European Commission

EU Bioeconomy Strategy Progress Report

European Bioeconomy Policy: Stocktaking and future developments

Research and Innovation

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European Commission
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Bioeconomy Policy:
Stocktaking and future developments

Directorate-General for Research and Innovation
Healthy Planet

2022

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Progress Report

Staff Working Document

EXECUTIVE SUMMARY

The European Green Deal sets the EU's ambition to become climate neutral by 2050, safeguarding people, planet and prosperity. The transition to a modern, resource-efficient, prospering and competitive economy, in which environment, health and wellbeing are priorities, requires deep and widespread action across all sectors of the economy. By 2022, in light of this new policy context, the European Council asked the European Commission[1] to provide a progress report on the implementation of the EU 2018 Bioeconomy Strategy and to assess whether or not the Strategy and/or its Action Plan requires updating.

The Bioeconomy Strategy, with its systemic perspective, plays an important role in achieving climate neutrality and environmental, economic, and social sustainability.

Bioeconomy encompasses all sectors and associated services and investments that produce, use, process, distribute or consume biological resources, including ecosystem services. As such it is a natural enabler and result of the European Green Deal transformation.

Bioeconomy policies take a **cross-sectoral perspective** to improve policy coherence and **identify and resolve trade-offs**, for example on **land and biomass demands**. Bioeconomy policies contribute to build a bioeconomy addressing all three dimensions of sustainability:

(1) Environment: management of land and biological resources within ecological boundaries;

(2) Economy: sustainable value chains and consumption; and

(3) Society: social fairness and just transition.

The 2018 Bioeconomy Strategy complements sectoral policies and **enables countries and regions to design transition pathways** according to their specific challenges and opportunities, benefitting from a non-prescriptive, integrated and systemic framework

This Progress Report shows that the **actions** are on track in achieving the main objectives of the Bioeconomy Strategy:

- An **increasing number of national and regional bioeconomy strategies** promote cross-sectoral cooperation and sustainability principles, and invest in bioeconomy innovation.

- **Progress on bioeconomy deployment has been achieved in Central and Eastern European countries**, aided by significant EU funding contributions and the establishment of new fora and networks.

[1] Council conclusions on the updated EU Bioeconomy Strategy, 14594/19

- Mobilisation of private **investments and research and innovations** in food and other bio-based industries are increasing and **show promising developments**. Europe has a strong position in the global market for bio-based chemicals and materials.

This review has also identified **gaps in the current Action Plan** that require further action. First, increased focus on how to better manage land and biomass demands to meet environment and economic requirements in a climate neutral Europe. Second, work on more sustainable consumption patterns to ensure environmental integrity.

The bioeconomy is now more important than ever to contribute to the **green and fair transition in Europe**. The EU Bioeconomy Strategy has shown to be successful; yet continued implementation of the Action Plan should put an increased focus on better management of biological resources and sustainable consumption patterns.

1 Introduction

Our current fossil-based economy has reached its limits[2] and the transition to a new societal and economic model, based on the sustainable and circular use of resources, has become one of the Union's core tasks.

To tackle this challenge the European Commission adopted a Bioeconomy Strategy in 2012[3], and updated it in 2018[4] (see Figure 1). The updated Strategy reaffirmed the five original objectives: (i) ensure food and nutrition security, (ii) manage natural resources sustainably, (iii) reduce dependence on non-renewable, unsustainable resources, (iv) mitigate and adapt to climate change and (v) strengthen European competitiveness and create jobs. These objectives, in line with the targets of the European Green Deal, are now more relevant than ever, following the unprovoked Russian invasion of Ukraine and the need to speed up achieving independence on energy[5] and to strengthen food security[6]. The **EU Bioeconomy Strategy** enables a green and just transition and **covers all three dimensions of sustainability:** environment, society and economy.

To reach these objectives, the updated Bioeconomy Strategy was accompanied by a targeted Action Plan along three main action areas: (1) strengthen and scale-up the bio-based sectors, unlock investments and markets; (2) deploy local bioeconomies rapidly across Europe; and (3) understand the ecological boundaries of the bioeconomy.

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[2] Statement by Commission President von der Leyen on the European Green Deal, 14 July 2021 (https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_21_3701)
[3] COM(2012)60. Innovating for Sustainable Growth: A Bioeconomy for Europe
[4] COM(2018)673. and SWD(2018)431. A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment.
[5] REPowerEU: Joint European Action for more affordable, secure and sustainable energy, COM(2022)108
[6] COM(2022)133. Safeguarding food security and reinforcing the resilience of food systems

The Council of the European Union recognised the importance of the **bioeconomy as a major component for the implementation of the European Green Deal**[7] in a Europe of regional diversity. It has asked the European Commission to provide a progress report on the implementation of the Bioeconomy Strategy by 2022, marking the **10th anniversary of the first EU Bioeconomy Strategy**. This document aims to reply to the Council request.

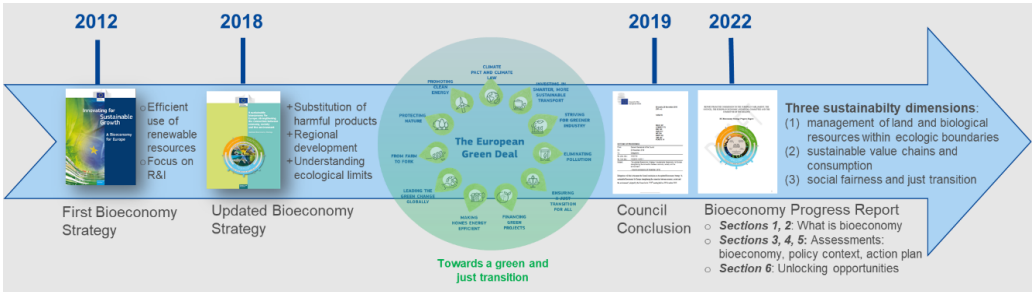

Figure 1: Development of the EU Bioeconomy Strategy and structure of this report.

2 What is the bioeconomy?

Key messages:

- Bioeconomy is a natural enabler and result of the European Green Deal transformation
- Bioeconomy governance is crucial to maximise synergies and resolve trade-offs
- Bioeconomy policies should be built on all sustainability dimensions: (1) management of land and biological resources within ecologic boundaries; (2) sustainable value chains and consumption; and (3) social fairness and just transition.

The concepts of bioeconomy and of bioeconomy policy have evolved from the first EU Bioeconomy Strategy in 2012[8], to the updated 2018 Bioeconomy Strategy[9] (see Figure 1). The bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, organic waste), their functions and principles. The EU Bioeconomy Strategy can help to **identify, assess and address trade-offs** between policy targets and competing uses of land, sea and biomass[10] in order to optimise the

[7] Council conclusions (14594/19) on the updated Bioeconomy Strategy "A sustainable Bioeconomy for Europe: strengthening the connection between economy, society and the environment"
[8] COM(2012)60. Innovating for Sustainable Growth: A Bioeconomy for Europe
[9] COM(2018)673. A sustainable Bioeconomy for Europe.
[10] https://materialeconomics.com/latest-updates/eu-biomass-use

use of material resources and services, including ecosystem services. This allows to identify **win-win solutions** that generate economic gains, preserve the environment, and increase resilience and capacity for recovery.

Bioeconomy governance is crucial to maximise synergetic effects of sectoral policies[11], create a level playing field and to frame coherent sustainability criteria across policy areas. Fostering **interministerial cooperation, policy coherence** and vertical **coordination at local, national, EU and international levels** allows the bioeconomy to fulfil its potential.

Bioeconomy policies help to build a bioeconomy based on all sustainability dimensions[12]. They enable all people to **enjoy a 'bio-based' lifestyle,** providing them with bio-based material (food, fibre, bio-based materials, energy) and non-material (clean air and water, biodiversity, climate mitigation and adaptation, recreation) products and services, thus contributing to the objectives of the New European Bauhaus[13] and its values of sustainability, inclusion and quality of experience.

2.1 Environmental sustainability: Management of land and biological resources within ecological boundaries

By optimising the use of biological resources from land and sea, the bioeconomy maximises **co-benefits[14]**, such as production of **biomass**, mitigating **climate change** and enhancing **biodiversity**, while safeguarding and benefiting from **other ecosystem services**. This implies dedicating land and aquatic area to preserving and restoring ecosystems, as well as achieving the targets set out in, for example, the EU Biodiversity[15] and Sustainable Blue Economy strategies[16], the EU's and national Adaptation Plans[17], and regulations on Land Use, Land Use Change and Forestry (LULUCF)[18] and deforestation-free products[19]. Nature based solutions and sustainable management of terrestrial and aquatic ecosystems help regenerate natural ecosystems and respect maximum sustainable yields[20], safeguard multi-functionality of forests[21], avoid harmful pollution[22], and improve ecosystem resilience.

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[11] See recommendations of the Policy Support Facility https://op.europa.eu/s/vzU7
[12] In line with the Sustainable Development Goals: https://sdgs.un.org/goals
[13] COM(2021)573. New European Bauhaus: Beautiful, Sustainable, Together.
[14] Co-benefits: The positive effects that a policy or measure aimed at one objective might have on other objectives, thereby increasing the total benefits for society or the environment. Co-benefits are often subject to uncertainty and depend on local circumstances and implementation practices, among other factors. Co-benefits are also referred to as ancillary benefits. IPCC, https://www.ipcc.ch/sr15/chapter/glossary/
[15] For example protection of at least 30 %, and strict protection of 10 % of land and sea areas, https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en
[16] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:240:FIN
[17] https://ec.europa.eu/clima/eu-action/adaptation-climate-change/eu-adaptation-strategy_en
[18] For example, climate neutrality of the land sectors by 2035 and net GHG sink of 310 Mt CO_2eq yr^{-1} by 2030. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52021PC0554
[19] https://ec.europa.eu/environment/publications/proposal-regulation-deforestation-free-products_en
[20] CFP, sustainable blue economy

2.2 Economic sustainability: Sustainable value chains and consumption

Use of biomass and other biological resources obtained from land and sea must fulfil and respect human needs and rights, such as the right to adequate and nutritious food[23] and the right for land managers and primary producers to fair living and working conditions[24]. The bioeconomy contributes to most of the Sustainable Development Goals (SDGs), among others SDG 2 (Zero Hunger), 12 (Sustainable Consumption and Production), and 13 (Climate Action). **Sustainable consumption patterns**[25] ensure wellbeing for all within planetary boundaries.

Bioeconomy policies **boost sustainable innovation**[26] and create solutions for sustainable food and bio-based products, bio-based and bio-derived chemicals, advanced biofuels and the bioenergy of the future. Several Horizon 2020, Bio-Based Industries Joint Undertaking and regional projects showcase **industrial modernization** and **sustainable value chains** (SWD Chapter 7). **Resource and energy efficiency** are achieved through principles such as the **circular economy**, the **cascading use**, the **waste hierarchy**, or the **Avoid-Shift-Improve** approach.[27]

2.3 Societal sustainability: Social fairness and just transition

Bioeconomy policies enable a green and socially fair transition[28] by developing sustainable business models[29] based on the principles of due diligence and by promoting sustainable trade and social fairness in Europe and beyond. This will reduce disparities, and generate new green jobs in emerging circular, bio-based and food industries and services, adding value to the regional economies. Examples such as the Rhenish coal mining area in Germany (BioeconomyREVIER)[30] or the Bulgarian Stara Zagora region (BE-RURAL)[31] show that the bioeconomy contributes to **rural and coastal development** and helps a **fair and just transition**.

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[21] COM(2021)572 final: New EU Forest Strategy for 2030
[22] EU Zero Pollution Action Plan https://ec.europa.eu/environment/strategy/zero-pollution-action-plan_en
[23] https://www.ohchr.org/Documents/Publications/FactSheet34en.pdf
[24] COM(2021)102 final: The European Pillar of Social Rights Action Plan.
[25] E.g. in line with the New Consumer Agenda https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12464-A-New-Consumer-Agenda_en
[26] Supported by actions on carbon removals via carbon farming and industrial solutions, https://ec.europa.eu/clima/eu-action/forests-and-agriculture/carbon-farming_en#ecl-inpage-1624; see also www.bbi.europa.eu/projects
[27] Avoid unsustainable and shift to more sustainable consumption, improve production systems elaborated in Creutzig et al., Nature Climate Change, 2021. https://doi.org/10.1038/s41558-021-01219-y
[28] Proposal for a Council Recommendation on ensuring a fair transition towards climate neutrality, COM(2021)801 final
[29] e.g. the Farm to Fork Strategy's EU Code Of Conduct on Responsible Food Business and Marketing Practices, https://ec.europa.eu/food/system/files/2021-06/f2f_sfpd_coc_final_en.pdf
[30] https://www.biooekonomierevier.de/home
[31] https://be-rural.eu/

3 General trends in the Development of the bioeconomy in Europe

Key messages:

- National bioeconomy strategies are becoming more numerous throughout Europe
- The main use of biomass is for food and feed; woody biomass is increasingly used
- The cascading principle must apply to the use of all biomass
- Important innovations in food and other bio-based industries show the potential of the bioeconomy
- Public involvement in R&I has shown good results so far and should be strengthened

In this section, latest available data from the European Commission's Knowledge Centre for Bioeconomy[32] are used to outline the situation of the bioeconomy in Europe. Section 3.1 provides an overview of currently existing national and regional bioeconomy strategies in Europe, while Section 3.2 shows the development of biomass supply and use until 2017. Section 3.3 provides an overview of economic figures of the bioeconomy and outlines the current role of bio-based research and innovation.

3.1 Development of bioeconomy strategies at national and regional level

Successful deployment of bioeconomies depends on local environmental, social and economic potentials and challenges.[33] The 2018 Bioeconomy Strategy Action Plan included specific actions to encourage the adoption, update and coherence of national and regional bioeconomy strategies throughout Europe. Since its adoption, substantial progress has been achieved. There are currently **ten EU Member States** with **dedicated bioeconomy strategies** and **seven EU Member States that are in the process of developing their respective strategies** (Fig. 1, details see SWD Chapter 2.1). Hence, since 2018 three more Member States have developed a national strategy, while five more Member States started the process of developing one.

Many EU Member States are also involved in three macro-regional level initiatives: BIOEAST[34] bringing together eleven Member States from Central and

[32] https://knowledge4policy.ec.europa.eu/bioeconomy

[33] See action on 'Integrated bioeconomy land and sea use assessment' in the Sustainable Carbon Cycles Communication

[34] The Central-Eastern European Initiative for Knowledge-based Agriculture, Aquaculture and Forestry in the Bioeconomy – BIOEAST – offers a common political commitment and shared strategic research and innovation framework for working towards sustainable bioeconomies in the Central and Eastern European (CEE) countries: Bulgaria, Czechia, Estonia, Croatia, Hungary, Lithuania, Latvia, Poland, Romania, Slovenia and Slovakia.

Eastern Europe, the Nordic Bioeconomy[35], or the Bioeconomy in the Baltic Sea Region initiative.[36]

The sectorial scope of those strategies generally reflects the scope of the European Strategy. Their actions focus on measures to:

- promote the implementation of principles for cascading use of biomass, circularity, and resource efficiency, investments in bioeconomy research, innovation and market development;
- integrate bioeconomy concepts or priorities within existing regulatory frameworks;
- facilitate intra-governmental and stakeholder collaboration;
- promote public procurement of bio-based products, national labels and standards, and actions that enhance knowledge and promote bioeconomy education or training (SWD Table 1).

Furthermore, 28 EU regions[37] have in place their own dedicated bioeconomy strategies and another region is in the process of developing one; 69 other EU regions are in the process or have already adopted strategies in which the bioeconomy is one of the key elements and 96 other EU regions have strategies with a minimum bioeconomy content (SWD Figure 1). Sector-specific regional strategies that guide the management of specific biological resources and/or bioeconomy sectors as well as broader, overarching and cross-cutting strategies (on e.g. circular economy, research and innovation, etc.) also exist and support the deployment of regional bioeconomies.[38]

[35] Three Member States: Denmark, Finland and Sweden: https://www.norden.org/en/bioeconomy
[36] Eight Member States: Germany, Denmark, Estonia, Finland, Lithuania, Latvia, Poland, Sweden, http://bsrbioeconomy.net/
[37] At NUTS1, NUTS2 and NUTS3 scale, or a combination thereof.
[38] JRC (2022). https://publications.jrc.ec.europa.eu/repository/handle/JRC128740

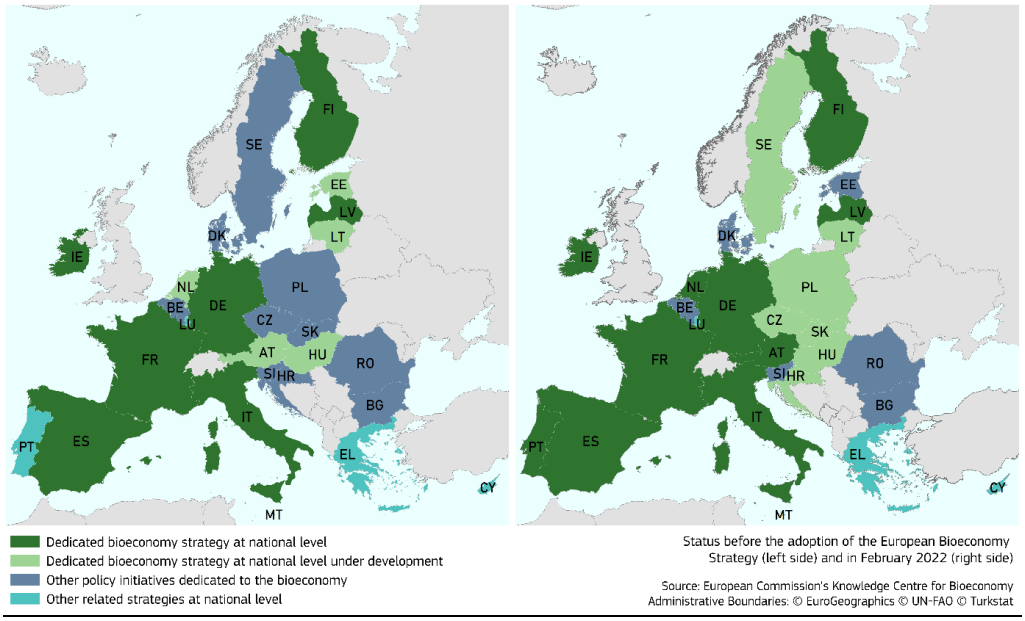

Figure 2. National bioeconomy strategies in the EU before the adoption of the European Bioeconomy Strategy[39] (left side) and in February 2022 (right side).[40]

3.2 Supply, transformation and use of biomass

The EU-27 sources roughly 1 billion tonnes dry matter of biomass per year. This biomass is mainly from the agriculture and forestry sectors, while fisheries and aquaculture supply less than 1 % of biomass dry matter. The biomass used for food purposes amounts to about half of all biomass used in the EU-27 (see Figure 3 and SWD Figure 2).

Approximately 80 % of the biomass produced for food in the EU-27 are destined for animal-based food, while 20 % is plant-based food[41]. The increase of the use of biomass in the period 2009-2017 was in the order of 1 % for food and 10 % for non-food purposes over the past two four-year periods of

[39] SWD(2018)431. A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment

[40] JRC (2022). https://knowledge4policy.ec.europa.eu/visualisation/bioeconomy-different-countries

[41] In 2017, approximately 416 M tonnes of vegetal material used for feed and bedding result in a production of 53 M tonnes of animal-based food, of which 23 M tonnes are exported in the form of live animals or animal-based food. In the EU27, 27 M tonnes of animal-based food are available for consumption (46 % fats, 32 % proteins, 13 % carbohydrates and 9 % others) by the population. As for plant-based food, 93 M tonnes (71 % carbohydrates, 12 % fats, 8 % proteins and 9 % others) are available for human consumption. All figures are in net trade terms. JRC (2022). https://publications.jrc.ec.europa.eu/repository/handle/JRC128384

available data (2010-2013 and 2014-2017). Primary[42] and secondary[43] woody biomass use has increased by 25 % and 29 % respectively in the past two decades. Energy-use of woody biomass has increased in the EU by about 12 % over the past two four-year periods of available data (2010-2013 and 2014-2017).[44]

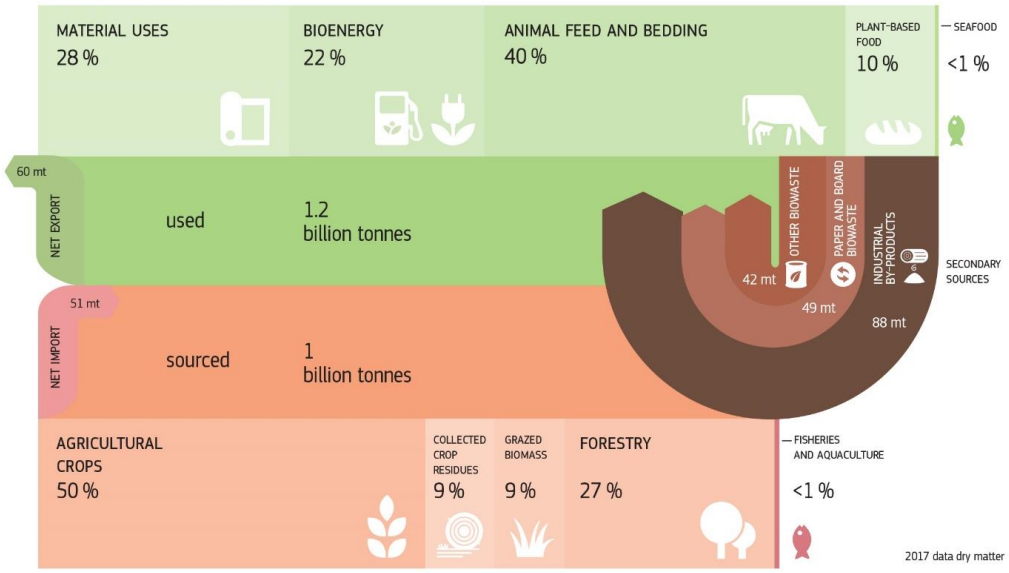

Figure 3. Biomass sources and uses in the EU-27
(based on 2017 data[45], units in tonnes dry matter)

At least half of all woody biomass used in the EU for energy (49 %), and about 19 % of all woody biomass entering the industrial process for materials, is from secondary sources and post consumer wood[46]. Although the use of the secondary woody biomass emphasises the cascading use of biomass in the forest-based industries, it could be improved by reinforcing the implementation of the cascading principle[47] and more emphasis on long-lived materials and products, for example in buildings and furniture. Such materials and products can enable the transformation of the built environment into a carbon sink rather than a source of emissions, helping to protect and expand the biosphere,

[42] Approximately 551Mm^3 Solid Wood Equivalent (SWE). https://knowledge4policy.ec.europa.eu/glossary-item/primary-woody-biomass_en, https://knowledge4policy.ec.europa.eu/glossary-item/solid-wood-equivalent_en

[43] Almost 260 Mm^3 SWE. https://knowledge4policy.ec.europa.eu/glossary-item/secondary-woody-biomass_en

[44] JRC (2021). https://publications.jrc.ec.europa.eu/repository/handle/JRC126552

[45] JRC Biomass Mandate, https://knowledge4policy.ec.europa.eu/projects-activities/jrc-biomass-mandate

[46] JRC (2022). https://ec.europa.eu/knowledge4policy/publication/forestry-sankey

[47] The Cascading Principle as applied to woody biomass, is when woody biomass is used according to its highest economic and environmental value in the following order of priorities: Wood-based products; Extending their service life; Re-use; Recycling; Bioenergy; Disposal.

stabilise the climate, and ensure human health and well-being, in line with the New European Bauhaus objectives.[48] Moreover, in order to improve the circularity of the wood-based industries, focus should be put on the recovery and reuse of the post-consumer wood (currently 38 Mm^3 SWE). In view of increasing biomass demands and a limited sustainable biomass supply, a gap in biomass availability is expected (see Chapter 4).

3.3 Economy, jobs and R&I in food and other bio-based industries

The biomass production and biomass conversion into food, beverage, manufactured bio-based products[49] and liquid biofuels and bioelectricity represent 8.3 % of the European labour force and 4.7 % of its GDP in 2019 (i.e. 17.42 million workers and EUR 657 billion value added in the EU's post-Brexit sectorial composition) (SWD Figure 3). The bio-based share of about 3 % in EU's domestic chemical market shows an important growth potential[50] (SWD Figure 4). Europe's **global market share for bio-based chemicals and materials** of about 31 % is twice the one of the fossil-based sector (16 %).[51] The role of **bioeconomy sectors in generating economic wealth has improved** in the past decade (SWD Figure 5) with gains in labour productivity (value added per worker) observed in all countries[52] (SWD Figure 6). Highest labour productivity was seen in the production of bioelectricity, the manufacturing of bio-based chemicals, pharmaceuticals, plastics and paper.[53]

The highest **substitution of fossil-based by bio-based chemical products** took place in bio-based solvents, bio-based polymers, bio-based packaging, biofuels and agrochemicals, with comparable production costs to fossil-based products (SWD Table 2). Substitution of fossil-based inputs for chemical platform products and polymers for plastics is currently at low shares with high future potential.[54] **Biorefineries** at scale could play an important role (see Section 5). Direct and indirect **impacts on local economies** of circular solutions underpinned by biotechnology have been demonstrated by a municipal waste-based nutrient valorisation strategy for agricultural use in Italy, showing that a total added value of EUR 8.5 million and 85 jobs can be generated for every 100,000 tons of sewage sludge turned into fertiliser.[55]

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[48] European Commission, Directorate-General for Research and Innovation, Schellnhuber, H., Widera, B., Kutnar, A., et al., Horizon Europe and new European Bauhaus NEXUS report: conclusions of the High-Level Workshop on 'Research and Innovation for the New European Bauhaus', jointly organised by DG Research and Innovation and the Joint Research Centre, 2022, https://data.europa.eu/doi/10.2777/49925

[49] The term "manufactured bio-based products" refers here to tobacco products, bio-based textiles, bio-based wearing apparels, leather, paper and wooden products, and bio-based chemicals, pharmaceuticals, plastics and rubber.

[50] JRC (2021). https://publications.jrc.ec.europa.eu/repository/handle/JRC112989

[51] JRC (2021). https://publications.jrc.ec.europa.eu/repository/handle/JRC124141

[52] Ronzon et al., 2020, Sustainability. https://www.mdpi.com/2071-1050/12/11/4507

[53] JRC (2022). https://publications.jrc.ec.europa.eu/repository/handle/JRC128361

[54] Baldoni et al. (2021). Renewable and Sustainable Energy Reviews. https://doi.org/10.1016/j.rser.2021.110895

[55] Tassinari et al. (2021). https://biomonitor.eu/wp-content/uploads/2022/02/D8.8-Report-on-case-study-The-Bioeconomy-Pilot-from-the-Vanguard-Initiative.pdf

While the restructuring of European agriculture[56] dominates the overall size of the work force, growth in the food and other bio-based industries in the EU27 was higher than the primary sectors. The manufacturing of food, beverage, tobacco, bio-based textiles, wood products and furniture, paper, bio-based chemicals, bio-based pharmaceuticals, bio-based plastics and bioelectricity provides 7.92 million jobs with a value added of EUR 433 billion.[57] The food, beverage and tobacco sector has with 55 % the largest share of value added (EUR 237 billion). An **increasing number of novel food applications.**[58]

Research and development has progressed quickly in the private sector and regressed in the public sector[59], indicating that the mobilisation of private stakeholders in research, demonstration and deployment of bio-based solutions has been fruitful. However, public involvement in R&D should further strengthen and expand the bio-based sectors, as was successfully done in the **Bio-based Industries Joint Undertaking** (and its successor **Circular Biobased Europe Joint Undertaking[60],** see Section 5.1, and SWD 1.1 Box 1).

Service activities, such as scientific research and development, digitalisation, logistics, etc., are an important element in a bioeconomy and could more than double the employment and "bioeconomy size". Studies point to EUR 400 to 1000 billion of value-added generated by bioeconomy-related services in the EU[61], growing between 2005 and 2015 on average faster than the primary production bioeconomy sectors[62]. However, current statistics are not well adapted to provide reliable information. Also, the scope of service sectors (SWD Figure 7) considered in the bioeconomy varies considerably between Member States.

[56] Agriculture employs 8.83 million workers in Europe, of which 4.41 million in CEE countries (2019 data). JRC (2022) https://publications.jrc.ec.europa.eu/repository/handle/JRC128361

[57] JRC (2022). https://publications.jrc.ec.europa.eu/repository/handle/JRC128361

[58] Kardung & Drabik (2021). Ecological Economics. https://doi.org/10.1016/J.ECOLECON.2021.107146

[59] Based on assessing a representative selection of 10 Member States, Kardung & Drabik (2021). Ecological Economics. https://doi.org/10.1016/J.ECOLECON.2021.107146

[60] https://www.bbi-europe.eu

[61] JRC (2020). http://publications.jrc.ec.europa.eu/repository/handle/JRC120324; Cingiz et al., 2021. Sustainability. https://www.mdpi.com/2071-1050/13/6/3033; Ronzon et al., 2021. Structural Change and Economic Dynamics. https://www.sciencedirect.com/science/article/pii/S0954349X21001375

[62] Cingiz et al., 2021, Sustainability. https://www.mdpi.com/2071-1050/13/6/3033

4 EU Bioeconomy Strategy objectives in the context of the European Green Deal

Key messages:

- Europe is generally moving towards the objectives of the EU Bioeconomy Strategy but environmental challenges persist
- There is a need for policy coordination as a consequence of multiple pressures on land from material demand, notably in sensitive labour markets.
- There is a need to transform and re-skill the work force in all parts of Europe for a just transition.
- The continued implementation of the EU Bioeconomy Strategy and Action Plan should focus on the challenges identified.

