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Trends in the EU bioeconomy - update 2024

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Contents

Abstract

Policy monitoring frameworks allow decision makers to assess the performance and progress towards specific strategic objectives that reflect an overall vision. The bioeconomy consists of complex social, economic, and environmental systems. The EU Bioeconomy Monitoring System was developed by the JRC to fulfil the need for a holistic policy monitoring framework and track economic, environmental and social progress towards a sustainable bioeconomy through relevant indicators. The first assessment based on the EU Bioeconomy Monitoring System was published in early 2023. This report is an updated assessment of the EU bioeconomy development to date, using the data available as of September 2024.

Foreword

The bioeconomy is an enabler for implementing green transitions in a sustainable, competitive and just way. **Sustainability** calls for a holistic view, taking into account biomass scarcity, biodiversity, climate mitigation and de-fossilisation, ecosystem services and the needs of future generations. **Competitiveness** requires less dependency on third countries, thereby enhancing the strategic autonomy of the EU. The circular economy has a key role in increasing resource efficiency, improving biomass recovery, valorising secondary feedstock, fostering innovation, and creating circular business models and green jobs. The main aim of the sustainable, circular, and competitive bioeconomy is to create more added value using fewer natural resources. The **just way** needs the involvement of all citizens, urban and rural populations, leaving no-one behind, and providing the required education, re-skilling and up-skilling of the workforce.

The enabling potential of the bioeconomy is increasingly recognised on the international scale. Under this year's G20 presidency, Brazil led a multilateral initiative on the bioeconomy, which is to be continued under the 2025 Presidency of South Africa. Another milestone was the major gathering of leaders and experts at the Global Bioeconomy Summit (GBS2024) in Kenya.

The progress of the EU bioeconomy is followed by the European Commission's Knowledge Centre for Bioeconomy, in particular via the EU Bioeconomy Monitoring System. We live in an era of data that feed our scientific input to policy. The Knowledge Centre for Bioeconomy has harvested and analysed this data using bioeconomy indicators that help monitor progress towards the five objectives of the 2018 EU Bioeconomy Strategy: Ensuring food and nutrition security; Managing natural resources sustainably; Reducing dependence on non-renewable, unsustainable resources; Mitigating and adapting to climate change; and Strengthening European competitiveness and creating jobs.

This report gives insights as to where we stand and how we are moving towards our bioeconomy objectives. It identifies trade-offs and synergies and the need for continued dialogue on both the challenges facing agriculture and forestry, biotechnology and biomanufacturing, and on how to ensure the sustainable and circular use of natural resources in the EU while securing biodiversity and healthy ecosystems. We hope that this report will provide valuable inputs to the future EU bioeconomy strategy and help strengthen science-based policymaking in the European Union.

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Executive Summary

Policy context

This report supports the EU Bioeconomy Strategy and aims to inform its upcoming revision. It was prepared by the European Commission's Knowledge Centre for Bioeconomy (KCB) hosted by the Joint Research Centre (JRC). The report describes progress towards a sustainable bioeconomy and provides insights into the state of play of national and regional bioeconomy strategies in the EU Member States (MS). The report addresses a key policy issue, as a sustainable and circular bioeconomy is crucial for achieving the EU's climate and environmental goals.

The 2018 update of the EU Bioeconomy Strategy reconfirmed five key objectives for a sustainable and circular bioeconomy: ensuring food and nutrition security, managing natural resources sustainably, reducing dependence on non-renewable resources, mitigating and adapting to climate change, and strengthening European competitiveness and creating jobs. The EU Bioeconomy Monitoring System (EU-BMS) was developed to track progress towards these objectives, with a conceptual framework that operationalises the strategy into a vision for a sustainable EU bioeconomy. The EU-BMS is managed and further developed by the KCB as part of its broader knowledge base, supported by complementary research activities that enhance understanding of the EU bioeconomy and its ecological boundaries.

Key conclusions

The main policy-relevant conclusions of this report are:

- Coordination and cooperation among MS is important to ensure a coherent EU bioeconomy policy framework and to share knowledge advances in a fast-changing policy area.
- Coherence across bioeconomy strategy objectives is key to properly manage trade-offs and ensure sustainability of the bioeconomy.
- The report highlights the need of policy actions for improving the sustainability of the bioeconomy, including reducing consumption, fostering innovation, and improving biomass circularity.

Main findings

The report presents the following main findings:

- The EU-BMS has been developed to track progress towards the EU Bioeconomy Strategy's five objectives, and the assessment reveals that Europe is generally moving towards the objectives, but environmental challenges persist.

- The report identifies several key trends and patterns in the EU bioeconomy, including progress in resource and energy efficiency, but also challenges in managing natural resources sustainably and mitigating and adapting to climate change.

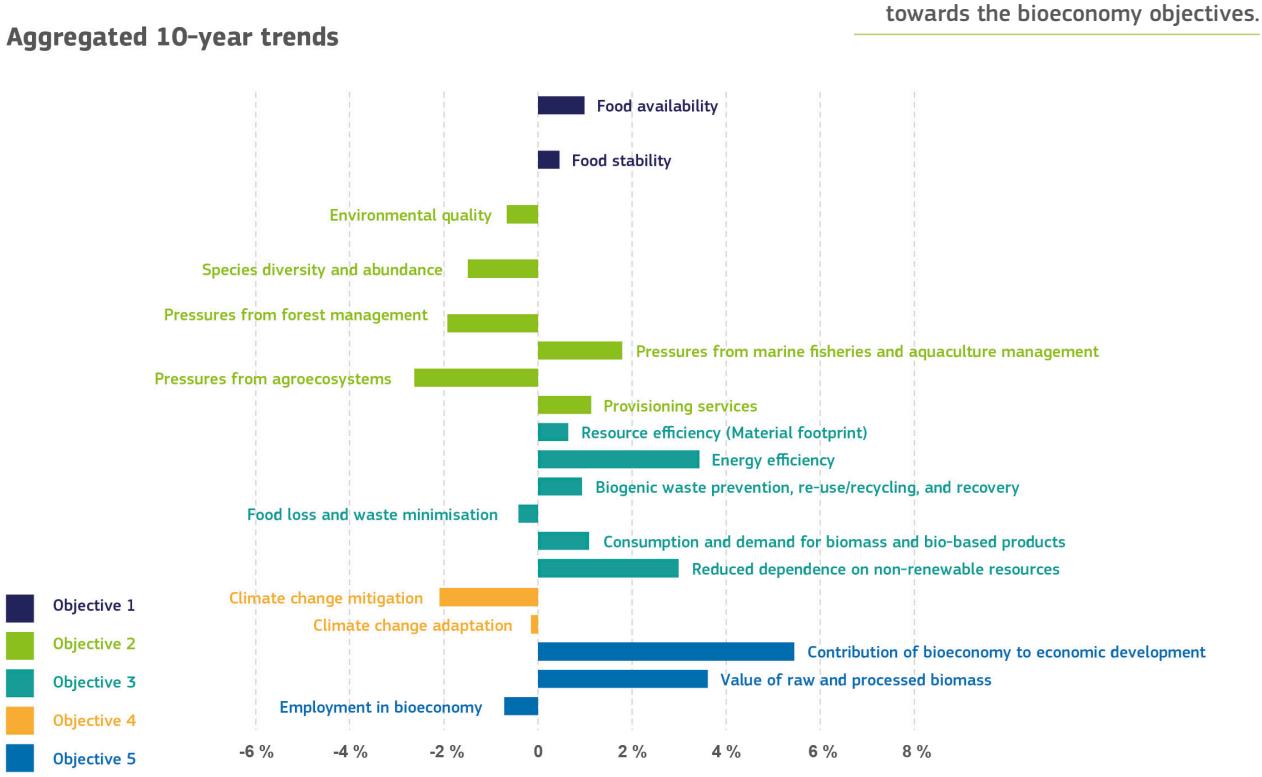
- Overall, trade-offs between bioeconomy objectives remain key issues to be addressed. Whereas food security, reduced dependency on non-renewable resources with substitution by bio-based sources, and socio-economic indicators exhibit positive trends, the environmental and climate change indicator trends remain reasons for concern (*Figure 1*).

- Despite some relatively positive signals regarding nature conservation efforts and the status of marine habitats, the pressure on inland natural resources remains high, affecting negatively environmental quality and species diversity, as well as threatening the climate change mitigation potential of forests. The positive trends in ecosystem services are due to the improvement of provisioning services mostly driven by increased biomass extraction, which in turn is negatively affecting the forest habitats and depleting the LULUCF carbon sink. In agriculture, the clearly positive signs from the increasing trends of agricultural factor income, coupled with the marked increase of the share of organic farming and the slight decrease in livestock density, are counterbalanced by an increase of more intense farming practices, with overall signs of negative impacts on water quality and species diversity.

- National bioeconomy strategies in EU MS are diverse and reflect different national priorities and contexts, with 11 MS having dedicated national bioeconomy strategies, while in the other EU countries it is embedded in other related initiatives or under development.

- Despite the diversity among MS in the development of locally adapted strategies, an overall common conceptual framework has been maintained grounded on the EU approach to bioeconomy.

Figure 1. Contribution of the average 10-year trend of the key components towards the bioeconomy objectives.



Source: own elaboration

- The assessment highlights the importance of service sectors associated with the bioeconomy, which are currently not part of the EU-BMS, and suggests that they should be included in future assessments as they constitute a significant part of the European bioeconomy.

- The assessment shows that the EU bioeconomy is a complex and dynamic system, requiring ongoing monitoring and evaluation to ensure that it is evolving in a sustainable, circular and equitable way.

Related and future JRC work

This report is part of the JRC's ongoing work to support the EU Bioeconomy Strategy and the green transition towards a competitive and prosperous EU. Future work will focus on further developing the EU-BMS and exploring new indicators and approaches for assessing the bioeconomy.

Quick guide

This report addresses the topic of monitoring progress towards a sustainable bioeconomy in the EU. Key terms and concepts used in the report include:

- Bioeconomy: according to the 2018 EU Bioeconomy Strategy, bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services.

- EU Bioeconomy Strategy: a strategy that aims to accelerate the deployment of a sustainable European bioeconomy. Its latest update is from 2018, and the Commission is working on a new update, foreseen by end of 2025.

- EU Bioeconomy Monitoring System (EU-BMS): a tool for tracking progress towards the EU Bioeconomy Strategy's five objectives.

- National bioeconomy strategies: strategies elaborated by EU MS to promote the development of their bioeconomies.

1 Introduction

Systematic monitoring of the progress in the bioeconomy for a responsible and inclusive governance and coherent policymaking is a key action of the 2018 update of the EU bioeconomy strategy[1]. Its action plan pledges the European Commission to build an EU-wide, internationally coherent monitoring system to track economic, environmental and social progress towards a sustainable and circular bioeconomy.

The EU Bioeconomy Monitoring System (henceforth 'EU-BMS') stems from this basis and was developed by the JRC in cooperation with a broad range of stakeholders around a conceptual framework (Giuntoli et al. 2020) that operationalises the objectives of the bioeconomy strategy into a vision for a sustainable EU bioeconomy. In essence, the EU-BMS is designed as a mechanism to measure the progress of the EU bioeconomy towards the strategic objectives of the Strategy. The EU-BMS was first released in 2020 and is maintained as part of the Knowledge Centre for Bioeconomy (KCB). The system can be consulted online through a dashboard published on the KCB platform[2].

In 2022, the EU-BMS was used as knowledge base to support the quantitative analysis for the EU bioeconomy progress report [3]. The system and the recent trends observed in the EU bioeconomy were presented more extensively in the "Trends in the EU bioeconomy" report (Mubareka et al. 2023). That report, which was the first assessment of EU bioeconomy trends building on the EU-BMS knowledge base, also discussed in detail the rationale behind the EU-BMS itself, its development history, as well as the development of the indicators implemented in the system until the end of 2022. Further in-depth description of the conceptual framework and structure of the EU-BMS and the latest updates of its indicator set are found in Giuntoli et al. 2020, Kilsedar et al. 2021, Kilsedar et al. 2023 and Patani et al. 2024.

In April 2023, the Council of the European Union adopted the "Conclusions on the opportunities of the bioeconomy in light of current challenges with special emphasis on rural areas"[4]. The Council provided recommendations for the European Commission to further integrate bioeconomy into all policies ensuring policy coherence, to facilitate knowledge transfer towards rural areas, and invited the Commission to deliver an update of the Bioeconomy Strategy.

1 European Commission: Directorate-General for Research and Innovation, A sustainable bioeconomy for Europe – Strengthening the connection between economy, society and the environment – Updated bioeconomy strategy, Publications Office, 2018.

2 https://knowledge4policy.ec.europa.eu/bioeconomy/monitoring

3 COM (2022) 283. EU Bioeconomy Strategy Progress Report European Bioeconomy policy: stocktaking and future developments

4 Council conclusions 8406/23 on the opportunities of the bioeconomy in the light of current challenges with special emphasis on rural areas

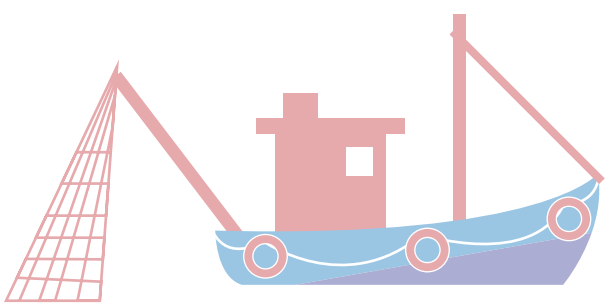
In March 2024 the Commission adopted the Communication "Building the future with nature: Boosting Biotechnology and Biomanufacturing in the EU"[5]. This Communication emphasises biotechnology and biomanufacturing as important enablers for the bioeconomy while at the same time acknowledges that they depend on bioeconomy for their input. In the Communication, the Commission pledges to review the EU bioeconomy strategy by the end of 2025, taking into account current societal, demographic and environmental challenges.

The expected update of the EU Bioeconomy Strategy by 2025 will have to be underpinned by robust scientific evidence. Hence, input from the KCB and the EU-BMS will be essential to support the policy process. There is a need for comprehensive, reliable and comparable information on the bioeconomy and its progress to support decision-making across sectors and across the EU territory at different scales.

The present report on EU bioeconomy trends seeks to respond to this need, describing the progress and recent trends in the objectives of the current EU Bioeconomy Strategy. The report builds on and updates with more recent data and methodologies the analyses in the Mubareka et al. (2023) report, using the data available in the EU-BMS until September 2024.

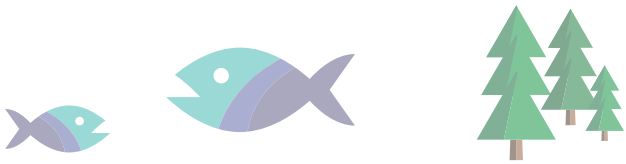
While the focus of this report is on presenting the trends in the EU Bioeconomy through the lens of the EU-BMS, the first part of this report (Chapter 2) takes stock of the different bioeconomy initiatives developed across Europe. It starts with an overview of the EU, then it moves to macro-regional and national policy initiatives that together make up the European bioeconomy's policy landscape. An analysis of the data in the EU-BMS follows, with an assessment pursued at two different levels: through the individual indicators within the EU-BMS (Chapter 3), and at a more aggregate level focusing on the key components of the EU Bioeconomy Strategy objectives (Chapter 4). The report concludes with a summary of the findings whereby insights and synthesis on bioeconomy trends are presented and discussed in Chapter 5.

5 COM (2024) 137 final. Building the future with nature: Boosting Biotechnology and Biomanufacturing in the EU



2 Bioeconomy policy landscape in Europe

The cross-sectoral nature of the bioeconomy and its diversity within Europe, mainly due to the diverse biophysical characteristics and industrial specialisation of EU regions (Fritsche et al. 2020), results into a rich multi-dimensional and multi-level policy landscape. The European bioeconomy is therefore shaped by policies at different levels. At the EU level: the dedicated European Bioeconomy Strategy, overarching policies like the European Green Deal (EGD), cross-cutting policies and related programmes such as those on research and innovation, regional development, climate change, environmental protection, the circular and blue economies as well as sectoral policies focusing on specific bioeconomy sectors including the biomass producing sectors and sectors mainly using biomass. Bioeconomy policies and initiatives also exist, or are being developed, in many of the MS and their regions as well as at macro-regional level.



2.1 EU policies and programmes

A Bioeconomy Strategy for the EU was first adopted in 2012[6], reviewed in 2017[7] and updated in 2018[8]. It has maintained through time five high level objectives: 1. Ensuring food and nutrition security; 2. Managing natural resources sustainably; 3. Reducing dependence on non-renewable, unsustainable resources, whether sourced domestically or from abroad; 4. Mitigating and adapting to climate change; 5. Strengthening European competitiveness and creating jobs.

The 2018 Bioeconomy Strategy provides a coherent framework that favours synergies and addresses trade-offs between sectors and between objectives and it includes an Action Plan along three main action areas: *(i)* strengthen and scale-up the bio-based sectors, unlock investments and markets; *(ii)* deploy local bioeconomies rapidly across Europe; and *(iii)* understand the ecological boundaries of the bioeconomy.

6 COM(2012)60. Innovating for Sustainable Growth: A Bioeconomy for Europe

7 European Commission, Directorate-General for Research and Innovation, Review of the 2012 European Bioeconomy Strategy, Publications Office, 2018

8 European Commission: Directorate-General for Research and Innovation, A sustainable bioeconomy for Europe – Strengthening the connection between economy, society and the environment – Updated bioeconomy strategy, Publications Office, 2018.

In 2019, the Commission launched the EGD with the ambition to transform the EU into a modern, resource-efficient and competitive economy. Under the EGD vision, there are no net emissions of greenhouse gases by 2050, economic growth is decoupled from resource use and no person and no place is left behind. The EGD triggered a wave of initiatives across the full EU policy spectrum in the period 2020-2024. Given the importance of the bioeconomy for EGD, recognised also by the Council[9] and the Commission[10], many of these initiatives address, or influence, the bioeconomy system e.g. biomass-producing sectors, sectors using biomass and marine and land ecosystems. These include reviews of well-established sectoral or thematic policies resulting to e.g. a new Common Agricultural Policy[11], a new Forest Strategy[12], a new Industry Strategy[13], a new Biodiversity Strategy[14], an updated Renewable Energy Directive[15]. They also included the development of fresh policy initiatives that take a more systemic perspective- such as a new Farm to Fork Strategy[16], a new Blue Economy approach[17], a new Circular Economy Action Plan[18], the Biotechnology and Biomanufacturing initiative[19], the Nature Restoration law[20], the Soil Strategy[21] and the proposed law on Soil Monitoring and Resilience[22] and follow-up initiatives e.g. a new EU policy framework on biobased, biodegradable and compostable plastics[23], a long-term Vision for the EU's Rural Areas[24], a sustainable carbon cycles initiative[25], an EU strategy to reduce methane emissions[26], a new Chemicals Strategy[27], the EU climate law[28] and the amended LULUCF Regulation[29], the proposed Regulation for a carbon removal certification framework[30].

The progress made in the Bioeconomy Strategy's implementation was assessed in a report published in 2022.[31] The progress report contextualises the EU Bioeconomy within the EGD recognising it as both *enabler* and *result* of the EGD. As an *enabler,* the bioeconomy is described as facilitating coherence (policy coherence, and vertical coordination at local, regional, national, EU and international levels); as a *result,* the bioeconomy is attributed to an aspirational way of life for Europeans.

In the "Conclusions on the opportunities of the bioeconomy in the light of current challenges with special emphasis on rural areas"[32], adopted in April 2023, EU Member States (MS) present a holistic and cross-cutting vision of the bioeconomy,

9 Council conclusions (14594/19) on the updated Bioeconomy Strategy "A sustainable Bioeconomy for Europe: strengthening the connection between economy, society and the environment"

10 COM (2022) 283. EU Bioeconomy Strategy Progress Report European Bioeconomy policy: stocktaking and future developments

11 The common agricultural policy: 2023-27

12 COM (2021) 572 final. New EU Forest Strategy for 2030

13 COM (2020) 102 final. a New Industrial Strategy for Europe

14 COM (2020) 380 final. EU Biodiversity Strategy for 2030 Bringing nature back into our lives

15 Directive (EU) 2023/2413 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652

16 COM (2020) 381 final. A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system

17 COM (2021) 240 final. A new approach for a sustainable blue economy in the EU.

18 COM (2020) 98 final. A new Circular Economy Action Plan For a cleaner and more competitive Europe

19 COM (2024) 137 final. Building the future with nature: Boosting Biotechnology and Biomanufacturing in the EU

20 REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on nature restoration and amending Regulation (EU) 2022/869

21 COM (2021) 699 final. EU Soil Strategy for 2030. Reaping the benefits of healthy soils for people, food, nature and climate

22 COM (2023) 416: Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Soil Monitoring and Resilience

23 COM (2022) 682 final. EU policy framework on biobased, biodegradable and compostable plastics

24 COM (2021) 345 final. A long-term Vision for the EU's Rural Areas - Towards stronger, connected, resilient and prosperous rural areas by 2040

25 COM (2021) 800 final. Sustainable Carbon Cycles.

26 COM(2020) 663 final. EU strategy to reduce methane emissions

27 COM (2020) 667 final. Chemicals Strategy for Sustainability Towards a Toxic-Free Environment

28 REGULATION (EU) 2021/1119 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing the framework for achieving climate neutrality

29 Regulation (EU) 2023/839 of the European Parliament and of the Council of 19 April 2023 amending Regulation (EU) 2018/841 as regards the scope, simplifying the reporting and compliance rules, and setting out the targets of the Member States for 2030, and Regulation (EU) 2018/1999 as regards improvement in monitoring, reporting, tracking of progress and review (Text with EEA relevance)

30 COM (2022) 672: Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a Union certification framework for carbon removals

31 COM (2022) 283. EU Bioeconomy Strategy Progress Report European Bioeconomy policy: stocktaking and future developments

32 Council conclusions 8406/23 on the opportunities of the bioeconomy in the light of current challenges with special emphasis on rural areas

acknowledging its positive impacts on the environmental, economic and social challenges and on the EGD targets.

The conclusions welcome the progress in implementing the 2018 Bioeconomy Strategy Action Plan, in particular mobilising private investments, start-ups, research and innovation in bio-based industries but also developing national and regional bioeconomy strategies. They explicitly acknowledge the efforts to enhance the knowledge base for policies by the KCB and the EU-BMS, to systematically monitor economic, environmental and social progress towards a sustainable EU bioeconomy.

The Council recommended the European Commission to further integrate bioeconomy into all relevant policies ensuring policy coherence, to facilitate knowledge transfer towards rural areas and finally to update the EU Bioeconomy Strategy and associated Action Plan, also carrying out an in-depth assessment of actions taken at EU level.

In March 2024, with the Communication "Building the future with nature: Boosting Biotechnology and Biomanufacturing in the EU"[33], the Commission announced the review of the bioeconomy strategy by end 2025, taking into account the current societal, demographic and environmental challenges, reinforcing the bioeconomy's industrial dimension and its links to biotechnology and biomanufacturing to contribute to a stronger EU economy.

Moreover, in their Conclusions on the future of industrial policy in May 2024[34], EU MS have urged the Commission "to finalise the update of the bioeconomy strategy by the end of 2025, to ensure that the bioeconomy contributes substantially to the green transition of the economy, to recognise biotechnology and the bio-based economy horizontally as an elementary part of the EU's industrial policy, and to ensure coordination in order to enhance policy coherence".

While preparations are ongoing for the strategy update, the bioeconomy is gaining further importance in the EU strategic agenda (see the EU Strategic Agenda 2024-2029[35], the European Investment Bank Roadmap 2024-2027[36], the EC Presidency political guidelines[37]). In parallel, international and global initiatives on the bioeconomy are flourishing, such as the Bioeconomy G20 Initiative on Bioeconomy promoted by Brazil[38], with the establishment of global bioeconomy high-level principles[39], the Global Bioeconomy Summit[40] and the International Bioeconomy Forum[41], with specific ad-hoc working groups and varied participation based on the topic.

