sustainable governance of the circular bioeconomy is not brought about by pro forma changes is a prerequisite of success. Network governance is an indispensable addition to conventional public governance.

Mapping, engaging, empowering, connecting and orchestrating circular bioeconomy frontrunners and initiatives in the BIOEAST countries could accelerate a green transition and speed up the transformative process. This is the power of network governance. While coherent centralised direction is a prerequisite, the success of the effort is determined by bottom-up initiative.

Additional recommendations for network governance:

- *A combination of top-down and bottom-up approaches should be practiced;*
- *Cooperatives of farms and foresters can be used as platforms of collaboration, innovation and empowerment of small and medium-sized stakeholders;*
- *Providing financial support, education and good practice are important for the change in current agricultural practices;*
- *Regional biomass hubs serve the processing of biomass to address the issue of small farms and foster the bioeconomy and bioeconomy incubators;*
- *Industrial synergies must be developed between universities and businesses to use the capacity of students with out of the box thinking;*
- *Public-private partnerships are a key ingredient for network governance;*
- *Interdisciplinary and cross-sectoral clusters are governed according to the principles of network governance;*
- *Local communities and citizens should be engaged through public events, workshops, and seminars – community gardens and agroecology can also involve local communities.*

Concerns with regard to network governance in the BIOEAST region:

- *Could the bottom-up approach fail as the level of understanding by business actors is not high enough? What is their level of readiness for a radical collaboration?*
- *What is the level of readiness of policy-makers? Should all the competences be shifted into a single ministry to simplify communication, or should we use a collaborative inter-ministerial taskforce to foster the collaboration?*

Finding common ground is an arduous task, which is unavoidable. Gathering representatives of a variety of stakeholders is crucial, as each one of them has a fragment to add to the puzzle of sustainable bioeconomy. Piecing the puzzle together requires a systematic overview and understanding of the matter – not to mention will and expertise to cooperate.

11.3 The role of scientific research

Informing the government in relation to a science-based policy is one of the major roles of scientific research. The problems to be addressed go across disciplines, so the scientific research community has a major role to play in identifying and describing the challenges with multidisciplinary collaboration. Research should serve to grow the competences of local government and state administration bodies. We recommend developing guidelines to ensure the effectiveness, integrity and independence of scientific advice. The research on which the advice is based should be published in peer-reviewed scientific journals and made accessible to both stakeholders and the general public. Note: It will be important to avoid conflicts of interest between researchers and those who make the political decisions.

Communication is the key – scientific breakthroughs should be communicated to raise the awareness and information of the general public and the bioeconomy stakeholders – what kind of new instruments could contribute to more effective translation, explanation and dissemination of the research results?

Additional recommendations for research communities:

- *Communication for the general public and stakeholders is of the utmost importance;*
- *A complex transition needs systemic change, for which openness of information in research is required – this also refers to private researchers;*
- *Communication skills are lacking in scientific environments – training is required, and collaboration networks with communication experts.*

Funding strategy diversification

Other than researching the hot topics of the circular bioeconomy, research institutions should diversify their funding options to tackle the current lack of funding. Some areas of intervention are:

- *The establishment of knowledge exchange channels with companies and startups that can bring projects to life;*
- *Participation in multi-organization consortia or partner teams to seize the opportunities of the allocated budgets of the EGD, the new CAP, and the CBE JU;*
- *Working together with the government for the development of public financing tools.*

Research and businesses

Collaborative research with businesses can bring innovation and a more rapid implementation of the circular bioeconomy. RDI funds supporting cooperation between research institutes and industries can help to scale up industrial production. Knowledge exchange can foster the development of new circular biobased business models and industrial symbiosis in the industrial environment. Including startups, to bring new ideas to the table and help them grow in these collaborative environments, can bring life to:

- *Moving up in the scale of technology readiness – enabling an environment where TRL7 or higher projects can be created and implemented successfully;*
- *More and better biorefineries – we need more biorefineries, and to develop second and third generation biorefineries;*
- *A biobased product portfolio that meets industrial requirements;*
- *Development of best practices through pilot projects and scale up.*

New research programmes

The establishment of new research programmes can provide innovative solutions for the sustainable use of natural resources, circular sustainable food systems, and the manufacture of novel bio-based products. In addition, research programmes for a wide variety of bioeconomy projects can accelerate the transition of businesses to a circular bioeconomy.

Areas of priority for RDI identified with experts and key regional stakeholders:

- *Research to ensure a greater presence of healthy foods in markets*
- *Biobased circularity*
- *Research programmes to ensure a reduction in GHG emissions and the development of renewable energy sources*
- *New models of value chains*
- *Research to ensure sustainable soil management, including fertilization and the microbial function of soil*
- *Research to ensure the sustainable use of natural resources*
- *Research on the introduction of digitalization to the bioeconomy sector*
- *Systematic LCA studies*
- *Development of appropriate indicators*
- *Innovative and marketable technology*
- *High-added value biobased products*
- *Development of alternative protein sources*
- *Development of living laboratories*
- *Development of biorefineries*
- *Promotion of fungi and algae biotechnology*
- *Phytopharmaceutical compounds in soils, sludge and other streams*
- *Closing the loops, exploiting waste as a resource and upcycling it to quality biobased materials and biofuels*
- *Harnessing lignin potential in by-products*
- *Promotion of agroecology practices, regenerative agriculture and eco-farming*
- *Small scale biogas and composting plants in rural areas*

Identifying what is not known is the foremost task of coordinating RDI efforts. Policymakers can enlist the assistance of researchers to bridge the gaps in knowledge. However, this requires treating both parties and other stakeholders as partners.

11.4 The role of environmental agencies and agroforestry chambers

Other than their main responsibilities, these agencies and chambers can contribute to the transition to a successful circular bioeconomy by boosting their role of communicators to the general public and the government.

Additional recommendations for agencies and chambers:

- *Active participation in specialized programmes of raising society awareness;*
- *A link between bioeconomy stakeholders and the policymakers – providing support to the government to avoid duplicative, contradictory or unnecessary policies;*
- *Identifying cross-sector trade-offs to help reach greater coherence between policy areas and ensure stronger cooperation;*
- *Creating programmes of financial support for research dedicated to the circular bioeconomy.*

11.5 The role of citizens

A strong understanding and awareness of environmental issues is crucial to making a circular bioeconomy transition. Society is the consumer of the biobased products, so consumer awareness of the effects of food and food systems and biobased products on health, climate and the environment is essential in order to encourage a sustainable transition.