This chapter aims to analyse whether Europe is moving towards the five objectives of the EU Bioeconomy Strategy. In a second step, these objectives will be matched with relevant initiatives and policies under the European Green Deal.

The **EU Bioeconomy Monitoring System**[63] assesses the progress towards a sustainable and circular bioeconomy based on the aspirational principles that guide the EU Bioeconomy[64] **covering all three sustainability dimensions**. In this framework, the five objectives of the EU Bioeconomy Strategy are broken down into more detailed statements that describe the pathways towards them. Europe's trajectory towards a desired bioeconomy is assessed using specific indicators to measure the progress along these pathways. The trends do not yet reflect the impact of the 2018 EU Bioeconomy Strategy[65] and are confounded by many other factors[66].

The trends based on data for the year 2012-2021 show that **Europe is generally moving towards the objectives described in the Bioeconomy Strategy** (see Box 1). However, the trends also show some negative developments. Despite substantial benefits delivered by EU environment and climate policies over recent decades, Europe is facing persistent environmental challenges.[67] Assessments[68] reveal that terrestrial and marine ecosystems in

[63] Knowledge Centre for Bioeconomy: https://knowledge4policy.ec.europa.eu/bioeconomy/monitoring
[64] JRC (2021). https://publications.jrc.ec.europa.eu/repository/handle/JRC123675
[65] The time period assessed was from 2012-2017, conditioned by the availability of data for all indicators.
[66] Such as weather, climate, other policies etc.
[67] EEA (2019). https://www.eea.europa.eu/soer/publications/soer-2020
[68] JRC (2021). https://publications.jrc.ec.europa.eu/repository/handle/JRC123783; IPCC (2021) Sixth Assessment Report https://www.ipcc.ch/report/ar6/wg1/; IPBES (2019) Global Assessment Report on Biodiversity and Ecosystem Services https://ipbes.net/global-assessment; Leclère et al., (2020), Nature Reviews. https://doi.org/10.1038/s41586-020-

Europe are under strain mainly due to direct or indirect anthropogenic stressors, such as pollution, persistent human interventions, and climate change (SWD Figure 8).

Table 1 shows the relationship between the European Green Deal initiatives and the five objectives of the Bioeconomy Strategy. Each initiative puts a focus on at least one objective of the Bioeconomy Strategy (dark green) and supports others (medium green). The assessment does not prejudge the actual impact the initiatives will have. In some cases, links with the objective of the Bioeconomy Strategy are only implicit and the initiative does not address or support it directly (pale green), as a consequence of economic or behavioural feedback effects. In such cases, specific attention is required (SWD Chapter 4 for additional details on the assessment).

Table 1 shows that various trade-offs and challenges need to be addressed: (a) increased **pressure on land for mitigation (carbon sequestration) and adaptation, nature protection (e.g. biodiversity) and supply of biomass**, (b) **increased demands for materials and bioenergy**, and (c) a mismatch between the existing and required work force (e.g. skills) calling for **transforming and re-skilling of Europe's work force**. For example, studies project a **biomass gap** by 2050 **of 40-70 %** between sustainable biomass supply and biomass demands for materials, and energy.[69]

The current crisis following the unprovoked Russian invasion of Ukraine clearly shows that Europe requires to increase its independence on energy and to strengthen food security, without leaving the path towards a sustainable, resilient, and fair economy as outlined by the European Green Deal. Holistic and environmentally sustainable production models are needed aiming at maximising synergies and minimising trade-offs to avoid potential additional pressure on natural resources and to develop smart and sustainable solutions. The continued implementation of the EU Bioeconomy Strategy and Action Plan and further actions should focus on these challenges.

2705-y; Bardgett et al., (2021). Nature Reviews. https://doi.org/10.1038/s43017-021-00207-2.

[69] Material Economics (2021). https://materialeconomics.com/latest-updates/eu-biomass-use

Summary of the assessment of indicators in the EU Bioeconomy Monitoring Framework. The detailed indicators are aggregated according to their position within the hierarchical conceptual framework described in the SWD Chapter 3.

Ensuring Food and Nutrition Security.

The EU is already a highly food secure region and is showing an overall tendency towards increasing food accessibility and utilisation. There are variations from year to year however, due to extreme weather events, and the variability in prices and the economic conditions of families. There are discrepancies in food and nutrition security between countries within the EU.

Mitigating and adapting to climate change.

Climate change adaptation is progressing at a stronger pace than mitigation. Mitigation shows a negative trend due to the decline of the forest sink, partly linked to an increase in harvest, which also includes unplanned harvesting due to natural disturbances and pests.

Strengthening European competitiveness and creating jobs.

Strong positive trends are seen in the value of raw and processed biomass, value added in bioeconomy sectors and contribution of bioeconomy to economic development. Moderate trends are seen in the overall employment in bioeconomy sectors.

Reducing dependence on non-renewable unsustainable resources, whether sourced domestically or from abroad.

The EU is showing strong[$] progress in biowaste prevention, re-use/recycling, and recovery, energy efficiency, and consumption and demand for bio-based products. In particular, the EU is improving in overall waste recovery. There is a strong negative trend in material footprint and food loss and waste minimisation for the period 2012-2017.

Managing Natural Resources Sustainably.

The increased land and marine areas designated as "Natura 2000 sites" have pushed the indicator group related to conservation areas to show very positive trends. A weak[&] positive trend is reported for structural and functional ecosystem attributes. Pressures from primary production systems vary.

Trends are improving for fisheries, neutral for agriculture and negative for forestry. Environmental quality and species diversity are showing stable trends. Although trends are overall positive for the period 2012-2017, ecosystem condition are still overall quite poor.

Notes:

[$] >+1 % or <-1 % = moderate to strong trend

[&] 0 to +/-1 % = weak to moderate trend

Table 1. Assessment of EU Green Deal initiatives in relation to bioeconomy sustainability objectives. The table shows how the European Green Deal initiatives focus on ('dark green') or support ('medium green') the sustainability objectives of the EU Bioeconomy Strategy or if specific attention is required to maintain overall coherence ('pale green').

		Ensuring Food and Nutrition Security	**Managing Natural Resources Sustainably**	**Reducing dependence on non-renewable unsustainable resources, whether sourced domestically or from abroad**	**Mitigating and adapting to climate change**	**Strengthening European competitiveness and creating jobs**
Circular Economy	[1]					
Industry Strategy	[2]					
Biodiversity Strategy	[3]					
Farm to Fork Strategy	[4]					
Renovation Wave	[5]					
European Climate Law	[6]					
Chemicals Strategy for Sustainability	[7]					
Adaptation Strategy	[8]					
Sustainable Financing	[9]					
Zero Pollution Action Plan	[10]					
LULUCF	[11]					
Renewable Energy	[12]					
Forest Strategy	[13]					
Sustainable Carbon Cycles	[14]					

[1] COM(2020)98. A new Circular Economy Action Plan. For a cleaner and more competitive Europe. **[2] COM(2020)102**. A New Industrial Strategy for Europe. And COM(2021)350 final. Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery. **[3] COM(2020)380**. EU Biodiversity Strategy for 2030. Bringing nature back into our lives. Targets include protection 30 % of the land and sea area, strictly protection of 10 % of land and sea area; reverse decline of pollinators; 50 % reduction in the number of Red List species threatened by invasive alien species; significantly reduce by-catch of species; three billion new trees are planted in the EU; aligned to targets of the farm to fork strategy. **[4] COM(2020)381**. A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system. Targets by 2030 include 50 % reduction in the use and risk of chemical pesticides and a 50 % reduction in the use of the more hazardous pesticides, hazardous chemicals, nutrient losses, and sales of antimicrobials in farming; 25 % of agricultural area under organic farming. **[5] COM(2020)662**. A Renovation Wave for Europe - greening our buildings, creating jobs, improving lives. See also **COM(2021)802** proposal for a directive on the energy performance of buildings (recast). **[6] EU(2021)1119**. 'European Climate Law'. Targets include by 2030 reduction of GHG emissions by 55 %; achieving climate neutrality by 2050. See also Carbon Border Adjustment Mechanism COM(2021)564 final. **[7] COM(2020)667**. Chemicals Strategy for Sustainability - Towards a Toxic-Free Environment. **[8] COM(2021)82**. Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change. **[9] COM(2021)390**. Strategy for Financing the Transition to a Sustainable Economy and EU(2020) 852. Taxonomy Regulation. **[10] COM(2021)400**. Pathway to a Healthy Planet for All - EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'. Targets by 2030 include reduce number of premature deaths by air pollution by 55 % and share of people chronically disturbed by transport noise by 30 %; sign. waste generation, residual municipal waste and plastic litter at sea (by 50 %), microplastics released into the environment by 30 %; nutrient losses and chemical pesticides' use by 50 %; EU ecosystems where air pollution threatens biodiversity by 25 %. **[11] COM(2021)554**. Proposal for amendment of the LULUCF regulation. Target of -310 Mt CO2eq/yr net greenhouse gas removals in the EU-27 LULUCF sector, with individual targets by Member State. **[12] COM(2021)557**. Amendment of EU(2018) 2001. On the promotion of the use of energy from renewable sources. Targets of amendment include increased to 40 % share renewable energy, increased sustainability criteria incl. cascading principle. **[13] COM(2021)572**. New EU Forest Strategy for 2030. **[14] COM(2021)800**. Communication on Sustainable Carbon Cycles; including a target of 20 % of the carbon used in the chemical and plastic products from sustainable non-fossil sources by 2030 and announcing an action on Integrated Land Use Assessments.

5 Progress of bioeconomy activities under the EU Bioeconomy Strategy Action Plan

Key messages:

- Overall implementation of the EU Bioeconomy Action Plan is well on track and has already contributed to the objectives of the European Green Deal.
- Strongest progress has been made in developing bio-based solutions through R&I and increasing public and private investments (action area 1).
- Improved cooperation with Member States and demonstration projects have laid the basis for regional and national bioeconomy deployments, with a focus on less developed countries (action area 2).
- Understanding of ecological limits of the bioeconomy has improved (action area 3). However, gaps remain on how to better manage biosphere use to meet environmental and economic requirements in a climate neutral Europe, and how to promote more sustainable consumption patterns to guarantee environmental integrity.

This chapter summarises the progress made on the **14 actions under three action areas** of the 2018 Bioeconomy Strategy and Action Plan. Most of the activities have medium and long-term processes and will deliver their final results in the future. More details on the actions can be found in the SWD Chapter 5.

5.1 Strengthen and scale up the bio-based sectors, unlock investments and markets

The first action area aims to strengthen and scale-up the bio-based sectors and unlock investments and markets. The actions also promote research and innovation along value chains and improve coordination in innovation activities. Promising innovations[70] in the bio-based sectors include analytical techniques and bioprospecting, design and engineering of biomolecules, and solutions for more sustainable biomass exploitation.

The **Bio-based Industries Joint Undertaking** (BBI JU, 2014-2021)[71] will have attracted private investment of EUR 2.73 billion by 2024 (end of last projects), matched with EUR 835 million support by the EU (details SWD Box 1). The new **Circular Bio-based Europe (CBE) Partnership**[72] (2021-2031) receives EUR 1 billion EU contribution to further strengthen and scale up the EU bio-based sectors in all stages of the innovation cycle, to be coupled with at least the equal contribution by the private partner, the Bio-based Industry Consortium.

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[70] European Commission (2021). https://op.europa.eu/s/vWEB

1. [71] EU(560)2014 amended by EU (2018)121. https://www.bbi-europe.eu and Impact Assessment COM(2021)87

[72] EU(2021)2085.

The **Bioeconomy Strategy Accelerator Toolkit**[73] (BSAT) integrates bioeconomy tools and support material developed within Horizon 2020 project POWER4BIO[74], e.g. the catalogue of bio-based solutions[75]. Investment readiness of the EU regions is supported by the Commission through a **Self-Assessment Tool**.

The EU Bioeconomy Strategy intended to facilitate the development of **new sustainable biorefineries** in Europe at scale, to provide emerging applications substituting fossil-based products[76] (SWD Infographic 1). As also confirmed by an **outlook for biorefineries for 2030 in Europe**[77], they could play a key role in transforming industrial facilities[78]. More than 300 chemical and material-driven biorefineries are operational in the EU (e.g. see Figure 4, BBI JU flagships and their value chains). For example, there are 139 woody biomass-based biorefineries in Europe, with another 28 planned to double their turnover by 2030. The policies and regulations, especially those taken since 2018, have been pivotal for investment decisions of private companies on biorefineries. However, market access remains challenging due to the lack of a comprehensive regulatory policy approach and the large gap between the current costs of bio-based products and the willingness of consumers to pay.

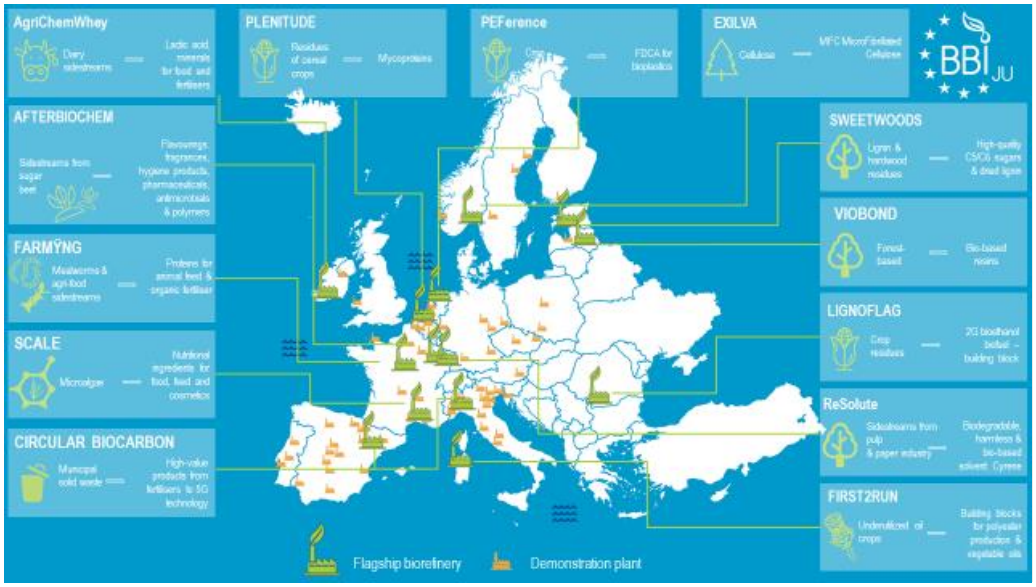

Figure 4. BBI-JU flagship biorefineries and demonstration plants across Europe.

[73] See activity 1.1.2 in SWD Chapter 5. http://bioeconomy-strategy-toolkit.eu/
[74] www.power4bio.eu
[75] https://www.bio-based-solutions.eu/#/
[76] JRC (2021). https://datam.jrc.ec.europa.eu/datam/mashup/CHEMICAL_BIOREFINERIES_EU/
[77] EC DG R&I (2021). https://op.europa.eu/en/publication-detail/-/publication/7223cd2e-bf5b-11eb-a925-01aa75ed71a1
[78] JRC (2021). https://data.jrc.ec.europa.eu/dataset/ee438b10-7723-4435-9f5e-806ab63faf37

The **Blue Bioeconomy Forum** identified several solutions that have been implemented in the coastal area. The Forum's recommendations have been one of the starting points for the forthcoming EU Algae Initiative, which the Commission intends to adopt in Q4/2022. The algae or shellfish aquaculture can serve as bioremediation tools by removing nutrients, carbon and pollutants from marine waters. The **BlueInvest platform** and the **European Maritime, Fisheries and Aquaculture Fund (EMFAF)** support investment in the broader blue economy including on algae. An increasing number of projects under Horizon 2020 and Horizon Europe, including the mission "Restore our Ocean and waters by 2030" support plastics free seas and oceans and algae related projects.

To unlock investments, the new **European Circular Bioeconomy Fund**[79] is a first venture fund exclusively focused on the bioeconomy and the circular bioeconomy in Europe, providing funding from Horizon 2020 and the European Investment Bank. The fund targets investments of EUR 250 million, with a further EUR 206 million in capital raised by the end 2021. Assessments show uneven distribution of bioeconomy activities among different EU macro-regions and Member States (e. g. distribution of chemical and material biorefineries[80], investment in the European Circular Bioeconomy Fund[81] and insufficient innovation intensity in bio-based sectors[82]), correlating at least to some extent with the innovation performance measured by the European Innovation Scoreboard.[83]

5.2 Deploy local bioeconomies rapidly across the whole of Europe

The European Commission has set up several work streams with Member States to deploy local bioeconomies rapidly across Europe. The **European Bioeconomy Policy Forum** facilitates exchange of knowledge and best practices between Member States for developing and implementing national and regional bioeconomy policies. Collaboration between Member States was facilitated via the **Bioeconomy Policy Support Facility** as a **Mutual Learning Experience**, identifying ten key policy messages[84] to guide national bioeconomy strategy and/or action plan development. A group of experts conducted the **BIOEAST Foresight exercise** which is the first of its kind in the region and raised awareness of the importance of investing in specific research and innovation and in national bioeconomy development programmes.[85]

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[79] Launched in December 2019, http://www.ecbf.vc/team
[80] See activity 1.5.1 in SWD Chapter 5
[81] See activity in SWD Chapter 5
[82] CBE Partnership - IMPACT ASSESSMENT REPORT Accompanying the document Proposal for a Council Regulation establishing the Joint Undertakings under Horizon Europe European Partnership for a Circular Bio-based Europe {COM(2021) 87 final} - {SEC(2021) 100 final} - {SWD(2021) 38 final]
[83] ec.europa.eu/info/research-and-innovation/statistics/performance-indicators/european-innovation-scoreboard_en
[84] EC DG R&I (2021). https://op.europa.eu/en/publication-detail/-/publication/2cf89630-e2bc-11eb-895a-01aa75ed71a1/
[85] https://bioeast.eu/wp-content/uploads/2021/10/BIOeast-Report-2021_FINAL_compressed-1.pdf

Several pilot actions to support coastal, rural and urban bioeconomy development demonstrate the bioeconomy's potential on the ground and **have been supported** through various EU instruments, such as the Common Agricultural Policy (CAP), the European Regional Development Fund (ERDF), the European Maritime and Fisheries Fund (EMFF), LIFE, the Innovation Fund, and Horizon 2020 and Horizon Europe with their partnerships (the BBI-JU and CBE) and missions (e.g. soil and ocean missions). To improve synergies and complementarities between EU initiatives, regional policies and their instruments, further investments in infrastructure are needed to tap the biomass potential.[86] A project on a strategic deployment agenda will address the fragmentation in the research and innovation landscapes, and strengthen interactions and complementarities between initiatives, instruments and policies.

The new **CAP** includes the bioeconomy explicitly under one of its specific objectives. The new CAP allows Member States to set out interventions adapted to their local realities to promote the development of the Bioeconomy in rural areas, providing the possibility to move from individual projects to a more systemic approach and supporting primary producers in their efforts to innovate and drive the bioeconomy.

EU structural funds remain significant financial contributors to bioeconomy deployment, including the European Maritime, Fisheries and Aquaculture Fund that has committed EUR 36 million to the blue bioeconomy.[87]

Horizon 2020 project HOOP received EUR 7.9 million as a EU contribution to support a pilot group of European cities to attract EUR 51 million of investments for the implementation of urban circular bio-based economy strategies, creating additional jobs and recycling/reducing waste.

In 2021 the European Commission established the **Circular Cities and Regions Initiative**[88] that will provide further support to circular bio-based economy projects at local and regional scale through demonstrations and project development/technical assistance.

Mainstreaming of bioeconomy relies on the next generation. Young people are important knowledge multipliers and ambassadors. Successful deployment also demands a workforce that is well-equipped for the shift towards better sustainability and circularity.[89] As activity under the EU Bioeconomy Strategy and in line with SGD 3, the Commission launched a study to explore the **development of bioeconomy educational and training content**.

[86] See activities 1.1.1, 1.1.2, and activity 2.2.1.1 in SWD Chapter 5

[87] Additionally, the Technical Support Instrument provides additional support to design and implement reforms in EU Member States in the context of EU priorities such as the green and the digital transition.

[88] https://ec.europa.eu/info/research-and-innovation/research-area/environment/circular-economy/circular-cities-and-regions-initiative_en

[89] Action: 2.4 - Promote education, training and skills across the bioeconomy

5.3 Understand the ecological boundaries of the bioeconomy

In the third action area the European Commission's Knowledge Centre for Bioeconomy builds the knowledge base on key issues, for example on sustainable biomass supply and demand and guidance on how to manage healthy and resilient ecosystems in the bioeconomy[90], and the development of a Europe-wide monitoring system[91] to assess the environmental, social and economic sustainability of the EU Bioeconomy (see Chapter 4). The forest information system for Europe (FISE) provides access to forest related data and acts as a motor of new harmonised forest information. The mapping and assessment of ecosystem services (MAES) provides information on the condition of terrestrial, freshwater and marine ecosystems as data foundation for future assessments and policy developments.

Major initiatives are being adopted to set up living labs accelerating the transition to agroecology and to increase the understanding of microbial biodiversity and to develop microbiome-based solutions. Living labs are also developed in the context of the EU mission "A soil deal for Europe" to re-establish soil fertility. To further deepen our understanding of microbiome solutions and applications, the Commission collaborates with international partners via a dedicated working group under the EU-led **International Bioeconomy Forum**.[92] An EU-wide pollinator scheme is being developed. The new European co-funded biodiversity partnership Biodiversa+ includes as one of its objectives support for biodiversity monitoring, including an EU Pollinator Monitoring Scheme (EUPOMS).

Overall, the activities under the third action area have contributed to a better understanding of the ecological limits of the bioeconomy. Yet, more work needs to be done in order to move from a better understanding towards a better implementation of the bioeconomy within the planetary boundaries. Knowledge gaps remain on how to better manage biosphere use to meet environmental and economic requirements in a climate neutral Europe, and how to promote more sustainable consumption patterns to guarantee environmental integrity.

[90] European Commission (2022), https://data.europa.eu/doi/10.2779/946677
[91] Knowledge Centre for Bioeconomy https://knowledge4policy.ec.europa.eu/bioeconomy/monitoring
[92] https://bioeconomy-forum.org/

6 Unlocking the opportunities of the bioeconomy

Key messages on possible future directions of the EU Bioeconomy Strategy:

- The implementation of the EU Bioeconomy Strategy needs to be strengthened for the European Green Deal
- Many activities have been successful and should be strengthened
- Future implementation of the actions of the bioeconomy will focus on understanding further the trade-offs on land-use and contribute to a consumption-based bioeconomy

6.1 Stakeholders' view

Feedback received from Member State experts, members of the European Bioeconomy Policy Forum as well as from external stakeholders show a positive perception of the EU Bioeconomy Strategy with its Action Plan. Numerous complementary activities are taking place at national and regional level (SWD Chapter 6). However, the feedback also identified further needs **to better respond and contribute to the new policy context since the adoption of the European Green Deal** and related initiatives, such as:

- A **stronger focus on sustainability** assessment and sustainable management and use of biological resources[93], e.g. by **addressing relevant trade-offs** and excessive consumption.
- A **broad multi-stakeholder engagement**, strong engagement of citizen and young people.
- A strengthened and comprehensive evaluation and monitoring system.
- **Socio-economic aspects** such as the impact on the local population and resource price.

6.2 Strengthening successful activities of the 2018 Bioeconomy Strategy Action Plan

Mirroring the views of our stakeholders and based on the findings of the assessment in Chapter 5, we have identified successful activities that could benefit from further engagement.

Transforming and re-skilling of Europe's workforce to be able to work in emerging bio-based value-chains, and ensuring and monitor the **quality of jobs,** remains a crucial task to advance a **socially fair and green transition** in various regions of Europe. **Research and innovation** have been the driving force for the successful development of bioeconomies from the beginning and

[93] In line with the findings of the CBE Partnership Impact Assessment, COM(2021)87; SEC(2021)100; SWD(2021)38.

will continue to be so. **People-centered** and **regional development** remains a core objective of bioeconomy policy.

The BBI JU and R&I breakthroughs have demonstrated the huge potential of the bio-based industries. Yet, a **stronger leverage for bio-based materials and products** must create an even playing field on the market, enhance innovation and co-operation with private sector initiatives, and stimulate start-up creation within industry ecosystems. Building on the European Circular Bioeconomy Fund, further investments are needed to overcome the particularly large "valley of death" in bioeconomy innovations, caused by **lack of financing** to transfer knowledge into innovations and **lack of a long-term policy pull**.

Further, **new standards, labels and the environmental footprint of circular bio-based products** remain an important issue and could also help to inform citizens.[94] Diversifying bio-based value-chains to meet the challenges of environmental sustainability calls for **more holistic policy in industries[95] and research**.

The successful deployment of the bioeconomy needs **improved bioeconomy stakeholder engagement** at all levels, in order to bridge policy work with local realities.[96] An important cornerstone of this engagement will be the collaboration with Member States through the **European Bioeconomy Policy Forum**. The Bioeconomy Policy Support Facility recommended Member States to **update their national bioeconomy policies** in light of new objectives and policy developments. Tailor-made advice or assistance particular in support for Member States under the **BIOEAST initiative** could be made available through dedicated activities under the European Bioeconomy Policy Forum. Equally, international cooperation should be strengthened, for example under the International Bioeconomy Forum (IBF), in support of global sustainable development.

While the activities under the action areas 1 and 2 of the 2018 Bioeconomy Strategy Action Plan progressed well, more attention is needed for action area 3. A key activity is the continuation of the EC's **Knowledge Centre for Bioeconomy** and its **Bioeconomy Monitoring System**[97], to increase understanding of the ecological boundaries. Better understanding of potential synergies and trade-offs of technology and policy options through **integrated assessments of policy changes** on the whole socioeconomic and environmental system is needed, accounting for interlinkages and feedback effects, also to increase resilience in times of trade disruptions, as seen during the early times of the COVID-19 crisis.

[94] See activity 1.6.1 in SWD chapter 5
[95] For instance CEPI Biorefineries Vision 2030: https://www.cepi.org/wp-content/uploads/2021/11/Future-Mill-Concept-2030_17.11-1.pdf
[96] See activity 2.2.2 in SWD chapter 5
[97] Knowledge Centre for Bioeconomy https://knowledge4policy.ec.europa.eu/bioeconomy/monitoring_en

6.3 Additional focus needed on some key aspects of the bioeconomy strategy

To meet the high stakes and ambitions of the European Green Deal it is essential to ensure **environmental integrity** and to close the projected **'biomass gap' between supply and demand of biomass for food, materials and energy**. While the three action areas of the 2018 EU bioeconomy Strategy aim to close this gap, additional focus should be given to resolve multiple pressures on land for mitigation, nature protection and supply of biomass. Also, a better understanding of overall consumption of biological resources is needed to help shifting to more sustainable consumption patterns.

6.3.1 Focus on resolving multiple pressures on land and sea

An additional focus in the implementation of the EU Bioeconomy Strategy Action Plan on achieving socio-economic and environmental sustainability[98] can enable bioeconomy policies to optimise the societal benefit from land, aquatic area and biological resources, including biodiversity and other ecosystem services. In line with the action area 3, *Understanding the ecological boundaries of the bioeconomy*, an **integrated bioeconomy land use assessment** has already been proposed as an action in the Communication on Sustainable Carbon Cycles.[99] This action and further focus on the activities of action area 3 of the EU Bioeconomy Strategy will provide the basis for reducing pressures on land and sea. The development of **territorial biomass strategies** from terrestrial and aquatic systems, as proposed by Member States, such as Germany, will further help to ensure the comprehensive integration of policy needs, resources availability, and innovation. In this way, potential conflicts can be identified, e.g. if the supply of sustainably produced biomass in a region is insufficient with regard to the biomass demand for food, materials and energy. On the European level, a **conceptual framework for resolving** such **trade-offs** could be explored, taking into account regional, environmental, technological, and skill needs and opportunities. Such a framework could be based on the work of Johan Rockström and his biosphere stewardship model[100], and must include an **economic valuation for the continuous or improved provision of ecosystem services** such as clean air, water replenishment, biodiversity, carbon sequestration and storage, or recreation. This could also help developing **sustainable and inclusive business models** that empower primary producers and other rural and supply chain actors, and turn climate and environmental challenges into opportunities, enhance and diversify incomes, and create skilful jobs. **Safe nature-human interfaces** for healthy ecosystems, animals and people according to the OneHealth principle, must be further ensured.