Several instruments are available to provide public financial support to bioeconomy projects in the form of grants, loans and equity, starting from the EU's research and innovation programmes. Under Horizon 2020, the European Commission already dedicated substantial public investment into bioeconomy projects in the period 2014-2020, including under the Bio-based Industries Joint Undertaking (BBI JU). Further research on innovative bioeconomy areas is currently being financed through the Horizon Europe programme (2021-2027), including Circular Bio-based Europe Joint Undertaking[42] (CBE JU), successor of BBI-JU.

Other relevant EU funding programmes include the LIFE programme and the European Structural and Investment Funds (ESIFs), comprising the European Agricultural Fund for Rural development fund (EAFRD), the European Maritime and Fisheries Fund[43] (EMFF), which committed €23.9 million to the blue

33 COM(2024) 137 final - Building the future with nature: Boosting Biotechnology and Biomanufacturing in the EU

34 Council conclusions 10127/24 - A competitive European industry driving our green, digital and resilient future

35 European Council, Strategic Agenda 2024-2029, 2024.

36 European Investment Bank, EIB Group 2024-2027 Strategic Roadmap, 2024.

37 von der Leyen, U., Political Guidelines for the next European Commission 2024-2029

38 https://www.g20.org/en/tracks/sherpa-track/bioeconomy-initiative

39 https://www.g20.org/en/news/g20-reaches-consensus-and-establishes-high-level-principles-on-bioeconomy

40 https://gbs2024.org/

41 https://research-and-innovation.ec.europa.eu/research-area/environment/bioeconomy/global-partnerships_en

42 https://www.cbe.europa.eu/

43 https://oceans-and-fisheries.ec.europa.eu/funding/european-maritime-and-fisheries-fund-emff_en

bioeconomy by the end of 2020[44] and was succeeded by the new European Maritime, Fisheries and Aquaculture Fund[45], in force until 2027; the Cohesion Fund (CF) and the European Regional Development Fund (ERDF), focusing its investments on several key priority areas including innovation and research and the low-carbon economy, under which EU regions publish Smart Specialisation Strategy documents which outline priority R&I areas such as agriculture, waste processing and biorefineries.

2.2 Macro-regional initiatives

There are currently four large macro-regional bioeconomy initiatives in Europe, involving governmental authorities:

- **BIOEAST - Central and Eastern European initiative for knowledge-based agriculture, aquaculture and forestry in the bioeconomy**[46] (see also *Focus box 1*): Since 2016, the initiative offers a shared strategic research and innovation framework for working towards sustainable bioeconomies in 11 Central and Eastern European (CEE) countries[47], promoting bioeconomy development, calling for a macro-regional perspective and a wider cooperation with the rest of EU countries. BIOEAST is supported by the European Union's Horizon Europe Programme for Research and Innovation. BIOEAST has led two Coordination and Support Actions (BIOEASTSUP[48], Boost4Bioeast[49]), high-level events on the role of the initiative within the Green Deal and on the deployment of the bioeconomy at the regional level, including Regional Innovation Valleys, as well as a macroregional foresight exercise, highlighting possible transition pathways for the deployment of the bioeconomy in the macro-region. Recently, BIOEAST has published a stakeholder manifesto on sustainable supply chains and strengthened local processing of bioresources in Central and Eastern Europe.

- **Nordic bioeconomy**[50]: Under the Nordic Bioeconomy Panel, convened in 2014, it draws up proposals for a strategy covering the area[51] and outlines options and practical measures to promote sustainable bioeconomies, with a focus on forestry and blue economy, following a specific action plan[52], which calls for innovation, acceleration and networking activities. Under the West Nordic Bioeconomy Panel, the West Nordic Bioeconomy[53] is an initiative whose goal is to suggest a sound strategy for the West Nordic region (Iceland, Greenland and Faroe Islands) in order to maintain and strengthen its bioeconomy, as well as to communicate that strategy.

- **A bioeconomy for the Baltic Sea Region**[54]: Bioeconomy is one of the 13 policy areas covered by the EU Strategy for the Baltic Sea Region (EUSBSR). The Nordic Council of Ministers leads the work on the bioeconomy together with partners from Finland, Sweden and Lithuania. In this capacity, the Nordic Council of Ministers provides an access point and support function for stakeholders that wish to pursue bioeconomy cooperation activities that support overall objectives of the EUSBSR.

- **WestMED[55], Initiative for the sustainable development of the blue economy in the western Mediterranean: established in 2017**[56] by the European Commission and endorsed by the Council, it is focused on blue economy development in 10 Western Mediterranean countries, including 5 EU MS

44 https://op.europa.eu/en/publication-detail/-/publication/ae0a36d3-eac3-11ec-a534-01aa75ed71a1

45 https://oceans-and-fisheries.ec.europa.eu/funding/emfaf_en

46 https://www.bioeast.eu

47 Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia

48 https://bioeast.eu/bioeastsup/

49 https://bioeast.eu/objectives/

50 https://www.norden.org/en/bioeconomy

51 Denmark, Finland, Iceland, Norway and Sweden have been members of the Nordic Council of Ministers since 1971. Greenland, the Faroe Islands and Åland have followed.

52 http://norden.diva-portal.org/smash/get/diva2:1222743/FULLTEXT01.pdf

53 https://www.matis.is/media/utgafa/actions_for_sustainable_bioeconomy_in_the_west_nordic_region.pdf

54 https://eusbsr.eu/policy-area-bioeconomy/

55 https://westmed-initiative.ec.europa.eu/

56 COM (2017) 0183 final, Initiative for the sustainable development of the blue economy in the western Mediterranean

and 5 Southern partner countries[57]. They are collaborating and supporting each other on a set of priorities, including sustainable consumption and production, blue skills and jobs, decarbonisation of the blue economy and, importantly, boosting the Marine Renewable Energy sectors, increasing ambition for preserving marine and coastal biodiversity in the Mediterranean, promoting training and technology transfer.

The European Territorial Cooperation Programmes – Interreg - play an important role in developing regional and, especially, multi-regional bioeconomy strategies. They are the motor behind additional macro-regional initiatives, the first two are currently active, the other four have ended:

- **BIOECO-UP, Circular BioEconomy Market Uptake and Policy Support in Central Europe**[58] (2023-2026): this project aims to establish the concept of circular bioeconomy across central Europe. The partners[59] aim to design new circular value chains for the bioeconomy and initiatives to change consumer behaviour, as well as to support the policy makers to mainstream circular bioeconomy policies, in collaboration with the BIOEAST initiative.

- **INNOBIOVC, Innovation Express for Circular Bioeconomy Value Chains (2023-2024): this project builds on solutions developed by the two Interreg Alpine Space projects ARDIA-NET and AlpLinkBioEco to create a new tool that allows partners**[60] to find out about funding opportunities, best partners, and to measure sustainability gains of circular products.

- **Danube Region (DanubeBioValNet, 2017-2019)**[61]: this project launched in 2017 is a cross-regional partnership involving 16 partners from 10 Danube regions to develop three bio-based value chains: phytopharma, eco-construction and bio-based packing (bioplastic) as well as the hemp industry.

- **AlpLinkBioEco, Linking BioBased Industry Value Chains Across the Alpine Region (2018-2021)**[62]: a cross-regional and circular bio-based economic strategy which released the Masterplan towards a joint bioeconomy strategy for the Alpine Space.

- **BIO-ECOnomy Research Driven Innovation for the Adriatic-Ionian Region (Bioeco-RDI-ADRION, 2018-2020)**[63]: an initiative to support the development of a regional innovation system for the Adriatic-Ionian area.

- **Bio-Innovation Support for Entrepreneurs throughout NWE Regions (BioBase4SME, 2016-2019)**[64]: initiative involving organisations from 6 European countries (BE, DE, NL, IE, FR and the UK) to advise SMEs from across North-West Europe on how to develop new ideas into marketable products.

57 Countries covered: Algeria, France, Italy, Libia, Malta, Mauritania, Morocco, Portugal, Spain and Tunisia.

58 https://www.interreg-central.eu/projects/bioeco-up/

59 Countries covered: Austria, Croatia, Czechia, Hungary, Italy, Poland, Slovakia, Slovenia.

60 Countries covered: Germany, Austria, Slovenia, Italy, Switzerland

61 https://www.interreg-danube.eu/approved-projects/danubiovalnet.

62 https://www.alpine-space.eu/project/alplinkbioeco/

63 https://bioecordi.adrioninterreg.eu/.

64 https://www.nweurope.eu/projects/project-search/bio-innovation-support-for-entrepreneurs-throughout-nwe-regions/#tab-1.

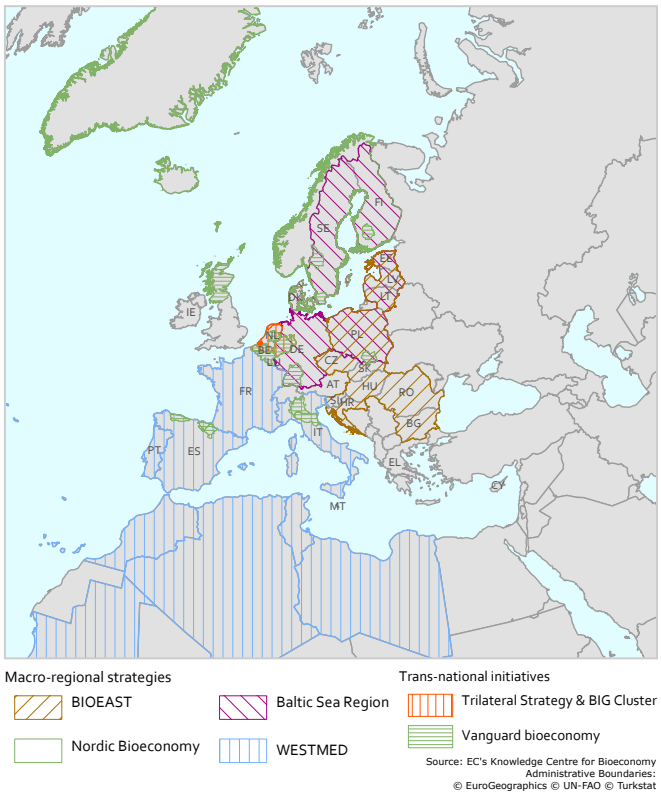
Additional trans-national initiatives with a bioeconomy focus are driven by private companies and innovation clusters:

- **The Trilateral Strategy for the chemical industry**[65]: trilateral Strategy for the Chemical Industry Cross-border Cooperation of the Netherlands, Flanders, and North-Rhine Westphalia to strengthen the competitiveness of the chemical industry and to improve economic growth.

- **Bio Innovation Growth mega Cluster (BIG-Cluster)**[66]: Cross-border 'Smart Specialisation Initiative' aiming at transforming Europe's industrial mega cluster in the Flanders region of Belgium, the Netherlands and the German state of North Rhine-Westphalia into the global leader of biobased innovation growth.

- **Vanguard Initiative**[67]: the Vanguard Initiative was established in 2013 by ten European regions as a showcase of industry-led interregional cooperation, co-creation, and co-investment, based on smart specialisation. The Bioeconomy Pilot in Vanguard has a two-fold objective: i) support the deployment of technologies with high Technology-Readiness-Level (TRL), through the setting up of trans-regional value chains and ii) identify critical challenges beyond the capabilities of a single region to team up skills, energies and resources that can make a difference in market terms. Seven demo cases are being developed, from lignocellulose biorefinery to food and feed ingredients form algae. The bioeconomy initiative is co-lead by two regions, Lombardia (IT) and Randstat (NL) with 17 additional regions participating (see *Figure 2*).

Figure 2. Macro-regional bioeconomy initiatives in Europe (updated September 2024)



Source: European Commission's Knowledge Centre for Bioeconomy, 2024

65 https://www.trilateral-chemical-region.eu/strategy.

66 https://www.bigc-initiative.eu/index.php.

67 https://www.s3vanguardinitiative.eu/pilots/bio-economy

Focus box 1. Facts and figures on bioeconomy in the BIOEAST area

Bioeconomy in the BIOEAST area has different development status among the countries, however it is overall quite important for the area. In most of the BIOEAST countries national bioeconomy strategies are either under development or embedded in other policy initiatives. Two countries have a dedicated bioeconomy strategy at national level (Latvia and Estonia), six countries have a dedicated bioeconomy strategy at national level under development (Croatia, Czechia, Hungary, Lithuania, Poland, Slovakia), while the remaining three (Bulgaria, Romania and Slovenia) include the bioeconomy under other policy initiatives, such as circular economy strategy or agricultural policy. The analysis of the dedicated bioeconomy strategies in Latvia and Estonia, is summarised in *Table 1*. In most countries, the ministry of agriculture is among the lead institutions, together with ministries of economics and of innovation (data from the KCB Country dashboards).

In 2021, the area employed in total 6.92 million people in biomass producing and converting sectors, around 1/3 of the EU total. The sectors with most people employed are agriculture, food, beverage and tobacco, wood products and furniture, with a declining trend over the last decade. The value added in biomass producing and converting sectors reached 107 billion in 2021 (1/7 of EU total), with an increasing trend in the last decade (*Figure 3*).

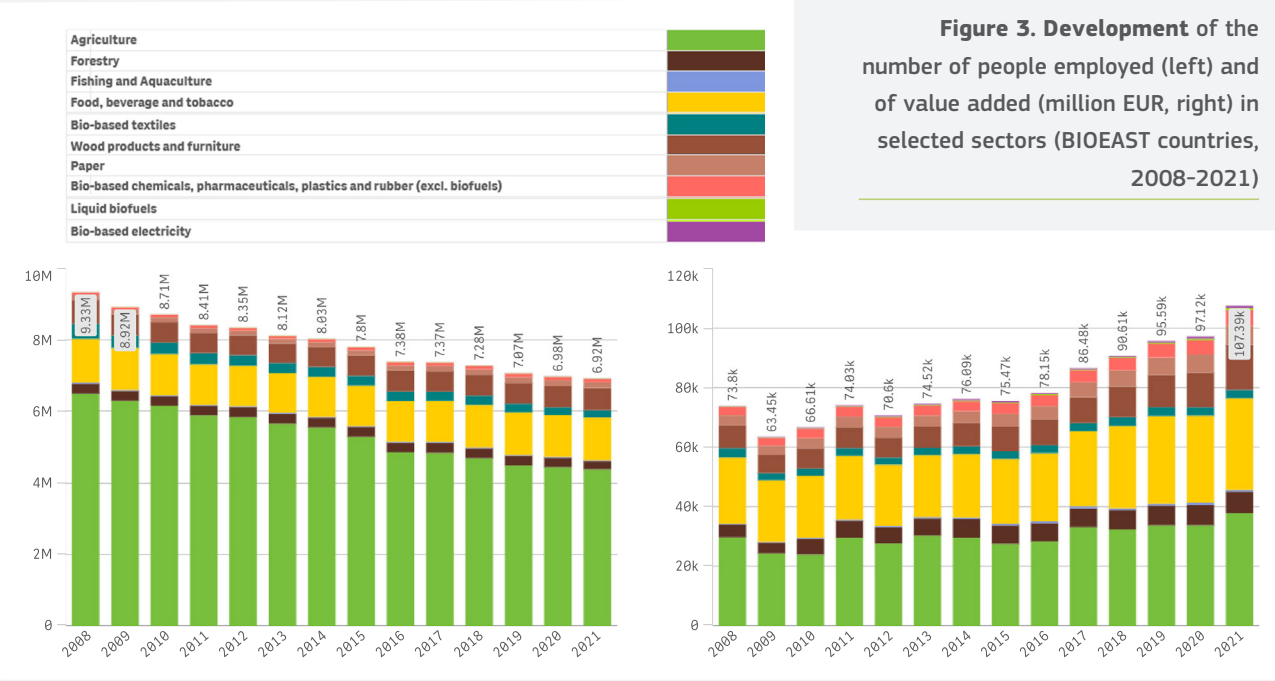


Figure 3. Development of the number of people employed (left) and of value added (million EUR, right) in selected sectors (BIOEAST countries, 2008-2021)

Source: Lasarte-López et al. 2023b.

The concept of bioeconomy is understood similarly across the 11 BIOEAST countries [68], with a focus on the sustainable use of biological resources to produce food, feed, bio-based products, and bioenergy. Most countries emphasise the importance of a circular economy approach, where biomass is used efficiently and waste is minimised. However, differences and specific focus areas in the scope of bioeconomy can be observed.

At the regional level, Poland is a country with intense regional strategic action to deploy bioeconomy, with more than 15 regions with bioeconomy-relevant strategies and more than one strategy per region. Czechia, Croatia, Hungary, Lithuania, Latvia, Romania and Slovakia, have moderate regional strategic action to deploy bioeconomy (between 1 and 15 regions with bioeconomy-relevant strategic frameworks). Bulgaria, Estonia and Slovenia had no bioeconomy-relevant regional strategies at the time of the analysis in 2021 (Haarich et al. 2022).

68 BioEastsup bioeconomy concept papers, https://bioeast.eu/documents/

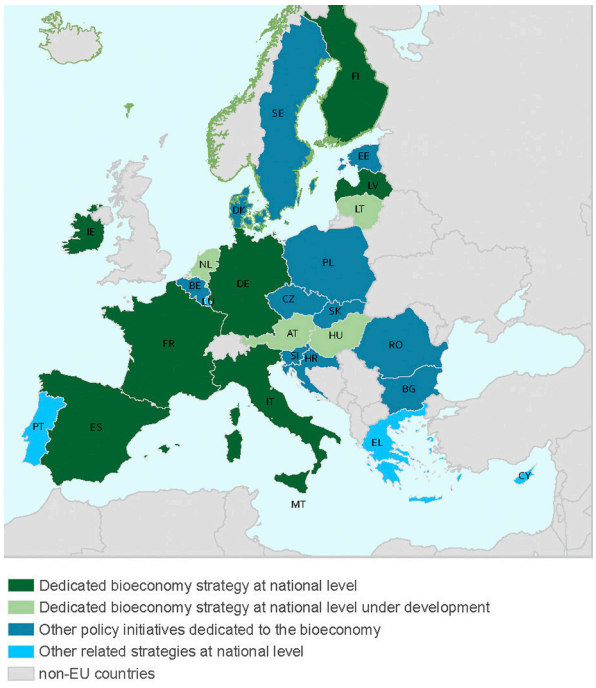
2.3 National bioeconomy strategies and other policy enabling measures

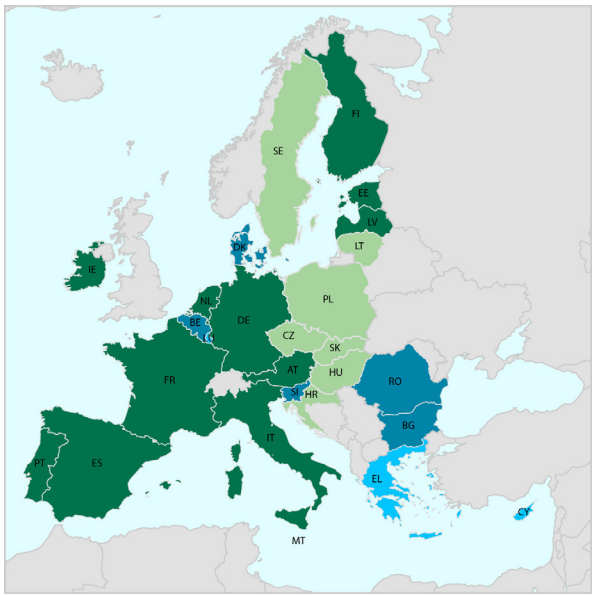
As of September 2024, there are eleven MS with national strategies dedicated to the bioeconomy (Austria, Germany, Spain, Estonia, France, Finland, Ireland, Italy, Latvia, Netherlands and Portugal) and seven other MS with such strategies under development (Czechia, Croatia, Hungary, Lithuania, Poland, Sweden and Slovakia). Five MS have other policy initiatives dedicated to the bioeconomy (namely sub-national bioeconomy strategies in Belgium and the macro-regional strategies described in section 1.2 in Bulgaria, Denmark, Romania and Slovenia). The remaining four MS (Cyprus, Greece, Luxemburg and Malta) have strategies related to the bioeconomy such as National Energy and Climate Plans, National Strategies on Adaptation to Climate Change and Circular Economy Strategies (see *Figure 4*).

The JRC report on trends in the EU bioeconomy published in February 2023 (Mubareka et al. 2023), provided a comprehensive overview of the developments in bioeconomy national policies since 2018. More recent developments include a new circular bioeconomy strategy in Estonia[69] and a new National Bioeconomy Action Plan 2023-2025 for Ireland[70] (see *Figure 5*).

For the eleven MS with dedicated bioeconomy strategies, the policy documents were screened to identify: i) the different economic sectors addressed and; ii) specific policy actions and initiatives included in the national strategies or action plans, aiming at enabling the bioeconomies in the different countries[71].

Figure 4. Status of national bioeconomy strategies in the EU-27 before the EU Bioeconomy strategy 2018, (above) and as of September 2024 (below).





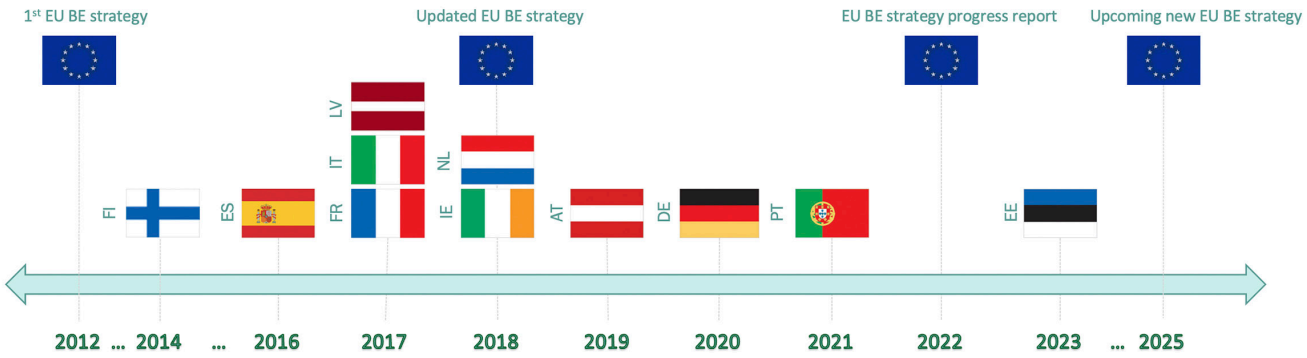
Source: European Commission's Knowledge Centre for Bioeconomy, 2024

69 https://www.agri.ee/en/objectives-and-activities/bioeconomy

70 https://www.gov.ie/en/publication/a1bb6-bioeconomy-policy/

71 Generic and/or broad actions without a dedicated focus, e.g. "*Promotion of bioeconomy and public involvement*" or "*Maintain and developing jobs during the transformation to the bioeconomy*", were not considered in this analysis.

Figure 5. Timeline of national bioeconomy strategies' adoption in the EU-27



Source: European Commission's Knowledge Centre for Bioeconomy, 2024

All main bioeconomy sectors are addressed in most national bioeconomy strategies (*Figure 6*). Two exceptions are the Austrian bioeconomy strategy, not explicitly addressing the fisheries sector; and the Estonian bioeconomy strategy, not addressing the sectors of "bio-based textiles", "bio-based chemicals and materials", "organic food waste" and "ecosystem services". 'Other specific sectors addressed in national strategies include e.g. bio-pharmaceuticals (DE); bio-fertilisers, bioplastics, bio-stimulants and bio-lubricants (IT); construction, water treatment and supply, nature tourism (FI); footwear and natural resin (PT), etc.

Most common policy measures or actions adopted in national strategies are those related to promote "investments in bioeconomy research, innovation, market development", "communication campaigns for awareness raising" and "the principles of cascading use, circularity and resource efficiency for biomass". Initiatives of those categories were found in the action plans or strategies of all 11 MS analysed. Some examples of actions to promote investments are the creation of public funds or funding instruments for innovation partnerships, cooperation platforms and for bioeconomy-specific research and innovation; the creation of open marketplaces based on public sector innovation and procurement needs, etc. The actions found in the national strategies aiming to 'promote the principles of cascading use, circularity and resource efficiency for biomass' are typically generic statements of support to the recovery and valorisation of different types of wastes and by-products.