Additional recommendations for citizens:

- *Citizens and interested community groups should be included in policy development at the European and national levels;*
- *Changes in societal awareness require the work of many: experts, agricultural corporations, research institutes, non-governmental organizations, environmental agencies, city councils, national leaders, media organizations, schools and more. New ways of collaboration should be encouraged;*
- *Social acceptance is crucial for and effective implementation of projects. In some cases, the lack of social acceptance hinders the realization of projects e.g. biowaste processing plants. Future initiatives in the region should address this issue. Studies on the social acceptance of innovations which throughout the region and elsewhere have hindered the development of technological projects.*
- *Open communication and nourishing of the dialogue between citizens and decision-makers can significantly improve the level of acceptance of new, circular bioeconomy solutions.*

11.6 The role of businesses

Businesses are crucial actors in the implementation of biobased solutions and the development of biobased markets. Where should our SMEs find relevant information? Where should they invest? How can they become more productive, innovative and sustainable? While the BIOEAST region is on the conservative business side, it has plenty of innovative potential. The question is whether the BIOEAST region, where assembly plants and proven technologies are typical, is capable and ready to move towards research and innovation in the long run?

How breakthrough technologies and other solutions that could enable enterprises to better valorize agricultural and forest biomass in the BIOEAST region be identified and implemented?

Additional recommendations for businesses:

- *Supporting studies on projects on the circular bioeconomy;*
- *Organising supply chains in "industrial symbiosis" networks of facilities and food distribution systems;*
- *New business models and value chains – business model transformation;*
- *Restructuring of existing value chains – optimization, new resilient value systems;*
- *Promoting and developing local chains, especially for food – enabling a reduction in food waste, environmental impacts and chain complexity;*
- *Diversifying supply chains, particularly at the regional scale – enabling farmers to invest in agroecology and on-farm diversification of products and services; use of ICT tools to reduce food costs;*
- *Developing cascading value chains;*
- *More diverse supply chains and markets.*

New business models and the agrifood system – challenges to be addressed:

- *Biodiversity and the sustainable management of natural resources;*
- *Include nutrition and sustainability in agrifood business models;*
- *Support circular practices and resource efficiency;*
- *Focus on high-quality products;*
- *Cascading use of biomass;*
- *Building connections and developing local markets;*
- *Collaboration between urban and rural areas;*
- *More added-value to be kept on the farm – through new environmental and tourist services, high quality products, branding, on-farm processing, or short supply chains.*

11.7 The role of education

In the BIOEAST macroregion, the lack of human resources in higher education and research is one of the main bottlenecks to accomplishing the goals of the European Green Deal. Structural reforms of education are more than needed. New transdisciplinary educational programmes can lead to a knowledge-based transformation towards a biobased economy that is sustainable and empowering. Not only new jobs, but also new employment opportunities are encouraged within the field of the circular bioeconomy, but without a supportive education system they cannot be realized.

Additional recommendations for the education system:

- *Education about the bioeconomy, the circular economy and sustainability should develop horizontally across curricula and at all levels of education (from primary schools up to universities);*
- *The inflow of competent staff to national and local governments must be insured;*
- *Focus of education on the reality we are living in – too often education is concentrated in theory and detached from the practical dimension;*
- *Involvement of NGOs and businesses in education programmes to showcase the circular bioeconomy;*
- *Empowerment of experts and professionals through a comprehensive system of education and training.*

Europe's six leading universities in the field of bioeconomy are intensifying their cooperation and joining forces in research, teaching, education, and innovation. They have laid the cornerstone for the "European Bioeconomy University" consortium: University of Bologna (Italy), University of Eastern Finland (Finland), University of Hohenheim (Germany), AgroParisTech, Paris Institute of Technology for Life, Food and Environmental Sciences (France), University of Natural Resources and Life Sciences, Vienna (BOKU, Austria), Wageningen University and Research (Netherlands).

11.8 Food for thought

- ***Climate adaptation***

We need climate adaptation practices. They will increase regional resilience, especially for farmers who depend on climatic conditions and natural resources. We suggest a greater focus on water management and soil management practices. The health and availability of these two resources is directly impacted by climate change.

- ***Biomass and resource priorities***

Water and soil health should be ensured since they are the sources of primary biomass, and can have an impact throughout the whole circular biobased value chain and society. Their health should be mapped throughout the region by collaborative research projects.

Biomass – there are several biomass sources, as seen in our CBE model. Policy-makers, together with experts, should define biomass priorities with a systematic approach within the bioeconomy strategies. The highest priority should go to food and feed to nurture our society. The rest should be sustainably managed and used for the production of non-food bio-based products:

- *Bioenergy*
- *Biobased plastics*
- *Biobased materials for construction*
- *Biobased textiles*
- *Biobased chemicals*
- *Biobased fertilizers*
- *And many others*

The biomass used for non-food bio-based materials raises important questions about potential competition with food and feed. The latter can harm the innovation of biobased products. Further studies and evaluations on this matter are highly recommended.

Key questions for biomass use

- *How to manage competitiveness between food and non-food outputs from biomass?*
- *How can we make better use of biomass?*
- *What do systematic Life Cycle Assessments say?*

- ***Incentivization pathways***

Subsidies offered should have a clear preference and criteria for sustainable projects. Sustainable use of bioresources may entail the transformation of present value chains accompanied by socio-economic effects (especially in the primary sector) in the short term. The state must give subsidies and preferences to marginal areas to ensure regional development and income generation for the local population.

Stability and reliability of the rule of law and economic incentives for stakeholders representing the circular bioeconomy are required.

Value added could be achieved by enhancing the product development and marketing performance of small producers with a strong orientation towards export.

New macroeconomic metrics should be developed for long-term sustainable development.

Tax incentives for encouraging the development of novel technology should be offered.

Development of conscious consumerism by increasing society's knowledge of the bioeconomy (ecological footprints, biodiversity, etc.) and making bioeconomy products affordable and accessible

Development of favourable regulation

- ***The right implementation needs the right data***

Good decisions are made based on sound data. Measuring the bioeconomy is not merely an academic endeavour. It is vitally important for all market actors to be involved in the strategic planning. The right measures and indicators can support the identification of strengths, leverage points, criticalities and opportunities to develop a well-balanced circular bioeconomy. Digitalization can only help in this direction!

- *What to measure? Biomass flows, soil and water quality, economic and environmental impacts to better understand the ecological boundaries of the bioeconomy, product LCAs.*

- *Where to measure? Nationally and regionally.*

- *How to measure? Efforts need to be made in the direction of data and indicator harmonization, so data can be used across sectors and countries. The same applies to methodologies and reporting.*

How about the idea of developing a regional BIOEAST observatory for collecting and managing data about the bioeconomy, providing free available data to bioeconomy stakeholders, educators and students, and entrepreneurs, who can bring positive change to society.