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[98] Rockström et al., 2021. https://www.pnas.org/content/118/38/e2115218118
[99] COM(2021)800. Sustainable Carbon Cycles.
[100] We need biosphere stewardship that protects carbon sinks and builds resilience: https://www.pnas.org/doi/10.1073/pnas.2115218118

6.3.2 Focus on the overall consumption of biological resources

Based on the holistic approach of the bioeconomy, and in line with action area 2, *Deploying the bioeconomy rapidly across Europe*, **consumption patterns** need to become more **sustainable** to guarantee environmental integrity, as technological solutions alone are not able to close the gap between sustainable supply of biological resources and demand. With additional focus on the **total demand for biological resources**, more **sustainable consumption choices** based on true costs could be better assessed and measured. Demand-driven bioeconomy action can trigger high **investments in sustainable bioeconomy businesses** and drive the sustainable transformation of regions and Member States.

7 Conclusion

Following the unprovoked Russian invasion of Ukraine, the need to enhance the transition towards both clean energy and sustainable, resilient, and fair food systems has never been stronger and clearer. Future implementation of the EU Bioeconomy Action Plan will have to take into account the implications on food and energy prices, as well as prices of energy-intensive products, and global supply chains, and address resulting additional pressure on natural resources within ecosystem boundaries.

A **strong EU Bioeconomy Strategy** with a focus on all three dimensions of sustainability contributes to achieve the goals outlined in the European Green Deal. Progress of the 2018 updated Bioeconomy Strategy is promising and encourages to continue and further strengthen various activities. However, to in order to fully exploit the strength of the Bioeconomy Strategy, additional efforts are needed, especially with regard to further actions on resolving multiple pressures on land and sea and on the overall consumption patterns of biological resources.

COMMISSION STAFF WORKING DOCUMENT

Accompanying the document

EU Bioeconomy Strategy Progress Report

European Bioeconomy Policy: Stocktaking and future developments

1 Introduction

The present Staff Working Document accompanies the Commission Report to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the regions, entitled "European Bioeconomy Policy: Stocktaking and future developments" (hereafter, also the "Report").

The Report assesses the implementation of the updated EU Bioeconomy Strategy from 2018 and its 14 actions, while also describing the role of the Bioeconomy Strategy in achieving Europe's green and just transition, as set out in the European Green Deal.

The structure of this Staff Working Document is reflecting the structure of the Report. Chapter 2 provides further data on the development of the bioeconomy in Europe, supporting the statements made in the Report. This chapter maps the development of bioeconomy strategies at national and regional level, provides a summary of the trends in pressures and condition of ecosystems, showcases biomass flows and the economic impact of the bioeconomy, while also providing information on the state-of-play and potential of the innovation and the bio-based industries. Chapter 3 give detailed background information further insights on the method and results of the Bioeconomy Monitoring Framework developed by the JRC as part of the Commission's Knowledge Centre for Bioeconomy.

Chapter 4 provides complementary information in support of Table 1 of the Bioeconomy Progress Report assessing initiatives under the European Green Deal in relation to Sustainability Dimensions as formulated in the five objectives of the EU Bioeconomy Strategy.

Chapter 5 provides detailed information on the Action Plan of the EU Bioeconomy Strategy on implementation, impact the various activities, including an outlook on possible continuation. Though most activities have an EU wide focus, complementary activities are also being carried out by Member States. A brief overview on such activities related to each action of the updated Bioeconomy Strategy is given in Chapter 6.

Finally, chapter 7 provides some examples of relevant projects of relevance for the bioeconomy.

2 Development of the Bioeconomy in Europe - data basis

2.1 Development of bioeconomy strategies at national and regional level

The 2018 Bioeconomy Strategy Action Plan included specific actions to encourage the adoption, update and coherence of national and regional bioeconomy strategies throughout Europe.

Since 2018, there have been several developments at national level: Austria[1], the Netherlands and Portugal[2] have developed a (new) national strategy while Croatia, Czechia[3], Poland[4] and Slovakia (supported by the BIOEAST[5] intitiative) as well as Sweden, started the process of developing one. Furthermore, Germany[6], Ireland[7], Italy[8] and Finland[9], have updated their existing strategies or action plans and Finland[10], France[11] and Spain are currently updating their existing national strategies or action plans. As a result, there are currently ten EU Member States with dedicated bioeconomy strategies. The sectorial scope of those strategies generally reflects the scope of the European Strategy. Their

[1] Austria published its national dedicated bioeconomy strategy in 2019; a progress report about the implementation of key-measures was published in July 2021 (https://www.bmk.gv.at/en/topics/climate-environment/climate-protection/bioeconomy/flagship-projects.html).

[2] The "Plano de Ação para a Bioeconomia Sustentável (PABS) – Horizonte 2025" was approved by the Council of Ministers on the 26th November 2021 and published in the national official journal on the 28th December 2021 (https://apambiente.pt/apa/bioeconomia).

[3] As a first step, the "Bioeconomy concept in the Czech Republic from the perspective of the Ministry of Agriculture" was published in 2019 (https://eagri.cz/public/web/mze/poradenstvi-a-vyzkum/vyzkum-a-vyvoj/koncepce-a-strategie/koncepce-biohospodarstvi-v-ceske.html)

[4] Besides, the "Roadmap towards the Transition to the Circular Economy"[4] was adopted by the Council of Ministers in 2019, where the bioeconomy is one of the pillars and has associated a specific set of actions for its development. https://circulareconomy.europa.eu/platform/sites/default/files/md_goz_final_en_r4_4.pdf

[5] https://bioeast.eu/

[6] A new national bioeconomy strategy was adopted in 2020 (https://www.bmbf.de/bmbf/en/research/energy-and-economy/bioeconomy/bioeconomy_node.html) and a dedicated Bioeconomy Action Plan is currently under elaboration.

[7] In Ireland, after the adoption of the "National Policy Statement on the Bioeconomy" in February 2018, the Bioeconomy Implamentation Group published its First Porgress Report in autum 2019, which includes an Action Plan for 2019-2020 (https://www.gov.ie/en/publication/9a7e1-the-bioeconomy/)

[8] Italy adopted an updated Bioeconomy Strategy in 2019 (https://cnbbsv.palazzochigi.it/media/1953/bit-ii-2019-en.pdf) and its Implementation Action Plan (2020-2025) in 2021 (https://cnbbsv.palazzochigi.it/media/2079/iap_2332021.pdf)

[9] Finland published its updated national bioeconomy strategy in April 2022 (https://julkaisut.valtioneuvosto.fi/handle/10024/163969).

[10] Finland is preparing an update of its 2014 Bioeconomy Strategy. The update will build upon the 2018 EU Bioeconomy Strategy and the Council conclusions (https://valtioneuvosto.fi/en/-/1410877/updated-finnish-bioeconomy-strategy-aims-to-promote-sustainable-growth-and-climate-objectives).

[11] France is preparing a future Bioeconomy Action Plan 2021-2022 to update the former Action Plan 2018-2020 (https://www.franceagrimer.fr/Actualite/Etablissement/2020/Commission-Thematique-Interfilieres-Bioeconomie-du-3-decembre-2020). Furthermore, a public consultation for a specific strategy to accelerate bio-based products and sustainable fuels has taken place in Q1 2021 (https://agriculture.gouv.fr/consultation-publique-sur-la-strategie-dacceleration-produits-biosources-et-carburants-durables).

actions focus on measures to promote the implementation of principles for cascading use of biomass, circularity, and resource efficiency, investments in bioeconomy research, innovation and market development, actions to integrate bioeconomy concepts or priorities within existing regulatory frameworks, actions to facilitate intra-governmental and stakeholder collaboration, to promote public procurement of bio-based products, national labels and standards, and actions that enhance knowledge and promote bioeconomy education or training.

Bioeconomy Strategies of Member States / Focus		AT	DE	ES	FR	FI	IE	IT	LV	NL	PT
Sectors covered	Agriculture	●	●	●	●	●	●	●	●	●	●
	Forestry	●	●	●	●	●	●	●	●	●	●
	Fisheries		●	●	●	●	●	●	●	●	●
	Aquaculture	●	●	●	●	●	●	●	●	●	●
	Organic waste	●	●	●	●	●	●	●	●	●	●
	Food	●	●	●	●	●	●	●	●	●	
	Wood, wood products & furniture	●	●	●	●	●	●	●	●	●	●
	Pulp & paper	●	●	●	●	●	●	●	●	●	●
	Biotechnology	●	●	●	●	●	●	●	●	●	●
	Bio-based textiles	●	●	●	●	●	●	●	●	●	●
	Bio-based chemicals and materials	●	●	●	●	●	●	●	●	●	●
	Bioenergy (incl. transport biofuels, bioelectricity and H&C)	●	●	●	●	●	●	●	●	●	
	Ecosystem services	●	●	●	●	●	●	●	●	●	●
	Other specific sectors	●	●			●	●	●	●		●
Policy actions	Embed the bioeconomy into new legislative frameworks				●			●			
	Revisit existing regulatory frameworks to include bioeconomy concepts/priorities	●	●		●	●	●	●	●	●	●
	Promote the establishment of intra-governmental groups to support policy coherence or collaboration amongst different bioeconomy stakeholders	●	●	●	●	●	●	●	●		●
	Promote labels and standards for bio-based products	●	●	●	●	●	●	●	●		●
	Promote public procurement of bio-based products	●	●	●	●	●	●	●	●		●
	Enhance land management for new production systems and ecosystem functions	●	●			●		●	●		●
	Promote specific bioeconomy sectors	●	●		●	●		●	●		●
	Promote the principles of "cascading use", "circularity" and "resource efficiency" for biomass	●	●	●	●	●	●	●	●	●	●
	Enhance the knowledge on bioeconomy by setting-up knowledge hubs, observatories, information systems, web portals, conferences, etc.			●	●	●	●	●			●
	Implement specific studies (feasibility, impact assessments, land use, territorial development analyses, market analyses, foresight studies etc).	●	●	●	●	●	●	●	●		●
	Develop monitoring systems for the bioeconomy		●			●	●	●		●	●
	Promote communication campaigns for awareness raising (e.g. bioeconomy awards, information systems, events, etc.)	●	●	●	●	●	●	●	●	●	●
	Promote educational/training programmes	●	●	●	●	●	●	●	●		●
	Promote investments in bioeconomy research, innovation, market development	●	●	●	●	●	●	●	●	●	●
	Market incentives for bio-based production/consumption (e.g. subsidies, taxes)	●	●		●	●		●	●	●	

SWD Table 1. Overview of sectors and actions in Bioeconomy Strategies of Member States (source: JRC (2021). European Commission's Knowledge Centre for Bioeconomy) https://knowledge4policy.ec.europa.eu/bioeconomy).[12]

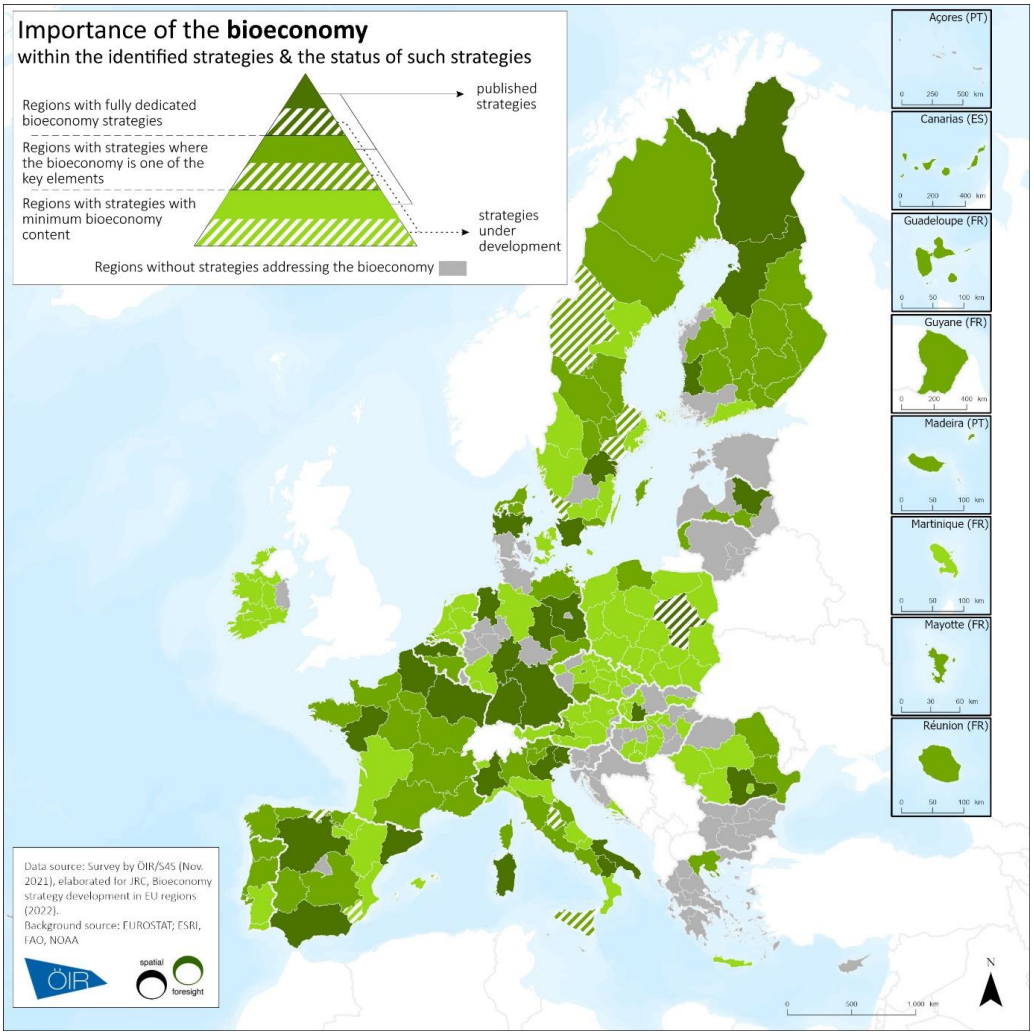
Other Member States opted to integrate the bioeconomy in sector-specific or cross-cutting policies, e.g. Bulgaria is currently developing a Strategy for "Strengthening the Role of the Agricultural Sector in the Bioeconomy" and the "National Strategy for Transition to a Circular Economy". Estonia is preparing a

[12] The mapping is indicative of the main focus areas of Bioeconomy Strategies of Member States. It is based on identification and classification of individual actions stated in the national bioeconomy strategies and action plans, according to broader groups of policy actions.

national policy framework document on the bioeconomy, which is planned to be adopted by the Government at the beginning of 2022. In Hungary and Lithuania, work towards a dedicated bioeconomy strategy, launched before the 2018 European Bioeconomy Strategy, has not yet been concluded.

At regional level, 28 regions in EU-27 (NUTS-1, NUTS-2, or NUTS-3) have in place their own dedicated bioeconomy strategies and another region is in the process of developing one whereas 62 other regions have adopted strategies within which the bioeconomy is one of the key elements and 7 regions are in the process of doing so. Furthermore, 94 other EU regions have strategies with a minimum bioeconomy content with 2 more regions developing such strategy. Sector-specific regional strategies that guide the management of specific biological resources and/or bioeconomy sectors as well as broader, overarching and cross-cutting strategies (on e.g. circular economy, research and innovation, etc.) also exist and support the deployment of regional bioeconomies[13].

[13] JRC (2022), https://publications.jrc.ec.europa.eu/repository/handle/JRC128740

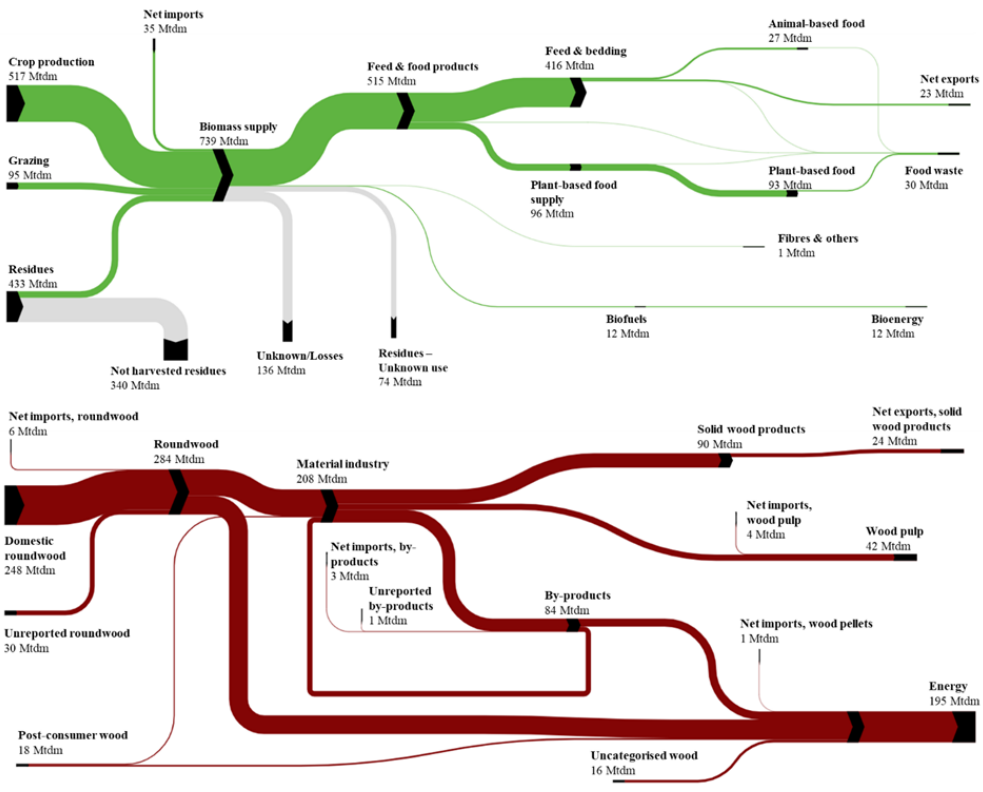


SWD Figure 1. EU regions (NUTS-1, NUTS-2 or NUT-3 scale) with strategies and other policy initiatives on the bioeconomy according to the role the bioeconomy plays (fully dedicated to the bioeconomy / strong bioeconomy focus / minimum bioeconomy content) and the status (published / under elaboration). Source: JRC (2022). https://publications.jrc.ec.europa.eu/repository/handle/JRC128740

2.2 *Supply, transformation and use of biomass*

The EU-27 total supply of biomass was 1.066 million tonnes of dry matter (Mtdm) in 2017. About 70% of this biomass is of agricultural origin. Most of the agricultural biomass is sourced domestically, with crop production being the main source of collected biomass. The crop residues harvested for further use represent only about a fifth of the residues produced. The rest of the residues remain in the fields, contributing to soil fertility, biodiversity and other ecosystem services, or are utilised on site. Most of the harvested agricultural biomass is used for food production, of which the largest share is destined for production of animal-based food. It is also important to note that, while food waste is not very significant in the production, processing and distribution stages of the food chain, almost 18% of the biomass destined for food consumption (in dry matter) is wasted.

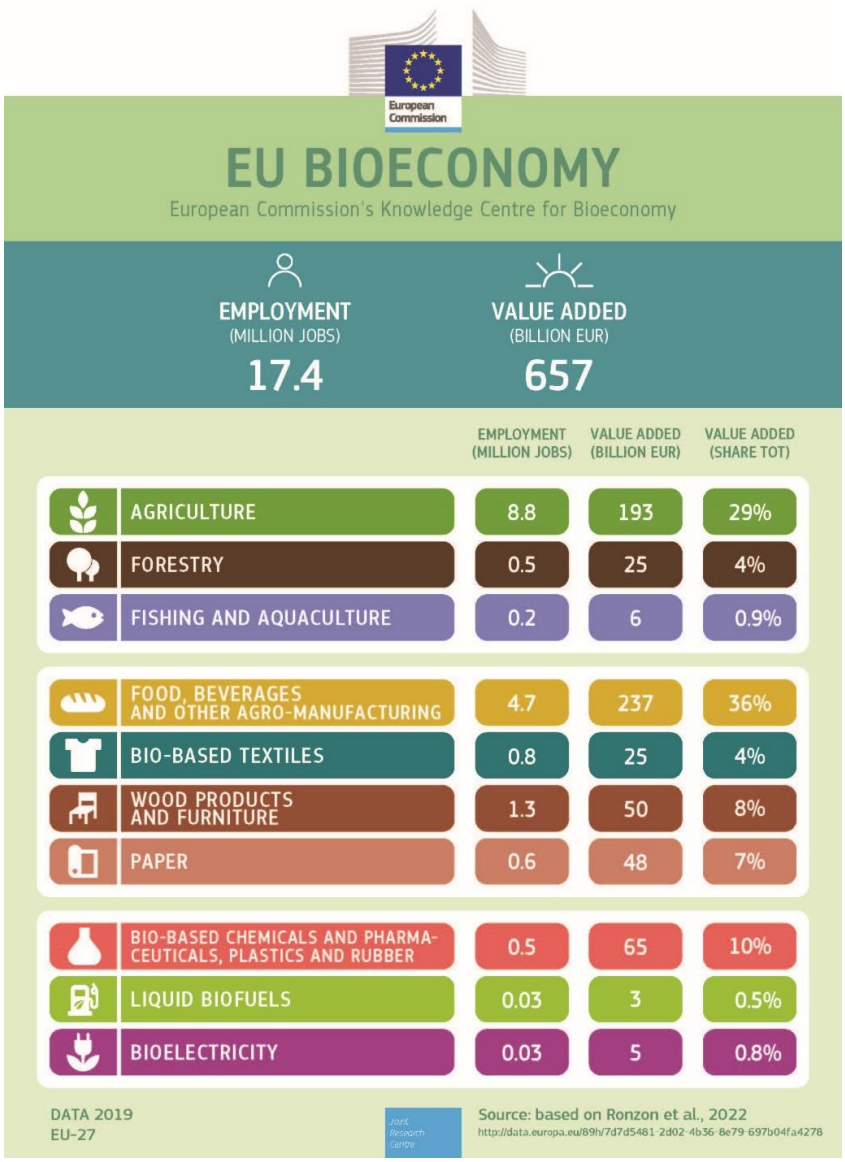
Forestry is the second largest biomass source in the EU-27, most of it in the form of domestic roundwood. Circular flows reflect the importance of the cascading use of woody biomass, with by-products of the material industry or recycled wood being reused by the material industry again or used in energy production. As a final destination in the cascading use of wood, energy production constitutes the main destination of woody biomass.



SWD Figure 2. EU Biomass flows from agriculture (top) and forestry (bottom). 2017 data, net trade. Source: JRC (2022). https://datam.jrc.ec.europa.eu/datam/mashup/BIOMASS_FLOWS/index.html

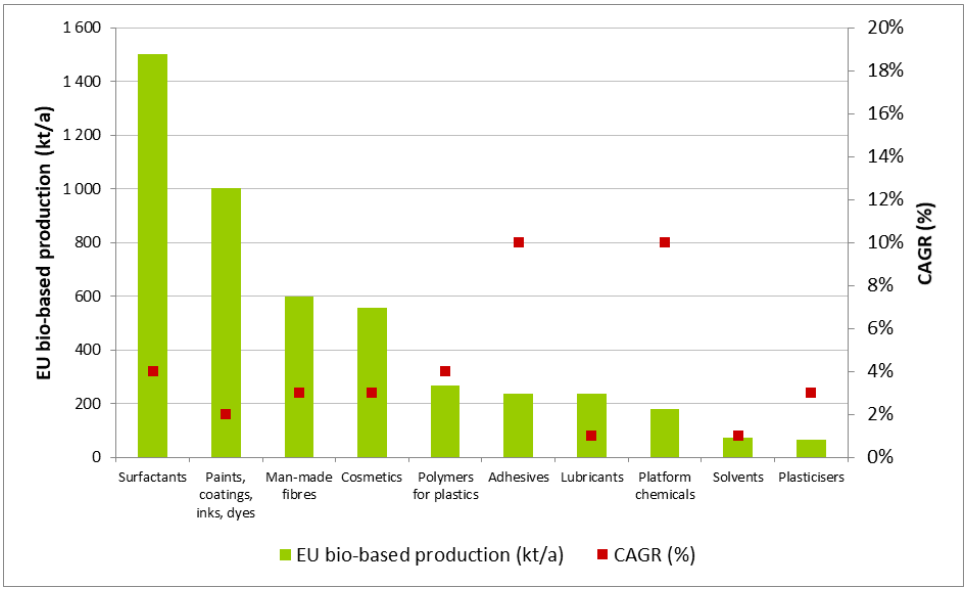
2.3 Jobs and value added in bioeconomy sectors

The biomass production and biomass conversion into food, beverage, manufactured bio-based products and liquid biofuels and bioelectricity employs 17.42 million workers and generates EUR 657 billion value added in the EU's post-Brexit sectorial composition in 2019 (Figure 3). These sectors of the bioeconomy therefore concentrate 8.3% of the European labour force and provide 4.7% of its GDP. Agriculture and the manufacture of food, beverage and tobacco provide 65% of the total value added generated by the sectors aforementioned. The manufacturing of bio-based products refers here to tobacco products, bio-based textiles, bio-based wearing apparels, leather, paper and wooden products, and bio-based chemicals, pharmaceuticals, plastics and rubber.



SWD Figure 3. Employment and value added generated in the biomass producing and manufacturing sectors in the EU-27

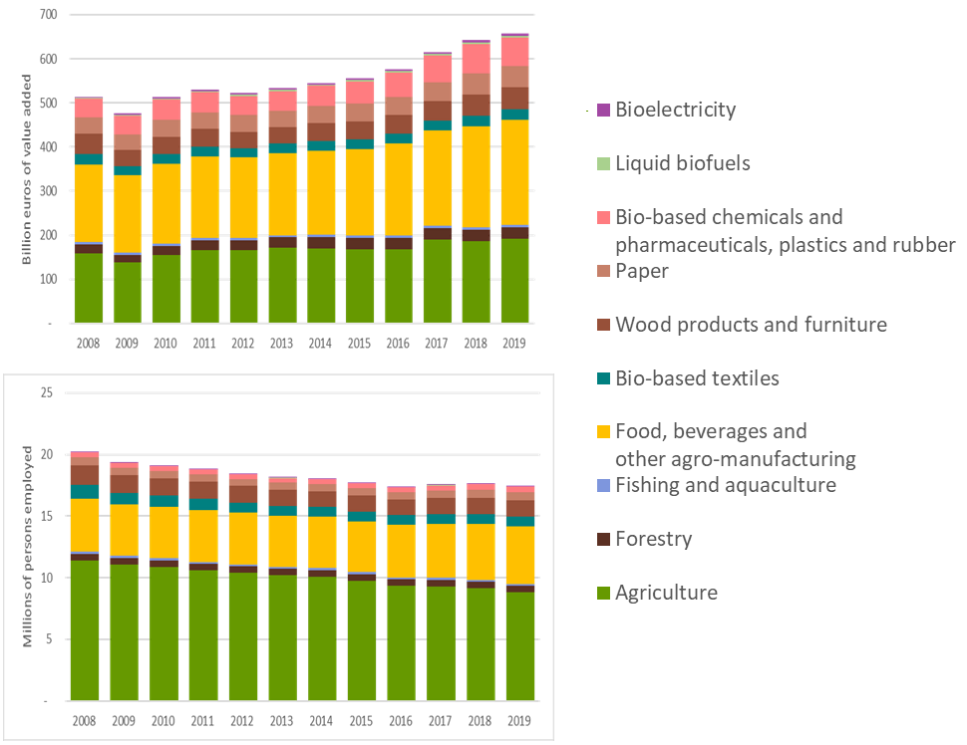
The bio-based chemical market is relatively small, with the average share of bio-based chemical products in the overall chemical market being 3.0%. Therefore, there is a significant potential for growth. Among bio-based chemical categories, platform chemicals and adhesives show the highest potential for growth with an expected CAGR of 10% by 2025 (Figure 4). Polymers for plastics and surfactants also show promising development with an expected CAGR of 4%.