Figure 6. Overview of sectors and actions in Bioeconomy Strategies of EU Member States.

Focus		Bioeconomy Strategies of Member States: AT	DE	EE	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)	●	●	●		●	●		●	●	●	

Source: elaboration of data from the European Commission's Knowledge Centre for Bioeconomy, 2024.

The following groups of actions were identified in the national strategies or action plans in most of the 11 MS analysed:

- Actions to 'revisit existing regulatory frameworks to include bioeconomy concepts/priorities'. These included e.g. promotion of bioeconomy priorities and actions in the frame of national and regional Smart Specialisation Strategies (IT); administrative fees associated with the use of secondary raw materials (PT); removal of regulatory obstacles and facilitation of investment on agricultural methanisation (FR), etc.

- Actions to 'promote the establishment of intra-governmental groups to support policy coherence or collaboration amongst different bioeconomy

stakeholders', e.g. a National Bioeconomy Coordination Board to coordinate and monitor the implementation of the Action Plan (DE); a national bioeconomy panel to step up interaction between the government, the scientific community and enterprises and industry (FI); a Bioeconomy Strategy Management Committee to foster implementation of the strategy's measures (ES).

- Actions to promote labels and standards for bio-based products, e.g. adaptation of labels for the designation of bio-based products (AT); set up a recognised label "Biobased product" at European scale on the bio-based content (FR); identify existing certifications/logos/labels (such as bio-based, biodegradable and/or compostable certification, eco-labels) and analyse barriers to the adoption of accredited certifications (PT).

- Actions to promote public procurement of bio-based products, e.g. strengthen the acquisition of bio-based products in the review of the National Strategy for Ecological Public Procurement (PT); replacement of non-renewable resources with bio-resources in public procurement (LV); updating government resolutions on public contracts to also cover bioeconomy procurements by 2016 (FI).

- Actions to implement specific studies, e.g. assessment of the institutional and legal framework as well as regional and local effects of the bioeconomy (AT); evaluate the sustainability of biomass use by generally accepted methods (FI); publish a feasibility study on the establishment of National Marine Biomaterials Repository (IE).

- Actions to promote 'educational and/or training programmes', e.g. provision of excellent education services for the needs of bioeconomy industries (LV); creation of new Bachelors and Masters' University degree programs in Bioeconomy (IT); inclusion of bioeconomy as topic in new training and further education programmes, courses at vocational and technical schools and technical colleges and universities (DE).

Some other policy actions were found to be less common in the national bioeconomy strategies or action plans. These included measures to enhance land management for new production systems and ecosystem functions (e.g. in Italy to monitor degraded land areas or lands at risk of climate change impacts to underpin actions for soil health improvement); to promote specific bioeconomy sectors (in Germany where it is encouraged to develop, exploit and deploy digital technologies in agriculture and forestry and analyse associated innovative business models); enhance the knowledge on bioeconomy (e.g. the creation of the Spanish bioeconomy observatory); develop monitoring systems for the bioeconomy (measures to improve monitoring and exploration capacity in the Netherlands and the creation of statistics system on the bioeconomy in Finland, see *Focus box 3*); and market incentives for bio-based production/consumption (e.g. creation of predictable and stable tax policy for the bioeconomy sector in Latvia).

'Embedding the bioeconomy into new legislative frameworks' is a policy action contemplated in only two national bioeconomy strategies. In Finland the development of a bioeconomy regulation is planned, while in Italy it is encouraged to embed the bioeconomy strategy into a legislative framework to guarantee its recognition and application, according to a biannual implementation plan.

The regulatory frameworks such as strategies, roadmaps or action plans set a direction where European, national or regional governments intend to direct their policies, i.e. they outline the public policy objectives, but do not usually imply legally binding obligations. Thus, some of the policy actions and measures mentioned above may not be eventually deployed.

The list of policy documents considered and related actions extracted for this mapping is detailed in *Table 1.*

Table 1. Bioeconomy policy documents considered for mapping the actions in EU Member States with dedicated bioeconomy strategies.

Country	Source document	Comment / details
Austria	*The Austrian Bioeconomy Strategy*	The Austrian bioeconomy strategy sets six target areas which are broken down into operational targets that "will enable an effective transition to the actions in the Action Plan". Furthermore, the Austrian strategy establishes "fields of action" in 23 different areas (called in the strategy "spheres"), including "circular economy", "Wood as a Construction and Building Material", "science and research", etc. For each of these fields of action, a series of more specific measures are detailed.
Estonia	*Circular Bioeconomy Roadmap for Estonia*	Estonia aims to become a recognised development centre for bioeconomy in Europe and has integrated it as a horizontal and cross-cutting theme in its Agriculture and Fisheries Development Plan 2030 and other related plans. The country has a strong biomass production base, but there is a need to increase added value and innovation potential for sustainable development of the circular bioeconomy, contributing to climate change mitigation, biodiversity preservation, social, and economic development. The circular bioeconomy roadmap defines activities for its development in Estonia, with regional roadmaps focusing on local bio-resources, community needs, and opportunities for innovative local initiatives and collaborations.
Finland	*The Finnish Bioeconomy Strategy*	The Finnish strategy sets a vision and objective for the national bioeconomy, together with generic, but measurable, targets in terms of jobs and turnover. Furthermore, the strategy establishes four strategic actions to help implement such vision and targets, such as "creating a competitive operating environment for the bioeconomy" and "securing the accessibility and sustainability of biomasses". For each of these actions the strategy sets specific (2 to 6) goals; each of these goals is accompanied by a series of (2 to 5) measures. The strategy allocates responsibilities for these measures (namely governmental organisations and ministries) as well as other actors to be involved.
France	*A Bioeconomy strategy for France - Action Plan 2018-2020*	Translated from the original document in French. The action plan identifies 5 priority axes, from "enhancing the knowledge on bioeconomy" to "removing obstacles and mobilise funding". For each of those axes, the action plan establishes a series of (4 to 18) operational and specific actions, detailing an estimated timeline, expected deliverables, etc.
Germany	*National bioeconomy Strategy from Germany*	The German strategy sets 6 central action areas for a sustainable bioeconomy to improve the policy framework, from "Reduction of the pressure on land" to "Exploitation of the potential of digitisation for the bioeconomy". Furthermore, an additional cross cutting action area on political coherence linking industry policy, energy policy, agricultural, forestry and fisheries policy and climate and environmental policy is detailed.
Ireland	*National Policy Statement on the Bioeconomy* and on *Bioeconomy Implementation Group - First and Second Progress Report*	The national statement of Ireland identifies 7 broad key actions for the future success of the bioeconomy in Ireland, based on extensive consultation and analysis. These actions include from "Ensuring that there is coherence between all sectoral strategies which impact on the bioeconomy in Ireland" to "examining how greater primary producer, public and consumer awareness of the bioeconomy". The first Progress Report assessed the advancement in the seven key actions from the policy statement by taking stock of the specific milestones achieved at the time of its publication (Q3 of 2019). The second progress report, published in 2023, outlines steps on accountability, transparency, coherency, participation and fairness.

Country	Source document	Comment / details
Italy	*Bioeconomy Strategy of Italy* and the *Italian Implementation Action Plan*	The strategy identifies the R&I agenda and priority actions as well as measures creating and guaranteeing the framework conditions required for its effective implementation. It also sets measurable targets of turnover and employment. The Italian Bioeconomy Implementation Plan identifies operational actions under four broad headings, from "Promoting the development/adoption of policies, standards, labels and emerging market-based actions and incentives" to "Promoting awareness, skill upgrading, education, attitude, training, and entrepreneurships across the Bioeconomy". Each action is accompanied by a set of (5 to 14) sub-actions and recommendations.
Latvia	*Latvian Bioeconomy Strategy 2030*	Only the short summary available in English was analysed. The Latvian strategy establishes five key integrated and complementary groups of measures, from "Attractive business environment for the entrepreneurship in bioeconomy" to "Socially responsible and sustainable development". Each of these groups comprise a series of (3 to 10) actions, some quite specific and targeted (e.g. "Replacement of non-renewable resources with bio-resources in public procurement") some others rather broad and abstract (e.g. "Export promotion measures").
Netherlands	*The position of the bioeconomy in the Netherlands*	This document establishes 8 pillars (themes) vital in the development of bioeconomy policy, including "Using resources within the planetary boundaries", "Sustainable resource management" or "Regional strategy and rural development". The position paper also establishes a transition agenda to boost the bioeconomy in the Netherlands, most of them quite general and some others (e.g. "transition agenda for biomass and food") more concrete. NB. Since this analysis the document "the position of the bioeconomy in the Netherlands" has been recently removed from official websites of the Dutch government.
Portugal	*Action Plan for a Sustainable Bioeconomy. Horizon 2025*	Translated from the original document in Portuguese. The action plan identifies five axes of action, including "Encouraging sustainable production and intelligent use of regionally-based biological resources"; "promoting research, development and innovation and enhance the national scientific and technological capacity of excellence"; "monitoring the bioeconomy", etc. For each axis, the action plan establishes several objectives and specific measures and points to relevant instruments and other relevant strategic documents. The measures are well described and classified into areas of intervention.
Spain	*The 2016 Action Plan from the Spanish Bioeconomy Strategy*	The "Spanish Bioeconomy Strategy, Horizon 2030" is accompanied by the 2016 Action Plan. This action plan includes 5 groups of actions broken down each of them into a series of measures, some quite generic but some others very targeted and specific.

Source: own elaboration

Focus box 2. EU Member States' position papers

Recently, EU Member States have started to bring together reflections around bioeconomy and sustainability, in order to inform the next EU policy cycle with their perspective.

In February 2024, Estonia, Finland, Italy, Latvia, Spain and Sweden have prepared a non-paper on key actions for Bioeconomy in the EU [72], highlighting that *'The EU must maintain its leading role in bioeconomy and transcend global competitiveness by investing heavily in strategically important areas such as biotechnology and biosecurity. It is crucial for the EU to rapidly unleash the full potential of its sustainable bioeconomy'*. The non-paper suggests a series of action points for the EU Commission including: aim for policy coherence with bioeconomy as integral part of the EU industrial policy; funding targeted R&D efforts, including innovations and bio-based industrial applications; establishing an industrial alliance, generating supporting actions for collaboration among academic and private sectors.

In April 2024, the Netherlands, Czechia, Ireland, Slovakia, Spain, Romania and France have signed a joint statement on sustainable Carbon Policy Package[73], stressing the importance of an overarching policy framework to realise the shift from fossil to sustainable carbon feedstock, calling for: a market for chemicals and plastics made from sustainable carbon sources; tools to support a strategic industry in the field and ensure a global level playing field, and a sustainable carbon availability strategy aligned with the Waste Framework Directive and the EU bioeconomy strategy.

72 Non-paper on bioeconomy: Key Actions for Bioeconomy in the EU, signed by Estonia, Finland, Italy, Latvia, Spain and Sweden

73 Joint Statement on a European Sustainable Carbon Policy Package, signed by The Netherlands, the Czech Republic, Ireland, France, Slovakia, Spain and Romania

Focus box 3. Bioeconomy monitoring frameworks in EU Member States.

Out of the 11 MS that have adopted a national bioeconomy strategy, six (DE, FI, IE, IT, NL, PT) have foreseen or have already in place a monitoring system for the bioeconomy (see *Figure 6*).

Germany initiated a comprehensive monitoring programme for the bioeconomy in 2016, aiming to track trends in the development of the bioeconomy and to better understand dependencies and impacts[74]. It is structured along three topic areas: (i) resources and their sustainability; (ii) economic effects and economic development of the bioeconomy, and (iii) systemic monitoring, integrating data, indicators and models to provide a systemic, holistic insight into the bioeconomy (Robert et al. 2020).

Finland started monitoring with a focus on the socio-economic dimensions of the bioeconomy in its 2014 strategy but in the new Finnish strategy[75], published in 2022, the monitoring system is broadened to address ecological, economic and social sustainability mostly by using existing indicators, including ecosystem services-related indicators and those from the EU Bioeconomy Strategy[76].

Italy[77] in its first strategy[78] identified a monitoring system along 8 areas (biomass availability, productive and employment structure, human capacity, innovation, investment, demographics and markets) and an additional set of sustainability indicators structured along 5 environmental and social objectives (in line with the EU Strategy objectives). The national strategy updated in 2019[79] also aims to adopt a methodological framework and use standardised indicators to measure the value of ecosystem services and to align funding mechanisms.

In some MS the work towards a national monitoring system is in its initial stages. For instance, the bioeconomy national strategy of Portugal[80] (2021) foresees an action to develop a system of key performance indicators at national and regional levels to assess/measure the evolution of Bioeconomy in Portugal; while Ireland specifically includes in its 2019-2020 Action plan[81] an action to liaise with the EU Commission on the EU-wide, internationally coherent monitoring system to track the progress towards a sustainable, circular bioeconomy in Europe and to underpin related policy areas. A prototype bioeconomy monitoring dashboard is under development within the nationally-funded project InformBIO[82].

Some MS, such as Spain and Finland, aim to monitor specifically the implementation of the strategy (i.e. not the progress of the Bioeconomy) mainly by assessing a few socio-economic indicators (e.g. employment, value added, investment, etc.). Spain in 2016 additionally foresaw the establishment of the Spanish Bioeconomy Observatory in charge of developing a monitoring system for the national bioeconomy, for which an initial set of 20 biophysical and socio-economic indicators was set (e.g. number of companies, biomass produced, etc. - see plenary session day 2 in the bioeconomy community of practice workshop (JRC, 2020)).

74 https://www.monitoring-biooekonomie.de/en/; https://iaf.monitoring-biooekonomie.de/?lang=en
75 https://julkaisut.valtioneuvosto.fi/handle/10024/163969
76 https://www.luke.fi/en/statistics/indicators/bioeconomy-innumbers
77 https://group.intesasanpaolo.com/it/research/la-bioeconomia-in-europa
78 https://cnbbsv.palazzochigi.it/it/bioeconomia/strategia-italiana/
79 https://cnbbsv.palazzochigi.it/media/1951/bit-italiano-14feb2020.pdf
80 https://apambiente.pt/apa/bioeconomia
81 https://www.gov.ie/en/publication/a1bb6-bioeconomy-policy/#irelands-bioeconomy-action-plan-2023-2025
82 https://informbioproject.ie/informbio-tools/bioeconomy-monitoring-framework/

Besides national strategies, diverse policy measures and instruments are already in place in the MS which collectively create an encouraging environment for public institutions and the private sector, as well as for researchers, consumers and citizens to ultimately foster a sustainable and circular bioeconomy.

Available data on bioeconomy enabling policy measures[83] can be structured along 6 main blocks:

- Enable the **governance of the bioeconomy across sectors, policies and institutions.** These measures include the presence of an advisory council, monitoring systems of the national bioeconomies and strategies, as well as the existence of national register / list (or statistics) of bio-based industries or bio-refineries.

- Support **infrastructure** and **capacity building** with instruments that promote pilot and demonstration facilities, bioeconomy-specific educational programmes, develop cooperation platforms to mobilise biomass resources or promote industrial clusters.

- Initiatives that promote **research & innovation** like the creation of bioeconomy-specific research centres and Public-Private Partnerships (PPP), the funding of research and innovation specifically on the bioeconomy, etc.

- Measures that promote the **production** and **commercialisation** of bio-based products such as bio-based quotas or bio-tickets, mandates or subsidies for bio-based products, access to capital, regulated prices of bio-based products, etc.

- Measures that facilitate the **demand** for bio-based products, including national standards and labeling systems of bio-based products, public procurement programmes, campaigns of aware raising, etc.

- And initiatives that promote **collaboration** in the bioeconomy, for example promoting multi-stakeholder involvement, transfer of technology, etc.

Among the total number of policy measures by block type (*Figure 7*), measures dedicated to support infrastructure and capacity building are the ones more frequently applied (27 % of the total). The share of policy measures types adopted in the 11 MS examined is in *Figure 8*.

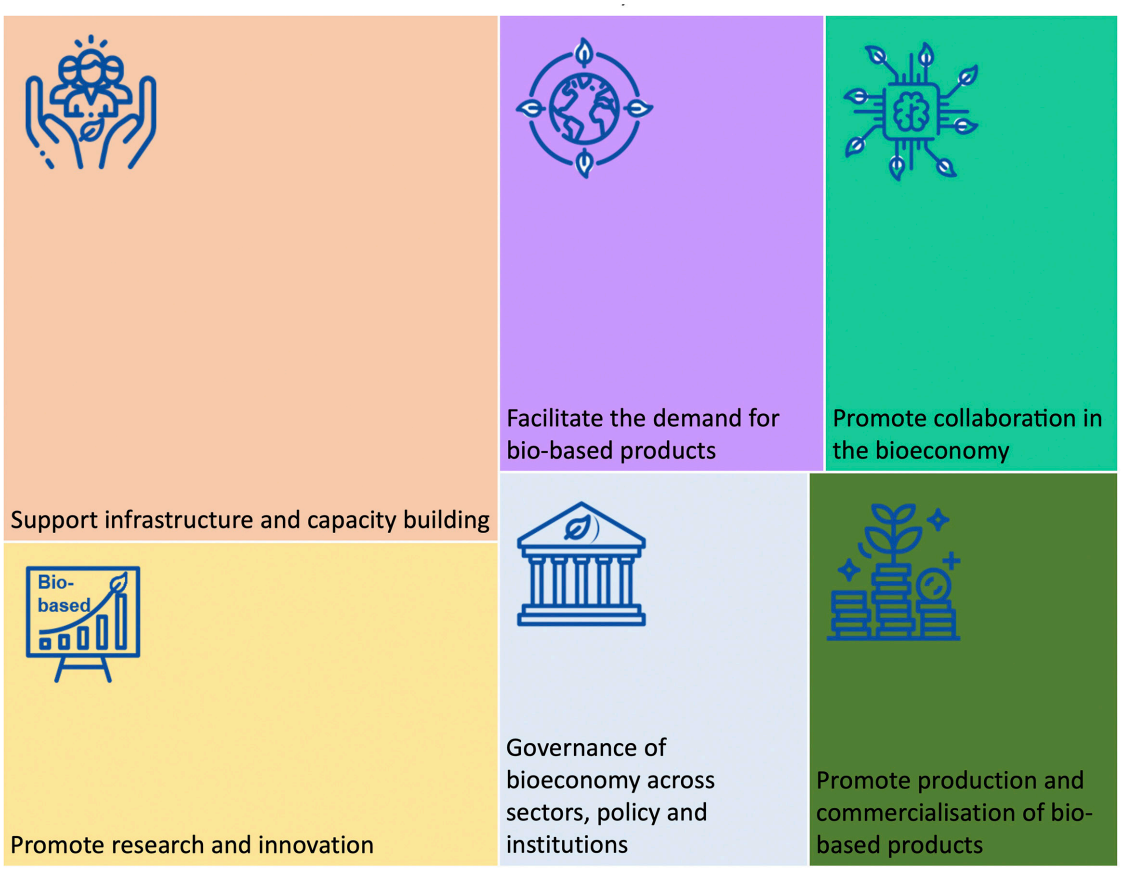
Interestingly, a high number of measures at national level are dedicated to support the infrastructure and capacity building in Italy (39 % of all the Italian measures identified), Ireland (36 %), Estonia (30 %), and Germany (28 %). A high number of measures dedicated to promoting collaboration was reported in Austria (26 %) and Estonia (23 %). Other interesting insights include the high number of measures dedicated to facilitating the demand for bio-based products in Croatia (26 %) and the low number of measures dedicated to facilitating the demand for bio-based products in Denmark (4 %) and Portugal (5 %). Poland did not report any policy measure aiming at promoting the production and commercialisation of bio-based products.

The specific measures adopted in each MS can be consulted on the Knowledge Centre for Bioeconomy platform[84].

83 Data were collected by 44 experts from 33 different organisations in 11 Member States (AT, HR, DK, EE, FI, DE, EL, IE, IT, PL, PT) during a survey in 2021 coordinated by the JRC, that subsequently updated it through the European Bioeconomy Policy Forum (EBPF).

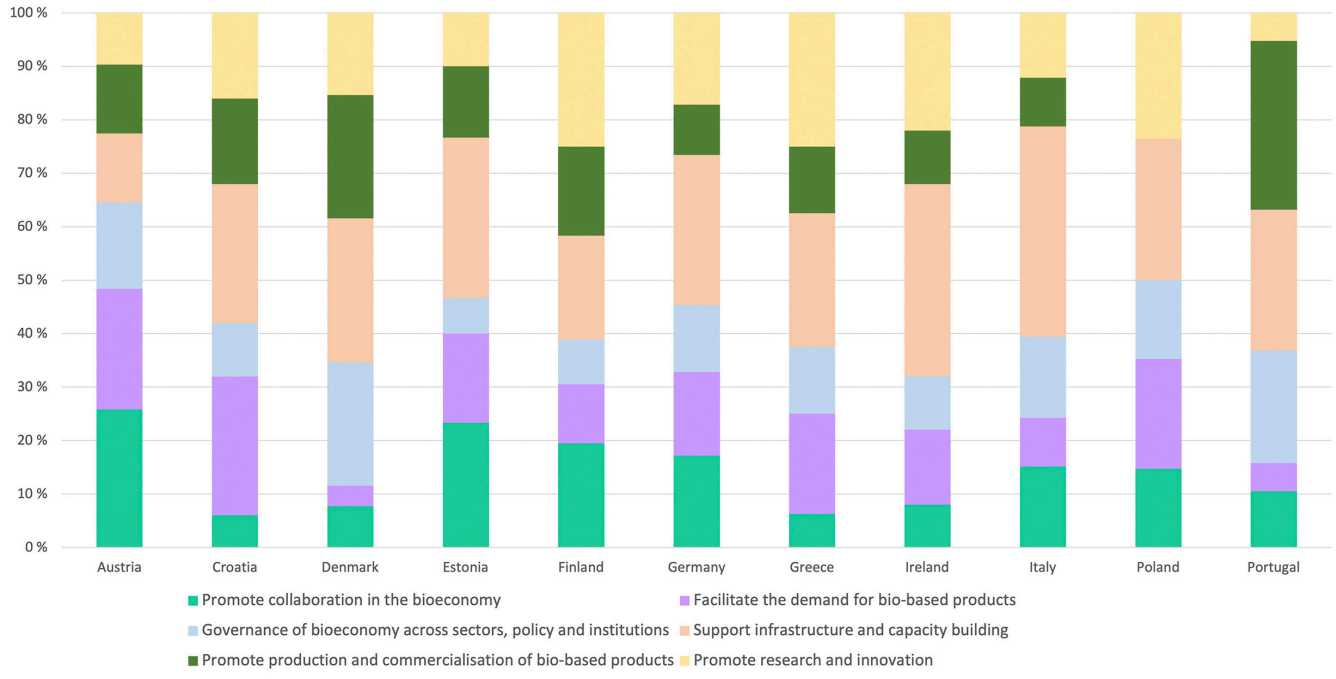
84 https://knowledge4policy.ec.europa.eu/visualisation/bioeconomy-different-countries

Figure 7. Number of policy measures identified in the MS by block type.



Source: European Commission's Knowledge Centre for Bioeconomy, 2024

Figure 8. Share of bioeconomy enabling policy measures by block type in each Member State.



Source: European Commission's Knowledge Centre for Bioeconomy, 2024

Focus box 4. Relevance of the territorial dimension in bioeconomy policies

One of the key aspects of bioeconomy is its potential to contribute to regional development, particularly in rural and remote areas where many biomass value chains are located, while advancing in sustainability. Recent socio-economic challenges, including disruptions in global supply chain and inflationary pressures on food and energy due to the COVID-19 pandemic and the Russian invasion of Ukraine, have further highlighted the potential of the bioeconomy to provide bio-based alternatives to imported products and foster regional development (Galanakis et al. 2022; Lasarte-López et al. 2023a). In effect, rural areas can play a crucial role in valorising biomass resources and developing local, circular, resilient, and sustainable biomass value chains.