12 References

Chapters 2.1 to 2.3

1. *Aguilar A., Wohlgemuth R., Twardowski T. (2018): Perspectives on Bioeconomy. New Biotechnology, 40, 181–184. https://doi.org/10.1016/j.nbt.2017.06.012*

2. *Bayer P., Aklin M. (2020): The European Union emissions trading system reduced CO_2 emissions despite low prices. Proceedings of the National Academy of Sciences of the USA, 117(16), 8804–8812. https://doi.org/10.1073/pnas.1918128117*

3. *Camia A., Robert N., Jonsson R., Pilli R., García-Condado S., Lopez-Lozano R., et al. (2018): M'barek R. Biomass production, supply, uses and flows in the European Union. First results from an integrated assessment. Luxembourg: EUR 28993 EN. European Union*

4. *Carus M., Dammer L. (2018): The Circular Bioeconomy – Concepts, Opportunities, and Limitations. Indian Biotechnology, 14, 83–91. https://doi.org/10.1016/j.biteb.2019.100277*

5. *Clomburg J.M., Crumbley A.M., Gonzalez R. (2017): Industrial biomanufacturing. The future of chemical production. Science, 355, aag0804. http://dx.doi. org/10.1126/science.aag0804*

6. *D'Amato, D., Droste, N., Allen, B., Kettunen, M., Lähtinen, K., Korhonen, J., Leskinen, P., Matthies, B.D., Toppinen, A. (2017): Green, circular, bio economy: A comparative analysis of sustainability avenues. Journal of Cleaner Production, 168, 716–734. https://doi.org/10.1016/j.jclepro.2017.09.053*

7. *Dubois O., Gomez San Juan M. (2016): How Sustainability is Addressed in Official Bioeconomy Strategies at International, National and Regional Levels. An Overview. http://www.fao.org/3/a-i5998e.pdf*

8. *DEAL (n.d.). About Doughnut Economics. Doughnut Economics Action Lab. https://doughnuteconomics.org/about-doughnut-economi*

9. *Ellen MacArthur Foundation (2013): Towards the Circular Economy- – Economic and Business Rationale for An Accelerated Transition. https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur- Foundation-Towards-the-Circular-Economy-vol.1.pdf*

10. *EURACTIV (2020): German cabinet agrees CO_2 price of €25 from January 2021. https://www.euractiv.com/section/energy-environment/news/german-cabinet-agree s-to-a-co2-price-of-e25-from-january-2021*

11. *Europa Bio (2017): Strengthening Biotechnology and the EU Project. Europa Bio Brussels, Belgium*

12. *European Commission (2015): Biomass flows, biomass balances in the European Union (EU- 28), Brussels, Belgium. European Commission, 2019. https://datam.jrc.ec*

13. *European Commission (2017): Expert Group Report – Review of the EU Bioeconomy Strategy and its Action Plan, European Commission, Brussels, Belgium*

14. *European Commission (2018): A Clean Planet for all – a European long-term strategic vision for a prosperous, modern, competitive and climate - neutral economy. Depth Anal. Support Communication, 773, 114*

15. *European Commission (2018): A sustainable bioeconomy for Europe, strengthening the connection between economy, society, and the environment. Brussels, Belgium. European Commission, Directorate-General for Research, and Innovation Unit F – Bioeconomy, 1–107. https://ec.europa.eu/research/bioeconomy/pdf/ec_bioeconomy_strategy_2018.pdf#view=fit&pagemode=none*

16. *European Commission (2018): European Commission's Knowledge Centre for Bioeconomy, Brief on jobs and growth of the bioeconomy 2009–2015. 1–8. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC112875/jrc112875_jobs_growth_bioeconomy_brief_web.pdf*

17. *European Commission (2020): The Circular Economy Action Plan. https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf*

18. *Friedlingstein P., Jones M., O'sullivan M., Andrew R., Hauck J., Peters G, et al. (2019): Global Carbon Budget 2019. Earth System Science Data, 11(4), 1783–1838. https://doi.org/10.5194/essd-11-1783-2019*

19. *Giampietro, M. (2019). On the circular bioeconomy and decoupling: implications for sustainable growth. Ecological Economics, 162, 143-156. https://doi.org/10.1016/j.ecolecon.2019.05.001*

20. *Godina Košir, L., Korpar N., Potočnik, J., Kocjančič, R. (2015). Roadmap towards the Circular Economy of Slovenia. https://static1.squarespace.com/static/5b97bfa236099baf64b1a627/t/5beabb62f950b773950d1ce7/1542110257669/ROADMAP+TOWARDS+THE+CIRCULAR+ECONOMY+IN+SLOVENIA.pdf*

21. *Godina Košir, L., Korpar, N., Lah Poljak, E. (2020). Roadmaps Towards the Circular Economy. Monograph Sustainable Business in a Modern Society (pp 17-34). DOBA Business School: Maribor.*

22. *Godina Košir, L., Cutaia, L. (2019). Circular Economy Stakeholder Platform: the ECESP model. Energia, ambiente e innovazione 3/2019: Rome. http://eai.enea.it/archivio/rivoluzione-economia-circolare/circular-economy-stakeholder-platform-the-ecesp-model*

23. *Godina Košir, L. (2018). 5 Steps to help you lead the systemic Circular Change. Europa Info 4/2018: Vienna. https://www.eu-umweltbuero.at/assets/EU-Umweltbuero/Magazin-EUropainfo/EUropainfo-2-18.pdf*

24. *Godina Košir, L., Giacomelli, J. (2017). Introducing the Circular Triangle. https://www.circularchange.com/projects-1/2018/11/13/introducing-the-circular-triangle?rq=triangle*

25. *Gurria P., Ronzon T., Tamosiunas S., Lopez R., Condado SG., Guillen J, et al. (2017): Biomass flows in the European Union, the Sankey biomass diagram- – towards a cross-set integration of biomass. Seville, Spain: Joint Research Centre (Seville site). 1–77. http://publications.jrc.ec.europa.eu/repository/handle/JRC106502*

26. *Investopedia. Horizontal Integration. https://www.investopedia.com/terms/h/horizontalintegration.asp*

27. *Kardung M., Cingiz K., Costenoble O., Delahaye R., HeijmanW., Lovri´c M., van Leeuwen M., M'Barek R., van Meijl H., Piotrowski S., et al. (2021): Development of the Circular Bioeconomy: Drivers and Indicators. Sustainability, 13 (1), 413, 1–24. https://doi.org/10.3390/su13010413*

28. *Kircher M. (2012): The transition to a bioeconomy: emerging from the oil age. Biofuels Bioproducts Biorefining, 6(4), 369–375. https://doi.org/10.1002/bbb.1352*

29. *Kircher M. (2019): Bioeconomy: markets, implications, and investment opportunities. Economies, 7(3), 73, 1–36. https://doi.org/10.3390/economies7030073*

30. *Korpar, N., Godina Košir, L. et al. (2017). Na poti v krožno gospodarstvo: Pogled v regije Slovenije. Ministrstvo za okolje in prostor RS: Ljubljana. https://static1.squarespace.com/static/5b97bfa236099baf64b1a627/t/5dfcb0679c3fb66d7755549e/1576841341025/Pogled+v+regije+Slovenije+2017.pdf*

31. *Langeveld, J. W. A., Dixon, J., & Jaworski, J. F. (2010). Development perspectives of the biobased economy: a review. Crop Science, 50, S-142. https://doi.org/10.2135/cropsci2009.09.0529*