SWD Figure 4. EU bio-based chemical production by chemical category in 2018 and associated expected annual growth rate by 2025.
Source: JRC (2021). https://publications.jrc.ec.europa.eu/repository/handle/JRC112989)

Note: CAGR stands for Compound Annual Growth Rate

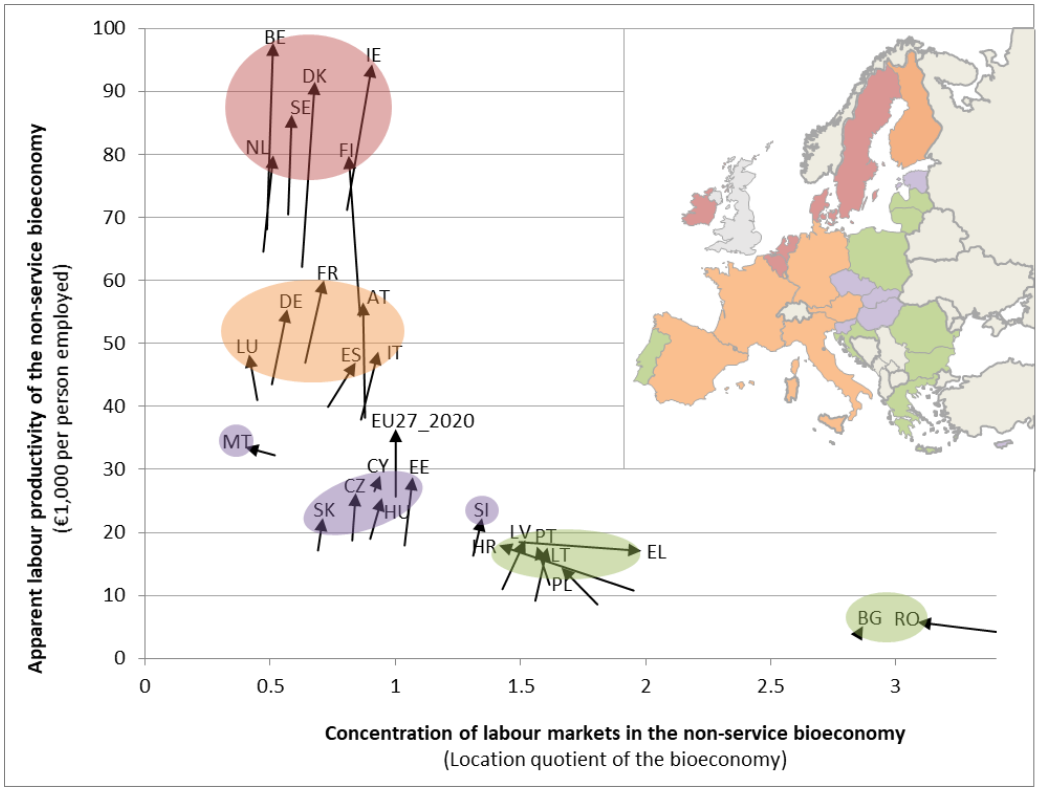
The role of bioeconomy sectors in generating economic wealth has improved in the past decade in the EU-27. The overall value added of biomass producing and processing sectors has indeed increased by EUR 143 million between 2008 and 2019 (Figure 5, top chart). The biggest increases occurred in the manufacturing of food, beverage and tobacco (+62 million euros), agriculture (+34 million euros), the manufacturing of bio-based chemicals, bio-based pharmaceuticals and bio-based plastics (+21 million euros) and the manufacture of paper (+11 million euros). However, the manufacture of liquid biofuels and of bio-electricity were the most dynamic sectors with a growth of 129% and 100% respectively over the period. On the other hand, an overall reduction in the number of workers employed in biomass producing and processing sectors is observed (Figure 5, bottom chart). This decline is driven by the reduction of the employment in agriculture. Interestingly, all sectors represented experienced an improvement in their level of labour productivity, expressed in terms of value added per person employed.



SWD Figure 5. Value added (top chart) and employment (bottom chart). 2019 data for EU-27. Source: JRC (2022). https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html

During the period 2008-2019, the labour productivity of the (non-service) bioeconomy sectors has improved in all Member States, except in Greece (vertical axis in Figure 6). The highest improvements are observed in Northern and Western European Member States circled in red and orange in Figure 6.

Eastern Member States tend to employ more people in biomass production sectors than other EU Member States. Baltic and Central Member States have diversified their bioeconomy, but the proportion of workers in low productive sectors was higher than in Northern and Western Member States. The latter showed a more diversified bioeconomy into high labour-productive manufacturing sectors.

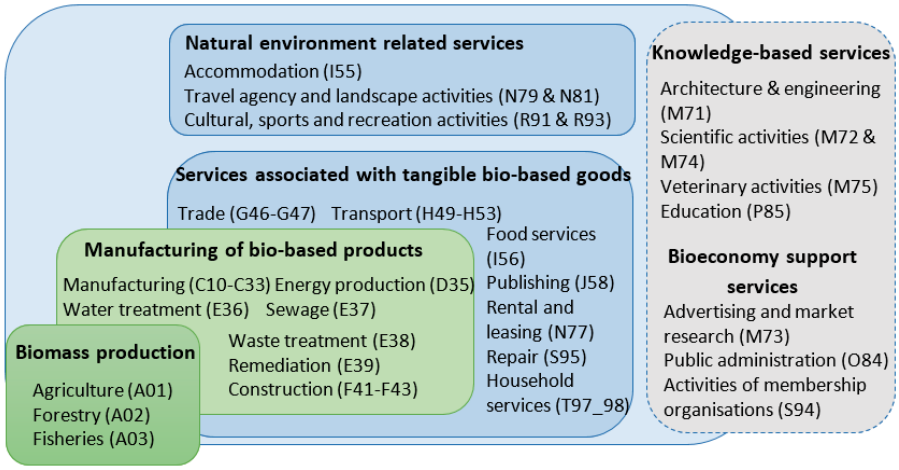


Note: The coloured circles indicate four groups of Member States: (i) Green group: Eastern Member States, Portugal, and Greece characterized by a labour market highly specialised in the non-service bioeconomy (1.5 ≤ location quotient) and a below-average apparent labour productivity of the non-service bioeconomy (≤ half the EU27 labour productivity); (ii) Purple group: Estonia and Central Member States, less specialised in the non-service bioeconomy, but more labour productive (location quotient ≤ 1.4; labour productivity between half the EU's and the EU's); (iii) Orange group: Western Member States with exacerbated characteristics compared to the purple group (location quotient ≤ 0.9; labour productivity above the EU's), (iv) Red group: Northern Member States with even higher labour productivity (location quotient ≤ 0.9; labour productivity above twice the EU's). The 27 EU Member States are referred to by their two-letter code: Austria (AT), Belgium (BE), Bulgaria (BG), Croatia (HR), Cyprus (CY), Czechia (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (EL), Hungary (HU), Ireland (IE), Italy (IT), Latvia (LV), Lithuania (LT), Luxembourg (LU), Malta (MT), Netherlands (NL), Poland (PL), Portugal (PT), Romania (RO), Slovakia (SK), Slovenia (SI), Spain (ES), and Sweden (SE).

SWD Figure 6. Bioeconomy patterns across EU-27 Member States in 2008–2010 and 2017–2019. Source: updated from Ronzon et al. (2020). Sustainability. https://doi.org/10.3390/su12114507)

The scope of service sectors considered in the bioeconomy varies considerably between Member States. Ronzon et al. (2022) point to four broad categories of bio-based services (Figure 7). Bioeconomy services associated with tangible bio-based goods include trade, transport, rental and leasing and repairing of bio-based products, as well as food services, publishing activities and some household services. Natural environment-related services of the bioeconomy do not relate with a tangible good but they are associated with the natural environment. They cover nature and rural tourism through the activities of rural accommodation, travel agencies, landscape service and cultural, (outdoor)

sports and recreation activities. Knowledge-based services in the field of the Bioeconomy refer to the production and application of knowledge in life sciences and bio-based processes. They are provided by the activities of bio-based architecture, technical consultancy, scientific activities, veterinary activities and education. Finally, some service activities support the development of bio-based market, e.g. advertising and market research, public administration and membership organisations.



Note: Service activities (NACE divisions G to T) are represented within the large light-blue frame. As a further distinction, the dark blue frames indicate the service activities that are based on the use of biological resources or on the services provided by land and marine ecosystems (in the wording of the European Commission (2018)). The grey frame indicates other bioeconomy-related services. Non-service bioeconomy activities are represented within green frames.

SWD Figure 7. Categorisation of the bioeconomy activities within the NACE classification. Source: Ronzon et al. (2022). Structural Change and Economic Dynamics. https://doi.org/10.1016/j.strueco.2021.10.005)

2.4 Innovation and the bio-based industry

With regard to the substitution of fossil-based by bio-based products in chemical applications (Nace C20), it should be noted that information is still limited. The H2020 BioMonitor project made a first assessment (forthcoming), with highest substitution rates shown in bio-based solvents, bio-based polymers, bio-based packaging, biofuels and agrochemicals.[14]

The following figure summarises for representative chemicals, plastics, and pharmaceuticals the bio-based production in ktonnes/year and share in total production for different world regions. It depicts as well the prices for bio-based compared with that of the fossil industries resulting in the cost disadvantage/advantage ratio. The key difference is the higher cost shares in feedstock, particularly in the plastics sector and for the use of vegetable oil, where the feedstock costs increase. This can be explained by the higher price of vegetable oil compared to sugar or starch. It should be noted that bio-based cost shares are based on the bio-based products which have successfully reached large-scale production. These results are therefore biased towards bio-based products which can compete with their fossil-based counterparts. The cost shares of all bio-based products, regardless of their successes in large-scale production, would better reveal where the hurdles are for the large-scale production of innovative bio-based products.

[14] BioMonitor consortium (2022, forthcoming). Future market outlooks for new bio-based commodities. Deliverable 5.2. BioMonitor project.

Industrial sector	Chemicals			Plastics		Pharmaceuticals	
Intermediary chemical	**Acetic acid**	**Propylene glycol**	**Succinic acid**	**PET**	**PUR**	**Lactic acid**	**Levulinic acid**
Drop in or dedicated	drop-in	drop-in	drop-in	drop-in	drop-in	dedicated	dedicated
Total (fossil & bio-based) production	16546	2520	50	24059	22334	769	6
Bio-based production ktonnes/year	346	424	10	559	7.5	769	6
- Europe	72	28	10	0	0	149	3
- North America	34	196	0	0	7.5	245	0
- Asia	240	200	0	161	0	375	3
- Rest of the world	0	0	0	0	0	0	0
Bio-based share in total production	2.1%	17%	20%	2.3%	0.03%	100%	100%
- Europe	0.4%	1%	20%	0	0	19%	50%
- North America	0.2%	8%	0	0	100%	32%	0%
- Asia	1.5%	8%	0	100%	0	49%	50%
- Rest of the world	0	0	0	0	0	0%	0%
Price bio-based €/kg	0.94	1.34	2.61	1.13	2.04	1.17	4.50
Price fossil-based €/kg	0.56	1.34	2.25	1.05	1.76	1.75	N/A
Cost disadvantage (-) /advantage (+) ratio	-66.70%	0%	- 16%	-7%	-16%	+ 33%	N/A

SWD Table 2. Summary of production and cost data collected per value chain (ktonnes/year). Source: JRC (2021). https://publications.jrc.ec.europa.eu/repository/handle/JRC124141

2.5 Ecosystems

Ensuring that ecosystems achieve or maintain a healthy state or a good condition is a key prerequisite of a sustainable bioeconomy, as we depend on them for biological resources but also for biodiversity, clean air, clean water, climate regulation and other services.

The recent EU ecosystem assessment shows that, despite substantial benefits delivered by EU environment and climate policies over recent years, Europe's terrestrial and marine ecosystems are suffering from intense pressures caused by intensive land or sea use, climate change, pollution, overexploitation and invasive alien species.

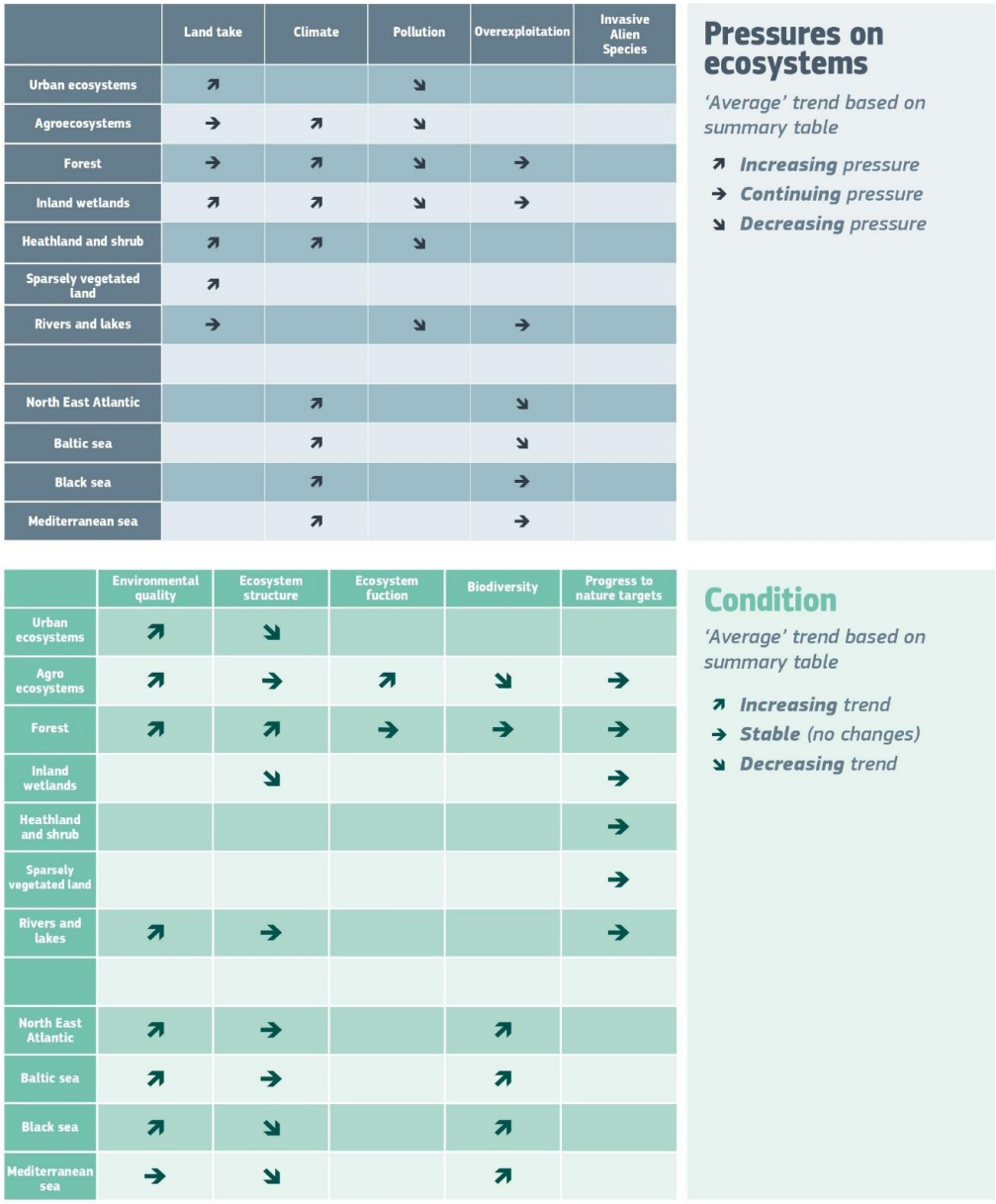
The EU ecosystem assessment is based on a single, comparable methodology using European data on trends of pressures and condition relative to the policy baseline 2010. The assessment integrates the information from 132 pressure and condition indicators for which trend data are available at EU scale.

The following main conclusions are drawn (see summary in Figure 8): Pressures on ecosystems exhibit different trends. Land take, or the sealing of soil by impervious substrates, is increasing. The adverse impacts of climate change on ecosystems are increasing. Atmospheric emissions of air pollutants and critical loads of nitrogen are decreasing but the absolute values of all these pressures remain too high. Although no trends could be established, invasive alien species of union concern are observed in all ecosystems, but their impact is particularly high in urban ecosystems and grasslands. Pressures from overfishing activities and marine pollution are still high. In the long term, air and freshwater quality is improving. In forests and agroecosystems, which represent over 80% of the EU territory, there are improvements in structural condition indicators (biomass, deadwood, area under organic farming) relative to the baseline year 2010 but some key bio-indicators such as tree-crown defoliation continue to increase. This indicates that ecosystem condition is not improving. Biodiversity-related indicators show no progress or further declines, particularly in agroecosystems.

The analysis of trends in ecosystem services concluded that the current potential of ecosystems to deliver timber, protection against floods, crop pollination, and nature based recreation is equal to or lower than the baseline values for 2010. At the same time, the demand for these services has significantly increased. A lowered potential in combination with a higher demand creates risks of further eroding the condition of ecosystems and their contribution to human well-being[15].

The report concludes that more efforts are needed to bend the curve of biodiversity loss and ecosystem degradation and to put ecosystems on a recovery path.

[15] JRC (2021), https://publications.jrc.ec.europa.eu/repository/handle/JRC123783



SWD Figure 8. Summary of trends in pressures and condition of ecosystems. The trends are based on changes, relative to the baseline year 2010, in a set of indicators. They are calculated as percentage change per decade (10 years): changes higher than, or equal to +5% or lower than or equal to -5% per decade are shown as upward (increasing) and downward (decreasing) pressures/trends, depending on the sign and the interpretation of the indicator; changes within the interval of -5% and +5% per decade are shown as stable trends (no changes). Source: JRC (2021). https://publications.jrc.ec.europa.eu/repository/handle/JRC123783)

3 The Bioeconomy Monitoring Framework

The EU Bioeconomy Monitoring System is structured hierarchically to ensure coverage of the Strategy Objectives. These broad objectives are broken down into normative criteria, which are further broken down into key components, as described in JRC (2020)[16]. This nested structure allows for the aggregation of the indicators to the different levels of the hierarchy (Figure 9).

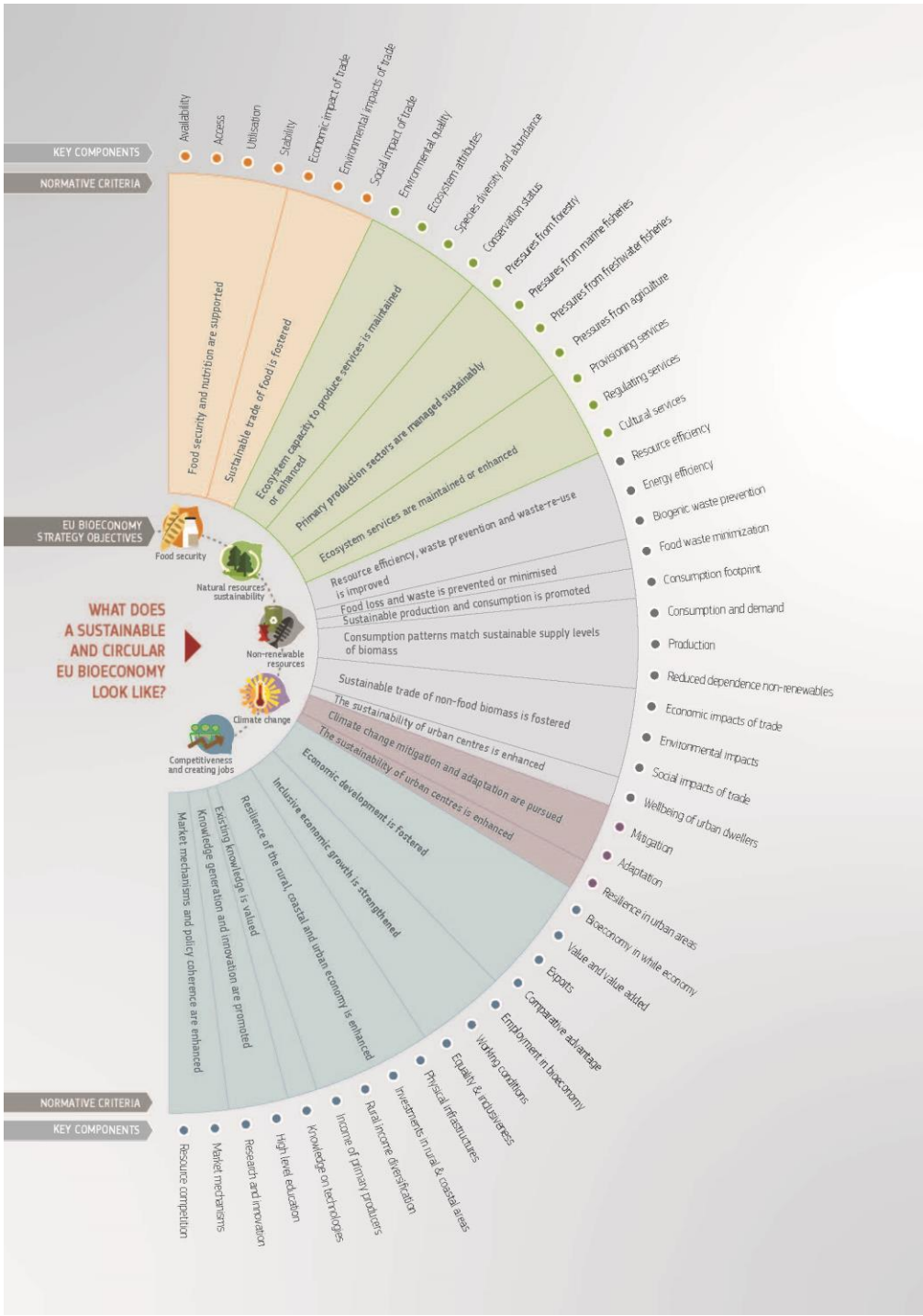
The assessment that was made in Section 4 of the main document is based on the indicators that are currently available in the EU Bioeconomy Monitoring System (detailed in JRC(2021)[17]).

Bioeconomy is a broad concept. As such, the EU Bioeconomy Monitoring System's aim is to monitor the EU performance towards achieving its objectives. The indicators that were selected to be presented within the nested system have a particular meaning based on where they are located within the framework. The individual indicators do not say much about bioeconomy until they are localised within the framework: A generic indicator on the amount of biomass used in the EU is not a meaningful indicator unless put into the framework, for instance under Ensuring Food and Nutrition Security (objective) -> Food security and nutrition are supported (normative criteria) -> Food availability (key component) -> Total biomass supply for food purposes, including inputs (indicator).

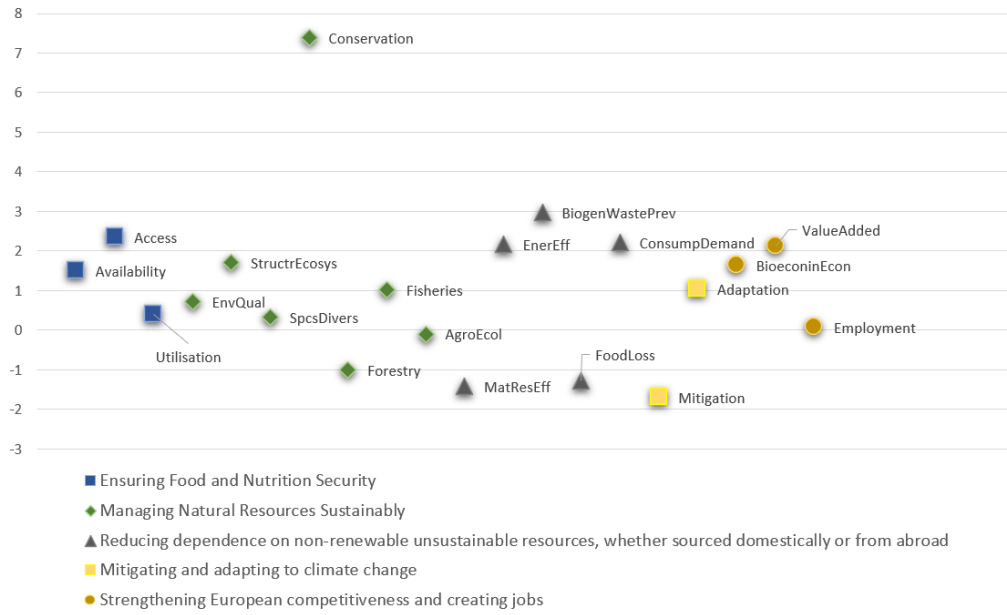
It is not possible to attribute a causal link between the EU Bioeconomy Strategy and the EU performance in the different indicators. In the example of biomass use for food and feed, the indicator is impacted by different policies, climate, weather, trade, consumer behaviour etc. However, we can say that if this and other indicators in the same group increase, food availability in Europe is improving hence the EU is moving in the right direction.

With the purpose of the monitoring system in mind, we assess the trend of the indicators within the EU Bioeconomy Monitoring System. The trends can be read and interpreted at indicator level, or at any aggregate level. For the purposes of this review, the most appropriate level of aggregation is the key component level because it combines the very specific measures of the indicators (e.g. employment in specific bioeconomy sectors, or levels of a single pollutant in rivers) to a more comprehensive level that can be recognised and understood as a family of indicators (e.g. employment in all bioeconomy sectors or environmental quality). When aggregated at this key component level, it is apparent that some key components are showing increasing trends towards the Strategy Objectives while others are showing the opposite effect (Figure 10).

[16] https://publications.jrc.ec.europa.eu/repository/handle/JRC119056
[17] JRC (2021), https://publications.jrc.ec.europa.eu/repository/handle/JRC123675



SWD Figure 9. Nested structure of the EU Bioeconomy Monitoring System.



SWD Figure 10. Summary of trend analysis of the key components contributing to a sustainable and circular bioeconomy. Long names of key components are: Food availability, Food accessibility, Food utilisation, Environmental quality, Species Diversity, Structural and functional ecosystem attributes, Conservation status of habitats and species, Pressures from forests, Pressures from fisheries, Pressures from agroecosystems, Material Resource efficiency, Biogenic waste prevention, re-use, recycling, and recovery Biogenic waste prevention, re-use, recycling, and recovery, Food loss and waste minimization, Consumption and demand for biomass and bio-based products, Climate change mitigation, Climate change adaptation, Contribution of bioeconomy to economic development, Value of raw and processed biomass, value added in bioeconomy sectors, Employment in bioeconomy.

The approach used for this assessment is based on the methods presented by Eurostat in its 2021 assessment of the SDGs. The Compound Annual Growth Rate (CAGR) is computed for a selected period, in this case 2012-2017. In the bioeconomy framework, the directionality of the indicator is critical. Some indicators, when showing a positive trend, are actually saying that a move in the wrong direction with respect to the Strategy Objectives is taking place (e.g. food waste) while others are saying the opposite with their positive trends (e.g. food waste recovery).

The conceptual framework of the EU Bioeconomy Monitoring System foresees a total of 49 key components (see Figure 9). Here we present only 20. The reasons many are not shown are due to the gaps in the indicators. Details are described in JRC 2021[18].

[18] Kilsedar, C., Girardi, I., Gerlach, H. and Mubareka, S., Implementation of the EU Bioeconomy Monitoring System dashboards, Publications Office of the European Union, Luxembourg, ISBN 978-92-76-46204-0 (online), doi:10.2760/691217 (online), JRC127762.

4 Bioeconomy in the context of the European Green Deal

Table 1 of the Bioeconomy Strategy Progress Report provides an assessment of EU Green Deal initiatives in relation to bioeconomy sustainability objectives. The table shows how the European Green Deal initiatives focus on ('dark green') or support ('medium green') the sustainability objectives of the EU Bioeconomy Strategy), though the assessment does not prejudge the actual impact that the initiatives will have. In some cases, links between the European Green Deal initiative and the objective of the Bioeconomy Strategy are only implicit and the initiative does not address or support them directly (pale green), for example as a consequence of economic or behavioural feedback effects, or increased demand of land or resources. In such cases, specific attention is required to maintain overall coherence possibly looking for solutions in the wider bioeconomy.

The initiatives were assessed on the basis of concrete targets, their objectives, and actions. Only concrete targets and a strong focus on a sustainability dimension lead to the assessment of 'alignment'. Specific attention was identified e.g. if an initiative requires resources (such as land) but the implications of this additional demand are not discussed. Table 3 provides additional supporting information.

SWD Table 3. Assessment of EU Green Deal initiatives in relation to bioeconomy sustainability objectives. The table shows how the European Green Deal initiatives focus on ('dark green') or support ('medium green') the sustainability objectives of the EU Bioeconomy Strategy or if specific attention is required to maintain overall coherence ('pale green').

		Ensuring Food and Nutrition Security	**Managing Natural Resources Sustainably**	**Reducing dependence on non-renewable unsustainable resources, whether sourced domestically or from abroad**	**Mitigating and adapting to climate change**	**Strengthening European competitiveness and creating jobs**
Circular Economy	[1]		Reduced waste reduces pressures on the environment; precautions for chemicals of concern taken	Very strong focus on waste reduction and consumer empowerment	No explicit mention, but reduced consumption 'throughflow' implicitly contributes to climate mitigation.	Some support to the economic transformation; international engagement.
Industry Strategy	[2]		Link to circular economy action plan. Circular electronics initiative.	Action plan on critical raw materials; sustainable textile and chemical strategies	Comprehensive strategies to contribute to the climate targets: clean steel and other energy-intensive industries; renovation wave; offshore renewable energy. Carbon Border Adjustment. Just Transition Platform to support regions facing challenges.	Focus on green growth, including international and trade policies and working conditions

Biodiversity Strategy	[3]	Exclusion of land and sea area from production and/or extensification can lead to conflicts with food production.	Targets on land and sea protection, pollution by pesticides and nutrients, high ambitions in protecting natural and managed ecosystems, including agriculture, forestry, marine and freshwater ecosystems.	Focus on international cooperation and consumption-oriented actions, such as the legislation on 'placing of products associated with deforestation or forest degradation', global/international engagement including equity aspects.	Synergies between biodiversity and climate mitigation and adaptation likely but trade-offs possible e.g. through additional land demand.	Sustainable finance, biodiversity business models. Exclusion of land and sea area from production and/or extensification can lead to conflicts with businesses.
Farm to Fork Strategy	[4]	Broad range of actions to increase nutrition, including through the CAP, fighting non-communicable diseases, though no quantitative targets and mainly 'soft' actions planned. Focus on food safety with target to reduce antimicrobials.	Strong focus on sustainable production with targets on pesticides, nutrients, and organic farming practices; additional actions planned to improved sustainability monitoring.	Resource efficiency addressed focusing on reduction of retail and consumer food waste; overall consumption sustainability addressed by informative policies.	Planned activity on carbon farming will contribute to climate mitigation; organic farming can increase resilience, but no target on agricultural GHG emissions or adaptation.	Individual actions to protect primary producers and protect them with respect to other food chain actors and to fight food fraud
Renovation Wave	[5]	Additional demand for bio-based materials.	Additional demand for bio-based materials.	Integration of resource efficiency and sustainability principles, considering the life-cycle and resilience of buildings.	Contribution to climate target in the building sector.	Focus on affordability; fight against energy poverty; various financial instruments used to leverage uptake.