This vision is emphasised by recent policy initiatives, such as the 2023 EU Council Conclusions on the opportunities of the bioeconomy[85]. In addition, the widespread adoption of bioeconomy strategies in European regions reflects the recognition of the bioeconomy potential for territories. In 2021, a majority of regions already had a specific bioeconomy strategy or one closely related to it (Haarich and Kirchmayr-Novak, 2022). These strategies are crucial due to the heterogeneity in the territorial distribution of bioeconomy activities, with regions specialising in different stages of the biomass production, transformation, and distribution chain.

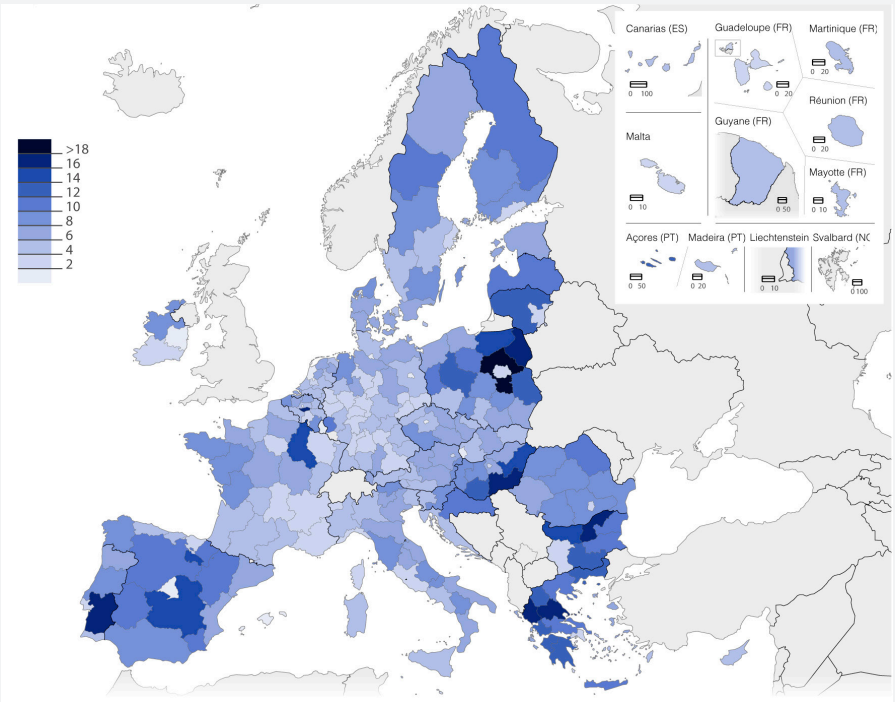
In light of the above, it is crucial to monitor the structure and trends of the bio-based economy at regional level to assess the degree of fulfilment of policy objectives and the analysis of the role of the bioeconomy for rural development and regional competitiveness. For these purposes, JRC is developing a methodology to quantify employment and value added in the bio-based economic activities for European NUTS2 regions. In 2023, the BioRegEU pilot database was published, offering preliminary results and enabling an initial insight into the structure of the bioeconomy across European regions. The methodological approach used to develop these indicators is described in Lasarte-López et al. (2022, 2023a).

Figure 9 provides an overview of employment and value-added distribution across European bioeconomy sectors. The bioeconomy creates more jobs in Eastern European regions, particularly Romania and Bulgaria. However, Western European regions typically have higher value added in bioeconomy sectors due to their specialisation in the bio-based manufacturing sectors compared to Eastern regions, which focus on biomass production.

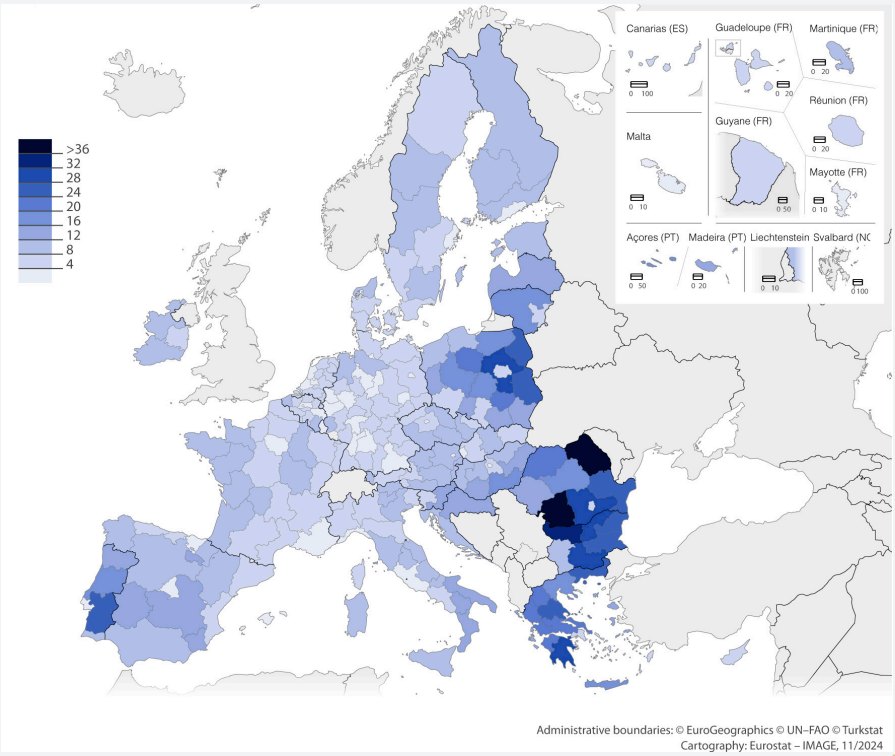
85 Council conclusions 8406/23 on the opportunities of the bioeconomy in the light of current challenges with special emphasis on rural areas .

Figure 9. Share of Value added (above) and Employment (below) in the bio-based economy of European NUTS2 regions

Value Added (% of NUTS2 region's GDP)



Employment (% of persons employed by NUTS2 region)



Source: BioRegEU pilot dataset

3 The EU Bioeconomy Monitoring System (EU-BMS)

3.1 Overview of the EU-BMS

The EU Bioeconomy Strategy (2018) pledged the Commission to build an EU-wide, internationally coherent monitoring system to track economic, environmental and social progress towards a sustainable bioeconomy. To fulfil this pledge, the JRC developed the EU-BMS which was launched in 2020 and is updated regularly as new data becomes available, its dashboard is accessible online from the KCB platform[86].

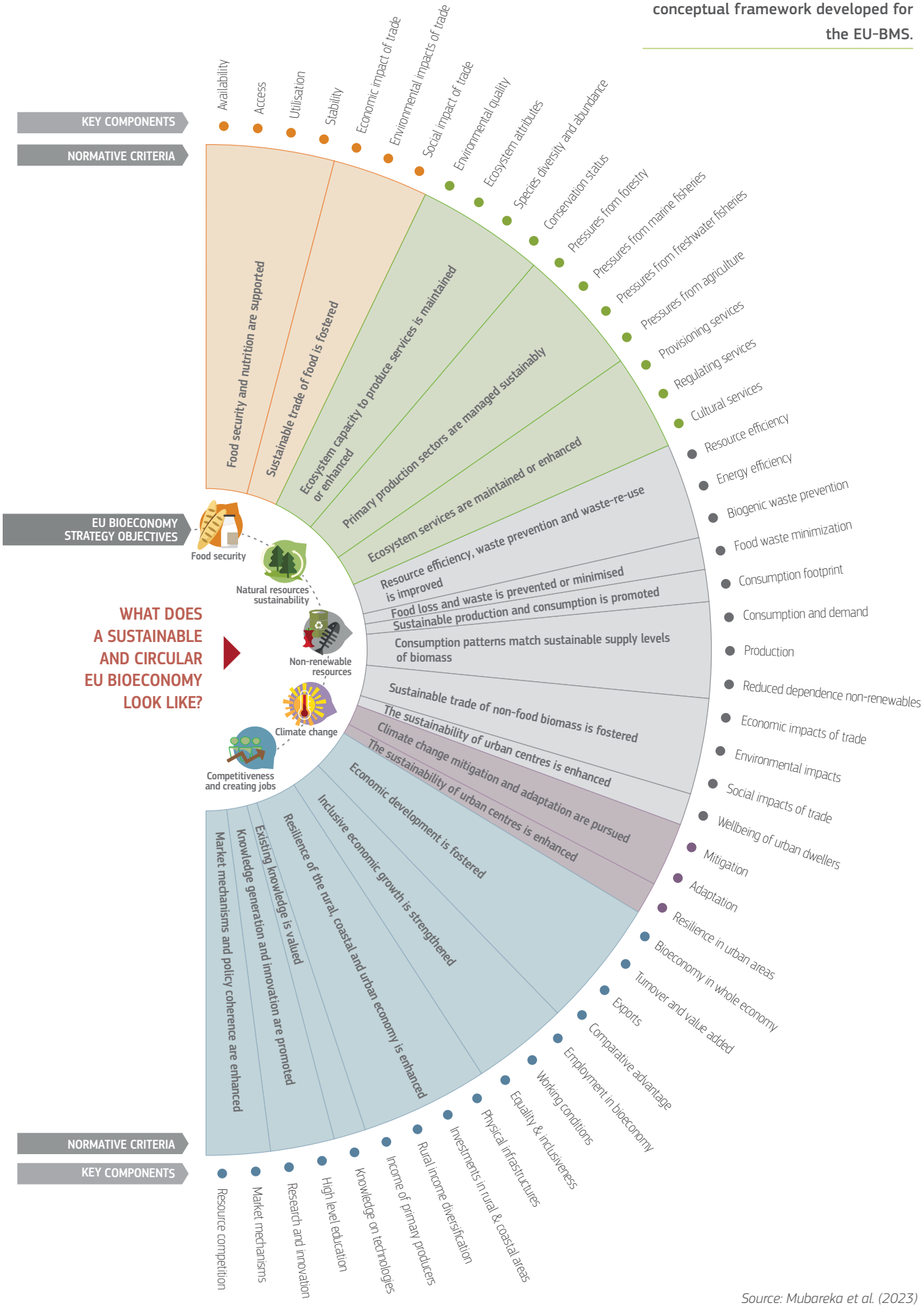
The conceptual framework of EU-BMS operationalises the **five objectives** of the EU bioeconomy strategy into a vision for a sustainable EU bioeconomy (Giuntoli et al. 2020):

1) Ensuring food and nutrition security;
2) Managing natural resources sustainably;
3) Reducing dependence on non-renewable, unsustainable resources, whether sourced domestically or from abroad;
4) Mitigating and adapting to climate change;
5) Strengthening European competitiveness and creating jobs.

To operationalise these objectives, two additional hierarchical levels were introduced (*Figure 10*): **Normative Criteria**, which define how each objective can be achieved; and **Key Components**, which reflect more specific aspects within each criterion. A more detailed description of the process and ideas that led to the framework can be found in (Giuntoli et al. 2020; Robert et al. 2020). The development of the bioeconomy on these three hierarchical levels is monitored within the EU-BMS using a set of selected **indicators**, derived both from existing statistical databases and from dedicated JRC analysis.

86 *https://knowledge4policy.ec.europa.eu/bioeconomy/monitoring*

Figure 10: Visualisation of the conceptual framework developed for the EU-BMS.



Source: Mubareka et al. (2023)

4 Trends in the EU bioeconomy

This chapter presents a quantitative analysis of the indicators currently implemented in the EU-BMS and publicly available in the EU-BMS dashboard on the KCB platform[87]. The individual indicators and their development over time provides insights on the different facets of bioeconomy and are presented both as time series as well as a set of scoreboards grouped by strategy objectives.

The overall aim of the EU-BMS is to portray a holistic view of the bioeconomy and its several aspects. The system was designed as a conceptual framework and not as a data-driven system based on the readily available indicators. Therefore, the EU-BMS and the related dashboard keep evolving as the methodologies for implementing new indicators are being defined and new data become available.

Consequently, some of the foreseen indicators are currently not yet available – at least on the EU level – which leads to these indicators to appear as placeholders, resulting as data gaps in the system. Accordingly, the reader should keep in mind that key components of the EU-BMS presented here are described through the indicators currently implemented in the system, not necessarily representing the full picture of all aspects related to bioeconomy development in the EU as foreseen in the EU-BMS.

4.1 Methods

The methodology used in this report stems from that of the first report on *Trends in the EU Bioeconomy* (Mubareka et al. 2023) for the individual indicators with some modifications. The time series for most relevant indicators in the EU-BMS are provided in this report as separate diagrams, and the short-term (5 latest years available) and long-term (10 latest years available) trends for each indicator are computed into scoreboards. The scoreboards are presented separately for each strategy objective and show data for the EU-27[88]. The data for each EU Member State (when available) are available online in the EU-BMS dashboard[89].

87 https://knowledge4policy.ec.europa.eu/visualisation/eu-bioeconomy-monitoring-system-dashboards

88 EU-27 composition after 2020.

89 https://knowledge4policy.ec.europa.eu/bioeconomy/monitoring

From left to right, the scoreboards capture:

- **The Conceptual framework structure** (see *Figure 10*): Normative criterion, Key Component, Indicator Name, Indicator Unit.

- **Trend analysis results:** in these 4 columns the short-term (latest available 5-years) and longer-term (latest available 10-years) trends are assessed.

    - The trend analysis approach is designed to resemble the analysis in Maes et al. (2020).

    - For short-term trends the latest 5 years available are considered, starting from the most recent available data point. E.g. if the most recent known data point is 2022, data points from 2018-2022 inclusive are analysed. Similarly, for long-term trends the latest 10 years are considered.

    - If the latest five/ten years series has missing values, then data are interpolated using linear interpolation, with the following rules:

        - Only interpolate, not extrapolate. Missing values are not estimated outside the time range of observed values.

        - The entire time series is interpolated before sub-setting to the latest 5 or 10 years. This means that missing values inside the 5- or 10-year ranges can be interpolated using known data points outside of that range, if they are available.

- A linear regression is then calculated over the last 5 or 10 data points available. The average annual percentage change is estimated by an equation which is a simple function of the slope and intercept, specifically:

$$\frac{\%\ change}{year} = \frac{slope \cdot 1}{intercept + slope \cdot first\ year\ of\ the\ interval}$$

To assess the statistical significance of the trend, a Mann-Kendall test was performed for each indicator for the 5-year and 10-year trends. This test is used to determine whether a time series has a significant monotonic upward or downward trend. The results for which the Mann-Kendall test indicates a monotonic trend are marked in bold font in the scoreboards.

Based on the above, the trend of the indicator was assessed in terms of development towards the bioeconomy objective and reported in the last column of the scoreboard. When the trend was not statistically significant ($p>0.05$) the indicator trend was marked as “no trend”. In all cases of statistically significant trends, the developments of the indicators towards the bioeconomy objective were marked as slightly positive or slightly negative when the absolute value of the average change was less than 1%/year, and marked as positive or negative when more than 1%/year.

The aggregated trends for the key components under each objective were calculated as an arithmetic average of the individual indicators’ average annual percentage change.

Focus box 5: Main sources of data for the EU-BMS

JRC Biomass Mandate (JRC-BIOMASS)

The JRC Biomass Mandate (i) is a long-term task given to the JRC by twelve European Commission services (DG AGRI, DG CLIMA, DG INTPA, DG ENER, DG ENV, DG GROW, DG MARE, DG MOVE, DG REGIO, DG RTD, DG TRADE, SG) in 2015. The mandate provides data, models and analyses on EU and global biomass supply and demand and its environmental, social and economic sustainability. In the EU-BMS, data related to biomass supply and forest biomass uses is produced by the JRC Biomass mandate.

JRC Data-Modelling platform of resource economics (DataM)

DataM (ii) provides estimates on the economic analysis of sustainable resources related to bioeconomy. In the EU-BMS, the economic indicators under Objective 5 are based on analysis from DataM.

JRC indicators for food waste accounting

On food waste statistics, the EU-BMS relies on the data and analysis produced by the JRC D.3. The most recent methodologies are described in JRC Technical Report by De Laurentiis et al. 2023 (iii).

JRC support for the Scientific, Technical and Economic Committee for Fisheries (STECF)

Indicators related to fish stock biomass and fish mortality in the EU-BMS are obtained from the data prepared by the JRC for STECF (iv).

Eurostat

Beyond the data prepared by the JRC, the EU's statistical office Eurostat's databases (v) are one of the main sources for data in the EU-BMS, used under Objectives 1-4.

EEA

The European Environmental Agency (EEA) (vi) collects and hosts data especially for environmental quality, providing data for some indicators under Objective 2.

FAO

The indicators in the EU-BMS on daily calorie supply per capita and the prevalence for severe food insecurity are based on data from the United Nation's Food and Agriculture Organization (FAO) (vii).

UNEP

In the EU-BMS, the indicator on Material footprint (Biomass) is based on the United Nation's Environment Programme's (UNEP) data (viii).

i. *https://knowledge4policy.ec.europa.eu/projects-activities/jrc-biomass-mandate_en*
ii. *https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/*
iii. *https://publications.jrc.ec.europa.eu/repository/handle/JRC133379*
iv. *https://stecf.ec.europa.eu/index_en*
v. *https://ec.europa.eu/eurostat/databrowser*
vi. *https://www.eea.europa.eu/en/analysis/indicators*
vii. *https://unstats.un.org/sdgs/dataportal/database*; *https://www.fao.org/faostat/en/#data/FBS*
viii. *https://wesr.unep.org/apps/sdg-data/indicator=863*

4.2 Objective 1: Ensuring food and nutrition security

Objective 1 of the EU Bioeconomy Strategy, *ensuring food and nutrition security,* is central for the bioeconomy. In the EU-BMS, the indicators linked to this objective mirror the food security components of FAO (2022), encompassing availability and access to sufficient quantities of food of appropriate quality, as well as stability (not prone to sudden shocks in availability and access) and utilisation of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met.

In addition, the EU-BMS has placeholder indicators, i.e. foreseen by the system but not implemented yet, for measuring the economic, social and environmental impact of trade on the countries that export food and feed to the EU.

The following key components and related available indicators are currently implemented in the EU-BMS for this objective:

- **Food availability**
  - Agricultural factor income per annual work unit. [source: Eurostat] This indicator measures the income generated by farming, which is used to remunerate borrowed or rented factors of production (capital, wages and land rents) as well as own production factors (own labour, capital and land). Factor income corresponds to the deflated (real) net value added at factor cost of agriculture.

  - Total biomass supply for food purposes, including inputs. [source: JRC-BIOMASS, Gurria Albusac et al. 2022] The indicator describes the total primary biomass used annually for food purposes. This includes plant-based food, the total plant biomass and primary fish biomass used for feed and bedding of animals or fish for food consumption.

  - Biomass directly consumed in the EU as food. [source: JRC-BIOMASS, Gurria Albusac et al. 2022] The indicator shows the total biomass of vegetal, animal and fish food consumed annually.

- **Access to food**
  - Prevalence of moderate or severe food insecurity in the total population. [source: FAOSTAT] An estimate of the percentage of a country's population that faces difficulties in accessing enough safe and nutritious food for normal growth and development and an active and healthy life. The data is collected through direct interviews by asking people about experiences associated with constrained access to food.

  - Food purchasing power. [source: Eurostat] Nominal expenditure as percentage of GDP. GDP is the monetary value of all the goods and services produced in a country. Nominal differs from real GDP in that it includes changes in prices due to inflation, which reflects the rate of price increases in an economy on, in this case, food and non-alcoholic beverages.

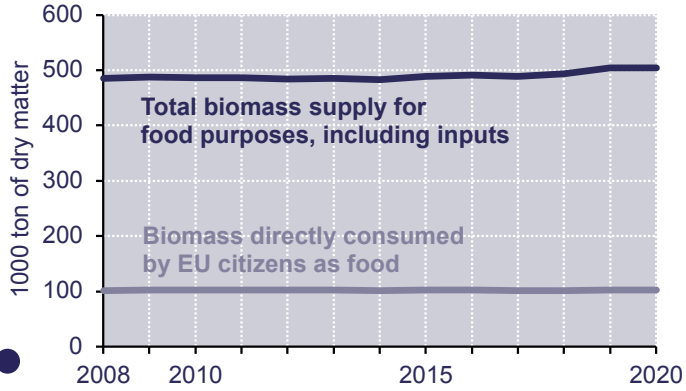
- **Food stability**
  - Daily calorie supply per capita. [source: FAOSTAT] The indicator shows the total daily calorie supply per capita, including both consumption and losses. The EU-BMS also provides the split into calories from animal products and vegetal products.

- **Food utilisation**
  - Government support to agricultural research and development. [source: Eurostat] The indicator is used to quantify the level of priority governments place on the public funding of R&D for agriculture.

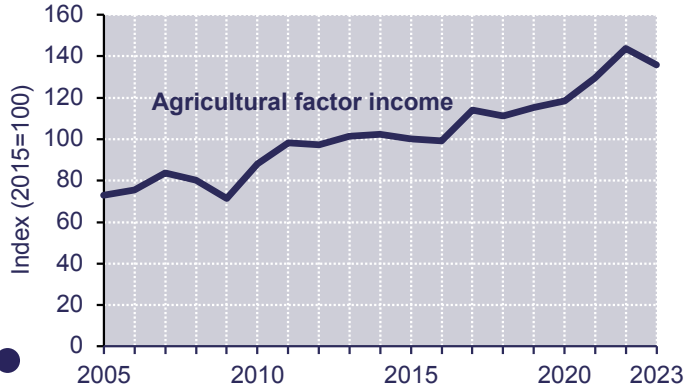
Here below we present and discuss the trends observed for these indicators. The full set of quantitative results is provided in the scoreboard at the end of this section (*Figure 11*).

Food availability

- Around one-fifth of all biomass used for food and feed is directly consumed by EU citizens in the form of plant-based food. The rest is used as animal feed and bedding for the production of animal-based food (either for domestic consumption or for export). The biomass supply and consumption have remained stable over time, with a slight increase of total biomass supply for food in the recent years, yet without a significant trend.



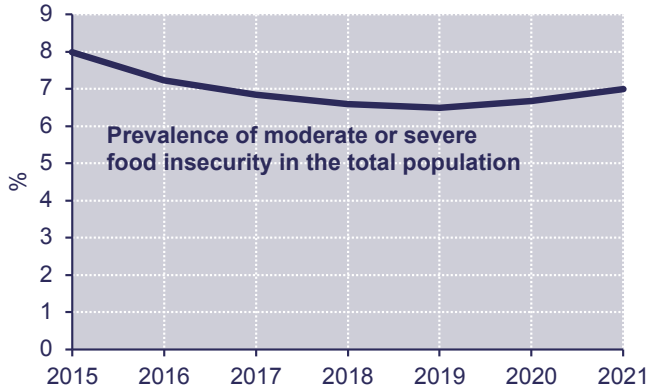
- Agricultural factor income measures the remuneration of all factors of agricultural production, i.e. the value added for land, capital and labour. This indicator has increased notably over time, and almost doubled since 2005. The peak value was recorded in 2022, with a slight fall back (-1.5 %) in 2023. The overall increase of the agricultural factor income reflects the gross value added in the whole economy that has increased over time. According to Eurostat statistics[90], the contribution of agriculture to the total EU's GDP in 2023 was 1.3 % in 2023, the same share as 15 years earlier, 1.3 %.



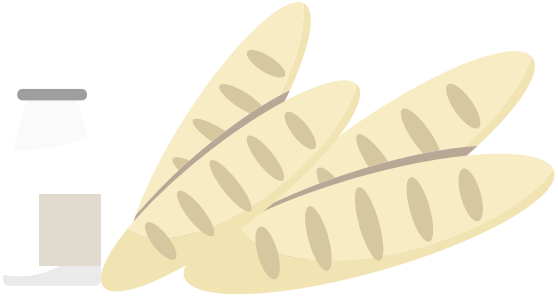
Overall, food availability in the EU, as described with the indicators selected, shows a positive trend.