32. *Levi PG., Cullen JM., (2018): Mapping global flows of chemicals, from fossil fuel feedstocks to chemical products. Environmental Science Technology, 52(4), 1725–1734. https://doi.org/10.1021/acs.est.7b04573*

33. *Market Insider Commodities (2020): https://markets.businessinsider.com/commo dities/co2-european-emission-allowances*

34. *Muizniece I., Zihare L., Pubule J., Blumberga D. (2019): Circular Economy and Bioeconomy Interaction Development as Future for Rural Regions. Case Study of Aizkraukle Region in Latvia. Environmental & Climate Technologies, 23(3). https://web.b.ebscohost.com*

35. *Parisi C. (2018): Research Brief. Biorefineries distribution in the EU. European Communication Jt. Res. Cent., 1–8.*

36. *Pülzl H., Kleinschmit D., Arts B. (2014): Bioeconomy- – an emerging meta-discourse affecting forest discourses? Scandinavian Journal of Forest Research, 29, 386–393. - https://doi.org/10.1080/02827581.2014.920044*

37. *REN21 (2018): Renewables, Global Status Report; Renewable Energy Policy Network for the 21st century. 2019. 1–324. https://www.ren21.net/wp-content/uploads /2019/08/Full-Report-2018.pdf*

38. *Segovia Bifarini, M.A.; Žitnik, M.; Griessler Bulc, T.; Krivograd Klemenčič, A. Treatment and Re-Use of Raw Blackwater by Chlorella vulgaris-Based System. Water 2020, 12, 2660. https://doi.org/10.3390/w12102660*

39. *Simionescu M., Albu L-L., Raileanu Szeles M., Bilan Y. (2017): The impact of biofuels utilisation in transport on the sustainable development in the European Union. Technological and Economic Development Economy, 23(4), 667–86. https://doi.org/10.3846/ 20294913.2017.1323318*

40. *Song - X. - (2018): Global estimates of ecosystem service value and change, taking into account uncertainties in satellite-based land cover data. Ecological Economics, 143, 227–235. https://doi.org/10.1016/j.ecolecon.2017.07.019*

41. *Svazas M., Navickas V., Krajnakova E., Nakonieczny J. (2019): Sustainable supply chain of the biomass cluster as a factor for preservation and enhancement of forests. Journal of International Studies, 12(2), 309–321. https://doi.org/10.14254/2071-8330.2019/12-2/20*

42. *Tvaronavičienė M., Prakapienė D., Garškaitė-Milvydienė K., Prakapas R., Nawrot Ł. (2018): Energy efficiency in the long run in the selected European countries. Economics & Amplified Sociology, 11(1), 245-254. https://doi.org/10.14254/2071-789X.2018/11-1/16*

43. *UNEP, ILO, UNIDO, UNDP, Unitar (2012): Advancing an Inclusive Green Economy: Rationale and Context-Definitions for Green Economy. https://unitar.org/sites/default/files/uploads/egp/Section1/PDFs/1.3%20Definitions%20for%20Green%20Economy.pdf*

44. *van den Born GJ., van Minnen JG., Olivier JGJ., Ros JPM. (2014): PBL – Report on integrated analysis of global biomass flows in search of the sustainable potential for bioenergy production. PBL publication number: 1509. The Hague, Netherlands: Environmental Assesment Agency, https://www.pbl.nl/sites/default/files/downloads/pbl-2014-integrated-analysis-of-global-biomass-flows-in-search-of-the-sustainable-potential-for-bioenergy-production-1509.pdf*

45. *Vivien, F. D., Nieddu, M., Befort, N., Debref, R., & Giampietro, M. (2019). The hijacking of the bioeconomy. Ecological Economics, 159, 189-197. https://doi.org/10.1016/j.ecolecon.2019.01.027*

46. *Bifarini, Marco Antonio Segovia. Evaluation of the Performance of a Blackwater Source Separation System and Blackwater Treatment with Algae. Diss. MA Segovia Bifarini, 2015.*

Chapter 2.4

1. *Hetemäki L., Hanewinkel M., Muys B., Ollikainen M., Palahí M., Trasobares A., Potoćnik, J. (2017): Leading the way to a European circular bioeconomy strategy. European Forest Institute. https://www.alphagalileo.org/Uploads/imported/129940_efi_fstp_5_2017.pdf*

2. *Shaw W., Lampén H. (2020): Potential for circularity in the agri-food system. An analysis of nitrogen and phosphorus flows in the Baltic Sea catchment area*

Chapter 2.5.

1. *Brizga J., Miceikienė A., Liobikienė, G. (2019): Environmental aspects of the implementation of bioeconomy in the Baltic Sea Region. An input-output approach. Journal of Cleaner Production, 240, 118238. https://doi.org/10.1016/j.jclepro.2019.118238*

2. *Challinor A.J., Adger W.N., Benton T.G. (2017): Climate risks across borders and scales. Nature Climate Change, 7, 621–623. https://www.nature.com/articles/nclimate3380.pdf*

3. *Hasenheit M., Gerdes H., Kiresiewa Z., Beekman V. (2016): D2. 2 Summary report on the social, economic and environmental impacts of the bioeconomy. European Union. https://www.BioSTEP_D2.2_Impacts_of_the_bioeconomy.pdf*

4. *Ellen MacArthur Foundation (2020) The EU's Circular Economy Action Plan: setting the world's largest single market on a transition towards a circular economy. https://www.ellenmacarthurfoundation.org/assets/downloads/EU-Case-Study-june2020-EN.pdf*

5. *Eurostat. (2020) Sustainable development in the European Union: Monitoring report on progress towards the SDGs in an EU context. https://ec.europa.eu/eurostat/documents/3217494/11011074/KS-02-20-202-EN-N.pdf/334a8cfe-636a-bb8a-294a-73a052882f7f?t=1592994779000*

6. *European Commission (2018). A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment: updated bioeconomy strategy. https://op.europa.eu/en/publication-detail/-/publication/edace3e3-e189-11e8-b690-01aa75ed71a1/language-en/format-PDF/source-149755478*

7. *European Commission (2018). Bioeconomy. The European way to use our natural resources : Action Plan 2018. https://op.europa.eu/en/publication-detail/-/publication/775a2dc7-2a8b-11e9-8d04-01aa75ed71a1*

8. *European Commission (2020). EU Biodiversity Strategy for 2030: Bringing nature back into our lives. https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF*

9. *European Commission (2020). A new Circular Economy Action Plan: for a cleaner and more competitive Europe https://eur-lex.europa.eu/resource.html?uri=cellar:9903b325-6388-11ea-b735-01aa75ed71a1.0017.02/DOC_1&format=PDF*

10. *European Commission (2020). Farm to Fork Strategy: For a fair, healthy and environmentally-friendly food system. https://ec.europa.eu/food/sites/food/files/safety/docs/f2f_action-plan_2020_strategy-info_en.pdf*