European Climate Law	[6]				Target on GHG emissions reductions by 2030 and climate neutrality by 2050.	
Chemicals Strategy for Sustainability	[7]		increasing sustainability of chemicals through a 'safe and sustainable by design' initiative	Protect consumers against harmful substances, minimise substances of concern thus facilitating circularity; advanced materials; address dependencies for strategic value chains.	low carbon production processes	access to risk finance; improve chemicals governance
Adaptation Strategy	[8]	Not mentioned - adaptation measures might impact FNS	Nature based solutions and systemic approaches are promoted but without concrete measures; specific measures on water use.	No consumption based action that reduces dependency.	Actions focus strongly on 'preparedness; and in the improvement of knowledge, monitoring & modelling of impact, capacity building and cooperation. No target or concrete measure.	Capacity building and financial instruments are included

Sustainable Financing	[9]	Food and nutrition security, indirect effect on land demand not addressed.	Sustainable taxonomy includes as environmental objective production including the sustainable use and protection of water and marine resources, the protection and restoration of biodiversity and ecosystems through sustainable management, and pollution prevention and control.	Sustainable taxonomy includes as environmental objective the transition to a circular economy; methodology based on life cycle approach; global cooperation considered; indirect effects not addressed.	Sustainable Taxonomy strong focus on climate mitigation and adaptation; improving access to green financing; climate neutral digital technologies.	Sustainable financing including social investment as important enabler of green and just growth.
Zero Pollution Action Plan	[10]		Improve quality of air, water, soil, as well as fighting loss of terrestrial and marine biodiversity loss.	Reducing waste; promoting zero pollution consumption pattern; reducing health inequalities.	Contributing to ecosystem health increasing resilience	
LULUCF	[11]		Reporting requirements for biodiversity-rich land to promote synergies between carbon management and management of natural resources		Climate mitigation target for the LULUCF sector.	

Renewable Energy	[12]	Potential land demand of renewable energy; limits set for energy from food and feed crops as well as fuels potentially associated with indirect land use change.	Additional land demand; strong safeguards introduced, such as the cascading principle and no-go areas, as well as lowing the threshold for installations	Reduction of dependence on fossil energy; possible new material demand for renewable energy technologies.	Share of renewables in the EU energy mix to 40% by 2030; enhanced sustainability criteria of bioenergy incl. GHG saving thresholds.	Creates jobs in the renewable energy sector; improves competitiveness; additional requirements could increase burden on businesses; challenges in fossil sectors.
Forest Strategy	[13]		Protecting, restoring and enlarging forests to strengthen their multi-functionality and resilience	Optimise wood use within sustainable limits in line with the cascading principle and the circular economy approach.	Climate benefit through LCA; carbon farming initiative.	Promote non-wood forest-based employment opportunities and capacity building for sustainable forest management Additional requirements could increase burden on businesses.
Sustainable Carbon Cycles	[14]	Additional land needs through extensification and material demand; integrated bioeconomy land use assessments to avoid adverse effects.	Co-benefits of carbon farming practices.	Substitution of fossil based products.	Contribution to climate mitigation through ecosystem carbon sequestration and storage of carbon in products.	New markets and industry investments

[1] COM(2020) 98. A new Circular Economy Action Plan. For a cleaner and more competitive Europe. **[2] COM(2020) 102**. A New Industrial Strategy for Europe. And COM(2021)350 final. Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery. **[3] COM(2020) 380**. EU Biodiversity Strategy for 2030. Bringing nature back into our lives. Targets include protection 30% of the land and sea area, stricIty protection of 10% of land and sea area; reverse decline of pollinators; 50% reduction in the number of Red List species threatened by invasive alien species; significantly reduce by-catch of species; three billion new trees are planted in the EU; aligned to targets of the farm to fork strategy. **[4] COM(2020) 381**. A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system. Targets by 2030 include 50% reduction of pesticides, hazardous chemicals, nutrient losses, and sales of antimicrobials in farming; 25% of agricultural area under organic farming. **[5] COM(2020) 662**. A Renovation Wave for Europe - greening our buildings, creating jobs, improving lives. See also **COM(2021) 802** proposal for a directive on the energy performance of buildings (recast). **[6] EU(2021) 1119**. 'European Climate Law'. Targets include by 2030 reduction of GHG emissions by 55%; achieving climate neutrality by 2050. See also Carbon Border Adjustment Mechanism COM(2021) 564 final. **[7] COM(2020) 667**. Chemicals Strategy for Sustainability - Towards a Toxic-Free Environment. **[8] COM(2021) 82**. Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change. **[9] COM(2021) 390**. Strategy for Financing the Transition to a Sustainable Economy and EU(2020) 852. Taxonomy Regulation. **[10] COM(2021) 400**. Pathway to a Healthy Planet for All - EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'. Targets by 2030 include reduce number of premature deaths by air pollution by 55% and share of people chronically disturbed by transport noise by 30%; sign. waste generation, residual municipal waste and plastic litter at sea (by 50%), microplastics released into the environment by 30%; nutrient losses and chemical pesticides' use by 50%; EU ecosystems where air pollution threatens biodiversity by 25%. **[11] COM(2021) 554**. Proposal for amendment of the LULUCF regulation. Target of -310 Mt CO2eq/yr net greenhouse gas removals in the EU-27 LULUCF sector, with individual targets by Member State. **[12] COM(2021) 557**. Amendment of EU(2018) 2001. On the promotion of the use of energy from renewable sources. Targets of amendment include increased to 40% share renewable energy, increased sustainability criteria incl. cascading principle. **[13] COM(2021) 572**. New EU Forest Strategy for 2030. **[14] COM(2021) 800**. Communication on Sustainable Carbon Cycles; including a target of 20% of the carbon used in the chemical and plastic products from sustainable non-fossil sources by 2030 and announcing an action on Integrated Land Use Assessments.

5 Detailed report on the Bioeconomy Action Plan

Split into three action areas and 14 actions, a total of 36 activities have been launched under the updated Bioeconomy Strategy from 2018. For each of these activities, the objectives, implementation, impact, and outlook will be outlined below.

The indicators, as outlined in the Action Plan of the updated Bioeconomy Strategy, generally build the framework for reporting on the progress of the implementation of the actions and activities. In some cases, those indicators had to be updated or replaced, as the original ones from 2018 were outdated and did not reflect the progress of the activity and action.

Action 1.1 - Mobilise public and private stakeholders, in research, demonstration and deployment of sustainable, inclusive and circular bio-based solutions

Activity 1.1.1 - Further engagement with public and private stakeholders under Horizon Europe

Objective

- Strengthen and scale up the EU bio-based sectors, by supporting all stages of the innovation cycle; Accelerate the substitution of fossil resources in line with the EU's commitments under the Paris Agreement as well as of other non-renewable resources
- Contribute to the Circular Economy goals; Support the renewal of the EU's industrial base through biorefinery deployment; help keep innovation within the EU.

Implementation

Implemented via the institutional **European Partnership on Circular Bio-based Europe** (CBE). On 23 February 2021, the European Commission published a proposal for a Single Basic Act establishing a number of joint undertakings under Horizon Europe, including the CBE, which entered into force on 30 November 2021 allowing the partnership to start by this date. The Strategic Innovation and Research Agenda (SIRA) of the CBE Partnership has been developed in co-creation with the private partner, Bio-based Industry Consortium, BIC, and will be adopted by the CBE Governing Board, constituted on 16 December 2021. The SRIA will provide the basis of the first Work Programme (2022) of the Partnership and is expected to be adopted by the CBE Governing Board in Q1 2022. First 2022 call CBE is expected to open by mid-2022.

Indicators

- Established partnerships, including governance structures
- CBE Strategic Research and Innovation Agenda (SIRA), developed jointly by the EC and bio-based industry (BIC), CBE annual Work programmes

Impacts by 2027-2030 include:

Environmental: Help the EU meet the climate change targets (fossil material substitution, carbon stores and sinks) and reduce long-term net emissions while preserving and restoring ecosystem services and biodiversity; Circularity:

Closed-loop production and processing of bio-based resources. Social: Revenue generation for primary producers. Additional (skilled) job opportunities in rural areas. Inclusive business models. Rural regeneration by reindustrialisation. Economic: Building productivity, competitiveness and growth in a world of resource constraints. Security of raw materials supplies by using local resources. Scale of investments in bio-refinery infrastructure and related logistics. Partnering: Leverage of investments, engagement and commitment of relevant actors.

Outlook

The Circular Bio-based Europe Partnership will draw on lessons learned from preceding public-private partnership, included in the CBE Impact Assessment, Bio-based Industry Joint Undertaking. Improved engagement with Member States and public authorities at regional and local levels, concerning bio-based innovation. Opening avenues for better synergies with the EU regional policies and their instruments (e.g. ESIF), crucial in the deployment phase both for investments in infrastructure and for tapping the biomass potential. CBE Partnership will contribute to this objective via deployment groups, including on primary biomass production.

Box on European bio-based industry initiatives
(Public-Private Partnerships BBI JU and CBE JU)

The establishment of the **Bio-based Industries Joint Undertaking** (BBI JU) is one of the main results of the 2012 EU Bioeconomy Strategy and its Action Plan[19]. BBI JU was launched in 2014[20] and was operating until 2021, with the aims to attract consistent private investment, promote R&I along whole values chains, to avoid fragmentation and duplication of efforts, and improve coordination in innovation activities of European bio-based industries. To support BBI JU. the EU, represented by the European Commission allocated EUR 975 million, to be matched by EUR 2.73 billion from the private sector represented by the **Bio-based Industries Consortium** (BIC). BIC originally included 35 bio-based companies and its membership has grown to over 250 (of which 150 associated members) entities from across different value chains[21], out of which 80% SMEs. By de-risking investments and financing projects in the bio-based industries, the BBI JU created a **positive impact** on the environment, society and economy[22], as (partialy) confirmed by its interim

[19] Commission Communication on Innovating for Sustainable Growth: A Bioeconomy for Europe" {COM(2012) 60 final], Action A10 Promote the setting up of networks with the required logistics for integrated and diversified biorefineries, demonstration and pilot plants across Europe, including the necessary logistics and supply chains for a cascading use of biomass and waste streams. Start negotiations to establish a research and innovation PPP for bio-based industries at European level (by 2013).

[20] Council Regulation (EU) 560/2014 amended by Council Regulation (EU) 2018/121 https://www.bbi-europe.eu

[21] https://biconsortium.eu/sites/biconsortium.eu/files/documents/BIC%20members%20list%20January%202020.pdf

[22] www.bbi.europa.eu/about/environmental-impact ; www.bbi.europa.eu/about/socio-economic-impact

evaluation[23]. Through its 142 projects, BBI JU has contributed to the transition towards a zero-emission, circular economy, protection of the environment, ecosystems and biodiversity by developing new bio-based products, chemicals and materials with a lower environmental impact than their fossil-based alternatives.

Based on the lessons learned from the BBI JU Partnership[24], and as one of the actions of the 2018 Bioeconomy Strategy[25], the new **Circular Bio-based Europe Joint Undertaking (CBE JU)** Partnership was launched[26] (2021-2031), with the aim to further strengthen and scale up the EU bio-based sectors, by supporting all stages of the innovation cycle. The Partnership is based on EU contribution of EUR 1 billion, coupled with, at least, the equal contribution by the private partner, the Bio-based Industry Consortium. This partnership will contribute significantly to the 2030 climate targets, paving the way for climate neutrality by 2050, and will increase the sustainability and circularity of production and consumption systems, in line with the European Green Deal. It aims to develop and expand the sustainable sourcing and conversion of biomass into bio-based products as well as to support the deployment of bio-based innovation at regional level with the active involvement of local actors and with a view to reviving rural, coastal and peripheral regions.

Jointly, **Bio-based Industries Joint Undertaking** (and its successor **Circular Bio-based Europe**) can be considered as the most ambitious research and innovation initiatives in the European bioeconomy. Through investing a combined amount of public and private funding of at least €5.7 bn in developing a sustainable and competitive bio-based industry and preparing the post-petroleum era, those Partnerships have been contributing to several objectives of the European Green Deal and UN Sustainable Development Goals.

Activity 1.1.2 - Inventory of most promising bio-based solutions suitable to operate at rural conditions

Objective

- To identify small-scale business models and their market potentials for the deployment in rural conditions.
- To increase awareness, education and understanding of the bioeconomy, its potentials and impacts.

[23] http://op.europa.eu/en/publication-detail/-/publication/eebcfc39-ae32-11e7-837e-01aa75ed71a1/language-en

[24] IMPACT ASSESSMENT REPORT Accompanying the document Proposal for a Council Regulation establishing the Joint Undertakings under Horizon Europe European Partnership for a Circular Bio-based Europe {COM(2021) 87 final} - {SEC(2021) 100 final} - {SWD(2021) 38 final]

[25] Bioeconomy Strategy Action Plan (2018): Action 1.1: Mobilise public and private stakeholders, in research, demonstration and deployment of sustainable, inclusive and circular bio-based solutions

[26] Council Regulation (EU) 2021/2085 of 19 November 2021 establishing the Joint Undertakings under Horizon Europe

- To mobilise regional stakeholders and support the development of bioeconomy strategies
- To disseminate good practices and facilitate knowledge sharing

Implementation

The two Coordination and Support Actions POWER4BIO and BE-Rural were funded under the Horizon 2020 topic, RUR-09-2018: Realising the potential of regional and local bio-based economies.
Two follow-up topics have been included in the Work Programme 2021-2022:

- HORIZON-CL6-2021-CIRCBIO-01-08: Mainstreaming inclusive small-scale bio-based solutions in European rural areas
- HORIZON-CL6-2021-GOVERNANCE-01-09: Revitalisation of European local communities with innovative bio-based business models and social innovation

Impact

- Potentials and suitable business models in rural conditions were analysed in total for 15 regions (10 regions in POWER4BIO and 5 regions in BE-rural).
- The Bioregional Strategy Accelerator Toolkit (BSAT) was made available as an open and free to access online platform for guiding decision-makers and stakeholders to develop their regional bioeconomy strategies:
- A catalogue of tested bio-based solutions, including best practice examples, to support regions in the development of sustainable bioeconomies was published.
- Numerous networking, capacity building and dissemination events with stakeholders in the pilot regions and policy makers at regional, national and EU-level

Outlook

EIP-AGRI together with Horizon Europe, including its work programmes and partnerships (in particular Circular Bio-based Europe), will further support the deployment of sustainable bioeconomies in rural settings. The Commission will continue to disseminate the outcomes to Member States and stakeholders.
To ensure a just transition in the bioeconomy, further actions will require:

- To promote strong cooperation between farmers (e.g. cooperatives) and other key bioeconomy actors in rural areas, especially regional and local authorities, and the civil society (call for strong social innovation and social engagement)
- To develop better-balanced business partnerships between primary producers and industrial partners, calling for new / fair innovation-oriented business models.

Activity 1.1.3 - Exploring ways to increase the EU financial advisory support for Research and Innovation bioeconomy projects

Objective

- Examining feasibility and expected results of a few key options for increasing the financial support for R&I Bioeconomy projects beyond EU Framework Programmes, based on available resources to EU schemes for financial advisory services e.g. European Investment Advisory Hub (EIAH) and other activities of the European Investment Bank

- For the option(s) analysed, determine what would be their expected results, as well as the enablers and obstacles to overcome to implement them.

Implementation

As recommended by the European Investment Bank's 'Access-to-finance conditions for Investments in Bio-Based Industries and the Blue Economy' report, the EIB Advisory team explored ways to increase EU financial advisory support for Research and Innovation bioeconomy projects. This included actions of the **EIB Innovation Finance Advisory**, including on Horizontal level, Financial Project Advisory level, and Financial Advisory level (EIAH). Actions to support access-to-finance conditions were supported also by EMFF. This include the BlueInvest initiative that aims at boosting innovation and investment in sustainable technologies for the blue economy, by supporting readiness and access to finance for early-stage businesses.

Impact

Significant impact noticed already confirms key importance of financial aspects for all bioeconomy (R&D) stakeholders. Examples include support to main EU R&D priorities underpinning the EU Green Deal, on thematic, EU project/programme and regional level:

- Nature-based Solutions - assessment of the access-to-finance conditions and investment needs for innovative NBS projects in urban, rural and natural settings in the EU, project ongoing.
- Plastics – 'Addressing Plastics Pollution as part of the Circular Economy Agenda' assignment is focused on analysing the plastics value chain in order to identify investment areas with the highest impact, and developing a pipeline of 50 projects.
- Mission Investment Agendas - upstream methodological guidance and specific finance-related intelligence to the EC Mission Secretariats (including the Soil, Ocean and Climate missions).
- Bioeconomy Access-to-Finance – the study resulted in the creation of the European Circular Bioeconomy Fund, which successfully raised over EUR 200m and already has 4 companies in its portfolio.
- Bio-based Joint Undertaking – umbrella agreement with the BBI JU, completed review of the organisation's portfolio of grant-funded and Synergy Label projects, resulting in 7 introductions for potential direct advisory support.
- Regional bioeconomy development (e.g. Nouvelle-Acquitaine Region (Alter'NA) – comprehensive web-based platform designed and developed to encourage farmers and agri-businesses to apply for a tailor-made bank guarantee instrument, backed by EU and national funds in support of sustainable agriculture projects offered through intermediary banks.
- Blue Economy – thanks to the BlueInvest so far 115 Companies completed the Readiness Assistance, among which 14 have secured investment.

Outlook

- Further actions of EIB to be continued, and likely to increase following the EGD deployment on the ground. A comprehensive analysis of the impacts and subsequent policy options has not been carried out yet. This could be foreseen as more comprehensive data from diverse EIB actions become available, and implemented, for instance, under the Commission's

Knowledge Centre for Bioeconomy. Such action might be recommended due to complex EU economy-wide effects, especially if any long-term effects are included in such analysis.

Activity 1.1.4 - Distributed Ledger Technologies (DLTs/blockchain) for the bioeconomy

Objective

This activity aims at exploring and harnessing the potential of Distributed Ledger Technologies (DLTs <-> blockchain) in the bioeconomy:

- facilitate data exchange and information sharing and thus improve transparency, efficiency, competitiveness, security and sustainability in various bioeconomy sectors;
- identify how DLTs could, in combination with AI, advanced sensors, Internet of Things, etc., address the challenges related to bioeconomy;
- support the development of effective blockchain solutions for the bioeconomy areas.

The food systems has been identified as a first focus area, due to the great potential of blockchain for this sector.[27]

Implementation

The following topics in Horizon Europe have been undertaken to meet the objectives:

- HORIZON-CL6-2021-FARM2FORK-01-17: Increasing the transparency of EU food systems to boost health, sustainability and safety of products, processes and diets: IA, 11.00 million - The successful project should accelerate the deployment of transparency innovations and solutions in EU food systems, especially among micro-enterprises and SMEs, and should ensure that future transparency innovations and solutions are demand-driven, systemic and cost-effective. The potential of validated technologies (blockchain, artificial intelligence, IoT, 5G/edge, 'big data') is expected to be explored.
- HORIZON-CL6-2021-FARM2FORK-01-07: Research & innovation roadmap for blockchain technologies in the agri-food sector: CSA, 3.00 million - The successful project should explore the potential of blockchain technologies in the agri-food sector, to enhance transparency and traceability in agri-food supply chains, to contribute to increase competitiveness and market power of producers, and to reduce transaction costs and administrative burdens.

Impact

The impact of the activities will be measurable once the Horizon Europe projects have concluded their work. Possible indicators for the work will include the number of European Commission initiatives related to DLT's for the bioeconomy and the amount of EUR invested in DLT research for the bioeconomy.

[27] Blockchain Now And Tomorrow: Assessing Multidimensional Impacts of Distributed Ledger Technologies, JRC Report, https://publications.jrc.ec.europa.eu/repository/handle/JRC117255

Outlook

According to the quality and completeness of the successful projects, complementary actions might have to be put into place, including a dedicated workshop or a potential complementary topic in the next Horizon Europe Work Programme.

Activity 1.1.5 – Report self-assessment tool for sustainable chemical production to support investment readiness of the EU regions

Objective

The European Union is aiming at decreasing its greenhouse gas emissions while stimulating the economic growth and increasing resource efficiency. There is a growing need of using more sustainable alternatives for fossil feedstocks. The self-assessment tool (SAT) helps a region to conduct a first assessment of the investment readiness level (IRL) in the region concerning sustainable chemical production. 'Sustainable chemical production' is the use of alternative raw materials to produce chemical products. These alternative raw materials are different from traditional fossil-based ones. This first assessment serves as a starting point for regional discussion on how to design better regional strategies.

Implementation

The SAT consists of an online questionnaire for each type of feedstock. It amounts to approximately 60 to 70 questions (around 8 per key factor). Once the questionnaire is filled in, the SAT generates a spider diagram with the marks in each of the factors. The marks range from 0 to 10. They show in which areas a region is strong and which could use improvement. These marks can be compared with those of other EU regions that have already used the tool. This will help clarify where a region stands in a European context. The SAT will also produce a document with the main conclusions and recommendations. This will help interpret the spider diagram. The tool is regularly used by EU regions and EU funded projects with a regional dimension (eg. POWER4BIO Horizon 2020 project).

Impact

The Self Assessment Tool has been developed and is hosted in two subsections of the DG GROW website:

- European Sustainable Chemicals Support Services
- Gaseous Industrial Effluents

The following three types of feedstock are considered:

- Biomass from agriculture and forestry
- Waste from farms, municipalities, sewage sludge, agri-food industry and paper & pulp industry
- Effluent gases, such as carbon dioxide (CO2), carbon monoxide (CO), nitrogen oxides (NOx), sulphur oxides (SOx), and hydrogen (H2)

Outlook

The tool can be further disseminated in the EU Member States for example through the European Bioeconomy Policy Forum or through funds supporting regional policy like the Cohesion Fund and the European Regional Development Fund.

Action 1.2 - Launch of the Circular Bioeconomy Thematic Investment Platform

Activity 1.2.1 - Launch of the Circular Bioeconomy Thematic Investment Platform

Objective

By end Q1/2020 successfully launch a new dedicated financial instrument for the bioeconomy, so that it could start financing innovative bioeconomy projects.

Implementation

- Action successfully completed. Implementation in the form of a new dedicated financial instrument, launched in December 2019, European Circular Bioeconomy Fund[28], which is a first venture fund exclusively focused on the bioeconomy and the circular bioeconomy in Europe.
- ECBF I SCSp is managed by Hauck & Aufhäuser Funds Services S.A. and advised by the ECBF Management GmbH.
- Target size: 250 M EUR, to which the European Commission has committed 100 million EUR. The Fund started its operations on 1 October 2020 and up until now (Sept 2021) has raised 206 M EUR in four investment rounds. The 14 investors involved come from 5 different countries. The ECBF remains open for new investors aiming to scale-up innovative bio-based companies.

Impact

- The fund analysed almost 2000 potential projects for investments, of which about 30 were screened in more detail. Currently 3 projects received financing and other 5 are in the stage of due diligence.
- At present, positive impact on individual companies.
- Larger scale effects to be analysed ex-post.

Outlook

- It is planned that with current budget the Fund will invest in around 25 innovative late-stage companies and projects within the Circular Bioeconomy. Investments in the fields of energy and Healthcare are excluded.
- The Fund will be able to invest with equity, mezzanine or debt instruments.
- The focus on circularity includes re-use, reduction and recycling of waste streams as well as on valuable raw materials. This includes new digital solutions that enable the transformation from linear to more sustainable circular value chains.
- For any follow-up, it is recommendable to conduct first an ex-post evaluation.

[28] https://www.ecbf.vc

Action 1.3 - Study and analysis of enablers and bottlenecks and provide voluntary guidance to the deployment of bio-based innovations

Activity 1.3.1 - Report on enablers and bottlenecks to unlock bio-based innovation potential: research needs, market uptake

Objective

- Take stock, map and identify the research and innovation still needed to realise the full potential of the bio-based innovations.
- Identify bottlenecks, enablers, and gaps that hamper the market uptake and industrial exploitation of bio-based innovations.
- Deliver the policy-level recommendations, to unlock bio-based innovation in the EU.

Implementation

- Action closed. Implementation through a publicly procured service contract. The tender has been supported via H2020 WP2018 budget, N° 2018/RTD/F2/OP/PP-07281/2018/ "Support to R&I policy on biobased products and services"[29] with 3 lots funding ca. 0,5 million EUR per each lot: Lot 1 - **Carbon economy;** study coordinated by COWI; Lot 2 - **Life and biological sciences and technologies as engines for bio-based innovation;** study coordinated by Fraunhofer ISI; Lot 3 - **Biorefinery pathways and outlook for deployment;** study coordinated by E4Tech (see Activity 1.5.1).
- All three lots of the tender started in January 2020 and have successfully closed in 2021 (14-month duration), resulting in publication of the respective final reports

Impact

- **Lot 1:** final report delivered successfully[30] on 11 May 2021. The final report mapped the current pathways available for the transition towards a low carbon economy as well as the barriers that hinder this transition. The authors set the scene for the future of the bio-based sector with a particular focus on ten case studies of regions and cities across the EU.
- **Lot 2:** final report delivered successfully[31] on 20 April 2021. This study presents the 50 most significant bio-based innovations for the next 5-20 years.
- **Lot 3:** final report delivered successfully[32] on 2 June 2021. This study presents scenarios on how demand and supply for bio-based chemicals and materials could grow to 2030, and provides roadmaps with actions required to increase the deployment of chemical and material driven biorefineries in the EU.

[29] https://etendering.ted.europa.eu/cft/cft-display.html?cftId=4574
[30] https://ec.europa.eu/info/news/carbon-economy-studies-support-research-and-innovation-policy-area-bio-based-products-and-services-2021-may-11_en
[31] https://ec.europa.eu/info/news/life-and-biological-sciences-and-technologies-engines-bio-based-innovation-2021-apr-20_en
[32] http://ec.europa.eu/info/news/eu-biorefinery-outlook-2030-2021-jun-02_en

Outlook

- It remains crucial to stay abreast those opportunities, but also the bottlenecks and enablers. For any future mapping or foresight close cooperation with JRC – (e.g. Knowledge Centre for Bioeconomy, Biorefinery database etc.) can be recommended.
- No follow-up foreseen at present.

Activity 1.3.2 - Provide guidance, identify bottlenecks, enablers, and gaps that influence synergies and deployment of bio-based innovations and report on regulatory landscape

Objective

This action aims to assess EU policies and regulations supporting, enhancing or hindering the deployment of bio-based innovations (e.g. bio-based alternatives to fossil-based chemicals, textiles, plastics, composites, etc.) from sustainably sourced biomass.

Implementation

Several topics to strengthen[33] R&I on the full potential of the bio-based sectors (agriculture, blue economy, forest-based sector, construction, biorefineries etc.) were included in the Horizon Europe Cluster 6 Work Programmes[34] and the Work Programmes of the Circular Bio-based Europe (CBE) EU Partnership. However, the deployment of bio-based innovations as part of overall competitiveness of European economy[35] to effectively substitute fossil-based products as well as eliminate their emissions of greenhouse gases and other pollutants - for the benefit of the environment and more resilient regional economies - appears slugging behind[36]. This relates to broad economic areas such as industrial policy, circular economy, construction, textiles, packaging, plastics, waste, fertilisers, CAP, environmental and human health etc. So, in spite of some advances (e.g.[37] SMEs, due diligence, green innovation procurement) the deployment of bio-innovations merits a specific regulatory action towards a holistic, coherent and effective uptake, with or without a strategy for negative emissions and sufficient incentives for products substitution[38].

Impact

The current policies and legislative developments (State Aid, Renewable energy directive II, Effort sharing regulation) support leveraging synergies in bioenergy (e.g. fuelwood and biofuels), but not bio-based materials and products. Thus, ensuring the comprehensive assessment of policy options, resulting in a level

[33] Recommendations of Commission Expert Group for Bio-based Products (http:// ec.europa.eu/growth/sectors/biotechnology/bio-based-products_en) and the Biorefinery Outlook to 2030 study (http://ec.europa.eu/info/news/eu-biorefinery-outlook-2030-2021-jun-02_en)

[34] especially, under Cluster 6 Intervention Area 6 "Bio-based Innovation systems in the EU"

[35] https://www.sciencedirect.com/science/article/pii/S2212567115014550

[36] CBE SIRA 2022 (in preparation) and CBE Impact Assessment

[37] https://ec.europa.eu/growth/smes/sme-strategy/sme-performance-review

[38] CEPS 2020 https://www.ceps.eu/wp-content/uploads/2020/11/PI2020-29_Forestry-based-industries.pdf

playing field and including the appropriate pricing for fossil resources will be critical for bio-innovations' thrive[39].