Access to food

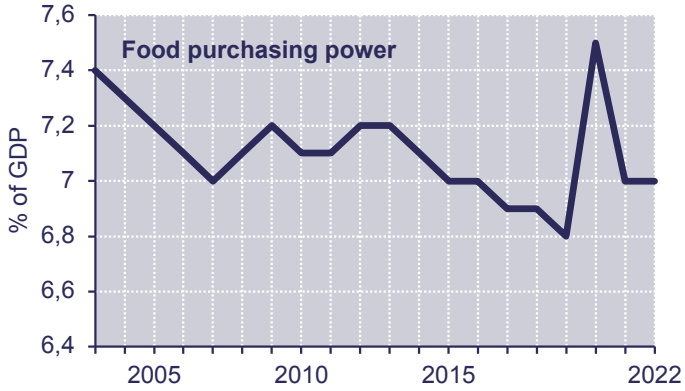
- The prevalence of moderate or severe food insecurity on the total population decreased from 8 % to ca. 6.5 % between 2015-2019, and then turned into a slight increase, reaching 7 % in 2021.



90 https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Performance_of_the_agricultural_sector&oldid=637887



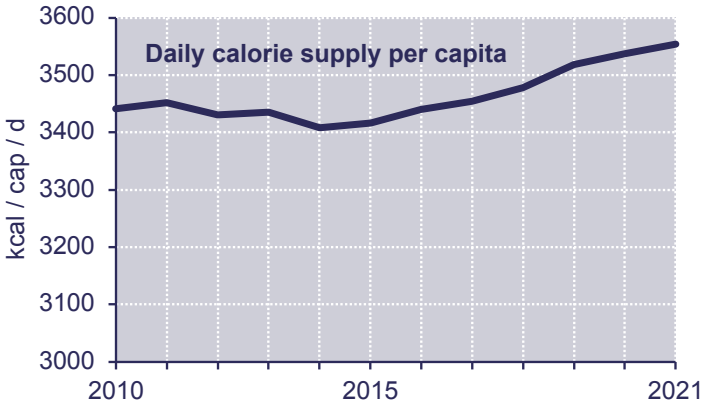
- Food purchasing power has remained close to 7 % of the GDP throughout the period available (2003-2022). The restrictions during COVID-19 pandemic caused a spike in the time series in 2020, and the otherwise slightly decreasing trend increased to 7.5 %. However, this effect was already bouncing back in 2021, when the food purchasing power was 7 %. This indicator has a negative directionality, which means that a decrease in the numerical values is considered to be positive development. Spending less of the GDP on food means that there is more disposable income for other essentials such as education, healthcare, and housing.



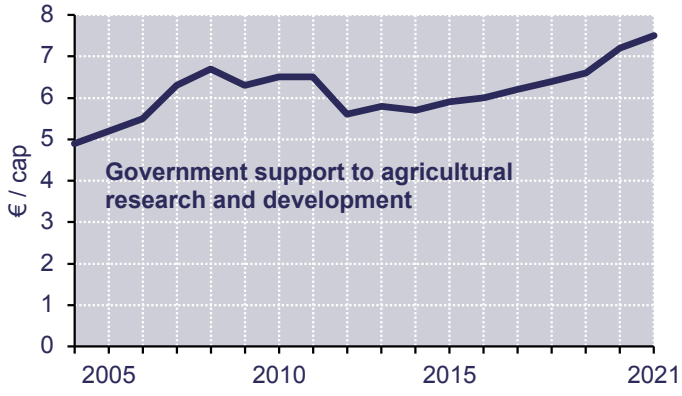
Overall, the indicators reflecting access to food and nutrition have remained on a relatively stable level.

Food stability and utilization

- In terms of stability of food and nutrition provision, the EU-BMS follows the daily calorie supply per capita. The indicator exhibits a slight increase since 2015, but the overall change in both last 5 and 10 years is still less than 1 %. The EU-BMS has additional disaggregation to calorie supply from animal and vegetal products (not shown in the graph); these show that the calorie supply from vegetal products has remained stable on the EU level, while the overall increase stems from an increase in calories supplied by animal products.



- The indicator tracking government support to agricultural research and development shows an increasing trend on the EU level both for the last 5 years (+6.5 %) and 10 years (+4.6 %).



The stability of food provision and its utilisation mark an overall slightly positive trend in the EU.

Figure 11: Scoreboard of indicators for Objective 1 of the EU bioeconomy strategy. Bold numbers in the average change per year indicate statistically significant trend (Mann-Kendall test).

Normative Criterion	Key component	Indicator name	Unit	Last year in the time series	Latest 5 years average change (%/year)	Latest 10 years average change (%/year)	Development towards bioeconomy objectives
Food security and nutrition are supported	Availability	Agricultural factor income per annual work unit (AWU)	Index (2015 = 100)	2023	5.7%	**4.9%**	Positive
		Total biomass supply for food purposes, including inputs	1000 t of dry matter	2020	0.9%	**0.5%**	Slightly positive
		Biomass directly consumed by EU citizens as food	1000 t of dry matter	2020	0.1%	0.0%	No trend
		Other indicators for this key component currently not implemented in the EU-BMS: New food products; New food value chains					
	Access	Prevalence of moderate or severe food insecurity in the total population, yearly estimates	%	2021	0.6%	NA	No trend
		Food purchasing power	% of GDP	2022	0.6%	-0.1%	No trend
		Other indicators for this key component currently not implemented in the EU-BMS: Average dietary supply adequacy					
	Utilisation	Daily calorie supply per capita by source	kcal/ cap/d	2021	**0.7%**	**0.5%**	Slightly positive
		Other indicators for this key component currently not implemented in the EU-BMS: Indicator concerning food quality, or food safety; Animal welfare					
	Stability	Government support to agricultural research and development (by sector)	€/cap	2022	**6.5%**	**4.6%**	Positive
		Other indicators for this key component currently not implemented in the EU-BMS: EU's self-sufficiency rate on protein for feed; Import dependency ratio of food (import/domestic production); Value of food imports over total merchandise exports					
Local economies, societies and environmental conditions of countries exporting food to the EU are not hampered but rather harnessed by the trade of raw and processed biomass and related technologies	Economic impact of food trade in exporting countries (to EU)	Economic impact of trade of food in exporting countries (to EU) is currently reported together with the indicator under Objective 3, "Economic impact of trade in exporting countries (to EU)"					
	Environmental footprints in of food trade exporting countries (to EU)	Key component indicator currently not implemented in the EU-BMS					
	Social impact of food trade in exporting countries (to EU)	Key component indicator currently not implemented in the EU-BMS					

Source: own elaboration

4.3 Objective 2: Managing natural resources sustainably

Objective 2 of the EU Bioeconomy Strategy, *managing natural resources sustainably,* emphasises the need to ensure healthy and resilient ecosystems, as a prerequisite for sustainable supply of biomass and other services linked to the bioeconomy. To monitor this objective, the EU-BMS was designed on the basis of the MAES assessment (Maes et al. 2020), according to three main normative criteria:

1. Ecosystem capacity to produce services is maintained or enhanced;
2. Primary production sectors are managed sustainably;
3. Ecosystem services contribution to human well-being is maintained or enhanced.

These criteria are further articulated into key components related to environmental quality, structural properties of the ecosystems, diversity, conservation status, pressures from natural resources management, and ecosystem services.

For this objective, the following key components and related indicators are currently implemented in the EU-BMS:

- **Environmental quality**
  - Biochemical oxygen demand in rivers. [source: Eurostat] Biochemical oxygen demand (BOD) is used to measure water quality. The cleanest rivers have BOD values of less than 1 mg O_2/L, moderately and heavily polluted rivers show values ranging from 2 to 8 mg O_2/L.
  - Phosphate in rivers. [source: Eurostat] Refers to concentration of phosphate (PO_4) in the dissolved phase of water samples. At high levels, phosphate can cause water quality problems, such as eutrophication, by triggering the growth of macrophytes and algae.
  - Nitrate in groundwater. [source: Eurostat] Indicator refers to concentrations of nitrate (NO_3) in groundwater. According to the Drinking Water Directive, a maximum concentration of 50 mg/L of nitrate in groundwater that is used for drinking water is allowed.
- **Structural and functional ecosystem attributes**
  - Share of organic farming in utilised agricultural area. [source: Eurostat] The indicator measures the share of total utilised agricultural area (UAA) occupied by organic farming (existing organically-farmed areas and areas in process of conversion).
  - Livestock density index. [source: Eurostat] Livestock density refers to the number of livestock units per hectare of utilised agricultural area. The livestock species that are aggregated for the purpose of this indicator are equidae, cattle, sheep, goats, pigs, poultry and rabbits.
  - Forest land growing stock. [source: Eurostat/ European Forest] This indicator describes the growing stock in forests, based on official statistics reported to FAO (FAO FRA) and gap-filled with modelled data using the Carbon Budget Model. Growing stock follows the FAO FRA definition “Volume over bark of all living trees with a minimum diameter of 10 cm at breast height (or above buttress if these are higher). Includes the stem from ground level up to a top diameter of 0 cm, excluding branches”.
  - Fish stock biomass in NE Atlantic & Mediterranean. [source: STECF, 2023] The indicator shows the model-based trend over time of fish stock biomass for three fish stocks (mackerel, blue whiting, horse mackerel).

- **Species diversity and abundance**
  - Common farmland bird index; Common forest bird index. [source: Eurostat] These indicators are multispecies indices that measure the average trend in relative abundance of a selection of common bird species associated with specific habitat. Rare species are excluded. Two groups of bird species are represented: common farmland species (39 species) and common forest species (34 species). The indicator is presented for EU-aggregates only and with smoothed values. The indicator draws from data produced by the European Bird Census Council and its Pan-European Common Bird Monitoring Scheme program.

  - Grassland butterfly index. [source: EEA, BCE] The indicator measures the population trends of 17 butterfly species at EU-level and is presented as Index 2000 = 100 with smoothed values. The indicator is based on data from 18 EU MS.

- **Conservation status of habitats and species**
  - Surface of marine sites and terrestrial sites designated under NATURA 2000. [source: DG ENV, EEA] The Natura 2000 network comprises both marine and terrestrial protected areas designated under the EU Habitats and Birds Directives with the goal to maintain or restore a favourable conservation status for habitat types and species of EU interest.

- **Pressures from forest management**
  - Ratio of annual fellings to net annual increment. [source: JRC] Ratio of fellings (including stem, branches, top and logging residues) over Net Annual Increment (NAI) of total aboveground biomass, based on JRC's own estimates. Detailed methods are published in Avitabile et al. 2023.

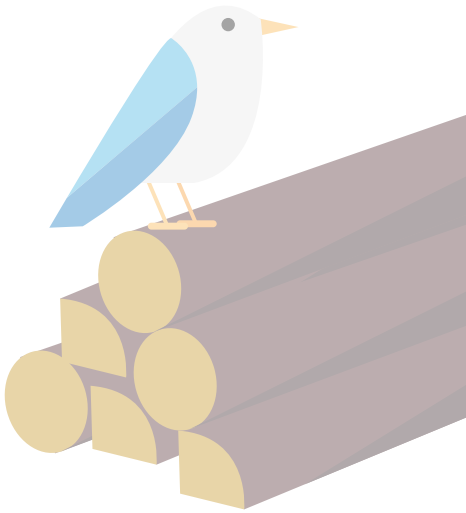
- **Pressures from marine fisheries & aquaculture management**
  - Fishing mortality of commercially exploited fish and shellfish exceeding fishing mortality at maximum sustainable yield in NE Atlantic & Mediterranean and Black Sea. [source: STECF, 2023] The indicator shows the model-based trend over time of fish stock biomass for three fish stocks (mackerel, blue whiting, horse mackerel).

- **Pressures in agroecosystems**
  - Intensification of farming (share of low, medium and high input farms in utilized agricultural area). [source: FADN] Percentage of utilised agricultural area (UAA) managed by low-, medium- and high-input farms and the number of hectares of UAA per category of farms.

- **Provisioning services**
  - Biomass production in EU from primary production sectors (agriculture, fisheries and forestry). [source: JRC-BIOMASS] Total biomass produced and harvested in agriculture, forestry and fisheries.

  - Roundwood removals. [source: JRC-BIOMASS] Total wood removals under bark derived from the Joint Forest Sector Questionnaire (JFSQ) and over bark using conversion factors from UNECE/FAO (2010).

Here below we present and discuss the trends observed for these indicators, the full set of quantitative results is provided in the scoreboard at the end of this section (*Figure 12*).

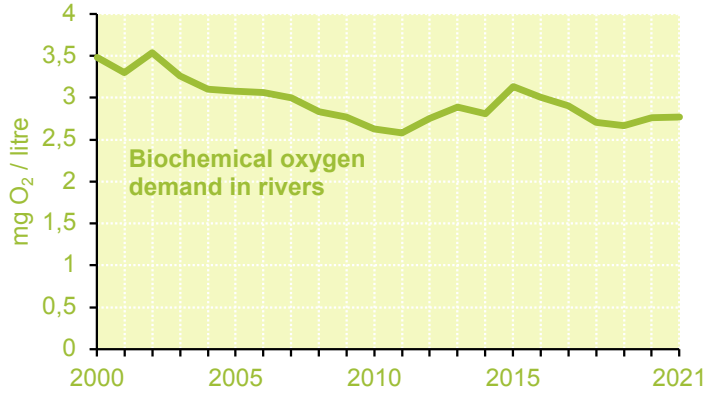


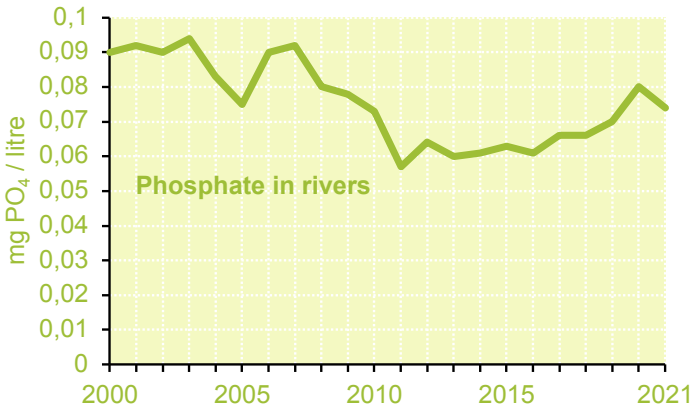
Environmental quality

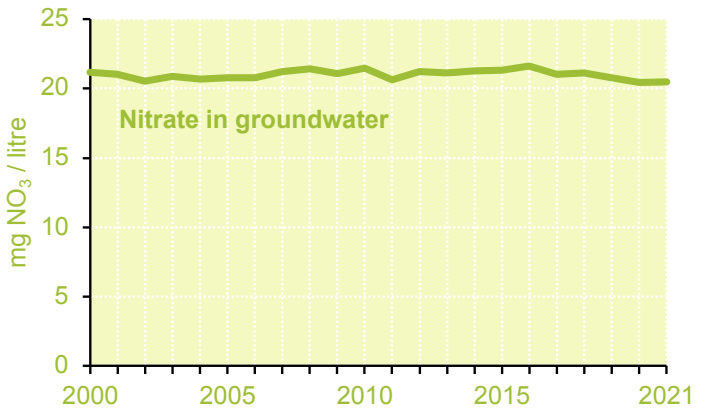
The indicators in the EU-BMS tracking environmental quality have a negative directionality, meaning that when their value gets greater, conditions are worsening, therefore a decrease in the time series corresponds to a positive trend for environmental quality.

- The biochemical oxygen demand in rivers and nitrate in groundwater indicators show no clear trend in the last 5 or 10 years.

- In contrast, the amount of phosphate in rivers has turned into an increase in the past 10 years, contrary to an overall decreasing trend between 2000 and 2011. This development is negative, because at high levels phosphate can cause water quality problems, such as eutrophication, by triggering the growth of macrophytes and algae.

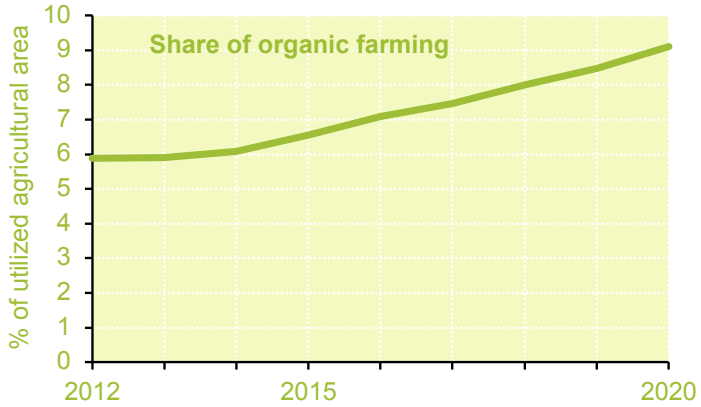




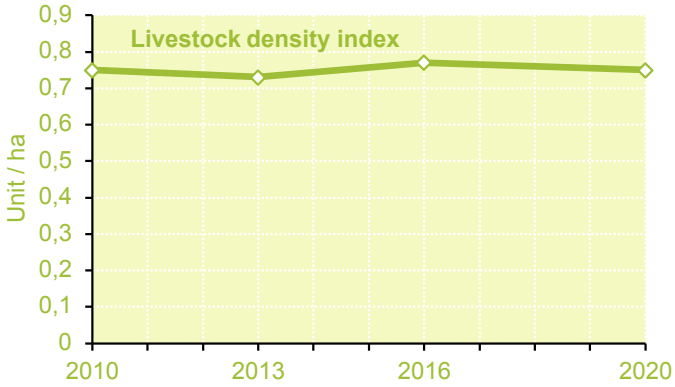


Structural and functional ecosystem attributes

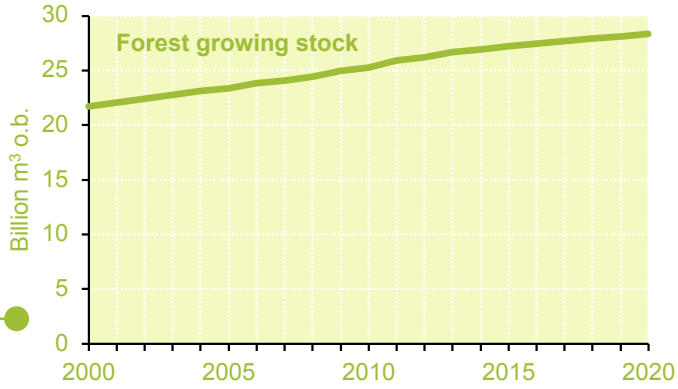
- The total area of land under organic farming in the EU has steadily increased over time, reaching 9.1 % of total EU agricultural land in 2020.



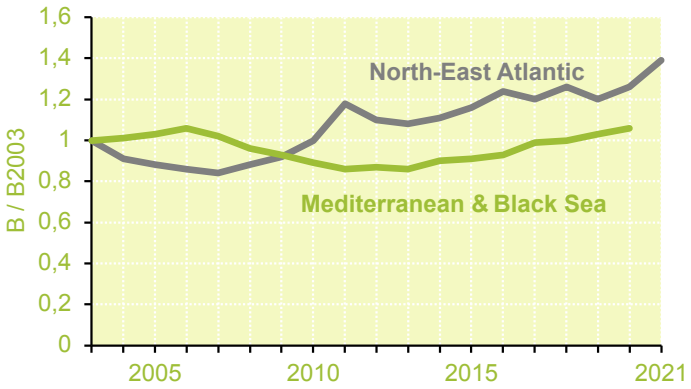
- The livestock density index describes the pressure of livestock farming on the environment. Therefore, the indicator has a negative directionality: the higher its value, the more adverse is the impact on the environment. In 2020, the average livestock density in the EU was 0.75 livestock units per ha, but the differences between the EU MS are considerable, ranging from 3.4 livestock units per hectare in the Netherlands, to 0.2 units in Bulgaria, Latvia and Lithuania.



- Forest growing stock describes the over bark-volume of living trees with a minimum diameter of 10 cm at breast height. This indicator has been constantly increasing in the EU throughout the reported time series 2000-2021. However, this increase shows signs of slowing down: while the 10-year trend shows an increase of 1 % per year, the last five years' trend is lower (0.8 % per year).



- The reported stocks of fish biomass show an increasing trend in both North-East Atlantic and Mediterranean areas. Especially the development on North-East Atlantic has been strong compared to the base year 2003, with 40 % more fish stock observed in 2021, compared to 2003.



Species diversity and abundance

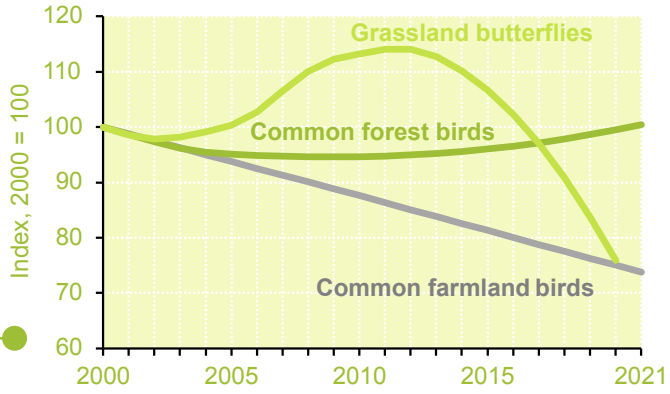
Species diversity and abundance is measured with three indices, all using the year 2000 as a base year: common farmland bird index, common forest bird index, and grassland butterflies index.

- Common forest bird index, tracking the presence and abundance of 34 species in forest habitats, shows a slight upward trend in the recent years, after having decreased between 2000 and 2010. In 2021, it is reported having just reached the same value as in year 2000.

- In contrast, for common farmland birds (39 species), the index development in time shows a

clear and continuous negative trend. In 2021, the index for farmland birds was only 74 % of the value reported for 2000.

- The index for grassland butterflies has turned into a sharp decline starting from 2013, after a clear increase between 2005 and 2013. The index was reported to be 76 in the last reporting year 2020, compared to the base value of 100 at the beginning of the time series in 2000.



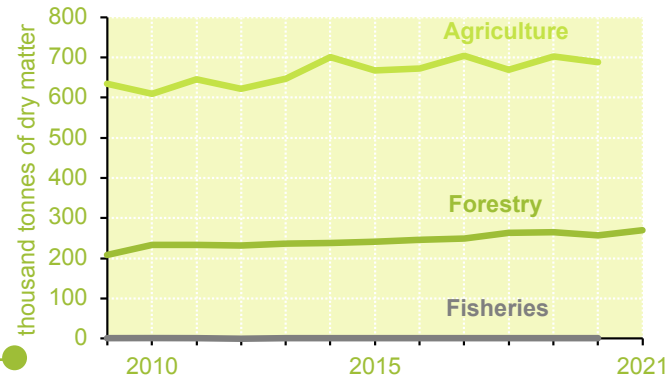
Conservation status of habitats and species

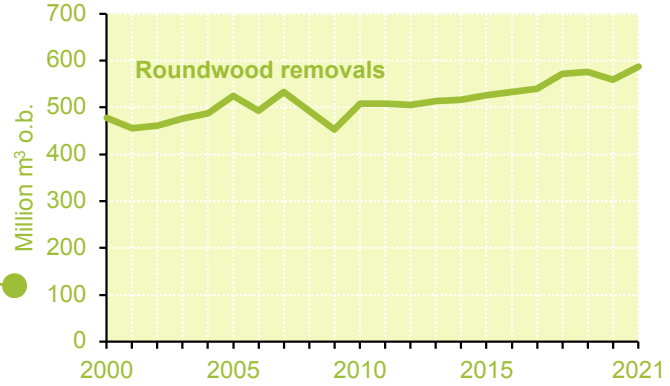
- The EU-BMS currently monitors the development of habitat conservation recording the extent of marine and terrestrial sites designated as part of the Natura 2000 network. This network, established after the 1979 Birds Directive and the 1992 Habitats Directive, constitutes the largest coordinated network of protected areas in the world.

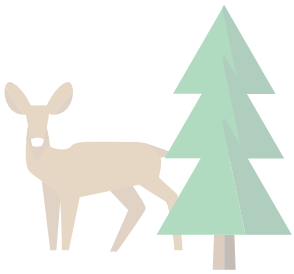
- The network covers approximately 18 % of the EU's land area, and 8 % of its marine area. The extent of the protected terrestrial area has remained broadly stable since 2012, while the area of protected marine sites has more than doubled between 2013 and 2020.