11. *European Commission (2020). Working with Parliament and Council to make the CAP reform fit for the European Green Deal https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/factsheet-cap-reform-to-fit-european-green-deal_en.pdf*

12. *European Commission (2020). Questions and answers on the CAP reform – 17 November 2020. https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/key_policies/documents/questions-and-answers-on-cap-reform_en.pdf*

13. *Lindner M., Maroschek M., Netherer S., Kremer A., Barbati A., Garcia-Gonzalo J., Seidl R., Delzon S., Corona P., Kolström M. et al. (2010): Climate change impacts, adaptive capacity, and vulnerability of European forest ecosystems. Ecological Management, 259, 698–709. https://doi.org/10.1016/j.foreco.2009.09.023*

14. *Shaw W., Lampén H. (2020): Potential for circularity in the agri-food system. An analysis of nitrogen and phosphorus flows in the Baltic Sea catchment area*

15. *Spencer W.F., Cliath M.M., van den Oever M., Molenveld K., van der Zee M., Bos H. (2017): Bio-Based and Biodegradable Plastics. Facts and Figures. Focus on Food Packaging in the Netherlands, Wageningen Food & Amplified Biobased Research. Wageningen, The Netherlands, ISBN 9789463431217*

16. *Spierling S., Knüpffer E., Behnsen H., Mudersbach M., Krieg H., Springer S., Albrecht S., Herrmann C., Endres H.J. (2018): Bio-based plastics – a review of environmental, social and economic impact assessments. Journal of Clean Production, 185, 476–491. https://doi.org/10.1016/j.jclepro.2018.03.014*

17. *Verkerk P.J., Martinez de Arano I., Palahí M. (2018): The bioeconomy as an opportunity to tackle wildfires in Mediterranean forest ecosystems. Policy Economics, 86, 1–3. https://doi.org/10.1016/j.forpol.2017.10.016*

Chapter 3

1. *European Commission (2020). Resilience and transformation. Report of the 5th SCAR Foresight Exercise Expert Group. Natural resources and food systems: transitions towards a 'safe and just' operating space. https://scar-europe.org/images/FORESIGHT/FINAL-REPORT-5th-SCAR-Foresight-Exercise.pdf*

2. *European Commission (2020). 2020 Strategic Foresight Report. Charting the course towards a more resilient Europe. https://ec.europa.eu/info/sites/default/files/strategic_foresight_report_2020_1.pdf*

3. *Fritsche, U., Brunori, G., Chiaramonti, D., Galanakis, C., Hellweg, S., Matthews, R. and Panoutsou, C., Future transitions for the Bioeconomy towards Sustainable Development and a Climate-Neutral Economy – Knowledge Synthesis Final Report, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-21518-9, doi:10.2760/667966, JRC121212.*

Chapter 4.1

1. *Camia A., Robert N., Jonsson R., Pilli R., García-Condado S., López-Lozano R., et al. (2018): Biomass production, supply, uses and flows in the European Union. First results from an integrated assessment, EUR 28993 EN*

2. *European Commission (2019a): Biomass flows, Biomass balances in European Union (EU-28), 2015*

3. *Iqbal Y., Lewandowski I., Weinreich A., Wippel B., Pforte B., Hadai O., Tryboi O., Spöttle M., Peters D. (2016): Maximising the yield of biomass from residues of agricultural crops and biomass from forestry, Final Report, Ecofys, Berlin*

4. *Vis M., Mantau U., Allen B. (2016): Study on the optimised cascading use of wood. No 394/PP/ENT/RCH/14/7689. Final Report. Brussels, 1–337.*

Chapter 4.2

1. *Ronzon T., Piotrowski S., M'barek R., Carus M., Tamošiūnas S. (2018): Jobs and wealth in the EU bioeconomy / JRC – Bioeconomics. European Commission, Joint Research Centre (JRC), [Dataset] http://data.europa.eu/89h/7d7d5481-2d02-4b36-8e79-697b04fa4278*

Chapter 4.3

1. *European Commission (n.d.) Increasing demographic imbalances. Knowledge4Policy. https://knowledge4policy.ec.europa.eu/increasing-demographic-imbalances_en*

2. *European Commission (n.d.). Changing nature of work. Knowledge4Policy. https://knowledge4policy.ec.europa.eu/foresight/changing-nature-work_en*

3. *Eurostat (2008): Population projections 2008-2060. Eurostat website. https://ec.europa.eu/eurostat/documents/2995521/5114642/3-26082008-AP-EN.PDF.pdf/dd7af0af-e8da-464f-a5f6-71a8f14f0f5e*

4. *European Commission (n.d.) Diversification of education and learning. Knowledge4Policy. https://knowledge4policy.ec.europa.eu/diversification-education-learning_en*

5. *European Commission (n.d.). Gap among and within countries. Knowledge4Policy. https://knowledge4policy.ec.europa.eu/foresight/topic/diversifying-inequalities/gap-within-among-countries_en*

6. *European Commission (n.d.). Urbanisation in Europe. Knowledge4Policy. https://knowledge4policy.ec.europa.eu/foresight/topic/diversifying-inequalities/gap-within-among-countries_en*

7. *Eurostat (2021): Demographic balances and indicators by type of projection. EC Data Browser. https://ec.europa.eu/eurostat/databrowser/view/proj_19ndbi/default/table?lang=en*

8. *Eurostat (2021): Population on 1st January by age, sex and type of projection. EC Data Browser. https://ec.europa.eu/eurostat/databrowser/view/proj_19np/default/table?lang=en*

9. *Mustalahti I. (2018): The responsive bioeconomy: the need for inclusion of citizens and environmental capability in the forest-based bioeconomy. Journal of Cleaner Production, 172, 3781–3790. https://doi.org/10.1016/j.jclepro.2017.06.132*

10. *Sutton M. A., Howard C. M., Erisman J. W., Billen G., Bleeker A., Grennfelt P., Grizzetti B. (2011): The European Nitrogen Assessment: Sources, Effects and Policy Perspectives. Cambridge University Press*

11. *UN., DESA., PD. (2017)*

Chapter 4.4

1. *Heimann T. (2019): Bioeconomy and SDGs: Does the bioeconomy support the achievement of the SDGs? Earth's Future, 7(1), 43-57. https://doi.org/ 10.1029/2018EF001014*

2. *Eurostat (2020): Sustainable development in the European Union. Monitoring Report on progress towards the SDGs in an EU context. https://ec.europa.eu/eurostat/documents/3217494/11011074/KS-02-20-202-EN-N.pdf/334a8cfe-636a-bb8a-294a-73a052882f7f?t=1592994779000*

3. *Ronzon T., Sanjuán A. I. (2020): Friends or foes? A compatibility assessment of bioeconomy-related Sustainable Development Goals for European policy coherence. Journal of Cleaner Production, 254, 119832. https://doi.org/10.1016/j.jclepro.2019.119832*

Chapter 4.5

1. *ECDC (2021): Covid-19 situation update for the EU/EEA, as of 29 March 2021. European Centre for Disease Prevention and Control. https://www.ecdc.europa.eu/en/cases-2019-ncov-eueea*