Outlook

The Green Deal actions strive for operating within the planetary boundaries. The recognition of benefits of bio-innovations can drastically reduce use of fossil resources and their respective pollution, and boost new regional economies. For instance[40], wood-based construction offers 14 times higher carbon storage (83 Mt) by 2050. Already now 25% (4 Mt) of plastic packaging could be replaced by fibre-based ones significantly cutting down emissions of GHGs, microplastics other pollutants. Similarly, wood/fibre insulation could already replace glass wool, stone wool or polyurethane with huge reductions in pollution. Woody biomass-based textile innovations replacing synthetic fibres might offer the largest substitution effect of 1,4-4,3 kg C/kg C while revitalising forest-rich regions. These indicates an enormous potential of the deployment of bio-innovations, in case regulatory actions will ensure the level playing field, considerably speeding up the deployment in the EU.

Action 1.4 - Promote and/or develop standards and emerging market-based incentives, and improve labels applicable to bio-based products on the basis of reliable and comparable data on environmental and climate performance

Activity 1.4.1 - Development of an inventory of high quality, Environmental Footprint compliant secondary life cycle inventory datasets for each EU Member State on bio-based materials

Objective

- Identification of the most relevant (mass/volume based) materials needed to support bioeconomy, including their geographical origin;
- Identification of the most relevant production processes/technologies involved in the production of biobased products;
- Development of country-based EF-compliant life cycle inventories;
- Development of harmonised PEFCRs (Product Environmental Footprint Category Rules) and/or Organisation Environmental Footprint Sectoral Rules (OEFSRs) for the modelling of similar materials produced in different regions of the world with different production processes.
- Development of an integrated digitalised solution to facilitate the transfer of environmental life cycle base information throughout the supply chains.

Implementation

The implementation of this activity has not started yet.

[39] Biorefinery Outlook to 2030 study (http://ec.europa.eu/info/news/eu-biorefinery-outlook-2030-2021-jun-02_en)

[40] ASSET study https://data.europa.eu/doi/10.2834/421958, Material Economics 2019 https://materialeconomics.com/publications/industrial-transformation-2050, EFI 2018 https://efi.int/sites/default/files/files/publication-bank/2018/efi_fstp_7_2018.pdf, Fachagentur Nachwachsende Rohstoffe (FNR) 2022

Activity 1.4.2 - New standards/labels/certification schemes published, which include elements on bio-based content

Objective

Promote and/or develop standards and incentives for bio-based products, particularly regarding: End of life management, waste, compostability, and sustainability.
Support the development of an integrated and harmonised regulatory system, by promoting and facilitating the dialogue between the relevant stakeholders (Policy, Industry, Civil Society, Research and standardisation bodies) at different levels (local, national and European), to identify gaps and hurdles, providing meaningful suggestions and shared solutions for the improvements of actual standards.

Implementation

Following a market needs' investigation mandated by the European Commission in May 2011 the European Standardisation Committee (CEN) initiated Technical Committee CEN/TC 411 on bio-based products whose main objective is to develop standards for bio-based products covering horizontal aspects.
This includes a consistent terminology for bio-based products, sampling, bio-based content, application of and correlation towards life cycle assessment (LCA) and sustainability of biomass used, and guidance on the use of existing standards for the end-of-life options.
CEN/TC 411 has completed the development of standards mandated by the European Commission.
In order to identify standardisation needs, the Commission has requested the European Committee for Standardisation (CEN) to perform a comprehensive mapping exercise of existing or ongoing standardisation work related to sustainable chemicals. This includes work by industry and other organisations in this area at national, European and international level. The report of the European Committee for Standardisation (CEN) was delivered in January 2019.
Webinar on available bio-based standards from CEN was conducted in 2021.

Impact

Standards are documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines or definitions, to ensure that materials, products, processes and services are fit for their purpose.
Standards provide a basis for mutual understanding among individuals, businesses, public authorities and other kind of organisations. They facilitate communication, commerce, measurement/testing and manufacturing. Most of the standards are voluntary market agreements.

Outlook

This action has been completed. CEN/TC 411 is continuing its work in further developing standards for bio-based products.

Action 1.5 - Facilitate the development of new sustainable biorefineries and confirm the type and estimated potential
Activity 1.5.1 - Outlook/roadmap for biorefinery deployment in the EU

Objective

- Gather evidence and engage with stakeholders and specialists in the development of an outlook for the deployment of integrated chemical/material driven biorefineries in Europe for 2030
- Development of databases and online dashboards of chemical and material driven biorefineries in the EU (as well as outside the EU) to describe and understand the current landscape. The biofuel/bioenergy oriented biorefineries were not in scope.

Implementation

- Action closed. Implementation through a publicly procured service contract. The tender supported via H2020 WP2018 budget, N° 2018/RTD/F2/OP/PP-07281/2018/ "Support to R&I policy on biobased products and services"[41] with one lot (no. 3) dedicated to this action – study BIOREFINERY PATHWAYS AND OUTLOOK FOR DEPLOYMENT (coordinated by E4Tech). Funding ca. 0,5 million EUR.

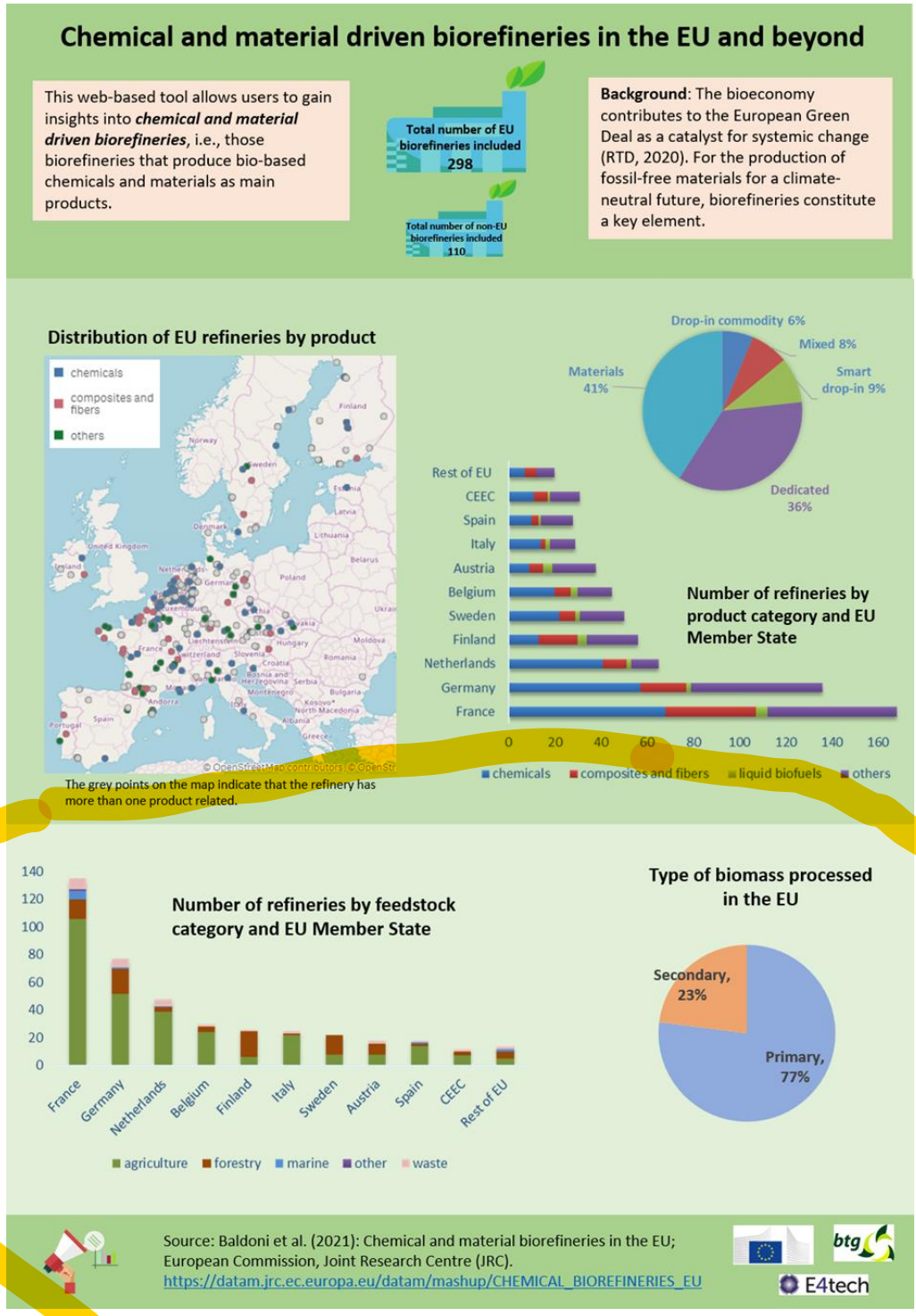
Impact

- Final report delivered[42] on 2 June 2021.

Outlook

- It remains crucial to stay abreast opportunities offered by bio-based innovation, but also the bottlenecks and enablers. For any future mapping or foresight close cooperation with JRC can be recommended.
- There are already a considerable number of chemical and material biorefineries in the EU. Their geographical distribution is uneven and, to support their development, further investigation is needed to understand the causes of the differentials. Some of these factors can be directly influenced in the medium term by policy-making.
- However, informed policy-making will require continuously updating the database and dashboards and carrying out quantitative analyses to shed lights on the major drivers of the growth of this sector.
- At this moment, such an activity is not foreseen. Small updates to the database and dashboards will be carried out when possible.

[41] https://etendering.ted.europa.eu/cft/cft-display.html?cftId=4574
[42] http://ec.europa.eu/info/news/eu-biorefinery-outlook-2030-2021-jun-02_en



SWD Infographic 1. Biorefineries

Activity 1.5.2 - Policies and regulations to develop new sustainable biorefineries in the EU

Objective

This action will consider policies and regulations boosting up private investments in the deployment of biorefineries and the market expansion of bio-based products while ensuring the sustainability of biomass supply and public acceptance.

Implementation

The policies and regulations, especially those taken since 2018, have been pivotal for investment decisions of private companies on biorefineries, but is also challenging for bio-based industries while offers market opportunities.
Although the number of biorefineries (today close to 350) and their production have increased in most Member States, this has been most often related to biofuels' (e.g. biodiesel, bioethanol, biomethanol, sustainable aviation fuels) production thanks to the Renewable Energy Directive (RED II). The regulation on land use, land use change and forestry (LULUCF) mentions the carbon storage of Harvested Wood Products, but has not boosted investments in woody biomass-based biorefineries. This is due to the absence of climate mitigation credits for producers. The proposed amendment of LULUCF will not change the situation.
The demand from the Single Use Plastics Directive for reduction of microplastic pollution boosted the uptake of nanocellulose-aided biodegradable fibre-based packaging. Yet the absence of similar demand for synthetic textiles has stalled investments in biorefineries for environmentally friendlier bio-based textiles.

Impact

The policy framework and legislative developments have supported leveraging synergies in biorefinery production of biofuels, but not bio-based materials and products. This is in spite of BBI-JU and other R&I breakthrough innovations especially in upcycling of residues for new materials and products replacing fossil-based ones. A CEPI (Confederation of European Paper Industries) study on Pulp and Paper Industry biorefineries in Europe lists 139 woody biomass-based biorefineries and 28 planned ones doubling their turnover by 2030.

Outlook

The Green Deal actions strengthen requirements for operating within the planetary boundaries. The political and legislative developments may boost biorefineries for upcycling of woody biomass residues and for the creation of vibrant regional bioeconomy hubs.
The CEPI Vision 2030 foresees new industrial ecosystems to emerge around large woody and other biomass processing plants in full industrial symbiosis with associated or built-in biorefineries. This will increase efficient use of local resources, reduce transport and offer new options for regional specialisation and attractive opportunities for skilled people. Their further replication with diverse breakthrough biorefinery products will provide 50% of the revenues of the pulp paper and recycling mills in 2050 – fully in line with the Green Deal goal for climate-neutral circular products as a norm by then.

Action 1.6 - Research and innovation investments for the development of substitutes to fossil based materials that are bio-based, recyclable and marine biodegradable, and of bio-remediation methods by mobilising the key actors in the relevant value chains including the plastics value chain and to contribute to plastic-free, healthy and productive European seas and oceans

Activity 1.6.1 - Support further research and innovation activities on pre- and co-normative research on plastics biodegradability, including in soil and marine environment. Development of recyclable and biodegradable bio-based substitutes to fossil-based plastics

Objective

Develop bio-based plastics, including recyclable plastics, which is biodegradable in soil and in marine open environments for specific applications. Deliver on the development of testing procedures of biodegradability in (soil and marine) open environments.
Objectives:

- Contribute to defining the EU policy framework for bio-based, biodegradable and compostable plastics.
- Contribute to the circularity of climate-neutral bio-based solutions replacing low environmental performing fossil-based plastics.

Implementation

- H2020 CE-BG-06-2019 - Sustainable solutions for bio-based plastics on land and sea: BIO-PLASTICS EUROPE Developing and Implementing Sustainability-Based Solutions for Bio-Based Plastic Production and Use to Preserve Land and Sea Environmental Quality in Europe; SEALIVE Strategies of circular Economy and Advanced bio-based solutions to keep our Lands and seas alIVE from plastics contamination
- Recent R&I activities on bio-based plastics which is either compostable and/or recyclable provide inputs to the EC initiatives that are preparatory for the planned EC Communication on the policy framework for bio-based, biodegradable and compostable plastics.
- R&I gaps framing the future work programme of Horizon Europe (and CBE)

Impact

- Better deployment of bio-based plastics in the European Green Deal, Circular Economy Action Plan and Taxonomy Regulation delegated acts.
- EUR 16,6 million invested in the two projects from the last Horizon 2020 call, however the total investment of relevant research and innovation projects exceeds this amount.
- Europe has a market share of 35% of bio-based plastics. R&I in the bio-based plastics sector can support climate neutrality while supporting EU industrial leadership.

Outlook

- More R&I and more targeted approaches are needed to develop bio-based value chains in the plastic sector to meet all the challenges of environmental sustainability, including circularity, and high technical performances
- R&I actions to address the 'programmed' biodegradability, both in controlled and in open environments, coupled with recyclability.

- Information of customers and consumers on bio-based plastics performances and end-of-life options should be developed in a more targeted way. Developing standards, certification schemes and labelling, b2b and b2c. Improve consumers' education.
- R&I actions to upgrade sorting techniques and recycling technologies to allow for recycling a broader range of plastics (both bio-based and fossil-based)
- EU investments in relevant research and innovation projects to leverage more MSs and private investments
- The sector of bio-based plastics is expanding in EU and a policy support of the best performing value chains can boost their climate mitigation potential

Activity 1.6.2 - Reports from the Blue Bioeconomy Forum

Objective

The aim of the Blue Bioeconomy Forum (BBF) was to develop a common understanding of the current status of blue bioeconomy in Europe and to collectively identify strategic developments, market opportunities, appropriate financial assistance, regulatory actions and research priorities.

Implementation

The BBF brought together stakeholders from the European Blue Bioeconomy, in order to produce a roadmap for the further development of the sector. The stakeholder forum was concluded in December 2019 with the formal handover of its deliverables to the Commission – a roadmap and a brochure[43] presenting successful projects. The roadmap also identified the sector's future needs along four topics: (1) Science, technology and innovation; (2) Consumers and supply chains; (3) Policy, environment and regulation; (4) Finance and business development. The roadmap recommendations are addressed to the European Commission, national and regional authorities, industry associations and other relevant players.

Impact

The Blue Bioeconomy Forum has identified 14 challenges that fall within four main themes. With the help of the BBF community, solutions were formulated to tackle the identified challenges. This allows a better targeting and planning of future actions. A number of solutions have already been implemented, e.g. the recommended BlueInvest platform has been established and is up and running, algae has been introduced into the terms of reference of European Maritime and Fisheries Fund and Horizon 2020 and Horizon Europe with an increasing number of launched projects. BBF recommendations have been one of the starting points for the forthcoming EU Algae Initiative and its impact assessment study. Two events were organised to develop the BBF roadmap in 2018 and 2019 each with around 100 stakeholders.

[43] https://webgate.ec.europa.eu/maritimeforum/en/node/4448

Outlook

The BBF Roadmap contributes to the industry's future competitiveness, by supporting the main stakeholders to: ~ Better understand the market's future regulatory, research, financial assistance and product needs; ~ Identify critical gaps between what exists and what is needed; ~ Define the short, medium and long-term actions that are required to unlock the potential of the sector.

Implementation of the identified solutions helped to close the market, funding, research etc gaps and better target and plan future actions e.g. to develop an EU Algae Initiative due for adoption by the Commission by mid-2022.

Activity 1.6.3 - This action will mobilise the key actors in the plastics value chain to support the development of alternatives to fossil-based plastics and new solutions to plastic waste and littering. This will support the implementation of the EU Plastic Strategy by industry including the Directive on Single Use Plastics.

Implementation

- BlueMed Hackathon[44](01/07/2021): The 3 winning teams of young professionals, developed ideas and solutions to promote sustainable blue growth and circular bioeconomy in the Mediterranean.
- Unlocking the potential of Ports and Harbours in preventing and reducing the effects of Marine Litter[45] (14/09/2021). This workshop looked at the most promising R&I solutions undertaken and policy instruments implemented, in the management and valorization of plastic litter in Ports/Harbours and their hinterland at Mediterranean level.
- The BlueMed Pilot healthy plastics-free Mediterranean Sea towards the 2030 targets: the strategy developed by the plastic producing and transforming operators of the area[46] (26/10/2021), looks at the solutions adopted for a smarter local use, management and recycling of plastics with a high impact in terms of replication trough the basin and among international governance structures.

The BlueMed Group of Senior Officials (GSO WG), the National hubs and the stakeholders participating in the BlueMed Pilot Action on a Healthy Plastic-free Mediterranean Sea, will contribute to the **EU Mission "Restore our Ocean and waters by 2030" and its "Lighthouses".** EU Missions are undertaking actions to face some of the greatest global challenges by setting 2030 targets. "Restore our Ocean and Waters" Mission includes actions to cleaning marine waters, restoring degraded ecosystems and habitats, decarbonising the blue economy.

Impact

Developing and implementing a shared vision for plastic in the circular economy in regards of the Mediterranean Sea. Identification of the key challenges ensuring a healthy and productive Sea together with the wide community of the Mediterranean. Identification of pathways that need to be implemented to obtain measurable results and meet the 2030 targets of the future Mission.

[44] http://www.bluemed-initiative.eu/the-bluemed-hackathon-winner-teams-announced/
[45] http://www.bluemed-initiative.eu/ports-harbours-venice-september-14-2021/
[46] http://www.bluemed-initiative.eu/pilot-ecomondo-2021-rimini/

Outlook

Future impact will be linked to the Mission "Restore our Ocean and Waters by 2030":

- Create a network of lighthouses at sea and river basin scale to implement the mission and expand the networks of marine protected areas
- Establish an EU-wide 'Blue Parks' initiative to provide new restoration and conservation opportunities
- Support effective water management through a digital knowledge system with a European Twin Ocean and improved environmental monitoring of ocean health

Action 2.1 - A Strategic Deployment Agenda for sustainable food and farming systems, forestry and bio-based production in a circular bioeconomy

Activity 2.1.1 - Strategic Deployment Agenda

Objective

The strategic deployment agenda will set-up a long-term vision **to deploy and scale up the bioeconomy in a sustainable and circular manner**, within the Green Deal framework.

Objectives:

- To provide a coherent framework for the development and deployment of knowledge, technologies and practices related to bioeconomy, in a systemic and interconnected approach;
- To set up key deployment pathways;
- To overcome fragmentation in the research and innovation landscapes to enable the deployment of bioeconomy across sectors, policies and territories.

Implementation

A topic on the strategic deployment agenda has been included in the Horizon Europe Work Programme 2021-2022: HORIZON-CL6-2021-GOVERNANCE-01-04: Strengthening bioeconomy innovation and deployment across sectors and all governance levels – CSA – 4 million EUR. The successful Horizon Europe project was launched early 2022.

Impact

The indicators given in the 2018 Bioeconomy Strategy Action Plan will be used to assess progress/achievement of this action once the successful project is known and launched.

Outlook

The implementation of the successful proposal will be closely followed up to ensure its continuous efficiency and policy relevance.

Action 2.2 - Pilot actions to support local bioeconomy development (rural, coastal, urban) via Commission instruments and programmes

Activity 2.2.1 - Unlock the high potential of the "Blue Bioeconomy" in coastal areas and islands through the Sea Basin Strategies, the European Maritime and Fisheries Fund and the Blue Bioeconomy Forum

Activity 2.2.1.1 - New and updated sea basin strategies

Objective

This activity is seeking to mainstream the blue bioeconomy within a regional dimension, in the concept of sea-basin and macro-regional strategies.
The objective is to improve the understanding of the blue bioeconomy on behalf of national and regional authorities, for increasing their capacity to get involved in relevant projects.

Implementation

Key initiatives after 2018 that have been undertaken to meet the objective:

- CMA includes actions on innovation in blue biotechnologies under Goal II.
- EUSAIR adopted a flagships tackling also *blue bio-technologies for bio-economy*.
- The 2021 UfM Ministerial Declaration on the Sustainable Blue Economy has highlighted the potential for development of aquaculture and blue bio-economy.
- BLUEMED identified blue growth trajectories, including biotechnologies, food.
- The revised Action plan of EUSBSR includes a priority action on Bioeconomy.
- WestMed Initiative has set up a technical group to promote sustainable aquaculture through innovation, including bioeconomy as one of the potential sectors.
- Outermost Regions are elaborating Blue Economy Strategies, according to a methodological guidance provided by MARE that includes Bioeconomy.

Impact

Boosting regional cooperation, helping countries to identify those elements that favour the growth of the sector. Contribution to the development of bioeconomy as an integral element for the new Approach on the Sustainable Blue Economy.
Indicators:

- EUSAIR: 1 flagship project
- EUSBSR: 1 revised Action plan with a priority action on Bioeconomy
- UfM: 1 Ministerial Declaration on the Sustainable Blue Economy, highlighting the potential for development of aquaculture and blue bio-economy
- WestMed Initiative: 1 technical group on sustainable aquaculture, including bioeconomy.

Outlook

The European Commission is focusing on boosting sustainable blue economy through the programming exercise for the new period 2021-2027. That will provide the opportunities for the countries to prioritise among others, interventions for the bioeconomy sector.
We are stressing our efforts to enhance this dimension in the Smart Specialisation Strategies as well, for new projects through transnational and interregional cooperation and via the setup of a dedicated smart specialisation platform for Blue Economy

Activity 2.2.1.2 - Projects funded through the European Maritime and Fisheries Fund

Objective

This action covers all funding to blue bioeconomy projects granted through the European Maritime and Fisheries Fund (EMFF). These could be grants under the direct management strand of the EMFF, such as the "blue calls", or projects funded through shared management

Implementation

Fisheries and aquaculture businesses are supported to diversify from their traditional business models, develop new products, find new markets, and become more efficient, often by valorising previously unused by-products.

Impact

By the end of 2020, €23.9 million of EMFF support was committed to 114 operations related to the blue bioeconomy which were financed under shared management.

Some examples include:

- Turning shellfish by-products into energy (France)
- Producing essential oils from marine plants (Portugal)
- Minced fish from unwanted by-catch (Finland)

By September 2021, nearly €12 million (11.832.623,47) of EMFF support was committed to 12 projects under the EMFF direct management. Some examples include:

- BIOGEARS is developing biobased gears as solutions for the creation of an eco-friendly offshore aquaculture sector, in a multitrophic approach, and new biobased value chains
- FISH4FISH produces film and trays prototypes for the fish packaging sector
- MERCLUB unreveil and exploit marine microorganisms for the bioremediation of Hg-contaminated marine sediments.
- ALGAENAUTS is developing a new line of sustainable and eco-friendly biopesticides line of products for agriculture from microalgae biomass cultivated recovering nutrients from wastewater and pig manure and also with seawater

Outlook

EMFF support is available to help transition and develop businesses in the field of the bioeconomy. Societal change and economic factors have also made this sector become increasingly viable. The outlook for further development is positive. Funding under the new European Maritime, Fisheries and Aquaculture Fund is available during the period 2021-2027 to finance similar initiatives.

Activity 2.2.2 - Support the deployment of inclusive Bioeconomies in rural areas through the Common Agricultural Policy: Initiatives to encourage Member States to invest Common Agricultural Policy funds into the Bioeconomy.

Objective

In the context of the new Common Agricultural Policy (CAP), this action focusses on disseminating good practices to National administrations and policy makers responsible for the implementation of the CAP. It aims at fostering the deployment of the Bioeconomy in rural areas by incorporating the Bioeconomy in the CAP National Strategic Plans in a way that adequately integrates primary producers. The Commission also supports the dissemination to all relevant stakeholders of good practices about governance and business models, as well as technological solutions in the area of the Bioeconomy at small, medium and large scale.

Implementation

To foster the deployment of the Bioeconomy in the new CAP, the Commission held a number of events with MS representatives but also with other public and private stakeholders as well as developed and disseminated materials. These include:

- High- and technical-level meetings to raise awareness about the Bioeconomy;
- Workshops and other capacity building events on how to foster the Bioeconomy through the new CAP addressed to National authorities and other stakeholders;
- Materials provided to Member States and stakeholders about existing good practices in supporting the deployment of the Bioeconomy in particular in rural areas;
- Recommendations to Member States to reiterate the important role the Bioeconomy have in revitalising rural areas.

Impact

- Number of events on the Bioeconomy for national authorities, and other stakeholders;
- Number of participants in the events or reached by the events;
- Number of materials provided to Member States about existing good practices in supporting the deployment of the Bioeconomy;
- Number of CAP National Strategic Plans proposed by Member States and their including interventions supporting the Bioeconomy.

Outlook

The new Common Agricultural Policy allows Member States to set out interventions adapted to their local realities to promote the development of the Bioeconomy in our rural areas. It is therefore of utmost importance that Member States take the designing of their CAP National Strategic Plans as an opportunity to further support and deploy the Bioeconomy in their territories.
Special attention would also need to be paid to the involvement of farmers and foresters in the future deployment of the Bioeconomy.

Activity 2.2.3 - Develop urban bioeconomies through piloting circular bioeconomy cities through Horizon Europe

Activity 2.2.3.1 - Support a pilot group of European cities to launch, finance, implement and assess their urban circular bio-based economy strategies and projects for the production of safe, sustainable and valuable bio-based products from urban biowaste and wastewater.

Objective

According to the 2018 EU Bioeconomy Strategy, cities should become major circular bioeconomy hubs, mainly by valorising their urban bio-waste and wastewater resources into bio-based products. This action aims to support a pilot group of European cities to launch, finance, implement and assess their urban circular bio-based economy strategies and projects.

Implementation

The project HOOP - Hub of circular cities boosting platform to foster investments for the valorisation of urban bio-waste and wastewater - was selected in the Horizon 2020 WP 2018-2020 CE-FNR-17-2020 call for proposals. The project lasting from October 2020 until 31 September 2024 provides a pilot group of cities with Project Development Assistance (PDA) to build their technical, economic and legal expertise for concrete investments to valorise their urban bio-waste and wastewater resources.
During this first period the main milestones achieved are: creation of local HOOP Committees to coordinate the PDA in the cities and regions, creation of the Circular Investors Board, and the set-up of the Bio-waste Clubs in 5 lighthouse cities and regions.

Impact

Expected impacts/outcomes of the activity:

- Delivery of sustainable circular bio-based economy concepts and 51 M € of investments, with the leverage factor 6 € investment/ 1 € PDA,
- Contribute to increased recycling of urban bio-waste and wastewater, reduce municipal bio-waste landfill to a maximum of 10% by 2035 and reduce GHG emissions by 1 M kg CO2 eq (bio-waste) and 9 M kg CO2 eq (water).

Measurable indicators to monitor the progress and impact of the activity:

- 8 cities/regions launch and implement urban circular bio-based economy strategies: Western Macedonia, Münster, Almere, Murcia, Porto, Bergen, Kuopio, Albano Laziale.
- 51 M € of financial investments for the implementation of these strategies.

Outlook

The key messages that have come out of the activity so far include:

- The main issue in urban bioeconomy initiatives is ensuring the quality of urban biowaste.
- There is a need of an adequate legislative framework that allows/boost the marketability of new bio-based products.

As a follow-up action, RTD.B1 established the Circular Cities and Regions Initiative's Coordination and Support Office (CCRI-CSO) in Q4/2021. The aim of the CCRI-CSO is to ensure the cooperation among the CCRI's projects (Horizon

2020 and Horizon Europe), and relevant initiatives. HOOP project consortium will participate in CCRI activities.

Activity 2.2.4 - Support pilot carbon farming initiatives through LIFE

Objective

Carbon farming can be defined as a green business model that rewards land managers for taking up improved land management practices, resulting in the increase of carbon sequestration by enhancing carbon capture and/or reducing the release of carbon to the atmosphere. The financial incentives can come from public or private sources and reward land managers for their management practice or the actual amount of carbon sequestered.