Provisioning services

- The biomass production indicator, i.e. domestic extraction of biomass from agriculture, forestry and fisheries all together, has been growing on average during the last 10 reported years by 1.1 % per year, with forestry biomass production showing the strongest increasing trends (on average +1.5 % per year in the last 5 years reported, and +1.8 % per year in the last 10 years). Agriculture, including crops, harvested residues and grazed biomass, is by far the biggest producer of biomass with around 700 k ton dry matter produced annually. Forestry production is approximately 270 k ton dry matter, corresponding to almost 600 million cubic metres, while fisheries produce ca. 1.5 k ton dry matter.

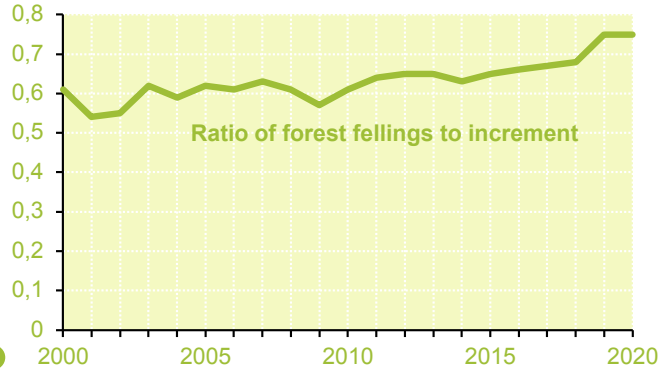




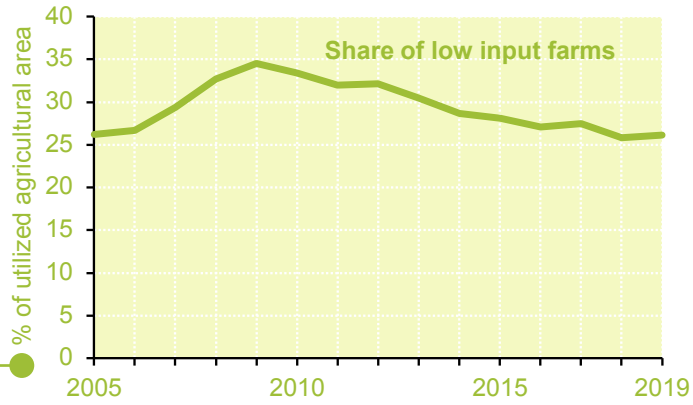


Pressures from primary production

- Increased production also puts pressure on the environment. This is especially evident in forests: while the woody biomass stock has kept increasing in the EU over time, the rate of increase has declined. This is a consequence of an increasing ratio of annual fellings over net annual increment: in 2021, 75 % of the total annual increment was felled, which is a substantial increase to 2000-2010 when the ratio fluctuated around 60 %.



- The EU-BMS uses intensification of farming as an indicator to describe pressures from agroecosystems. In the EU-BMS, this indicator is represented by the share of low, medium, and high input farms in utilized agricultural area (UAA). The share of low-input farms – those that spend less than 80 euro per ha per year on fertilisers, crop protection and concentrated feedstuff – has decreased clearly since the peak year 2009, and is now ca. 25 % of all UAA, a similar level as in 2005.



- Pressures from fisheries and aquaculture management are currently monitored for marine areas in the North-East Atlantic, and in the Mediterranean & Black Sea areas. The indicator describing this criterion is the fishing mortality of commercially exploited fish and shellfish exceeding fishing mortality at maximum sustainability yield (MSY). This indicator has a negative directionality – a decreasing trend is considered positive development for the environment. For both marine areas monitored in the EU-BMS, the trends are positive, with especially North-East Atlantic showing a clear decreasing trend.

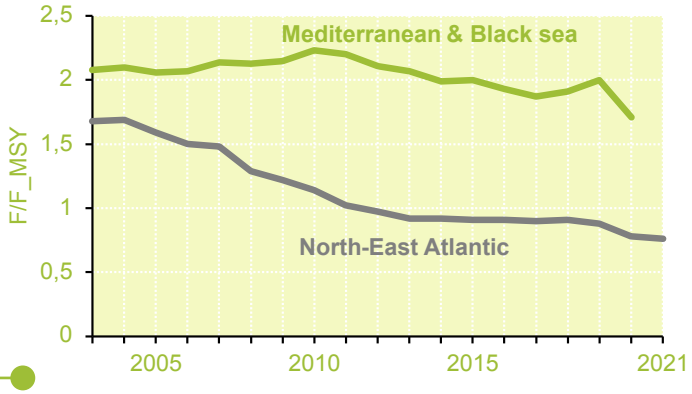


Figure 12: Scoreboard of indicators for Objective 2 of the EU bioeconomy strategy. Bold numbers in the average change per year indicate statistically significant trend (Mann-Kendall test).

Normative Criteria	Key components	Indicator name	Unit	Last year in the time series	5-year average change (%/year)	10-year average change (%/year)	Trend of contribution towards bioeconomy objectives
Ecosystem capacity to produce services is maintained or enhanced	Environmental Quality	Biochemical oxygen demand in rivers	mgO_2/l	2021	-0.7%	-0.6%	No trend
		Phosphate in rivers	$mgPO_4/l$	2021	4.6%	**3.0%**	Negative
		Nitrate in groundwater	$mgNO_3/l$	2021	-0.9%	-0.4%	No trend
		Key component indicators currently not implemented in the EU-BMS: Phosphorus in lakes; Nitrate in rivers; Nutrients in transitional, coastal and marine waters; Exposure of forest area to ozone; Exceedance of air quality standards in urban areas					
	Structural and functional ecosystem attributes	Share of organic farming in utilised agricultural area	%	2020	**7.2%**	NA	Positive
		Livestock density index	unit per ha	2020	**-0.6%**	0.3%	Slightly positive
		Forest and other wooded land growing stock	1000 m^3	2020	**0.8%**	**1.0%**	Positive
		Fish stock biomass in NE Atlantic	Index, 2003 = 1	2021	3.2%	**2.6%**	Positive
		Fish stock biomass in the Mediterranean	Index, 2003 = 1	2021	**2.4%**	**3.1%**	Positive
		Key component indicators currently not implemented in the EU-BMS: Percentage area of urban green space (or percentage of natural area within the city boundaries); Landscape fragmentation Index; Share of High Nature Value farmland in agricultural area; Forest fragmentation and connectivity index; Deadwood; Share of forest area; Ecological status of European waters					
	Species diversity and abundance	Common Farmland bird Index	Index, 2000 = 100	2021	**-1.6%**	**-1.5%**	Negative
		Common Forest bird Index	Index, 2000 = 100	2021	**0.8%**	**0.6%**	Slightly positive
		Grassland butterflies Index	Index, 2000 = 100	2020	**-6.4%**	**-3.6%**	Negative
		Key component indicators currently not implemented in the EU-BMS: Age and size distribution of commercially-exploited fish species					
	Conservation status of habitats and species	Surface of marine sites designated under NATURA 2000	km^2	2020	**9.5%**	NA	Positive
		Surface of terrestrial sites designated under NATURA 2000	km^2	2020	**0.1%**	NA	Slightly positive
		Key component indicators currently not implemented in the EU-BMS: Conservation Status of European Habitats; Conservation status of grassland; Threatened tree species in forests					

Normative Criteria	Key components	Indicator name	Unit	Last year in the time series	5-year average change (%/year)	10-year average change (%/year)	Trend of contribution towards bioeconomy objectives
Primary production sectors are managed sustainably	Pressures from forest management	Ratio of annual fellings (m^3/ha/year) to net annual increment (m^3/ha/year)	-	2020	**4.0%**	**1.9%**	Negative
		Key component indicators currently not implemented in the EU-BMS: Fraction of primary residues remaining in forest; Change in ecosystems extent: Forest and woodland; Land use / land cover type taken over by forest; Number of annual introductions of invasive alien species in forests; Certified forests					
	Pressures from Marine fisheries & aquaculture management	Fishing mortality of commercially exploited fish and shellfish exceeding fishing mortality at maximum sustainable yield - North-East Atlantic	F/F_MSY	2021	-4.4%	**-1.9%**	Positive
		Fishing mortality of commercially exploited fish and shellfish exceeding fishing mortality at maximum sustainable yield - Mediterranean & Black Sea	F/F_MSY	2020	-1.6%	**-1.8%**	Positive
		Key component indicators currently not implemented in the EU-BMS: Nutrient discharge from fisheries aquaculture; Number of annual introductions of invasive alien species in marine waters					
	Pressures from Freshwater fisheries & aquaculture management	Key component indicators currently not implemented in the EU-BMS: Number of annual introductions of invasive alien species in freshwater; Size of aquaculture production units; Number of integrated multi-trophic aquaculture production units					
	Pressures from agroecosystems	Intensification of farming (share of low input farms in UAA)	%	2019	-1.9%	**-2.6%**	Negative
		Key component indicators currently not implemented in the EU-BMS: Ammonia emissions from agriculture; Land use / land cover type taken over by agricultural land; Change in ecosystems extent: cropland & grassland; Number of annual introductions of invasive alien species in agroecosystems; Sales of pesticides					
Ecosystem services contribution to human well-being is maintained or enhanced	Provisioning services	Biomass production in EU from primary production sectors: Agriculture	tonnes of dry matter	2020	0.4%	**1.0%**	Positive
		Biomass production in EU from primary production sectors: Fisheries	tonnes of dry matter	2020	0.0%	0.6%	No trend
		Biomass production in EU from primary production sectors: Forestry	tonnes of dry matter	2021	1.5%	**1.8%**	Positive
		Roundwood removals	m^3 solid volume over bark	2021	1.5%	**1.8%**	Positive
	Regulating services	Key component indicators currently not implemented in the EU-BMS: Flood regulation (flood control, flow, demand, potential, unment demand, monetary values); Air quality; Net ecosystem productivity					
	Cultural services	Key component indicators currently not implemented in the EU-BMS: Aesthetics considerations of nature; Recreational services (recreation, flow, demand, potential)					

Source: own elaboration

4.4 Objective 3: Reducing dependence on non-renewable, unsustainable resources

This objective reflects the goal of the EU Bioeconomy to follow sustainable production and circular economy principles. The EU-BMS breaks it down into six normative criteria:

1. Resource efficiency, waste prevention and waste-re-use along the whole bioeconomy value chain is improved.
2. Food loss and waste is minimised and, when unavoidable, its biomass is reused or recycled.
3. Sustainable production and consumption of biomass and bio-based products is promoted (within EU).
4. Consumption patterns of bioeconomy goods match sustainable supply levels of biomass.
5. Sustainable trade of non-food biomass is fostered.
6. The sustainability of urban centres is enhanced.

As illustrated earlier, each criterion is articulated in the EU-BMS into a set of key components each of which in turn comprises a set of indicators. At the moment the indicators implemented in the system cover mostly the first and second criteria for this objective. More specifically the following key components and related indicators are currently implemented in the EU-BMS:

- **Resource efficiency (Material footprint)**
  - Domestic material consumption (biomass). [source: Eurostat] This indicator quantifies the amount of biomass consumed as a share of the total domestic material consumption. The total is the sum of the biomass, metal ores, non-metallic minerals and fossil energy materials and carriers.

  - Material footprint (biomass). [source: UN]. Total amount of raw materials extracted to meet final consumption demands. It is one indication of the pressures placed on the environment to support economic growth and to satisfy the material needs of people.

- **Energy efficiency**
  - Energy productivity. [source: Eurostat] The indicator results from the division of the gross domestic product (GDP) by the gross available energy for a given calendar year. It measures the productivity of energy consumption and provides a picture of the degree of decoupling of energy use from growth in GDP. This indicator refers to the whole economy and is used here as proxy for the bioeconomy, in absence of bioeconomy-specific indicators.

  - Share of renewable energy in gross final energy consumption. [source: Eurostat] The indicator measures the share of renewable energy consumption in gross final energy consumption according to the Renewable Energy Directive. This indicator refers to the whole economy and is used here as proxy for the bioeconomy, in absence of bioeconomy-specific indicators.

- **Biogenic waste prevention, re-use/recycling, and recovery**
  - Circular material rate. [source: Eurostat] The indicator measures the share of material recovered and fed back into the economy - thus saving extraction of primary raw materials - in overall material use. This indicator refers to the whole economy and is used here as proxy for the bioeconomy, in absence of bioeconomy-specific indicators.

  - Recycling rate of municipal waste. [source: Eurostat] The share of recycled municipal waste in the total municipal waste generation. This indicator refers to the whole economy and is used here as proxy for the bioeconomy, in absence of bioeconomy-specific indicators.

  - Biowaste generated by source (households; industrial and agricultural; total). [source: JRC] Biowaste generated by households and industry. JRC has developed a methodology to differentiate the biodegradable component of waste in the different waste categories using empirical evidence.

- Biowaste recovered by source (households; industrial and agricultural; total). [source: JRC] Biowaste recovered from household and industrial biowaste.

- **Food loss and waste minimisation**
  - Food waste along supply chain (primary production; processing and manufacturing; retail and distribution; consumption; total). [source: JRC, De Laurentiis et al. 2024] Food waste generated per year in EU MS by stage of the food supply chain.

  - Food waste by food category (cereals; cocoa and coffee; dairy; eggs; fish; fruits and nuts; meat; oilcrops; potatoes; sugarbeets; vegetables; total). [source: JRC, De Laurentiis et al. 2024] Food waste generated per year in EU MS by food type category.

- **Consumption and demand for biomass and bio-based products**
  - Total biomass consumed for energy. [source: JRC-BIOMASS] Total biomass of agricultural and woody origin consumed annually in the production of energy.

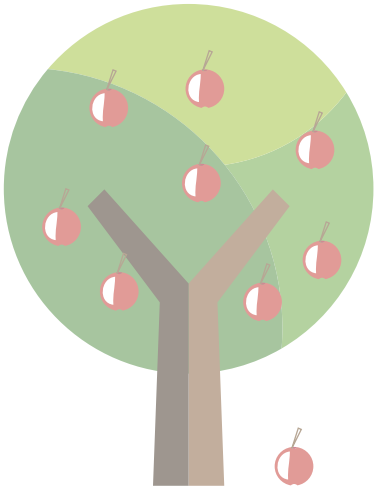
  - Total biomass consumed for material. [source: JRC-BIOMASS] Total biomass of agricultural and woody origin consumed annually in the production of materials.

  - Share of woody biomass used for energy. [source: JRC-BIOMASS] The indicator shows the total biomass of woody origin consumed annually in the production of energy as a share of total uses (energy + material).

- **Reduced dependence on non-renewable resources**
  - Share of renewables for transport, electricity, and heating & cooling. [source: Eurostat] This indicator is based on data collected by Eurostat in the framework of Regulation (EC) No 1099/2008 on energy statistics and complemented by specific supplementary data transmitted by national administrations to Eurostat.

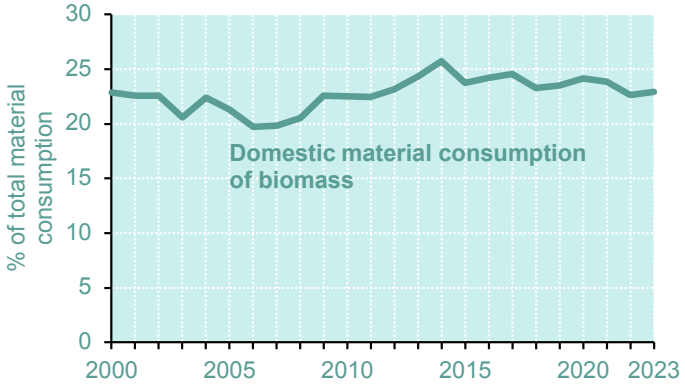
- **Economic impact of trade in exporting countries (to EU)**
  - Economic impact of trade in exporting countries (to EU). [source: JRC, Kilsedar et al. 2023 based on UN Comtrade, World Bank] The indicator shows the monetary volume from exporter countries to EU related to biocommodities and the share of GDP. It is subdivided into 5 categories: primary crops, livestock, fish, plants, timber. In this report, we report the total for these categories.

Here below we present and discuss the trends observed for these indicators, the full set of quantitative results is provided in the scoreboard at the end of this section (*Figure 15*).

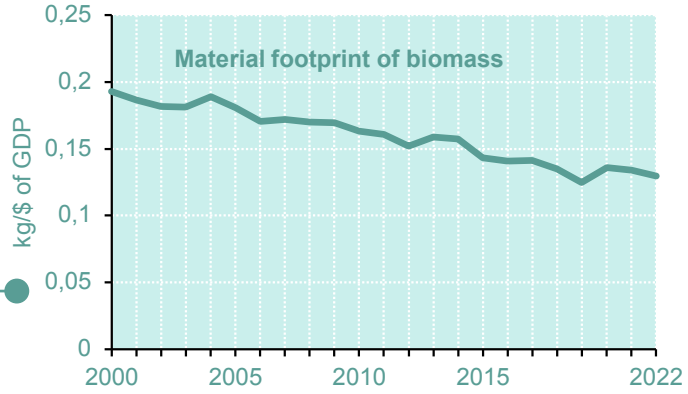


Resource efficiency (Material footprint)

- Domestic material consumption of biomass has fluctuated between 20 % and 26 % since 2000. The peak share of biomass in the total biomass consumption, 25.7 %, was recorded in 2014, but the share has decreased since then to 23 %.

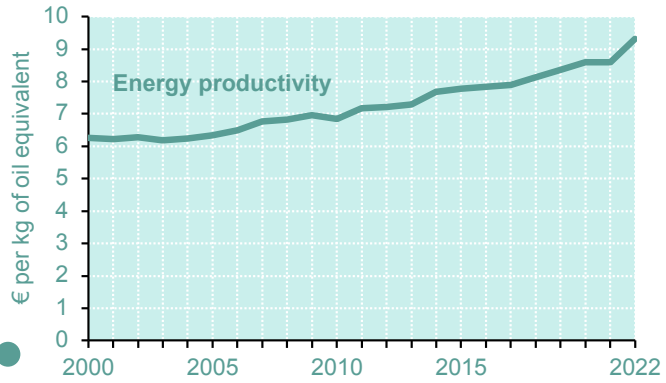


- The material footprint of biomass – expressed in the EU-BMS as kilogram per dollar of GDP – describes the total amount of raw materials extracted to meet final consumption demands. This indicator has a reversed directionality, i.e. a decrease in the value corresponds to positive development. In the EU, this indicator has shown a decreasing trend since 2000, but lately the development has stabilised: while the 10-year trend for 2013-2022 was 2 % decrease per year, the last 5 years available in the EU-BMS (2018-2022) show a trend of 0.1 % decrease per year.

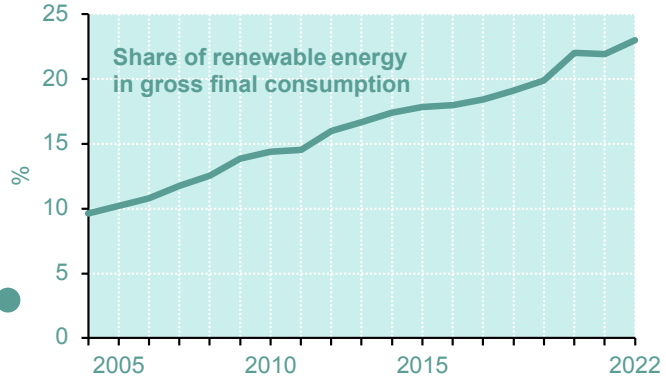


Energy efficiency

- Energy productivity in the EU-BMS is monitored with an indicator that divides the gross domestic product (GDP) by the gross available energy for a given calendar year. It measures the productivity of energy consumption and provides a picture of the degree of decoupling of energy use from growth in GDP. It includes all energy sources, also those beyond biomass. The trend in this indicator is clearly positive, with 3.2 % improvement per year in 2018-2022, and 2.5 % improvement over the 10-year period 2013-2022.

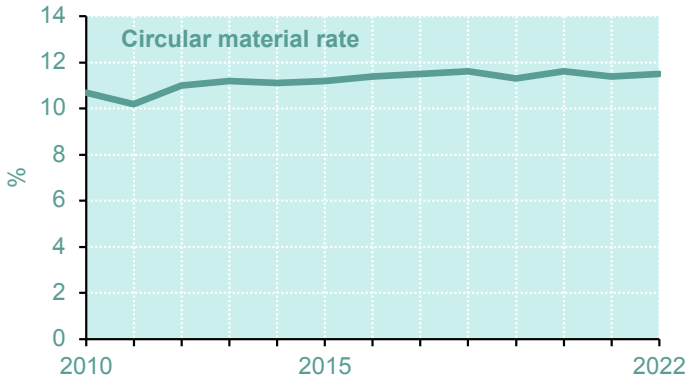


- In the meantime, the share of renewable energy in gross final consumption shows a strong and steady growth, with on average 5.1 % increase in 2018-2022, and 4.3 % in 2013-2022. Consequently, in 2022 the share of renewable energy reached 23 % of the gross final energy consumption on the EU level. There is large variation between the countries, with the highest share reported by Sweden (66 % in 2022), and lowest shares by Ireland and Malta (13 %).

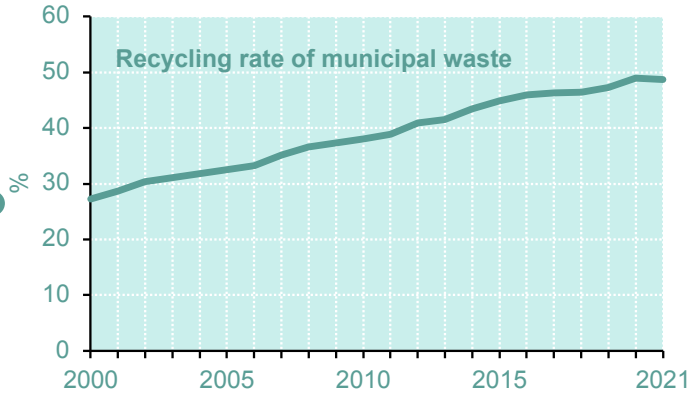


Biogenic waste prevention, re-use/recycling and recovery

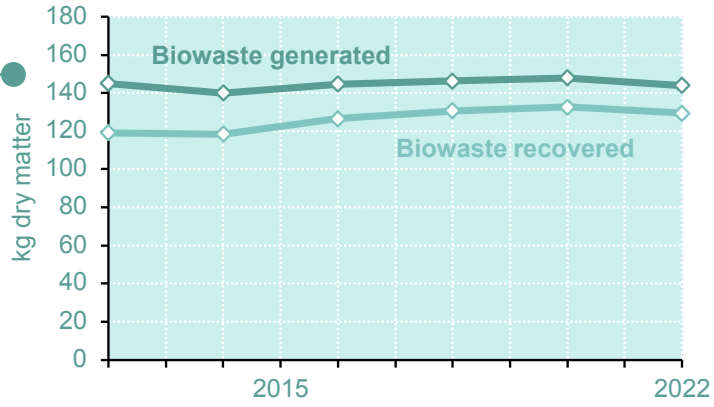
- Circular material rate measures the share of material recovered and fed back into the economy - thus saving extraction of primary raw materials - in overall material use. A higher circularity rate value indicates that more secondary materials substitute for primary raw materials, thus reducing the environmental impacts of extracting primary material. In the EU, this indicator has remained on a broadly stable level of ca. 11 % throughout the time series available.

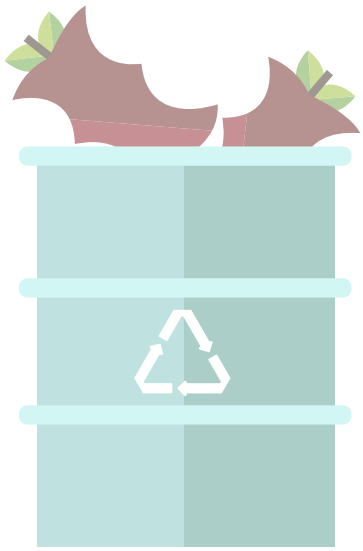


- Recycling rate of municipal waste shows the share of recycled municipal waste in the total municipal waste generation. This indicator has increased steadily over time, reaching almost 50 % in 2020, which is almost double the recycling rate in 2000.