2. *UNDP (2021): Impact of Covid-19 on the Sustainable Development Goals. https://sdgintegration.undp.org/accelerating-development-progressduring-covid-19*

3. *Upton L. (2020): Bio-based sector sees mixed coronavirus impact. Bio Market Insights. https://biomarketinsights.com/bio-based-sector-sees-mixed-coronavirus-impact/*

Chapter 5

1. *Brizga, J., Miceikienė, A., & Liobikienė, G. (2019). Environmental aspects of the implementation of bioeconomy in the Baltic Sea Region: An input-output approach. Journal of Cleaner Production, 240, 118238. https://doi.org/10.1016/j.jclepro.2019.118238*

2. *Campbell B. M., Beare D. J., Bennett E. M., Hall-Spencer J. M., Ingram J. S., Jaramillo F., Shindell D. (2017): Agriculture production as a major driver of the Earth system exceeding planetary boundaries. Ecology and Society, 22(4), https://www.jstor.org/stable/26798991*

3. *EEA. The European Environment — State and Outlook 2020 Knowledge for Transition to a Sustainable Europe, European Environment Agency (2019)*

4. *Eurostat (2020): Water Statistics. Extracted on December 2020. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Water_statistics#Water_abstraction*

5. *Hart et al., 2017 G3: Genes, Genomes, Genetics. August 1, 2017 vol. 7 no. 8 2719-2727; https://doi.org/10.1534/g3.117.041277*

6. *Mari Rivero I., Vandecasteele I., Lavalle C. (2015a): LF311 – Water Consumption (LUISA Platform REF2014). European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/jrc-luisa-lf311-water-consumption-ref-2014*

7. *Mari Rivero, I., Vandecasteele I., Lavalle C. (2015b): LF312 – Water Productivity (LUISA Platform REF2014). European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/jrc-luisa-lf312-water-productivity-ref-2014*

8. *Lavalle C., Perpina C., Carolina M. R.I., Maes J. (2015a): LF521 – Capacity of ecosystems to avoid soil erosion (LUISA Platform REF2014). European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/jrc-luisa-lf521-capacity-of-ecoystems-to-avoid-soil-erosion-ref-2014*

9. *Lavalle, C., Vallecillo S. (201b): LF622 – Landscape Fragmentation (LUISA Platform REF2014). European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/jrc-luisa-lf622-landscape-fragmentation-ref-2014*

10. *Tsiropoulos I., Nijs W., Tarvydas D., Ruiz P. (2020): Towards net-zero emissions in the EU energy system by 2050. Insights from scenarios in line with the 2030 and 2050 ambitions of the European Green Deal. https://www.buildup.eu/sites/default/files/content/toward1.pdf*

11. *UNCCD (2017):*

Chapter 6

1. *Brookes, G., Barfood, P., Farm Income and Production Impacts of Using GM Crop Technology 1996-2016.*

2. *Brookes, G., Yu, T.H., Tokgoz, S., Elobeid, A. (2010): The production and price impact of biotech corn, canola, and soybean crops. AgBioForum, 13(1) 25–52.*

3. *Copa-Cogeca Position on Climate Action*

4. *EuropaBio comments Farm to Fork Roadmap, March 2020*

5. *FAO report How to Feed the World in 2050: Microsoft Word - Synthesis_Report.doc (fao.org)*

6. *Field to Market program. Home – Field to Market*

7. *https://ec.europa.eu/environment/eussd/smgp/ef_pilots.htm#pef*

8. *https://ec.europa.eu/eurostat/statistics-explained/pdfscache/16817.pdf*

9. *http://www.fao.org/partnerships/leap/en/*

10. *Industrial Biotechnology Solutions for Sustainable Agriculture, EuropaBio, Jan. 2020*

11. *ISCC: Solutions for Sustainable and Deforestation Free Supply Chains, ISCC System (iscc-system.org)*

12. *PG Economics Press Release 31 May 2016. Global Economic Benefits of GM Crops Reach*

$150 billion (pgeconomics.co.uk)

13. *PLUS: Solutions for Sustainable and Deforestation Free Supply Chains › ISCC System (iscc-system.org)*

14. *Ronzon, T.; Piotrowski, S.; M'barek, R.; Carus, M.; Tamošiūnas, S. (2018): Jobs and wealth in the EU bioeconomy / JRC – Bioeconomics. European Commission, Joint Research Centre (JRC) http://data.europa.eu/89h/7d7d5481-2d02-4b36-8e79-697b04fa4278*

15. *RSB: Home | RSB*

16. *Smith, L.G., Kirk, G.J.D., Jones, P.J. et al. (2019): The greenhouse gas impacts of converting food production in England and Wales to organic methods. Nat Communications, 10, 4641, https://www.nature.com/articles/s41467-019-12622-7*

Chapter 6.3

1. *M. van Grinsven, JanWillem Erisman, Wim de Vries & Henk Westhoek (2015): Potential of extensification of European agrikultúra for a more sustainable food system. Environ. Res. Lett. (10) 025002 doi:10.1088/1748-9326/*

2. *Davy Vanham & Adrian Leip (2020): Sustainable food system policies need to address environmental pressures and impacts. Science of The Total Environment (Vol. 730) 139-151*

3. *Ana Moragues-Faus, Roberta Sonnino & Terry Mardsen (2017): Exploring European food system vulnerabilities: Towards integrated food security governance. Environmental Science & Policy (Vol. 75) 184-215*

Chapter 7

1. *Camia A., Robert N., Jonsson R., Pilli R, García-Condado S., López-Lozano R., et al. (2018): Biomass production, supply, uses and flows in the European Union. First results from an integrated assessment. EUR 28993 EN*

2. *Bioenergy Europe (2018): Statistical Report. 1–77. bioenergyeurope.org/bioenergy-europe-pellet-report-2018/*

3. *CEFIC (2019): 2020 Facts and figures of the European Chemical Industry. Brussels, Belgium, European Chemical Industry Council (CEFIC), 1–78.*

4. *DBnomics (2019): Supply, transformation and consumption of renewable energies – annual data*

5. *Gurria P., Ronzon T., Tamosiunas S., Lopez R., Condado S.G., Guillen J., et al. (2017): Biomass flows in the European Union: the Sankey biomass diagram- – towards a cross-set integration of biomass. Seville, Spain: Joint Research Centre (Seville site), Office of the European Union, 2016. 10:153649, 1–77.*

6. *European Commission (2017): Sustainable and Optimal Use of Biomass for Energy in the EU Beyond 2020, Annexes of the Final Report. Brussels, Belgium: EC Directorate General for Energy. EC Directorate General for Energy*

7. *European Commission (2018a): A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment. Brussels, Belgium: European Commission, Directorate-General for Research and InnovationUnit F – Bioeconomy. 1–107. df/ec_bioeconomy_strategy_2018.pdf#view fit&pagemode none*