Implementation

The Commission intends to promote carbon farming approaches in order to support the contribution of the land sector to the EU's ambitious climate objectives. To this end, the Commission has:

- Published the study "Technical Guidance Handbook – setting up and implementing result-based carbon farming mechanisms in the EU", which explored key issues, challenges, trade-offs and design options to develop carbon farming.
- Promoted carbon farming in its recommendations on the Member States' CAP Strategic Plans.
- Organised several workshops to gather experience from stakeholders
- Supported several LIFE and Interreg projects
- Launched relevant HE calls under the 2021-2022 work programme
- Supported several relevant EIP-AGRI Operational Groups

Impact

- 6 conferences / workshops organised
- 1 study published (Technical Guidance Handbook – setting up and implementing result-based carbon farming mechanisms in the EU)
- at least 8 relevant LIFE projects and 3 relevant Interreg projects
- 9 relevant HE calls in 2021-2022 work programme

Outlook

The study concluded that pilot initiatives should be developed at local or regional level in order to gather experience to upscale carbon farming. This will enable improving design aspects, in particular the certification of carbon removals. The discussion with stakeholders during the workshops highlighted several barriers to carbon farming. To address these barriers, the Commission announced in the Farm to Fork Strategy that in 2021 it will launch a Carbon Farming initiative. In addition, as announced in the Circular Economy Action Plan, the Commission will develop a regulatory framework for certifying carbon removals based on robust and transparent carbon accounting to monitor and verify the authenticity of carbon removals. On 14 December 2021, the Commission published the Communication "Restoring Sustainable Carbon Cycles" on the certification of carbon removals and carbon farming. The publication was followed by a high-level launch event.

Activity 2.2.5

Activity 2.2.5.1 - Setting up "living labs" to develop and test place-based innovations based on ecological approaches and circularity in agriculture

Objective

The action aims to set up living labs across Europe to develop place-based solutions based on ecological and circular approaches and foster the shift to more sustainable and resilient farming and food systems with the overall objective to strengthen the research and innovation ecosystem around agroecology in Europe.

Implementation

- Step 1- Two ongoing CSAs, funded under Horizon 2020: ALL-READY and AE4EU. They aim at creating a framework and prepare the community for the partnership (see step 2).
- Step 2- A co-funded Horizon Europe partnership "Accelerating farming systems transition: agroecology living labs and research infrastructures" is being co-created by the Commission and the SCAR "strategic working group on agroecology" (SCAR-AE), created on 01/01/2021.

Main next steps towards the start of the partnership are:

- Preparing the partnership topic text under Horizon EU WP 2023-2024 (during 2022)
- Developing the Strategic research and Innovation Agenda (by end 2022)
- Application, evaluation and grant agreement preparation (2023-2024)

Impact

- Official reports from the SCAR-AE and deliverables from the two CSAs are expected from 2022 onwards.
- The creation of the SCAR-AE has attracted a wide interest of 26 countries and, together with ALL-READY and AE4EU, has already succeeded in developing connections in the agroecological scientific and stakeholder community.
- This dialogue contributes to improving knowledge on the living lab approach applied to farming, likely to accelerate innovation. Member States are discussing how to lift barriers to funding agroecology living labs under their R&I funding schemes.

Outlook

Main messages so far include:

- The need to build capacities on approaches such as living labs and to remove lock-ins in R&I that prevent the funding of multi-stakeholder approaches.
- The concern that living labs take time to establish, their impact may be difficult to measure and take time to materialise.
- Time-bound R&I projects are not well suited to support engagement of actors in place-based innovation processes. The EU and the MS/AC need to think of new ways to sustain longer-term innovation processes to deliver greater impact.

Activity 2.2.5.2 - H2020 funds supporting projects developing urban Living Labs - Living Labs for urban food systems transformation

Objective

Implementing the FOOD2030 policy framework in City Region Food systems.

- SFS-18-2017 "FIT4FOOD2030"- To build a sustainable, multi-stakeholder FOOD2030 platform, mobilizing a wide variety of stakeholders from different sectors
- SFS-24-2019 "FOODSHIFT20303"- To create a citizen-driven transition of the European food system towards a low carbon circular future, including a shift to more plant based diets
- CE-FNR-07-2020 "FOODTRAILS"- To empower cities as agents of food system transformation, to translate the worldwide Milan Urban Food Policy Pact's shared vision

Implementation

- "FIT4FOOD2030"- Establishment of city labs, maps on vision, drivers, barriers, food policies and governance of EU food systems and related R&I
- "FOODSHIFT2030"- Establishment of 9 Accelerator Labs, recruiting and engaging Food System Innovators (FSIs), catalogued existing food system innovation, ready to go policy advisor plans for enabler labs

Upcoming activities

- "FOODSHIFT2030"- Plans for scaling up innovations co-create business plans; co-develop advisory plans for food system governance in follower city-regions
- "FOODTRAILS"- First report to be published, planned mapping of existing good practices, establishment of living labs and pilots for the development of urban food policies

Impact

- "FIT4FOOD2030"- The established FOOD 2030 Platform comprises three interlinked structures: EU Think Tank, Policy Labs and City and Food Labs, which interact regularly to exchange information, learn from one another, and plan actions
- 7 city and 7 food labs have been created to bring together policy makers, researchers, educators and citizens to work on their visions of FOOD 2030
- 4 public webinars "Towards sustainable food systems through Research and Innovation"
- "FOODSHIFT2030"- A core set of FoodSHIFT Indicators in development, 1114 indicators recorded and organized in the indicator inventory, first draft of food system governance framework, 90 innovators mapped, 9 Fast Accelerator Labs, 5 public webinars
- "FOODTRAILS"- no impact assessment yet

Outlook

- "FIT4FOOD2030"- Essential outcome of project is inclusion of new stakeholders who have not traditionally been engaged or who lack a voice in decision-making
- In order to produce lasting and high-quality results, change needs to be driven by the energy derived from the well-informed engagement of a multitude of different actors joining forces
- "FOODSHIFT2030"- Contingency plan created and activated as necessary

- Challenges to access funding beyond life cycle of project due to financing infrastructure

Action 2.3 - Set up an EU Bioeconomy policy support facility and a European Bioeconomy Forum for Members States Forum for Members States

Activity 2.3.1 - Set up an EU policy support facility for Member States to develop and implement national/regional bioeconomy strategies across Europe

Objective

To support Member States in developing and implementing their dedicated national bioeconomy strategies and action plans, with a focus on Central and Eastern European countries. The aim was to base this activity on the sharing of good practice and high-level expertise by national bioeconomy experts with the ultimate goal of increasing the total number of EU Member States with a national bioeconomy strategy.

Implementation

- The action was implemented as a Horizon 2020-funded Expert Group with 19 MS as its members. The work was steered by five independent experts in the form of a Mutual Learning Exercise.
- Four online workshops were organised in collaboration with hosting Member States to address the main objectives laid out in the Terms of Reference.
- The main output of the Expert Group – a final report containing 10 key policy messages and recommendations – was presented at the final dissemination in July 2021.

Impact

- The formulated key messages were well received by the participating Member States and confirmed as being policy-relevant in a dedicated meeting. The outcomes and main policy recommendations were further distributed at different fora such as the European Bioeconomy Policy Forum and a BIOEAST Conference.
- Several Member States reported revived activity on their national bioeconomy policy as a result of their participation in the workshops.
- Given the recent conclusion of the activity, it is not possible at this early point to establish a causal link to the adoption of national bioeconomy strategies by Member States.
- Until 15 October 2021, there have been 139 and 142 downloads of the final report and the accompanying policy brief, respectively. This indicator shows the success of the outreach activities of the Policy Support Facility.

Outlook

- The expected outcomes of the Horizon Europe topic *HORIZON-CL6-2021-GOVERNANCE-01-10* link loosely with the work under the Bioeconomy Policy Support Facility. The project under this topic will contribute to the increased awareness, interaction and engagement of decision makers and public administration in Member States without a bioeconomy strategy.
- The final report, among other recommendations, calls for Member States to continuously update their national bioeconomy policies in light of new objectives and policy developments. A need might therefore arise for a

more permanent type of support facility accessible by all Member States, e.g. in the form of a helpdesk which could provide more tailor-made advise or assistance with specific policy questions or problems.

Activity 2.3.2 - Support a European Bioeconomy Forum of Members States implementing bioeconomy strategies

Activity 2.3.2.1 - Support a European Bioeconomy Forum of Members States implementing bioeconomy strategies and **Activity 2.3.2.2** - List of Communication actions to support a European Bioeconomy Forum of Members States implementing bioeconomy strategies

Objective

This action aimed to set up a policy platform for Member States with a view to facilitating knowledge exchange on bioeconomy related issues and mutual learning on best practices in developing and implementing national and regional bioeconomy policies.

- Support cooperation and dialogue among Member States on bioeconomy policy issues and increase the visibility of different areas of the bioeconomy
- Encourage Member States towards joint actions to support bioeconomy development on the national and EU level and provide input for future EU bioeconomy actions

Implementation

- The European Bioeconomy Policy Forum was launched in November 2020 with an opening event with high-level participation.
- The Forum is governed according to the Terms of Reference agreed to by all participating Member States.
- The Forum operates on two levels – a high level and an expert level. The former addresses strategic/political topics while the latter focuses on the operational aspects of bioeconomy policy development and implementation.

Impact

- By the end of 2021, three expert-level and two high-level meetings of the EBPF took place. Moreover, there have been several meetings under the Working Group *'Knowledge for Bioeconomy'*, which operated under the EBPF and is led by the Joint Research Centre as contribution to the Commission's Knowledge Centre for Bioeconomy.
- Three tasks have been launched under the Working Group *'Knowledge for Bioeconomy'*, outlined in the Work Plan of the EBPF: 1. Improving the estimation of socio-economic indicators for the EU bioeconomy; 2. Monitoring the bioeconomy through a holistic lens; and 3. Mapping of policy-enabling measures. 42 experts (representatives of national authorities with political responsibility for bioeconomy strategy development and experts from research and academia) from 14 Member States are participating in these tasks.

Outlook

- The Forum aims to establish a regular meeting schedule with a minimum of two expert level meetings and two high-level meetings annually.

- It is envisioned that the strategic focus of the high-level meetings will be set in collaboration with the representatives of the Member State holding the presidency of the Council of the EU.
- The Forum aims to further promote its co-creation aspect, whereby the activities undertaken, outputs developed and the topics discussed in its meetings will be largely set by the Member States in a bottom-up manner.

Action 2.4 - Promote education, training and skills across the bioeconomy

Activity 2.4.1 - Contribute to the development of bioeconomy educational pathways for higher education, vocational training and entrepreneurship.

Objective

This action will support networking of education and training providers in the bioeconomy, for the development of education and training content that responds to the diverse needs of stakeholders.

- Support the relevant upgrade, adaptation and development of bioeconomy-related training and education to meet future workforce needs for the deployment of a sustainable and circular bioeconomy.
- Increase the research, technology and innovation capacity for the bioeconomy.
- Deliver up-to-date skills intelligence on the occupations in bioeconomy and specific occupational core profiles

Implementation

- On the 15th of October 2019, the European Commission organised a workshop in Brussels entitled "Promoting education, training and skills across the bioeconomy".
- A public procurement for a study to contribute to the development of educational and training content for the bioeconomy was launched in June 2021.

Future activities and deliverables:

- Study report and policy brief delivered by consultant experts (Q3/2022)
- Conference (Q3/2022)

Impact

Due to the early stage of the project, no measurable impact is yet available. Impact will be evaluated on the basis of number of: number of education and training providers offering updated/new bioeconomy relevant curricula, number of bioeconomy-relevant curricula, research training programmes and modules available at the EU Higher Education Institutes, vocational core curricula and teaching/training methods updated, vocational core curricula and teaching/training methods integrated in national vocational training systems

Outlook

- Enhancing the outcome of education and training for the sustainable and circular economy will requires a combined effort of professionals in education and industries
- Regional bioeconomy actors will contribute to identifying the education needs in relation to the local specificities.

- It is desirable to improve the knowledge sharing and knowledge management across bioeconomy experts groups and institutions for innovation

Action 3.1 - Enhance the knowledge on the bioeconomy, including on biodiversity and ecosystems to deploy it within safe ecological limits, and make it accessible through the Knowledge Centre for Bioeconomy

Activity 3.1.1 - Enhance information and the knowledge base on the bioeconomy, including sustainable biomass supply and demand, and forward looking, cross-sectoral assessments, and make it accessible through the Knowledge Centre for Bioeconomy

Objective

- To enhance the knowledge base on EU bioeconomy, including ecosystems and their services, primary production and bio-based sectors
- To enhance the understanding on biomass supply, uses and flows, assessing the physical, environmental, social and economic dimensions of the bioeconomy.
- To develop and implement forward-looking modelling capacity in the areas related to the bioeconomy, in order to assess policy options
- To make this information available to EU policymakers and other stakeholders in a transparent, tailored, concise and accessible manner through the Commission's Knowledge Centre for Bioeconomy[47].

Implementation

Research conducted by the Commission's Joint Research Centre, covered all key facets of the bioeconomy: the condition of land and marine ecosystems and their services, the supply of and demand for biomass across sources and uses, including bio-waste, and the associated environmental impacts, bio-based industries as well as socioeconomic aspects. It also included the development of forward-looking analysis tools such as modelling and foresight to explore scenarios and their socio-economic and environmental impacts and trade-offs[48]. Furthermore, the knowledge base was complemented by data and information from more than 170 other sources that were continuously screened, filtered and made accessible through the Commission's Knowledge Centre for Bioeconomy and by expertise from more than 700 specialists that contributed to workshops organised in the context of a Community of Practice.

Impact

Important advances in scientific knowledge achieved and documented in the scientific literature. In particular, between 11-Oct-2018 and 2-Feb-2022, the JRC has published 464 outputs capturing different aspects of the bioeconomy, including 275 scientific papers and 93 technical reports. These publications, complemented by more than two thousand additional resources (publications, datasets, data visualisations, online tools, etc.) curated from other sources, have been made publicly accessible through the Commission's Knowledge Centre for Bioeconomy. This distilled knowledge base has helped to shed light

[47] https://knowledge4policy.ec.europa.eu/bioeconomy
[48] https://knowledge4policy.ec.europa.eu/bioeconomy/key-publications

on key issues and trade-offs within the bioeconomy, including by providing indicators for the EU Bioeconomy Monitoring System (see action 3.2.2). It has also been used to inform several other EU policy initiatives, linked to the bioeconomy, including the Circular Economy, the Common Agricultural Policy and the long-term Vision for the EU's Rural Areas, the Biodiversity Strategy, climate action and renewable energy proposals, the new EU Forest Strategy, as well as the preparation of upcoming EU strategies on sustainable textiles and for the algae sector.

Outlook

The Commission and its Joint Research Centre plan to continue deploying, under the umbrella of the Knowledge Centre for Bioeconomy, a fully-fledged bioeconomy intelligence to tackle multi-faceted questions to increase understanding of the ecological boundaries.

Activity 3.1.2 - Strengthen the understanding, resilience and status of biodiversity and terrestrial and marine ecosystems, including their services and related socio-economic costs and benefits, also by filling knowledge gaps

Objective

This activity addresses a range of sub-objectives to enhance knowledge about ecosystems, their resilience and the services they provide in support to the EU Biodiversity Strategy 2030 and the foreseen EU Nature Restoration Plan:

- To suport calls for proposals under Horizon Europe
- To support the iniciative of the European Biodiversity Partnership (Biodiversa)
- To facilitate further development of work of the EU MAES including a thorough EU wide assessment of ecosystem condition, pressures and services and how they have changed over time (between 2010 and 2020)
- To identify key knowledge gaps to better develop ecosystem assessments at EU level
- To support the development of ecosystem service accounts under INCA project that will provide the monetary estimates of the benefits that ecosystems generate to society, but also will assess the overexplotation of ecosystem services or situations of ecosystem deficit where ecosystem's capacity should be enhanced

Implementation

Some of the actions under the aforementioned sub-objectives have been fulfilled. The key deliverables between 2019-2021 are summarized below:

- The summary for policy makers of the EU ecosystem assessment is currently being used as reference document in the development of the EU Nature Restoration Plan and its impact assessment
- EU ecosystem assessment:
- Detailed report on EU trends of ecosystem condition and services[49]
- Summary for policy makers[50]
- Natural Capital Accounting:
- Final INCA report[51]

[49] https://publications.jrc.ec.europa.eu/repository/handle/JRC120383
[50] https://publications.jrc.ec.europa.eu/repository/handle/JRC123783

- Pilot ecosystem service accounts report[52]
- Call for Proposals Green Deal Call, Area 7: Restoring biodiversity and ecosystem services[53]

Impact

- The summary for policy makers of the EU ecosystem assessment is currently being used as reference document in the development of the EU Nature Restoration Plan and its impact assessment
- EU MAES and INCA activities (that collectively include Commission Services ENV, RTD, ESTAT, JRC; as well the EEA; EU MS) have two websites to show updated data and most recent reports:
- MAES[54]
- INCA website for sharing all accounting data and maps for ecosystem services[55]
- Integration of some EU MAES indicators in the EU Bioeconomy Monitoring System in support to objective 2 of the EU Bioeconomy (Managing Natural Resources Sustainably)
- GIS based modules that can automate largely the production of ecosystem services accounts based on the JRC ecosystem services models and workflows

Outlook

This activity brings key knowledge on the state and trends of ecosystems and their services, as well as pressures they are exposed to. This is particularly important to understand where and how much ecosystems are degraded and threatened so as to guide priority and cost-effective restoration efforts.
In relation to ecosystem integrity assessment, further work would be required to align the work under MAES into to the international standard on ecosystem accounts defined by UN (SEEA EA[56])
Under INCA an updated version of ecosystem service accounts will be released soon, updated for 2018, including the following ecosystem services: crop provision, timber provision, carbon sequestration, habitat and species maintenance, water purification, soil retention, flood control and nature-based recreation. All data will become available at the INCA website[57]

Activity 3.1.3 - Provide better data on the status and management of forest ecosystems to support the sustainable availability of domestic biomass resources, carbon sequestration and ecosystem resilience

Objective

The Forest Information System for Europe (FISE) was first developed in the 2013 Forest Strategy to address the need for more accurate, frequent and

[51] https://op.europa.eu/en/publication-detail/-/publication/e489a6b2-d7b9-11eb-895a-01aa75ed71a1/language-en
[52] https://publications.jrc.ec.europa.eu/repository/handle/JRC126566
[53] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/lc-gd-7-1-2020
[54] https://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/index_en.htm
[55] https://ecosystem-accounts.jrc.ec.europa.eu/
[56] https://seea.un.org/ecosystem-accounting
[57] https://ecosystem-accounts.jrc.ec.europa.eu/

harmonised data and assessment tools on the status and management of Europe's forest ecosystems and to become a reference platform for forest-related data and information for various interest groups, while cutting across sectors and policy areas. The role of FISE was reaffirmed in the New EU Forest Strategy COM(2021) 572 to become the corner stone for harmonised forest data in Europe.

Its main objectives are:

- Collect, analyse, and make available harmonised forest data and information in a transparent manner for the EU and, to the extent possible, for the EEA.
- Support policymaking in forest-related sectors through tailor-made information products.
- Facilitate expert knowledge sharing, research and innovation.

Implementation

FISE is a partnership between the European Commission (EC) services and the European Environment Agency (EEA). It is online since 2019 and provides an ever-growing list of datasets and key information related to forest ecosystems for a broad public.

Future additions will include:

- New dashboards for key forest information, regular reports and lay summaries on forests in the EU will be incorporated to FISE.
- The future legislative proposal on EU Forest Observation, Reporting and Data Collection will be framed under FISE.
- The MapMyTree counter of the 3 Billion Trees Initiative will be hosted on the FISE website.

Impact

FISE represents a clear progress. Its impact on the accessibility of available forest related data and as a motor of new harmonised forest related information is difficult to quantify, but leaves no doubt. Relevant indicators are still under development, though candidates for quantitative indicators to measure progress are:

- the average monthly organic website traffic on the FISE homepage
- the total number of datasets available on FISE

Outlook

FISE is already effectively serving its purpose and it is expected to play a significantly more important role as a forest information platform in the future. The implications for the accessibility of forest related data could be game changing, though also dependent on the future legislative proposal on EU Forest Observation, Reporting and Data Collection.

Action 3.2 Increase observation, measurement, monitoring and reporting capabilities and build an EU-wide, internationally coherent monitoring system to track economic, environmental and social progress towards a sustainable bioeconomy

Activity 3.2.1 - Increase observation, measurement, monitoring and reporting capabilities on the condition of biodiversity, ecosystems and ecosystem services, to underpin ecosystem conservation and restoration

Objective

This activity will help to: better detect and assess trends in biodiversity and ecosystems and progress towards restoring degraded ecosystems, provide a sound basis for identifying and prioritising restoration actions, and support the provision of timely spatially explicit information on the state and condition of biodiversity and ecosystems.

Implementation

- Further development of official monitoring and reporting of ecosystems and biodiversity at EU level and by Member States coordinated by the European Commission (DG ENV in particular) and with the support of the EEA and its Topic Centres. This includes reporting linked to existing and future nature legislation but also covers work in other areas, eg the LULUCF reporting in the climate domain.
- Strengthening of cooperation between key actors in this field, including the European Commission, EU bodies such as the European Environment Agency, Member State bodies responsible for biodiversity monitoring and reporting, the research community and citizen science organisations that help compile biodiversity data on the ground
- Strengthening the development of Copernicus products in support of ecosystem and biodiversity monitoring
- Encouraging the further development of ecosystem and biodiversity monitoring at Member State level via funding, legislative action as well as capacity building and networking: Horizon 2020 ERA-NET COFUND project BiodivERsA as the main EU-level action.

Impact

- In 2020 the EEA published an assessment on the state of nature in the EU based on reports from Member States under the Birds (2009/147/EC) and the Habitats (92/43/EEC) directives and on subsequent assessments at EU or EU biogeographical levels.[58]
- A comprehensive EU-level review of the extent and condition of European ecosystems was published in 2020.[59]
- The EU INCA project ('Integrated Accounting for Natural Capital and Ecosystem Services') has tested and implemented the SEEA EA approach which has substantially contributed to EU level knowledge on the state of ecosystems and their ecosystem services.[60] Eurostat has coordinated the EU INCA project and is currently developing a module on ecosystem accounting under Regulation 691/2011, in interaction with EU Member States.

[58] https://www.eea.europa.eu/publications/state-of-nature-in-the-eu-2020
[59] https://publications.jrc.ec.europa.eu/repository/handle/JRC120383
[60] https://ec.europa.eu/eurostat/en/web/products-statistical-reports/-/ks-ft-20-002

- EU Copernicus satellite program, in particular the Copernicus land monitoring service coordinated by EEA (Copernicus Land Monitoring Service): A significant range of products is being developed – High Resolution Phenology and Productivity, CLC+ (a follow-up data set to CLC), as well as a European Ground Motion Service.
- Coordinated research actions to mobilise specialist expertise in ecosystem and biodiversity monitoring and to facilitate innovation and technological development: EuropaBON (established in 2020); MarBioME (Marine Biodiversity Monitoring in Europe).
- More than 200 European- and 300 international biodiversity monitoring programs are in place to date.

Outlook

- Follow-up work is currently in progress to develop an EU-wide methodology to map, assess and achieve good condition of ecosystems so they can deliver benefits such as climate regulation, water regulation, soil health, and pollination and disaster prevention and protection.

Activity 3.2.2 - Build an EU-wide, internationally coherent monitoring system to track economic, environmental and social progress towards a sustainable bioeconomy

Objective

The action is to develop and implement a comprehensive monitoring system to assess the environmental, social and economic sustainability of the EU Bioeconomy and make it publicly available via the Knowledge Centre for Bioeconomy.

Objectives

- To design a simple and comprehensive monitoring framework in collaboration with partner DGs, policy makers, Member States, scientific experts and other stakeholders from within and outside the EC Services
- To identify relevant indicators to gauge the progress and sustainability of the EU Bioeconomy both within and outside of the EU
- To ensure a flexible monitoring system that is conducive to modifications as new data and information becomes available
- To coordinate with other monitoring frameworks, in Member States and international organisations (e.g. FAO, OECD)
- To minimise reporting burdens on all data providers
- To improve data collection exercises in order to close identified gaps
- To review the framework periodically to ensure it is fit for purpose
- To disseminate the information in a user-friendly way, through dashboards and other dynamic visualisations in the Knowledge Centre for the Bioeconomy

Implementation

2019: The conceptual framework for the EU Bioeconomy Monitoring System was developed and published by the Commission's Joint Research Centre in collaboration with Member State experts, International organisations, academia, and policy officers from different European Commission DGs.

2020: Indicators, including ones developed by the Commission (see action 3.1.1) were identified and selected in collaboration with stakeholders; the

Monitoring System was launched on the occasion of the Global Bioeconomy Summit in November. To close data gaps, the Commission is working with external experts.
2021: Mapping of indicators for Bioeconomy to the SDGs and European Green Deal; initiation with MS Experts to conceive methods for holistic and system's level monitoring. Joint publication with FAO on *Guidelines for Monitoring Bioeconomy*[61].
Future work: Operational system-level reporting on overall EU Bioeconomy sustainability and Science to Policy report on the sustainability of the EU Bioeconomy.

Impact

- Online dashboards via the European Commission's Knowledge Centre for Bioeconomy: 39 indicators have been published; 43 are in the pipeline and 74 are aspirational indicators in various stages of completion
- Since its launch the Monitoring System has had 5808 hits of which 4366 unique (as of 2 Feb. 2022)
- Periodic reporting on progress towards the sustainability of the EU Bioeconomy: forthcoming (periodic reports on the state of the monitoring system are published as well)

Outlook

Fundamental is disseminating the underlying data and methodologies for use by stakeholders, hence numerous indicators are shown and kept up-to-date in the system, yet the JRC should also provide aggregate and system's level indicators (based on the underlying indicators already provided in the system).

Activity 3.2.3 - Increase monitoring of degraded land areas or land at risk of climate impacts such as desertification, to underpin action for restoration of land based systems

Objective

A key objective of the recently launched EU Soil Observatory is the development of an integrated soil and land monitoring system for the EU. Such a system will utilize a range of dataflows, building on the current LUCAS Soil Module (as the only coherent mechanism for the collection of harmonized soil data for the EU) but increasingly coherent with monitoring activities in Member States and complementary data streams (e.g. COPERNICUS, precision agriculture systems, citizen science). Its main objectives are:

- Collect, analyse, and make available harmonised soil and land degradation data and information in a transparent manner for the EU and, to the extent possible, for the EEA
- Support policymaking in soil and land degradation related sectors through information systems such as dashboards and indicators
- Facilitate coherent data collection through the development of an integrated soil monitoring system for the EU (in collaboration with MS).
- Provide a platform for knowledge sharing, research and innovation (links to Mission and Horizon Europe R&I Programmes)
- Support citizen engagement action, enhanced societal literacy on soil and

[61] https://publications.jrc.ec.europa.eu/repository/handle/JRC126052

land degradation

Implementation

EUSO is an institutional activity of the JRC, with a target to be operational by the end of 2022 by bringing a series of intermediate services online during 2022. Development will continue beyond 2022 to address the requirements of evolving policy needs. It is steered through an Interservice Advisory Committee reflecting the main policy interests. It collaborates closely with the EEA and its Land Information System for Europe (LISE). Its development builds on the European Soil Data Centre (ESDAC), which has been successfully providing an increasing selection of datasets and key information related to soils for the past 10 years. Extensive use will also be made of data collected through the 2022 LUCAS Soil Module.

Future additions will include:

- New soil health and soil policy dashboards that will form the basis for regular and formal reporting (for example, the Soil Strategy's Action to publish information every five years about the state of land degradation and desertification in the EU).Support the establishment of a methodology and relevant indicators to assess the extent of desertification and soil/land degradation in the EU, starting with the UNCCD's Methodology for SDG 15.3 indicator.
- In dialogue with Member States and other key stakeholders, develop a road map for a pan-EU integrated soil monitoring system, building on the work of the European Joint Programme Initiaitive on agricultural soil management.
- Provide EU-wide harmonised assessments of soil organic carbon stocks, biodiversity and soil pollution

Impact

Some indicators and trend data are currently available. The Soil Health and Food Mission Board's report presented evidence that showed that 60-70% of EU soils are in an unhealthy state.

These figures reflect the facts that: 24% of agricultural land has unsustainable water erosion rates; cropland soils losing carbon at a rate of 0.5% per year and 50% of peatlands drained and losing carbon; 23% of land with high density subsoil indicating compaction; 25% of land at High or Very High risk of desertification in Southern, Central and Eastern Europe in 2017 - an increase of 11% in desertification in just 10 years.

Other indicators of land degradation (e.g. diffuse pollution, soil compaction, soil health indicator) are still under development, often reflecting knowledge or data gaps. It should be noted that the costs associated with soil degradation in the EU exceed 50 billion € per year.