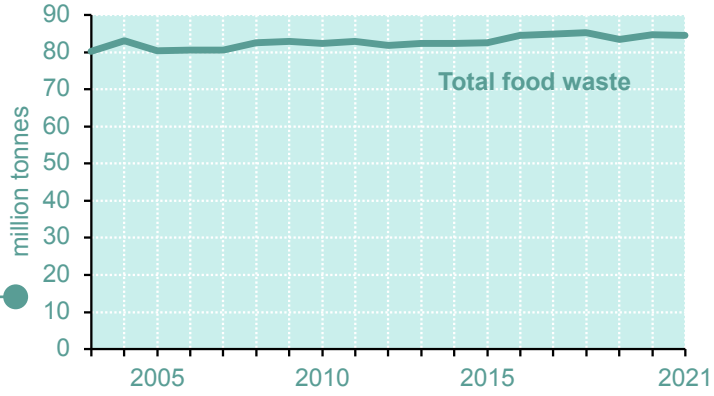
- For biowaste, the recovery rate is relatively high: almost 90 % of the generated biowaste is recovered. This share has increased somewhat from the start of the time series (82 % in 2012). A vast majority of the recovered waste is paper and cardboard wastes (both from households and industry) and wood wastes (mainly from wood-based industries).



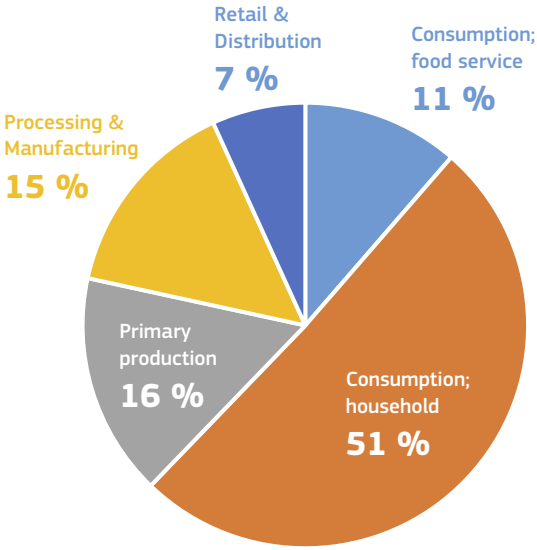


Food loss and waste minimisation

- The food waste is monitored in the EU-BMS for different sectors, as well as for different foods. The total food waste generated in the EU has fluctuated between 80 M tonnes and 85 M tonnes during the monitored period 2003-2021, with no clear trend detected in the recent years.

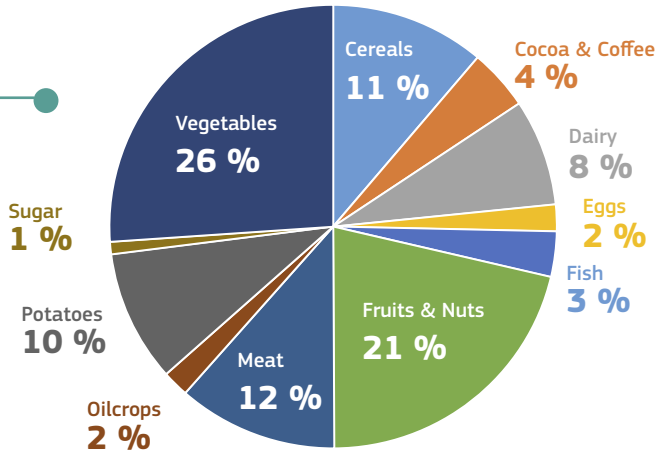


- More than half of the food waste in the EU is generated by households (51 %). Primary production generates 16 % and processing and manufacturing 15 % of the total food waste. The share of food services is 11 %, while retail and distribution stands for 7 % of the total food waste. These shares have remained virtually unchanged throughout the monitoring period available.



Food waste along supply chain in 2021

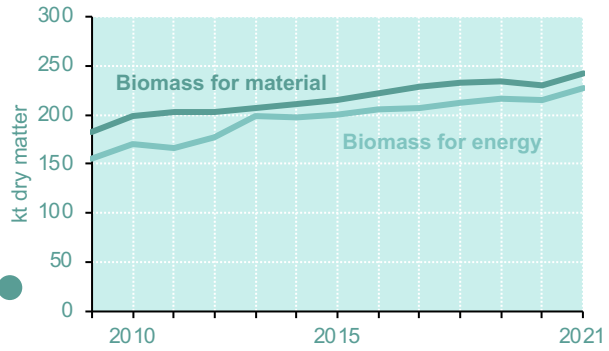
- Of the individual food categories, 57 % of all food waste in 2021 was generated from fruits, vegetables and potatoes. Meat stands for 12 % of the food waste, dairy for 8 %, and cereals for 11 %. Cocoa and coffee, eggs, fish, oilcrops and sugarbeet total for 13 % of food waste altogether. Also these shares have remained very similar over the years.



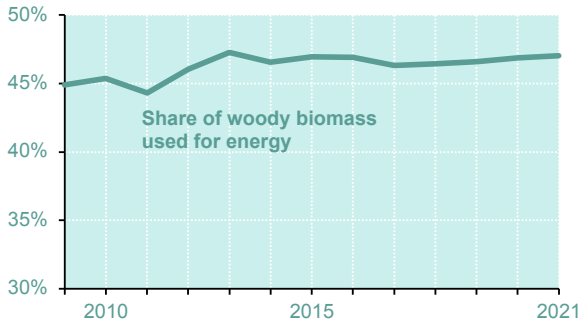
Food waste by food category in 2021

Consumption and demand for biomass and bio-based products

- Total production and consumption of biomass has increased over time by ca. 2 % per year. Slightly more than half of the total biomass used goes for material purposes, while the rest is used for energy. The share of energy use has increased from 45.8 % in 2009 to 48.4 % in 2021.



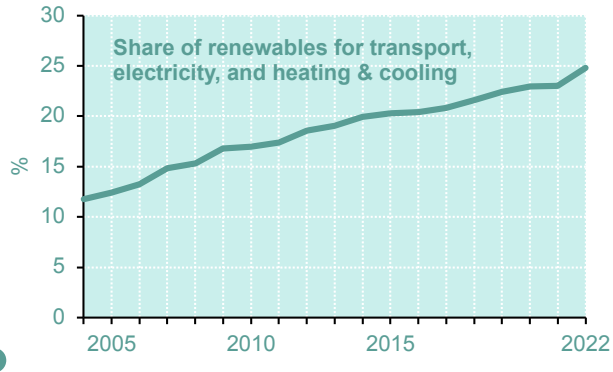
- The use of woody biomass for energy reflects this same trend and has increased proportionally more than material use. The share of energy use of the total biomass was 44.9 % in 2009, 46.3 % in 2017 and 47 % in 2021.



The indicators measuring the total production and consumption of biomass for material and energy uses are in the EU-BMS placed under the normative criterion “Consumption patterns of bioeconomy goods match sustainable supply levels of biomass”. There is ambiguity in whether an increase in these indicators contributes towards or against the objective of managing natural resources sustainably. Therefore, the assessment of the trend for these indicators was left undetermined.

Reduced dependence on non-renewable resources

- The share of renewables for transport, electricity and heating & cooling has increased steadily over time and reached 23 % in 2022. This is a substantial increase from only 9.6 % in 2004. Based on the Union Bioenergy Sustainability Report[91], 59% of of all renewable energy consumed in the EU in 2021 originated from biomass. Of this energy, 66% was produced from forest biomass, 26% from organic waste and 8% from agricultural biomass.



91 European Commission, 2023. Union Bioenergy Sustainability Report. COM(2023) 650 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52023DC0650

Focus box 6. Economic impact of trade and social condition in exporting countries to the EU

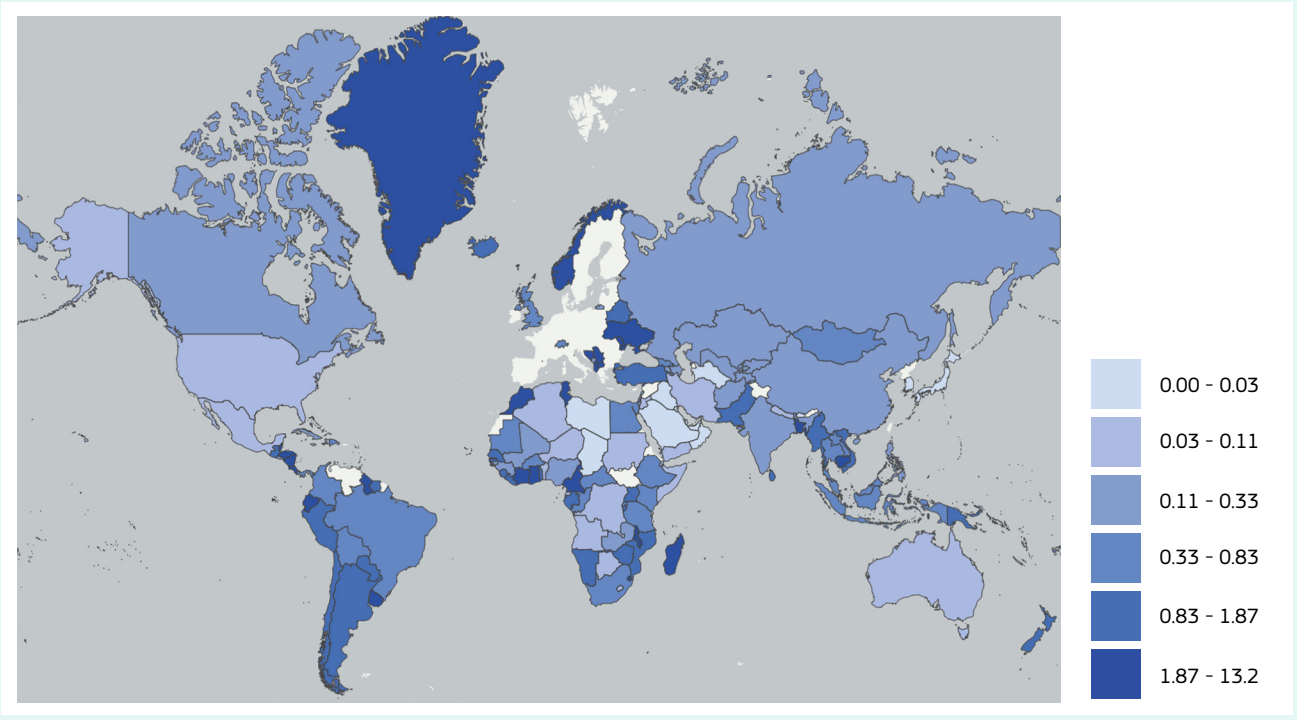
Two new types of trade-related indicators were implemented in the EU-BMS in 2022 (Kilsedar et al. 2023) under Objective 3. While the other indicators in the system describe conditions within the EU boundaries, “Economic impact of trade in exporting countries (to EU)” and “Social condition in exporting countries (to EU)” are reported for the countries trading various bio-commodities and bioproducts with the EU.

The economic impact of trade in exporting countries (to EU) indicator reflects the impact of exporting bio-commodities and related products to the EU on the economy of extra-EU countries. This indicator is divided into 5 categories related to the classification of bio-products as defined in De Laurentiis et al. (2022): primary crops, livestock, fish, plants and timber. The indicator is described in two units: the absolute volume of monetary exchange and the share of it with respect to national GDP (Figure 13) currently covering the period 2014-2019.

The social condition in exporting countries to the EU is currently described through a set of seven social sub-indicators (Melim-Mcleod et al. 2021): informal employment; compliance of labour rights; monthly minimum wage; poverty rate; infant mortality rate; coverage of essential health services; gender pay gap. The development of these indicators, when data is available, is presented in the EU-BMS for years 2012-2021.

The available time series is not considered long enough yet for a trend analysis.

Figure 13. Total trade to the EU as a share of GDP (percent) in 2019.



Source: EU-BMS

Focus box 7. Cascade use of wood.

Cascade use of wood (*Figure 14*) is promoted in a number of EU policy documents, such as the EU 2018 Bioeconomy Strategy, the New EU Forest Strategy for 2030, and the Revision of the Renewable Energy Directive COM(2021) 557. In the latter, it is defined as follows: *"The cascading principle aims to achieve resource efficiency of biomass use through prioritising biomass material use to energy use wherever possible, increasing thus the amount of biomass available within the system. In line with the cascading principle, woody biomass should be used according to its highest economic and environmental added value in the following order of priorities: 1) wood-based products, 2) extending their service life, 3) re-use, 4) recycling, 5) bio-energy and 6) disposal."* As described in Avitabile et al. (2023), based on Olsson et al. (2016) the term cascading can be used to refer to dimensions of time (recovery of wood as many times as possible), in value (recovering resources with the aim to increase its value within the cascade chain), or in function (to use each woody component for an optimal purpose in a way that maximises value).

In wood-based industries, cascade use of wood is a key element through the different interlinkages within the sector. Industry by-products and uncontaminated post-consumer wood can be used both for material and energy production: sawmilling by-products are widely used for wood-based panel and pulp industries as feedstocks, and recovered paper is an important feedstock in paper and paperboard production. Avitabile et al. (2023) conclude that there is potential to use more by-products for material, although it should be acknowledged that to quantify exactly how much, the technological, physical and geographical considerations should also be assessed.

In the EU-BMS, the indicator "cascade uses of wood resources" is presently estimated as the ratio of by-products and post-consumer wood used for material production on the total woody biomass used reported in the EU-27 and it shows an almost stable share of approximately 10 % in 2009-2017. However, because of the increasing importance of the concept and the need to better consider its different facets, the indicator is currently under revision. The main challenges in the update and implementation of the indicator are related to the uncertainties in the estimates for EU-level production and consumption of woody biomass, where considerable discrepancies have been identified in the reported data (Camia et al. 2020; Avitabile et al. 2023).

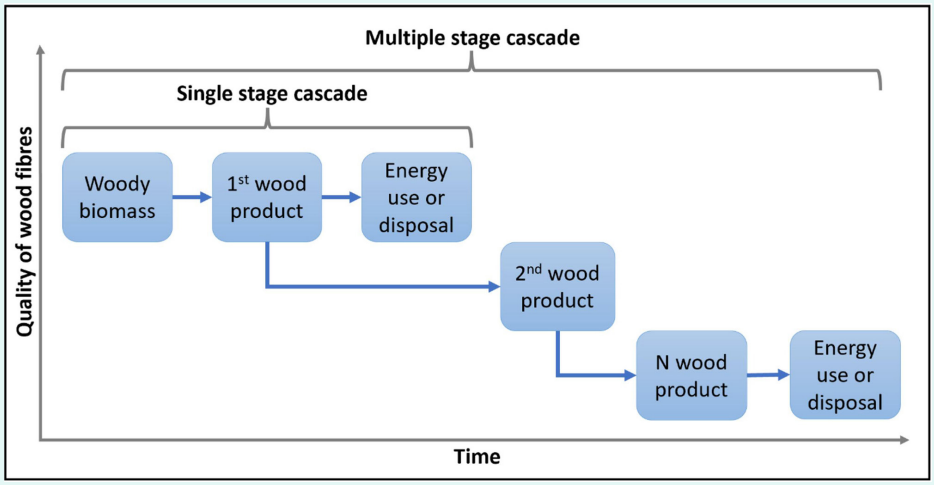


Figure 14. Schematic illustration of the cascade use of wood.

Original source: Avitabile et al. 2023

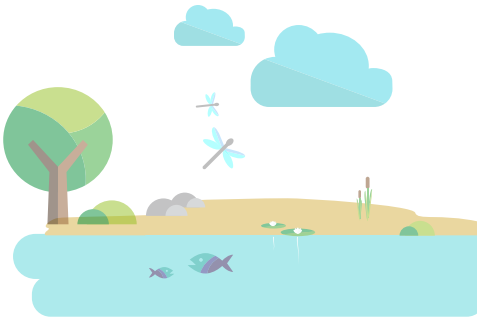
Figure 15: Scoreboard of indicators for Objective 3 of the EU bioeconomy strategy. Bold numbers in the average change per year indicate statistically significant trend (Mann-Kendall test).

Normative Criteria	Key components	Indicator name	Unit	Last year in the time series	5-year average change (%/ year)	10-year average change (%/year)	Trend of contribution towards bioeconomy objectives
Resource efficiency, waste prevention and waste-re-use along the whole bioeconomy value chain is improved	Resource efficiency (Material footprint)	Domestic Material Consumption (Biomass)	% of total Domestic Material Consumption	2023	-1.1%	**-0.9%**	Slightly negative
		Material Footprint (Biomass)	kg/$ of GDP	2022	-0.1%	**-2.0%**	Positive
		Key component indicators currently not implemented in the EU-BMS: Land footprint in EU of EU consumption (for non-food&feed)					
	Energy Efficiency	Energy productivity	€ per kg of oil equivalent	2022	3.2%	**2.5%**	Positive
		Share of renewable energy in gross final energy consumption	%	2022	5.1%	**4.3%**	Positive
		Key component indicators currently not implemented in the EU-BMS: Share of renewable energy in gross final energy consumption of bio based industries or bioenergy industries					
	Biogenic waste prevention, re-use/recycling, and recovery	Circular material rate	%	2022	-0.1%	**0.4%**	Slightly positive
		Recycling rate of municipal waste	%	2021	1.6%	**2.1%**	Positive
		Biowaste generated by source: Households	kg dry	2022	0.6%	**0.9%**	Slightly negative
		Biowaste generated by source: Industrial and Agricultural	kg dry	2022	**-1.1%**	0.0%	Negative
		Biowaste generated by source: Total	kg dry	2022	-0.4%	**0.4%**	Slightly negative
		Biowaste recovered by source: Households	kg dry	2022	1.1%	**3.0%**	Positive
		Biowaste recovered by source: Industrial and Agricultural	kg dry	2022	**-1.0%**	0.4%	Negative
		Biowaste recovered by source: Total	kg dry	2022	-0.3%	**1.3%**	Positive
		Key component indicators currently not fully implemented in the EU-BMS: Total energy supply from municipal waste; Cascading use of wood resources					
Food loss and waste is minimised and, when unavoidable, its biomass is reused or recycled	Food loss and waste minimization	Food waste along supply chain: Total	tonnes	2021	-0.1%	**0.4%**	Slightly negative
		Food waste along supply chain: Primary Production	tonnes	2021	-0.4%	0.2%	No trend
		Food waste along supply chain: Processing and Manufacturing	tonnes	2021	-0.4%	0.6%	No trend
		Food waste along supply chain: Retail and Distribution	tonnes	2021	-0.2%	**0.4%**	Slightly negative
		Food waste along supply chain: Consumption food service	tonnes	2021	0.2%	**0.3%**	Slightly negative
		Food waste along supply chain: Consumption household	tonnes	2021	-0.1%	0.4%	No trend
		Food waste by food category: Cereals	tonnes	2021	-2.2%	0.1%	No trend
		Food waste by food category: Cocoa and coffee	tonnes	2021	0.4%	0.5%	No trend
		Food waste by food category: Dairy	tonnes	2021	0.4%	**0.7%**	Slightly negative
		Food waste by food category: Eggs	tonnes	2021	1.7%	**1.1%**	Negative
		Food waste by food category: Fish	tonnes	2021	-2.7%	-0.1%	No trend
		Food waste by food category: Fruits and nuts	tonnes	2021	2.9%	**1.7%**	Negative
		Food waste by food category: Meat	tonnes	2021	0.8%	**0.7%**	Slightly negative
		Food waste by food category: Oilcrops	tonnes	2021	1.4%	**1.9%**	Negative
		Food waste by food category: Potatoes	tonnes	2021	-1.7%	-0.6%	No trend
		Food waste by food category: Sugarbeets	tonnes	2021	1.5%	**-4.0%**	Positive
		Food waste by food category: Vegetables	tonnes	2021	-1.3%	0.0%	No trend

Normative Criteria	Key components	Indicator name	Unit	Last year in the time series	5-year average change (%/ year)	10-year average change (%/year)	Trend of contribution towards bioeconomy objectives
Bioeconomy should promote sustainable production and consumption of biomass and bio-based products (within EU)	Bio-based products environmental impacts	Key component indicators currently not implemented in the EU-BMS: Environmental impacts based on product-based LCA and basket of representative products of the bioeconomy					
Consumption patterns of bioeconomy goods match sustainable supply levels of biomass	Consumption and demand for biomass and bio-based products	Total biomass consumed for energy	1000 t dry matter	2021	2.1%	**2.3%**	Undetermined
		Total biomass consumed for materials	1000 t dry matter	2021	1.1%	**2.1%**	Undetermined
		Share of woody biomass used for energy	%	2021	**0.4%**	0.1%	Undetermined
		Key component indicators currently not implemented in the EU-BMS: Import dependencies for energy (wood,biofuels, bioenergy)					
	Production of bio-based products	Key component indicators currently not implemented in the EU-BMS: Liquid biofuels production (bioethanol, pure biogasoline, biodiesel, bio jet kerosene and other liquid biofuels); Biogasses (indigenous) production; Production of bio-based materials (plastics, textiles, chemicals); Advanced biofuels production					
	Reduced dependence on non-renewable resources	Share of renewables for transport, electricity and heating & cooling	%	2022	**3.2%**	**3.0%**	Positive
		Key component indicators currently not implemented in the EU-BMS: Total consumption of energy, including fossil-based; Share of wood-based constructions; Share of consumption of bio-based plastics, textiles and chemicals					
Local economies of countries exporting non-food commodities to the EU are not hampered but rather harnessed by the trade of raw and processed biomass and related technologies	Economic impact of trade in exporting countries of non-food (to EU)	Economic impact of trade in exporting countries (to EU)	million US $	2019	3.0%	NA	Undetermined
	Environmental footprints in exporting countries of non-food (to EU)	Key component indicators currently not implemented in the EU-BMS					
	Social impact of trade in exporting countries of non-food (to EU)	Data available in the EU-BMS					
The sustainability of urban centres is enhanced	Enhanced well-being and health of urban dwellers	Key component indicators currently not implemented in the EU-BMS: Self-assessed satisfaction with recreational and green areas; Self-assessed satisfaction with living environment; Self-assessed overall life satisfaction					

Source: own elaboration

4.5 Objective 4: Mitigating and adapting to climate change



Objective 4 addresses the role of the bioeconomy in mitigating and adapting to climate change. In the EU-BMS, the objective is expressed in two normative criteria:

1. Climate change mitigation and adaptation are pursued;
2. The sustainability of urban centres is enhanced.

On climate change mitigation, the current implementation of the monitoring system focuses on net emissions from land and agriculture, while on adaptation the indicators available are water exploitation index (WEI) and a new indicator tracing the potential catch of fisheries, which may give indication of the climate change adaptation of marine bioeconomy. A number of indicators for monitoring this objective are foreseen in the EU-BMS but are currently not implemented yet in the system. These gaps should be kept in mind when considering the overall trends under this objective.

The indicators implemented, for which trends could be assessed, are shortly described in what follows.

- **Climate change mitigation**
  - Net GHG emissions from agriculture. [source: Eurostat] Agriculture emissions (mostly methane CH_4 and nitrous oxide N_2O) are mainly related to the management of agricultural soils (e.g. fertiliser and lime application), enteric fermentation by ruminant animals and manure management and, to a lesser extent, to rice cultivation and crop residue burning.

  - Net GHG emissions from LULUCF. [source: Eurostat] LULUCF covers emissions (CO_2 from agricultural lands, CO_2, CH_4 and N_2O from other lands) and CO_2 removals in forest land, cropland, grassland, wetlands, settlements and other lands from the following pools: Living biomass; Dead organic matter (deadwood and litter); Soil organic carbon (mineral and organic). Harvested wood products such as timber used in construction or furniture, wood panels, and paper and pulp products are reported as an additional pool under this indicator.

- **Climate change adaptation**
  - Crop yield (winter wheat, spring wheat, grain maize and corn-cob). [source: Eurostat] Climate change can measurably affect crop productivity, food security and agriculture competitiveness. Annual productivity (tonnes/ha yr) of three crops that are sensitive to climate change: Winter wheat, spring wheat and corn. This indicator is not provided for EU-27, but the individual MS data are available in the EU-BMS.