8. *European Commission (2018b): European Commission's Knowledge Centre for Bioeconomy, Brief on Jobs and Growth of the Bioeconomy 2009–2015. 1–8. 112875_jobs_growth_bioeconomy_brief_web.pdf*

9. *European Commission (2019a): Biomass Flows, Biomass Balances in the European Union (EU-28),*

10. *European Commission (2019b): The European Green Deal. Brussels, 11.12.2019 COM, 640 final. Brussels, Belgium, 1-24. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions; 2019. eu/info/sites/info/files/european-green-deal-communication_en.pdf*

11. *Eurostat (2019a): Statistics Explained, Glossary on Biomass. eurostat/statistics-explained/index.php?title Glossary:Biomass*

12. *Eurostat (2019b): Supply, Transformation and Consumption of Renewable Energies – Annual Data. Eurostat, Statistical Office of the European Union Luxembourg, sumption-renewable-energies*

13. *Eurostat (2021a): Statistics Explained, Renewable Energy Statistics, https://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics*

14. *Eurostat (2021b): Energy Statistics – an Overview, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_statistics_-_an_overview&oldid=492784#Final_energy_consumption*

15. *Hoefnagels R., Kluts I., Junginger M., Visser L., Resch G., Mantau U., et al. (2018): Biomass supply potentials for the EU and biomass demand from the material sector by 2030. Technical Background Report of the "BioSustain" study: sustainable and optimal use of biomass for energy in the EU beyond 2020, Annex 1. Brussels, Belgium: Directorate General for Energy Directorate C1-Renewables and CCS policy. 1–404. https://ec.europa.eu/energy/sites/ener/files/documents/biosustain_ annexes_final.pdf.*

16. *Leonard, M., Pisani-Ferry, J., Shapiro, J., Tagliapietra, S., Wolff, G. (2021): The Geopolitics of the European Green Deal. Bruegel-Policy Contributions, NA-NA*

17. *Panchaksharam Y, Kiri P, Bauen A, vom Berg C, Puente A, Chinthapalli R, et al. (2019): Roadmap for the chemical industry in Europe towards a bioeconomy strategy document. 1–192. map/RoadToBio_strategy_document.pdf*

18. *Parisi, C. (2018): Research Brief: Biorefineries Distribution in the EU. Eur. Comm. Jt. Res. Cent. 1–8.*

Chapter 8

1. *Antonucci, F., Figorilli, S., Costa, C. Pallottino, F., Raso, L., Menesatti, P. (2019): A review on blockchain applications in the agri-food sector. Journal of the Science of Food and Agriculture, 99, 6129–6138. https://doi.org/10.1002/jsfa.9912*

2. *Deloitte Circular goes Digital. https://www2.deloitte.com/content/dam/Deloitte/fi/Documents/risk/Circular%20goes%20digital.pdf*

3. *OECD (2020): The Digitalisation of Science, Technology and Innovation: Key Developments and Policies, OECD Publishing, Paris, https://doi.org/10.1787/b9e4a2c0-en*

4. *Walter, A.; Finger, R.; Huber, R.; Buchmann, N. (2017): Smart farming is key to developing sustainable agriculture. Proceedings of the National Academy of Sciences of the United States of America, 114, 6148–6150.*

5. *Watanabe, C.; Naveed, N.; Neittaanmäki, P. (2019): Digitalized bioeconomy: Planned obsolescence-driven circular economy enabled by Co-Evolutionary coupling. Technology in Society, 56, 8–30. https://doi.org/10.1016/j.techsoc.2018.09.002*

Chapter 9

1. *Belmonte, Martina; Conte, Alessandra; Ghio, Daniela; Kalantaryan, Sona; McMahon, Simon, Youth and Migration: an Overview, EUR 30435 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-24978-8, doi:10.2760/625356, JRC122402*

2. *Bosman, R., Rotmans, J. (2016): Transition Governance towards a Bioeconomy: A Comparison of Finland and The Netherlands. Sustainability, 8(10), 1017. http://dx.doi.org/10.3390/su8101017*

3. *Devaney, L., Henchion, M., Regan, Á. (2017): Good Governance in the Bioeconomy. EuroChoices, 16(2), 41–46. https://doi.org/10.1111/1746-692X.12141*

4. *Dietz, T., Börner, J., Förster, J. J., von Braun, J. (2018): Governance of the Bioeconomy: A Global Comparative Study of National Bioeconomy Strategies. Sustainability, 10(9), 3190. https://doi.org/10.3390/su10093190*

5. *European Commission (2012): COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Innovating for Sustainable Growth: A Bioeconomy for Europe (COM/2012/060 final). EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52012DC0060*

6. *European Commission (2018): COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A Sustainable Bioeconomy for Europe: Strengthening the Connection Between Economy, Society and the Environment (COM/2018/673 final). EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018DC0673*

7. *European Commission (2018): COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE, THE COMMITTEE OF THE REGIONS AND THE EUROPEAN INVESTMENT BANK A Clean Planet for All: A European Strategic Long-Term Vision for a Prosperous, Modern, Competitive and Climate Neutral Economy (COM/2018/773 final). EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0773*

8. *European Commission (2019): COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS The European Green Deal (COM/2019/640 final). EUR-Lex. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640*

9. *European Commission (n.d.). Bioeconomy. European Commission official website. https://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=strategy*

10. *European Commission (n.d.). National Long-Term Strategies. European Commission official website. https://ec.europa.eu/info/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-long-term-strategies_en*

11. *European Commission (n.d.) Bioeconomy Strategy. European Commission website. Retrieved March 25, from https://ec.europa.eu/info/research-and-innovation/research-area/bioeconomy/bioeconomy-strategy_en*

12. *La-Bhus Fah Jirasavetakul and Jesmin Rahman (2018): Foreign Direct Investment in New Member States of the EU and Western Balkans: Taking Stock and Assessing Prospects, IMF Working Paper, 2018 International Monetary Fund WP/18/187*

13. *László A.: Fifteen Years of Convergence: East-West Imbalance and What the EU Should Do About it, Intereconomics, Volume 54, 2019 · Number 1 · pp. 18–23, https://www.intereconomics.eu/contents/year/2019/number/1/article/fifteen-years-of-convergence-east-west-imbalance-and-what-the-eu-should-do-about-it.html*

14. *Loorbach, D. (2010): Transition Management for Sustainable Development: A Prescriptive, Complexity – Based Governance Framework. Governance, 23(1), 161–183. https://doi.org/10.1111/j.1468-0491.2009.01471.x*

15. *Papadopoulos, Y. (2007): Problems of Democratic Accountability in Network and Multilevel Governance. European Law Journal, 13(4), 469–486. https://doi.org/10.1111/j.1468-0386.2007.00379.x*

16. *Sweet, A. S. (1999): Judicialization and the Construction of Governance. Comparative Political Studies, 32(2), 147–184. https://doi.org/10.1177/0010414099032002001*