Outlook

The JRC's ESDAC and LUCAS Soil Module are already serving policy makers and other stakeholders through the provision of data on soil and land condition. This role will be enhanced through EUSO through the development of harmonized soil data flows, enhanced reporting of soil health and related degradational pressures. It will additionally serve the research community through the development of a portal to promote the outcomes of EU-funded R&I actions while developing and enhancing soil literacy throughout the EU at all levels. The EUSO is expected to a significantly role in the development and implementation of the proposed Soil

Health Law as well as soil related aspects of the Bioeconomy Strategy and other policy areas.

Action 3.3 Provide voluntary guidance to operate the bioeconomy within safe ecological limits

Activity 3.3.1 - Guidance will be published, based on analysis and assessments to operationalise knowledge on: demand pressures (such as land use change and land demand), ecosystem condition, multifunctional ecosystems, services and productivity, conservation, restoration and ecosystem resilience. This will build on guidance on integrating ecosystem services into decision making

Objective

The guidance document "Managing healthy and resilient ecosystems in the bioeconomy", is the final deliverable from a Specific Contract launched in 2019 to help support on integrating ecosystem services into decision making.
The guidance document was published in January 2022.[62]

Implementation

The guidelines document is set out a clear definition of what is meant by an "Ecological Approach to the Bioeconomy" and include perspectives from the bioeconomy that are underpinned by biodiversity, conservation and ecosystem approaches as defined in CBD, and relevant EU policy and legislation. It is then documented key principles, their definitions and rationales for managing healthy and resilient ecosystems and their services in agroecosystems, forest ecosystems and marine ecosystems. The principles are supported by best practice guidelines and indicators, drawing on case studies and visualisations (e.g. photos, infographics, maps, figures) to illustrate points that are made.

Impact

This guidance is positioned to realize joint agendas for the EU 2018 Bioeconomy Strategy and the EU Biodiversity Strategy for 2030. While contributing to the action plan that supports the EU 2018 Bioeconomy Strategy, this project is also strongly aligned to the EU Biodiversity Strategy for 2030, a core part of the European Green Deal.
The principles is supported by best practice guidelines and indicators, drawing on case studies. It will serve to policy maker to address biodiversity and include recommendation on ecological principles in the different sectors of bioeconomy.
This study can also usefully be disseminated across and beyond DG ENV and the Commission to relevant audiences (e.g. Member States authorities) as it will serve land managers, practitioners, and regulatory authorities in making decisions on how to design and implement the principles for managing healthy and resilient ecosystems in the bioeconomy, both on site and at regional level.

[62] https://op.europa.eu/en/publication-detail/-/publication/26949618-735c-11ec-9136-01aa75ed71a1

Outlook

The ecological guidelines use the principles, criteria and standards for ecological restoration as a starting point. However, these are customized for use in the sustainable and circular bioeconomy, which focuses on restoring ecological functioning and specific species, rather than necessitating full recovery of native ecosystems.
Three interacting sets of principles are highlighted to guide good practices for managing healthy and resilient ecosystems in the bioeconomy: ecosystem, enabling and systemic principles.
Ecosystem principles consider important requirements for species and ecological functioning.
Enabling principles are needed to underpin the implementation of the ecosystem principles, and include stakeholder participation, and enabling policy and finances.
Systemic principles acknowledge the complexity of interlinked global systems, and seek to make explicit the benefits and trade-offs of each good practice in relation to broader environmental, social and economic goals.

Action 3.4 - Better integrate the benefits of biodiversity-rich ecosystems in primary production through a specific support to agro-ecology, the development of microbiome-based solutions, and new tools to integrate pollinators in supply value chains

Activity 3.4.1 - Increasing the understanding of microbial biodiversity with a view to develop microbiome-based solutions

Objective

The action aims at fostering healthy and sustainable food and primary production systems by enhancing microbial biodiversity in the context of, land and marine ecosystems, including their health and environmental benefits and interactions within and between the ecosystems. The action aims also at developing, testing and deploying of effective microbiome-based solutions to improve *One Health* and environmental benefits in food systems, as well as building on existing initiatives and projects such as the International Bioeconomy Forum and ongoing H2020 and Horizon Europe and national projects.

Implementation

Implementation via WP 2018-20 and H2020 projects as well as the ongoing Horizon Europe calls covering aspects of microbiome in relation to: increased agricultural sustainability and productivity; increased food quality; nutrition; sustainable agriculture; biodiversity; marine microbiome; climate change adaptation and mitigation; bioeconomy; fresh water; soil health and restoration; new-genomic techniques; new industrial sectors and cross sector activates.
European Partnerships under Horizon Europe; Missions on: Adaptation to climate change including societal transformation; Healthy oceans, seas and inland waters; Soil health and food. Moreover, implementation is ongoing through the cooperation with International Partners, MS, the private sector and related DGs.

Impact

- Increase the knowledge on microbial diversity in organisms and ecosystems
- Development of Innovative Microbiome-based products and processes resulting in enhanced human diets and human health as well as increased resilience and quality of primary production systems
- Strengthened European and International cooperation in the field of Microbiome e.g. through the IBF Microbiome WG and enlargement of the IBF partners (consolidation of networks);
- Enhanced consumer perception of the role of the microbiome
- Enhanced biodiversity protection and regeneration in terrestrial and aquatic ecosystems

Outlook

The Commission and its JRC plan to continue developing and deploying microbiome-based solutions as per targets set in the European Green Deal.
On the public side, there is a need to improve engagement with Member States and public authorities at regional and local levels.
Future initiatives should be stimulated to use a systems approach and to work inter-disciplinarily and trans-disciplinarily to understand the role of microbiomes in different ecosystems and assess how microbiomes are inter-connected throughout ecosystems.

Activity 3.4.2 - Developing a roadmap for action to support agro-ecology mobilising the EU Research and Innovation Framework Programme, Common Agricultural Policy, LIFE Programme and other relevant EU instruments

Objective

The overall objective of this action is to contribute to accelerating the shift to more resilient, climate, ecosystem and biodiversity-friendly agri-food systems. The action aims at developing solutions based on agroecological approaches that are adapted to site-specific needs and have the potential to be widely adopted.

Implementation

The action is implemented through the co-creation of a roadmap for research and innovation activities on ‘’Ecological approaches in agricultural land-based primary production’’, which includes actions on agroecology, agroforestry and organic farming. This has led to the inclusion of seven topics in the first Work Programme of Horizon Europe (2021-2022). The roadmap is currently the basis for co-creating topics for the Horizon Europe Work Programme 2023-2024, including the topic for the co-funded partnership on ‘’Accelerating farming systems transition: agro-ecology living labs and research infrastructures’’ (see activity 2.2.5.1.)

Impact

Activities will increase evidence of the potential of agroecology to help achieve key targets of the Green deal, and overall improve the knowledge base to support the implementation of EU policies and initiatives relevant for the agricultural sector. Thanks to the increase in EU-funded research on agroecology through the above activities, and the creation of a Strategic

Working Group on Agroecology under the Standing Committee on Agricultural Research, bringing together 26 countries to build the agroecology partnership, connections in the agroecological scientific and stakeholder community at European and national level and the R&I ecosystem on agroecology is being strengthened.

Outlook

There is a need to continue supporting transnational, transdisciplinary and multi-actor research activities on the benefits, challenges and potential of agroecology in various contexts and locations. While time-bound research and innovation projects can deliver valuable knowledge on agroecology and its implementation in different pedo-climatic conditions, due to the long-term nature of ecological and social processes involved in agroecology, there is a need for instruments that are better adapted to measure and monitor the performance of agroecology, and to support longer-term innovation processes that are likely to deliver greater impact. The co-funded partnership on agroecology (action 2.2.5.1.) will provide an important contribution to this end.

Activity 3.4.3 - Developing tools for the integration of pollinators and pollination service into the design of sustainable biomass supply value chains

Objective

This activity aims to develop tools for businesses to assess the dependence of their supply chains on biomass whose production relies on animal pollination services, and risks and opportunities associated with it. This requires a robust knowledge base on the status and trends of pollinator populations as well as crop distribution and production. The tools will enable businesses to contribute more effectively to the EU actions on tackling pollinator decline and mitigate risks within their supply chains.

Objectives:

1. Support the implementation of an EU Pollinator Monitoring Scheme in all Member States;
2. Support business decision making with regard to pollinator-dependent supply chains by compiling the collected information and making it available through user-friendly tools (atlases, pollination deficit warning system, risk assessment tools).

Implementation

- Expert proposal for an EU Pollinator Monitoring Scheme (EUPOMS) developed and published in October 2020[63].
- Preparatory Action for piloting and testing EUPOMS launched in June 2021 (budget EUR 5 M)[64].
- A number of proposed topics in Horizon Europe's Work Programme for 2021/22 supports the development of tools and expert capacity building for the implementation of EUPOMS[65].

[63] https://publications.jrc.ec.europa.eu/repository/handle/JRC122225

[64] https://wikis.ec.europa.eu/display/EUPKH/SPRING+project

[65] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021-2022/wp-9-food-bioeconomy-natural-resources-agriculture-and-environment_horizon-2021-2022_en.pdf

- Biodiversa+, the new European co-funded biodiversity partnership[66], includes as one of its objectives support biodiversity monitoring, including EUPOMS.
- The Commission is working with Member States to address the exchange of, sharing, access to, and use of interoperable, non-personal, spatial data available in the CAP's Integrated Administration and Control System (IACS)[67].
- In 2021, the final report of the INCA project[68] was published. It showed that 50% of the land cultivated with pollinator-dependent crops faces a pollination deficit.

Impact

It is too early to report progress in quantitative terms. The implementation of EUPOMS on the ground is expected in 2023/24.

Outlook

The work on this activity continues. Implementation of a new and ambitious monitoring scheme for pollinators requires time and resources.
In Q1 2022, the Commission will set up an expert group on pollinators with a view to support further discussion with Member States on the development and rollout of EUPOMS.

[66] https://www.biodiversa.org/
[67] The IACS contains potentially valuable information on pollinators and pollination services such as the spatial distribution and location of crops, farming practices or CAP measures: https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/financing-cap/financial-assurance/managing-payments_en
[68] https://ec.europa.eu/eurostat/en/web/products-statistical-reports/-/ks-ft-20-002

6 Brief summary of the Member States' complementary initiatives

At the 2nd Expert Level Meeting in the framework of the European Bioeconomy Policy Forum (EBPF), the European Commission launched an informal exchange of views and experience with the EBPF Members and Observers on the Bioeconomy Strategy and the Action Plan. The feedback exercise, in form of an informal survey, took place between March and July 2021. 13 Member States provided their feedback to the five survey questions. This section presents the analysis of the feedback received on question 1: "With regard to the EU Bioeconomy Strategy Actions listed in the tables that follow, we invite you to briefly report on activities, if any, undertaken in your Member State relating to each action. These activities may directly contribute to the EU action or may be parallel/complementary actions in your Member State inspired by the EU Action."

The following tables list selected examples of initiatives and developments that Member States reported as complementary activities at national level related to each of the 14 actions outlined in the Bioeconomy Strategy Action Plan. Each of the three tables presents the reported initiatives in a dedicated action area.

Action area 1 – Strengthen and scale-up the bio-based sectors, unlock investments and markets

1.1 Mobilise public and private stakeholders, in research, demonstration and deployment of sustainable, inclusive and circular bio-based solutions	The Member States participating in the survey listed a number of different initiatives. Some of them include: • relevant R&I funding schemes; • innovation and demonstration platforms (e.g. AT, FI); • dialogue platforms or other type of collaborations (e.g. DE, IT, SE); • science, competence or innovation centres (e.g. HR, LV, LU); • awareness raising activities such as a science year dedicated to bioeconomy (DE), an annual conference on bioeconomy (SE), other information campaigns (DE); • relevant activities in the framework of the BIOEAST initiative (e.g. BG, HR), or in relation to the development/ update of national bioeconomy strategies (e.g. FI, HU, SE)
1.2 Launch of the EUR 100 million Circular Bioeconomy Thematic Investment Platform	A few Member States listed complementary actions at national level. For example, some mentioned national funding mechanisms (e.g. AT, DE, PT). One Member State (IT) holds an annual investment forum and implement relevant projects in the framework of their national bioeconomy strategy. Another Member State (FI) mentioned that their National Liaison Office for the Horizon Europe offers free services to actors interested in

	funding.
1.3 Study and analysis of enablers and bottlenecks and provide voluntary guidance to the deployment of bio-based innovations	Several Member States listed relevant national or other studies, for example: • Study on the legal framework and legal barriers to bioeconomy in the energy, construction, wood, bioplastic-materials and waste sector (DE) • Study on the implementation of the LEADER/CLLD approach (LV) • OECD study "Innovation, Agricultural Productivity and Sustainability in Latvia" (LV) • Study "ECO.BIO: Acceleration of solutions in circular economy and bioeconomy" (PT) • report conducted by the program BioInnovation, compiling challenges and opportunities for bioeconomy (SE) Some Member States mentioned that analyses of enablers and bottlenecks had been conducted in the framework of their national bioeconomy strategies (e.g. FI, IT, SE). Other mentioned also relevant funding schemes, a project for exchanging best practices, relevant activities pursued by other entities/ external platforms.
1.4 Promote and/or develop standards and emerging market-based incentives, and improve labels applicable to bio-based products on the basis of reliable and comparable data on environmental and climate performance	Different complementary initiatives were mentioned by the Member States, such as for example: • funding relevant projects (e.g. DE, PT) • development of a label for local wood (LU) or taking part in the development of CEN-standards for biobased products (SE) • conducting studies on ecological balances of bio-based products and solutions or on labels (e.g. DE) • natural resource centre provides information about environmental performance of bio based products (e.g. FI) • other indirect activities (e.g. provision of high quality data through INSPIRE, developing a common methodology for assessment of carbon footprint of agricultural enterprises, etc.)
1.5 Facilitate the development of new sustainable biorefineries and confirm the type and estimated potential	Most Member States participating in the survey listed funding projects as complementary initiatives for action 1.5: • More than ten projects in the field of biomass production, harvesting and processing (FR) • Funding for (new) biorefinieries (e.g. DE, IT, SE, EE), such as biodegradable waste recycling facilities (LV) One Member State conducted a study outlining the resource potential for biorefineries (AT), another

	established a Working Group with the involvement of various universities and business actors in order to map the opportunities for bio refineries (HU) and some other Member States mentioned less direct activities.
1.6 Research and innovation investments for the development of substitutes to fossil based materials that are bio-based, recyclable and marine-biodegradable, and of bio-remediation methods by mobilising the key actors in the relevant value chains including the plastics value chain and to contribute to plastic-free, healthy and productive European seas and oceans	For action 1.6, several Member States listed R&I funding schemes (e.g. AT, BG, HR, EE, DE, IT, LV, PT). Some Member States also mentioned the relevant work carried out by national technology competence and development centres or clusters (e.g. HU, LV, EE), including open access pilot plans (DE). Two Member States published relevant studies (on the situation and prospects of the Estonian bioeconomy sectors and development of business models) and a French study, which developed an inventory of bioresources from aquatic environments. Some Member States also mentioned the relevant work in the private sector (e.g. HR, FI, LU) and an establishment of a private-public-partnership research program (SE).

Action area 2 – Deploy local bioeconomies rapidly across Europe

2.1 A Strategic Deployment Agenda for sustainable food and farming systems, forestry and bio-based production in a circular bioeconomy	As complementary activities, Member States listed a development of local bioeconomy strategies (DE), revision of national bioeconomy strategy (IT) and related activities in the framework of the BIOEAST or the BIOEASTsUP project (HU). Many Member States listed other national strategies, laws or programmes that cover the issues in relation to Action 2.1: • Strategy for Strengthening the Role of the Agricultural Sector in the Bioeconomy (BG) • National Strategy/ Action Plan for Transition to a Circular Economy (BG, LV) • National strategy for food production (SE) • National forest program (SE) • National strategy for fishing and aquaculture (SE) • Climate and Energy Model Regions programme (AT) • Bio- and Circular Finland programme (FI)

	• Circular Economy Law (LV) • New General Waste Management Regime (PT)
2.2 Pilot actions to support local bioeconomy development (rural, coastal, urban) via Commission instruments and programmes	In relation to action 2.2, a number of Member States participating in the survey listed their relevant funding schemes or projects co-financed through Horizon or the ERDF (e.g. BG, HR, EE, DE, IT, LV, PT). Some of the projects mentioned include: • BIOPROCRO PROJECT aiming at scaling-up the cultivation of various marine species (sponges, algae, bacteria) in Adriatic Sea; • FORCRO!' aiming at constructing 17 logistics and trade centres for biomass, 169 collection stations for the purchase of biomass from citizens and legal entities as well as 17 biomass heating plants and boiler rooms • "Development of cooperation-based sustainable and safe food systems to achieve the goals of "Food 2030" • Natural Resin Project important for the development of the rural environment. Other Member States mentioned a coalition programme between regions with the goal to enhance and scaling up local and regional bioeconomy-related activities (SE), an annual seminar to promote the European funding tool "Bio-Based Industry" to research and industry stakeholders (FR) Living Lab concept development (EE), and the relevance of other national policies and strategies (LV).
2.3 Set up an EU Bioeconomy policy support facility and a European Bioeconomy Forum for Member States	Most Member States indicated their active engagement in the EU Bioeconomy policy support facility and the European Bioeconomy Forum for Member States (e.g. BG, HR, EE, FI, FR, DE, HU, IT). Two Member States listed additional activities, i.e. the "European Bioeconomy University (a network of five European universities) and the establishment of the Bioeconomy Platform at federal level and a platform at a regional level (the Green Transformation & Bioeconomy Platform in Lower Austria).
2.4 Promote education, training and skills across the bioeconomy	Two Member States suggested that education and training have been addressed in their national bioeconomy strategies (DE, IT) and one suggested that this is being addressed in the scope of the BIOEAST (HU). Several Member States indicated that they launched specific trainings and courses in relation to bioeconomy, for instance: • Faculty of Agriculture of the University of Zagreb has launched a graduate programme: 'Renewable energy resources in agriculture' (HR) • the concept of bioeconomy was introduced in several

	school curricula (FR) • AgroParisTech carried out numerous training and awareness-raising days on the bioeconomy (FR) • ForMAR is an adult training and educational organization devoted to the ocean, and therefore comprising the Blue Bioeconomy skills (PT) • university courses on bio-based production and use (SE). Some other mentioned awareness raising activities such as development of communication and e-learning materials (e.g. DE, SE), cross-sectorial cooperation (e.g. BG, SE), relevant work of competence centres or institutes (e.g. HU). One Member State established a task force that mapped national Master and PhD programmes focusing on bioeconomy (IT) and another has launched an international project for the development of educational programs on bioeconomy (BG). A few Member States mentioned specific national funding schemes (e.g. AT, DE).

Action Area 3 – Understand the ecological boundaries of the bioeconomy

3.1 Enhance the knowledge on the bioeconomy, including on biodiversity and ecosystems, to deploy it within safe ecological limits and make it accessible through the Knowledge Centre for Bioeconomy	Some of the Member States responding to the survey listed awareness raising activities such as a plan for development of organic production (BG), information meetings with stakeholders of the BIOEAST Initiative and seminars on circular (bio) economics (BG), bi-annual bioeconomy scientific conference and an annual seminar (FR). Two Member States mentioned the work of their national institutes/ agencies in this regard (SE, FI). Some also explained that this topic is covered by their national bioeconomy strategies (e.g. AT, DE) and one of them mentioned that they provide several funding schemes for research on climate effects, soil and biodiversity (DE).
3.2 Increase observation, measurement, monitoring and reporting capabilities and build an EU-wide, internationally coherent monitoring system	When it comes to monitoring, several Member States explained that the do not have a national bioeconomy monitoring system, however they monitor bioeconomy related developments at sectoral level (e.g. EE, SE, AT, FI, BG, PT, LV). One Member State indicated that they launched a bioeconomy monitoring in 2016 and a first comprehensive 'pilot report' was published in 2020 (DE). Another Member State launched a tailored task force with the objective to identify the most reliable indicators currently used in the country (IT). Some Member States

to track economic, environmental and social progress towards a sustainable bioeconomy	also mentioned their involvement in the EU-led activities (e.g., in the scope of the European Bioeconomy Policy Forum or the BIOEASTsUP project).
3.3 Provide voluntary guidance to operate the bioeconomy within safe ecological limits	In relation to action 3.3, some Member States mentioned relevant developments in the scope of other strategies, plans and laws (e.g. BG, FI, PT, LV). Austria formulated guidelines in the Austrian Bioeconomy Strategy and Italy highlighted the importance of this action in their bioeconomy strategy. Some Member States indicated that relevant guidance is provided by their national agencies, institutes or councils (FR, DE, SE). One Member State is funding a R&D project to investigate the sustainability requirements for the bioeconomy in line with the 2030 Agenda (DE).
3.4 Better integrate the benefits of biodiversity-rich ecosystems in primary production through a specific support to agro-ecology, the development of microbiome-based solutions, and new tools to integrate pollinators in supply value chains	As mentioned by two Member States, their national strategies explicitly address the objectives in relation to action 3.4 (DE, IT). Several Member States listed relevant funding schemes (e.g. BG, HR, EE, DE), for example: • specific schemes for farmers, e.g. for sustaining biodiversity and other agri-evironmental issues; • knowledge transfer projects e.g. stocktaking exercises, surveys and non-scientific studies; cross-sectoral schemes promoting projects on the subject of "biological diversity"; • modelling and demonstration projects in the field of conservation and innovative use of biodiversity; • research projects related to bio-based and bioeconomy-related sectors • agro-ecological support. Some other initiatives listed include studies (e.g. EE, FR), microbiome-based solutions carried out in private sector (e.g. BG), other national and regional measures (e.g. DE).

7 Examples of bioeconomy projects

The following gives a brief summary of some projects of relevance for the bioeconomy covering a wide range of topics addressing different issues over a number of bioeconomy sectors or challenges that the bioeconomy can help address.

1. **Horizon 2020 project - Built-In-Wood: Sustainable multi-storey wooden buildings.**

Developing a sustainable and innovative wood value chain for the construction of multi-storey wooden buildings. The project goal is to drastically increase the proportion of timber construction. The challenge is to offer high-quality, affordable and environmentally friendly housing.

https://www.build-in-wood.eu/

2. **Horizon 2020 project - GLOPACK: Aiming to food packaging with no environmental footprint.**

The project is developing home-compostable, biodegradable packaging made from agro-food residues. It is investigating food packaging with no environmental footprint and the ability to extend the shelf life of food products.

https://glopack2020.eu/

3. **Horizon 2020 project - HEREWEAR: Locally-produced bio-based textiles.**

Project aims to establish EU market for locally-produced textiles made from locally-sourced bio-based materials (e.g. three novel waste streams: seaweed, straw, lignin from wood). The bio-based material solutions will build further on the latest bio-based polyester and cellulose developments.

https://herewear.eu/

4. **Horizon 2020 project – FUSILLI: Developing new urban food plans**

Its' core are the 12 Living Labs in 12 different cities, whose main objective it is to develop urban food plans within their local contexts to achieve an integrated and safe holistic transition towards healthy, sustainable, secure, inclusive and cost-efficient food systems. Via an open knowledge community, cities will be empowered to implement innovative and personalized policies and actions, placing citizens in the heart of the process.

https://fusilli-project.eu/

5. **Horizon 2020 Projects Cluster: The crop diversification cluster - Joining forces to diversify European agriculture.**

The crop diversification cluster brings together research projects which operate in countries across Europe to increase the impact of crop diversification research. The cluster encourages sustained uptake of diversification measures by European farmers and through innovations across the agri-value chain. The diversification of crops through rotation, multiple cropping and species mixtures can allow farming systems to become more resource-efficient with fewer agronomic inputs. Diversified systems can help meet the needs of end users for food, feed and industrial products and simultaneously deliver other ecosystem services and public goods.

https://www.cropdiversification.eu/

6. **Bio-Based Industries Joint Undertaking – SSUCHY: Developing advanced bio-based composites.**

Sustainable structural and multifunctional bio-composites from hybrid natural fibres and bio-based polymers. Project develops bio-based aircraft wings to address plastic pollution. Trees, crops and even organic waste can be transformed into a bewildering array of plastics to use in products ranging from single-use bags to heavy-duty aeroplane wings.

https://www.ssuchy.eu/

7. **Bio-Based Industries Joint Undertaking – CIRCULAR BIOCARBON: Turning urban waste streams into added-value products**

The project will develop a first-of-its-kind flagship biorefinery to valorise the organic fraction of municipal solid waste into four value-added products and a range of other intermediate products. It will do this through a biorefinery, organised through a pool of cascading technologies. This will treat mixed urban waste streams, including the organic fraction of municipal solid waste and sewage sludge, in order to demonstrate that the process is capable of handling all the biowaste produced by a medium-sized city.

https://circularbiocarbon.eu/

8. **Interreg North Sea Region – Project: BEESPOKE: Increasing level of pollinators on farm lands.**

The project is funded by the. The aim is to increase levels of pollinators and crop pollination at local and landscape scales by providing land managers and policy makers with new expertise, tools and financial knowledge to create more sustainable and resilient agroecosystems. Pollination is an important ecosystem service, a key to more sustainable and resilient agroecosystems.

https://northsearegion.eu/beespoke/

9. **European Innovation Partnership (EIP-AGRI) – OG MUNTER: Integrating nature conservation, crop production and livestock farming.**

Project integrates objectives for water, soil and flood protection with broader objectives such as climate protection, biodiversity and animal welfare. For the first time, farmers, municipalities, water managers, nature conservationists and authorities worked out new multi-use concepts and implemented them together.

https://munter.stoffstrom.org/

https://enrd.ec.europa.eu/projects-practice/green-future-munter-germany_en

10. **A National project - BioökonomieREVIER Rheinland – Germany: from traditional fossil based economy to sustainable bioeconomy.**

The project in which the conversion of the traditional fossil based economy into a sustainable bioeconomy is adapted to the local conditions and future prospects. The project is implemented in the Rhineland region, where structured phase-out of lignite mining is done to gain a new profile by expanding and establishing novel options for creating value. The projects aims at identity, secure jobs and prosperity in the area to achieve quality life. The area once reliant on lignite mining, is to be transformed into a bioeconomy region in order to create a lighthouse project for sustainable and circular bioeconomy for Germany, Europe, and the whole world.

https://www.biooekonomierevier.de/

11. **New European Bauhaus Price finalist – TOCA Portugal**

TOCA Portugal: an innovative, interactive paper-based surface is NEB finalist on rising stars category. The product is a paper-based interactive (and ecological) surface that can take advantage of both worlds. People of all ages are able to write and draw on a common paper sheet, while all the content is wirelessly displayed at a computer and/or smartphone in real-time. Artists can bring their paper drawings to live by adding sounds, colours, and motion on TOCA software, enabling unlimited art possibilities.

https://prizes.new-european-bauhaus.eu/node/269429

12. **New European Bauhaus Prize finalist - Xifré's Rooftop Spain: Introducing nature to cities "Floating" Wild Garden.**

It combines both architecture and ecology in renovation project. Covering an early 19th-century block of ten buildings, this contemporary roof garden creates a "floating" wild space that enhances urban biodiversity and opportunities for social interaction between neighbours. Furthermore, the rooftop elements of the historic building have been carefully restored.

https://prizes.new-european-bauhaus.eu/node/267524

13. European Innovation Council Accelerator Programme - WOODIO Finland: Bio-based toilet sinks and bathroom design.

An eco-design and material technology company whose signature material is the world's first 100% waterproof solid wood composite with a minimal carbon footprint. The company manufactures easy to clean, durable bathroom furniture to provide an alternative to CO_2 high ceramic industry. Products are made of wood and resin based adhesives.

https://woodio.fi/en/

14. European Maritime and Fisheries Fund (EMFF): FISH4FISH

FISH4FISH: The EU-funded FISH4FISH project closes the circle between waste and consumption. FISH4FISH is developing a novel active polymeric material based on chitin from crustaceans combined with lignin waste for the fish packaging sector. Such packaging enhances shelf-life and, once it is has been used, could be processed completely in a home composting system and used as fertilizer and microbial preservatives for plants.

http://fish4fish.dbcf.unisi.it/

15. European Maritime and Fisheries Fund (EMFF): BIOGEARS

BIOGEARS: The EU-funded BIOGEARS project aims to develop innovative bio-based ropes for mussels and seaweed to contribute to a more sustainable aquaculture sector. The goal is to obtain a plastic that does not decompose at sea, but instead turns into compost, when it is no longer of use.

https://biogears.eu/

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The updated EU Bioeconomy Strategy from 2018 **"A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment"** provides the policy frame for the deployment of a circular and sustainable bioeconomy in Europe.

In November 2019, the Council of the European Union adopted conclusions on the 2018 EU Bioeconomy Strategy, calling upon the EC to deliver a Bioeconomy Strategy Progress Report by 2022. In response to this, the European Commission developed the Progress Report **"European Bioeconomy Policy: Stocktaking and future developments"**. The report:

- Outlines the state of play of the European Bioeconomy and assess the progress in the implementation of the 2018 EU Bioeconomy Strategy and its Action Plan.

- Identifies the gaps and future opportunities of the bioeconomy policy, in light of recent policy developments under the European Green Deal.

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