Chapter 10

1. *Benz, X. Z. (TUM) (2019): Biomonitor – Monitoring the Bioeconomy, D1.1: Framework for measuring the size and development of the bioeconomy, Date of document – 09/2019 (10/1), Projekt coordinator: Justus Wesseler*

2. *Bisoffi, S. (2019): A Meta-Analysis of Recent Foresight Documents, CASA Project: Study Meta-Analysis of Recent Foresight and Horizon Scanning Documents, PO 42195489 of 17.08.2018*

3. *Cingiz, K., Gonzalez-Hermoso, H., Heijman, W., Wesseler, J.H.H. (2021): A Cross-Country Measurement of the EU Bioeconomy: An Input-–Output Approach. Sustainability, 13(6), 3033, 1–39. https://doi.org/10.3390/su13063033*

4. *Circular Economy in Europe, Developing the Knowledge base, EEA Report No 2/2016, ISSN 1977-8449*

5. *Efken, J., Dirksmeyer, W., Kreins, P., Knecht, M. (2016): Measuring the importance of the bioeconomy in Germany: concept and illustration. NJAS – Wageningen Journal of Life Sciences, 77, 9–17. https://doi.org/10.1016/j.njas.2016.03.008*

6. *EU SDG Indicator set (2021): EUROPEAN COMMISSION EUROSTAT, Directorate E: Sectoral and Regional Statistics, Unit E-2: Environmental Statistics And Accounts; Sustainable Development,*

7. *European Commission (2011). Analysis Associated with the Roadmap to a Resource Efficient Europe, Commission Staff Working Paper, European Commission, Brussels, SEC(2011) 1067*

8. *Kuosmanen, T., Kuosmanen, N., El-Meligli, A., Ronzon, T., Gurria, P., Iost, S., M., Barek, R. (2020): How Big is the Bioeconomy? Reflections from an Economic Perspective. EUR 30167 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-17858-3, https://doi.org/10.2760/144526, JRC120324*

9. *Kardung, M., Costenoble, O., Lara Dammer, L., Delahaye, R., Lovrić, M., Myrna v Leeuwen, Robert M'Barek, R., van Meijl, H., Piotrowski, S..(2019). Biomonitor Project. D1.1: Framework for Measuring the Size and Development of the Bioeconomy*

10. *Ronzon T., (JRC), Verhoog D. (WEcR), Verkerk H. (EFI), Vrachioli M. (TUM), Wesseler J. (WU), Regulation 2019/1009 of the European Parliament and of the Council of 5 June 2019 laying down rules on the making available on the market of EU fertilising products*

11. *Regulation 2019/515 of the European Parliament and of the Council of 19 March 2019 on the mutual recognition of goods lawfully marketed in another Member State and repealing Regulation (EC) No 764/2008*

12. *Värnik R., Aste R., Ariva J. (2017. Sustainable Intensification in Crop Farming – A Case from Estonia. In: Pedersen S., Lind K. (Eds.) Precision Agriculture: Technology and Economic Perspectives. Progress in Precision Agriculture. Springer, Cham. https://doi.org/10.1007/978-3-319-68715-5_10*

13. *Wesseler, J., von Braun, J. (2017). Measuring the Bioeconomy: Economics and Policies, Annual Review of Resource Economics, 9, 275-298, https://doi.org/10.1146/annurev-resource-100516-053701*

13 Glossary

Concepts

*A **bioeconomy** (BE) or bio-based economy includes producing renewable biological resources and converting those resources and waste streams into added value products.*

*A **biobased product** is completely or partially derived from materials of biological origin, excluding fossilized or mineral materials.*

*A **biobased sector** produces biomass or processes it into added value products. Biobased sectors are agriculture, forestry, fishing, food, the beverage and tobacco industry, biobased textiles, wood products and furniture, paper and paper products, biobased chemicals, pharmaceuticals and plastics, biofuels, and biobased electricity.*

***Bioenergy** is energy produced from the conversion of biomass.*

*A **biofuel** is a liquid or gaseous transport fuel that is made from biomass.*

***Biomass** is the biodegradable fraction of products, waste and residues of biological origin or the biodegradable fraction of industrial and municipal waste.*

*A **biomaterial** is a substance developed to interact with biological systems for a medical purpose.*

*A **biorefinery** is a processing plant where biomass is converted and extracted into a range of higher added value products.*

*A **bioresource** is a non-fossil resource of biological origin.*

***Biotechnology** is a technology that uses biological systems, living organisms, or their derivatives to create products or processes for a specific use.*

***Biowaste** is biodegradable horticultural waste, food and kitchen waste, and similar waste from food processing plants, excluding forestry or agricultural residues, manure, sewage sludge, or other biodegradable waste, and by-products of food production that never become waste.*

*A **circular economy (CE)** is an economic system that creates value now and is sustainable in the future. Resources should be retained within the manufacturing and consumption cycles for as long as possible to retain the value of products, raw materials and material resources, and to minimize the production of waste.*

***Decarbonization** is the process of reducing carbon dioxide emissions by using low carbon power sources and lowering the output of greenhouse gases.*

*A **greenhouse gas (GHG)** is a gas that causes the greenhouse effect by absorbing and emitting thermal infrared radiation; the most abundant greenhouse gases are water vapour, carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, and hydrofluorocarbons.*

*A **green economy (GE)** aims to reduce adverse environmental and ecological effects to achieve sustainable economic development and increase human wellbeing.*

***Foresight** explores, anticipates, and shapes the future to anticipate developments by building and using collective intelligence via different scenarios.*

*A **scenario** illustrates visions of a possible future or aspects of possible future but is not a prediction.*

Institutions

***The Bio-based Industries Joint Undertaking (BBI JU)** is a public-private partnership between the European Union and the Bio-based Industries Consortium (BIC), which aims to release the European bioeconomy potential.*

***The Central and Eastern European (CEE)** countries is a term that usually includes Albania, Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia.*

***The Central-Eastern European Initiative for Knowledge-based Agriculture, Aquaculture and Forestry in the Bioeconomy (BIOEAST)** is a political initiative to facilitate moving towards a sustainable bioeconomy via strategic research and innovation activities by Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia.*

***The European Union** (EU27) is a political and economic union of 27 member states.*

Policies

***The Circular Economy Action Plan (CEAP)** is one of the main components of the European Green Deal; it declares initiatives throughout the life cycle of products to extend the use of resources in the European Union's plan to make the European Union's economy sustainable and climate neutral by 2050.*

***The Common Agricultural Policy (CAP)** is the agricultural policy of the European Union.*

The European Green Deal (EGD)

Under the auspices of the Central and Eastern European BIOEAST Initiative, a yearlong foresight exercise was successfully completed. A group of five independent experts steered the process and prepared a report that facilitates the understanding of existing trends and creating scenarios on future bioeconomy developments towards 2050. The report identifies specific macro-regional needs, challenges and opportunities offering recommendations to policy and decision makers for the development of sustainable national bioeconomies.