  - Water exploitation index (WEI). [source: Eurostat] Climate change can lead to longer and more frequent droughts across the EU, affecting both the demand and availability of water for, e.g., agriculture irrigation. Annual total water use – i.e., the difference between water abstraction and return after use - can be expressed as a percentage of the available renewable freshwater resources (groundwater and surface water) at given time. The higher the percentage, the higher pressure on renewable water resources due to water demand and the more vulnerable the system is. On average, values above 20 % indicate situations of water scarcity, while values above 40 % point to severe water scarcity and unsustainable use of water resources.

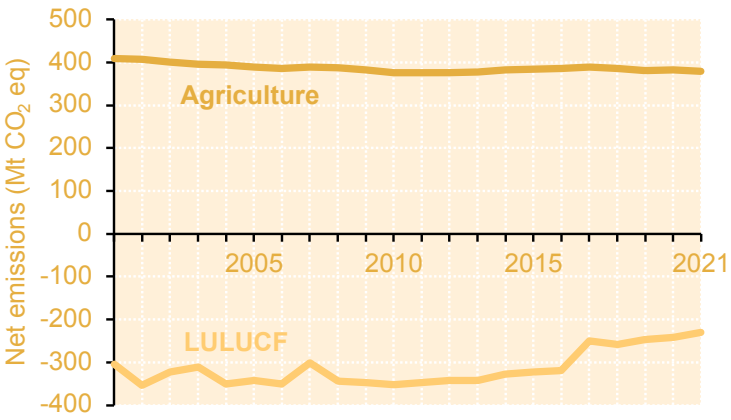
  - Adaptation in fisheries (potential catch). [source: EEA] Ratio of the number of Lusitanian species to the number of Boreal species in EU waters. Lusitanian species are warmer water species, hence their migration north to seas normally inhabited by boreal species suggests an adaptation to warming waters.

Here below we present and discuss the trends observed for these indicators, the full set of quantitative results is provided in the scoreboard at the end of this section (*Figure 16*).

Climate change mitigation

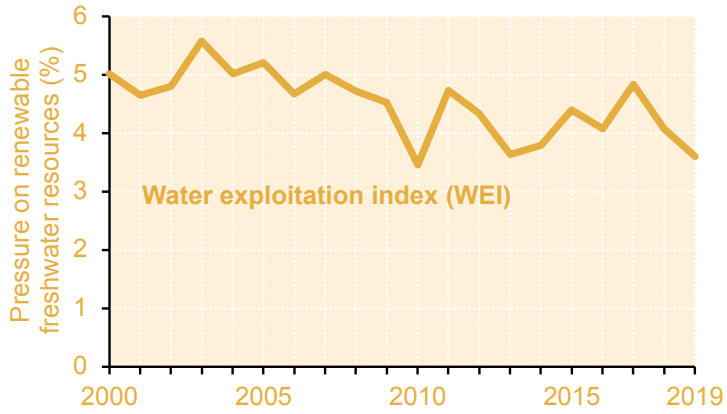
- The emissions from agriculture have remained largely stable since 2000, even though we note that in the meantime the agricultural production has increased. The agricultural sector – encompassing livestock management and fertilization of agricultural lands – emits yearly just below 400 Mt CO_2 eq, which is ca. 12 % of the total EU emissions.

- LULUCF sector, which includes forests, harvested wood products, and CO_2 emissions from agricultural lands, absorbs more CO_2 from the atmosphere than it emits in greenhouse gases. This net sink fluctuated between -300 and -350 Mt CO_2 eq in 2000-2010 but has since 2011 turned into a clear decline. Even though LULUCF is still a substantial sink on the EU level, the development is negative in terms of climate change mitigation. This trend is mainly driven by the decreasing carbon sink in forests: while still absorbing more CO_2 than they release, the EU forests have in recent years been heavily affected by disturbances such as droughts, windthrow and wildfires, and harvest levels have continued to increase. In the meantime, forest increment levels have not increased at the same rate, leading to an overall decreasing sink trend. In some countries, also increased emissions from organic soils (driven by increasing temperature) are contributing to the declining LULUCF sink.



Climate change adaptation

- Water exploitation index (WEI), defined as the ratio of the total volume of water abstraction over the total volume of available water, can range between 0 % and 100 %. The United Nations considers a WEI value of less than 10 % to indicate low water stress, while high water stress is denoted by an index of over 40 %. On the EU level, WEI shows considerable yearly fluctuation reflecting the weather conditions, it fluctuated between 3.5 % and 4.9 % in 2010-2019. The variation between MS is however high: while a low WEI is reported for most MS, water scarcity or severe water scarcity has been observed especially in Cyprus, Greece, Malta, Portugal and Romania.



- The ratio of the number of Lusitanian species to the number of Boreal species in EU waters is an indicator to monitor the adaptation of fish stocks to climate-change induced alterations in marine habitats. Lusitanian species are warmer water species, hence their migration north to seas normally inhabited by boreal species suggests an adaptation to warming waters. This ratio has remained relatively stable in three of the monitored sea areas (Bay of Biscay and the Iberian Coast; Celtic seas; and the Greater North Sea), while in the Baltic Sea the ratio declined between 2007 and 2013, but has since turned into a slight increase.

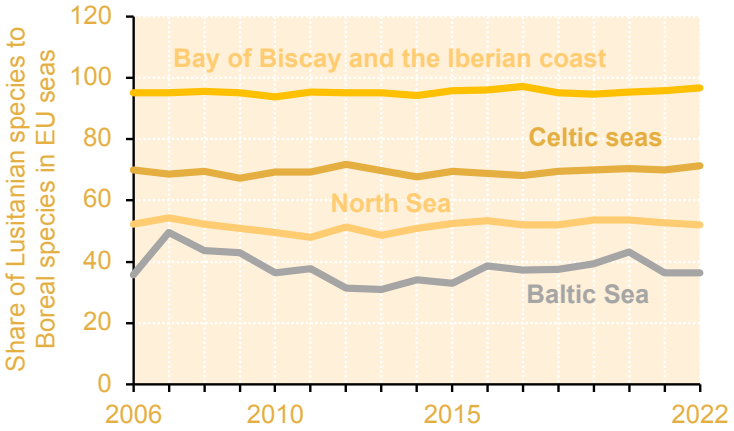


Figure 16: Scoreboard of indicators for Objective 4 of the EU bioeconomy strategy. Bold numbers in the average change per year indicate statistically significant trend (Mann-Kendall test).

Normative Criteria	Key components	Indicator name	Unit	Last year in the time series	5-year average change (%/year)	10-year average change (%/year)	Trend of contribution towards bioeconomy objectives
Climate change mitigation and adaptation are pursued	Climate change mitigation	net GHG emissions (emissions and removals) from agriculture	Million tonnes of CO_2 equivalent	2021	-0.6%	0.1%	No trend
		net GHG emissions (emissions and removals) from LULUCF	Million tonnes of CO_2 equivalent	2021	2.2%	**4.1%**	Negative
		Key component indicators currently not implemented in the EU-BMS: net GHG emissions (emissions and removals) from bioenergy (absolute and relative vs. total sector emissions); net GHG emissions (emissions and removals) from BBI (absolute and relative vs. total industrial emissions); net GHG emissions (emissions and removals) from bio-waste (absolute and relative vs. total waste emissions); GHG emissions from fishing and aquaculture; Financial support to bio-based sectors (climate action)					
	Climate change adaptation	Water exploitation index (WEI)	Pressure on renewable freshwater resources (%)	2019	-3.5%	0.2%	No trend
		Adaptation in fisheries (potential catch) in the Celtic Seas	Share of Lusitanian species to Boreal species in EU seas	2022	0.5%	**0.4%**	Slightly positive
		Adaptation in fisheries (potential catch) in the Greater North Sea (incl. Kattegat and the English Channel)		2022	-0.2%	0.6%	No trend
		Adaptation in fisheries (potential catch) in the Baltic Sea		2022	-1.4%	2.1%	No trend
		Adaptation in fisheries (potential catch) in the Bay of Biscay and the Iberian Coast		2022	0.4%	0.1%	No trend
		Key component indicators currently not implemented in the EU-BMS: Annual heating and cooling degree days; Crop yield (Winter wheat, Spring wheat, Grain maize and corn-cob); Soil moisture (seasonal average); Soil erosion / desertification; Soil organic carbon content; Adaptation in agriculture, share of farmers with CAP risk management tools (insurance); Adaptation in agriculture, share of agricultural land under commitments to improve adaptation (ha); Adaptation in agriculture, unsustainable water use: share of irrigated land under commitments to improve water balance; Adaptation in forest, # fire instances; Adaptation in forest, Burnt area; Adaptation in forest, natural disturbance events; MS Preparedness - Year of adoption of the National Adaptation strategy/Plan (NAS/NAP); Adaptation, International Transboundaries effects - loss in GDP					
The sustainability of urban centres is enhanced	Enhanced resilience/ adaptation to climate change for urban areas	Key component indicators currently not implemented in the EU-BMS: City preparedness - # cities signatories of COM - Adaptation; Investments in urban adaptation through nature-based infrastructures or EBA					

Source: own elaboration

4.6 Objective 5: Strengthening European competitiveness and creating jobs

Objective 5 of the 2018 EU Bioeconomy Strategy relates to the economic sustainability and viability of the bioeconomy, with a specific focus on competitiveness and employment. In the EU-BMS, it is delineated into five normative criteria, of which the first two are currently more developed in the system:

1. Economic development is fostered;
2. Inclusive economic growth is strengthened;
3. Resilience of the rural, coastal and urban economy is enhanced;
4. Knowledge generation and innovation are promoted;
5. Demand and supply-side market mechanisms and policy coherence between supply of and demand for food and non-food goods are enhanced.

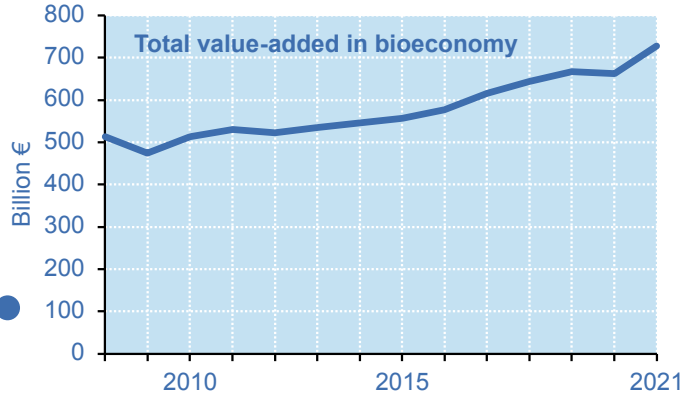
For the objective, the following key components and the related available indicators are presented in the EU-BMS:

- **Contribution of bioeconomy to economic development**
  - Value added per sector (agriculture; forestry; fishing and aquaculture); Value added per manufacturing sectors (bio-based textiles; bio-based wearing apparel; leather; wood products; paper and paper products; bio-based pharmaceuticals; bio-based plastics and rubber; wooden furniture; bio-based chemicals; generation of bio-based electricity; production of bio-diesel; production of bio-ethanol; food; beverages; tobacco). [source: DataM, Lasarte-López et al. 2023b] Value added refers to the value added at factor costs. It is the gross income from operating activities after adjusting for operating subsidies and indirect taxes. Value adjustments (such as depreciation) are not subtracted.
  - Gross value added per person employed in the bioeconomy. [source: DataM, Lasarte-López et al. 2023b] The value added at factor costs divided by the number of persons employed in a given sector measures the "Apparent labour productivity" of that sector.
- **Value of raw and processed biomass, total value added in bioeconomy sectors**
  - Turnover in bioeconomy per sector. [source: DataM, Lasarte-López et al. 2023b] Turnover comprises the totals invoiced by the observation unit during the reference period, and this corresponds to market sales of goods or services supplied to third parties.
  - Value-added per sector (total). [source: DataM, Lasarte-López et al. 2023b] Value added refers to the value added at factor costs. It is the gross income from operating activities after adjusting for operating subsidies and indirect taxes. Value adjustments (such as depreciation) are not subtracted.
- **Employment per bioeconomy sectors**
  - Persons employed per bioeconomy sectors. [source: DataM, Lasarte-López et al. 2023b] The number of persons employed is defined as the total number of persons who work in the observation unit, as well as persons who work outside the unit who belong to it and are paid by it. For Algae: Data collected and curated by JRC.D2 Water and Marine Resources. Note that the employment data under fishing and aquaculture includes also algae gathering.

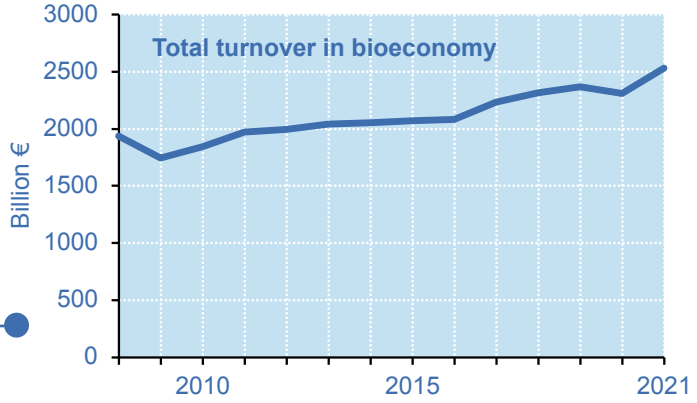
Here below we present and discuss the trends observed for these indicators, the full set of quantitative results is provided in the scoreboard at the end of this section (*Figure 17*).

Contribution of bioeconomy to economic development

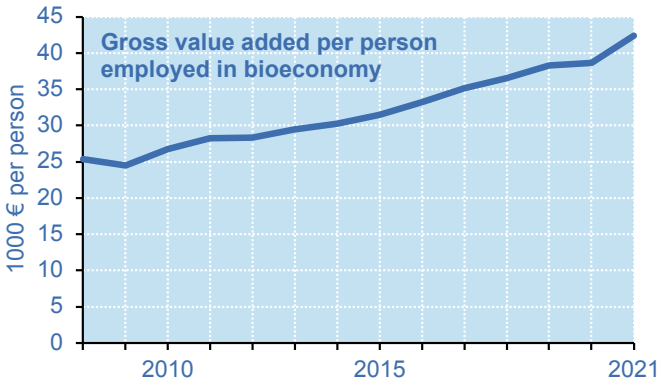
- The total value added in the EU bioeconomy has increased substantially over time, reaching EUR 728 billion in 2021 (54 % increase from EUR 474 billion estimated for 2009) and accounting for 5.0 % of EU's GDP in this year. Of the total bioeconomy value added, 60 % comes from agriculture and food industry. The increase in the two latter sectors from 2020 to 2021 is strongly driven by the high inflation as a consequence of the COVID-19 pandemic.

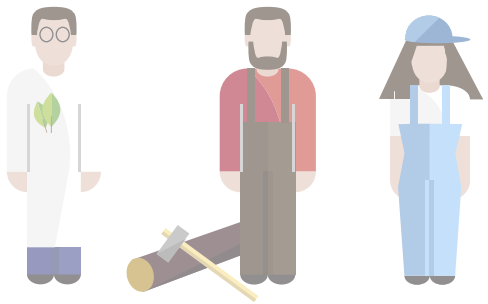


- Turnover depicts a value of more than EUR 2 500 billion, however is not further detailed, because of the double counting of several activities along the value chains.



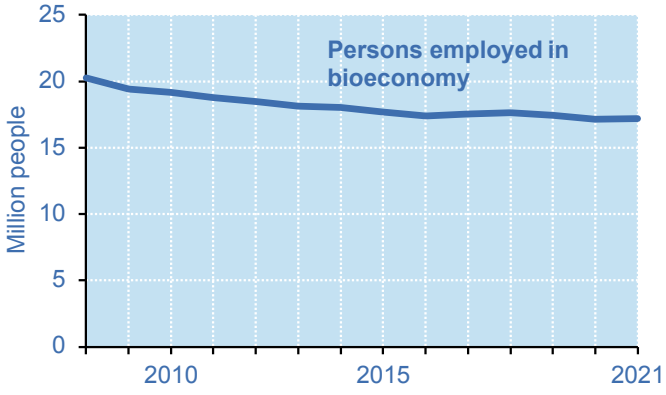
- The gross value-added per person employed in the bioeconomy has shown an impressive growth over the years. While this is clearly an improvement of the productivity, it is also the consequence of the reduced employment in primary sectors, in particular agriculture.





Employment per bioeconomy sectors

- The number of people working in the bioeconomy sectors has decreased considerably over time, although it has shown a stabilising trend in recent years. Most of this decline can be attributed to the decrease in the agricultural workforce, especially in Eastern Europe. At the same time, the gross value added per person has increased, suggesting a growing productivity trend in the job market, not only because of agriculture restructuring but also due to the growth of high value added manufacturing activities (e.g. chemicals).

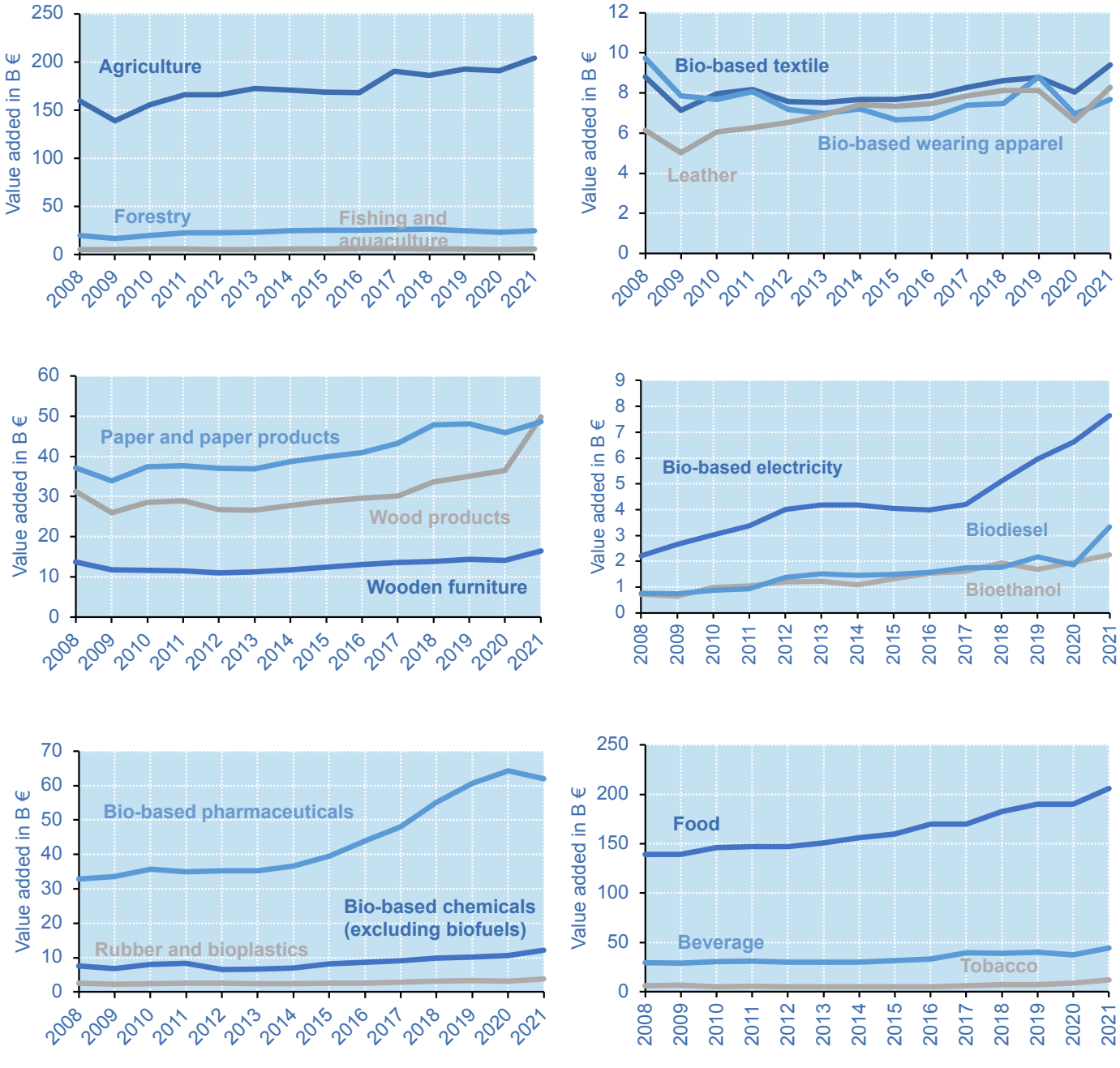


Value added in bioeconomy sectors

- The value-added from novel bio-based products (bio-based pharmaceuticals, bio-based chemicals, and rubber and bioplastics) has increased the most, while the trend in the bio-based textiles is stable over time. In particular bio-based pharmaceuticals have seen a peak in 2020 due to the increased demand during the COVID-19 pandemic.

- Bio-based electricity shows a clear increase in value added, while the increase in production of bio-based fuels is positive but less prominent.

- The improvement in value added in agriculture and its products is more articulated than that in forestry and wood products.



Normative Criteria	Key components	Indicator name	Unit	Last year in the time series	5-year average change (%/year)	10-year average change (%/year)	Trend of contribution towards bioeconomy objectives
Economic development is fostered	Contribution of bioeconomy to economic development	Value Added per sector: Agriculture	Million EUR	2021	1.7%	**2.4%**	Positive
		Value Added per sector: Forestry	Million EUR	2021	-2.0%	0.6%	No trend
		Value Added per sector: Fishing and Aquaculture	Million EUR	2021	-2.0%	0.8%	No trend
		Value Added per sector: Manufacturing of bio-based textiles	Million EUR	2021	2.0%	**2.4%**	Positive
		Value Added per sector: Manufacturing of bio-based wearing apparel	Million EUR	2021	0.1%	1.4%	No trend
		Value Added per sector: Manufacturing of leather	Million EUR	2021	-0.8%	**1.8%**	Positive
		Value Added per sector: Manufacturing of wood products	Million EUR	2021	**14.8%**	**8.5%**	Positive
		Value Added per sector: Manufacturing of paper and paper products	Million EUR	2021	2.0%	**4.0%**	Positive
		Value Added per sector: Manufacturing of bio-based pharmaceuticals	Million EUR	2021	7.3%	**11.9%**	Positive
		Value Added per sector: Manufacturing of bio-based plastics and rubber	Million EUR	2021	5.8%	**6.1%**	Positive
		Value Added per sector: Manufacturing of wooden furniture	Million EUR	2021	4.7%	**5.0%**	Positive
		Value Added per sector: Manufacturing of bio-based chemicals	Million EUR	2021	**7.3%**	**9.9%**	Positive
		Value Added per sector: Generation of bio-based electricity	Million EUR	2021	**19.8%**	**11.4%**	Positive
		Value Added per sector: Production of bio-diesel	Million EUR	2021	21.1%	**12.8%**	Positive
		Value Added per sector: Production of bio-ethanol	Million EUR	2021	8.1%	**11.2%**	Positive
		Value Added per sector: Manufacturing of food	Million EUR	2021	4.6%	**4.4%**	Positive
		Value Added per sector: Manufacturing of beverages	Million EUR	2021	2.1%	**5.3%**	Positive
		Value Added per sector: Manufacturing of tobacco	Million EUR	2021	**23.4%**	**16.6%**	Positive
		Gross value added per person employed in bioeconomy	Apparent labour productivity [1000 EUR per person]	2021	**4.7%**	**5.4%**	Positive
		Key component indicators currently not implemented in the EU-BMS: Contribution of the Bioeconomy to GDP (see *Focus box 8*); GVA to turnover ratio; Economic productivity (GVA/unit of biomass)					
	Value of raw and processed biomass, value added in bioeconomy sectors	Total turnover in bioeconomy	Million EUR	2021	2.6%	**2.8%**	Positive
		Total value-added in bioeconomy	Value added at factor cost in million euro	2021	3.9%	**4.4%**	Positive
	Exports of EU food and non-food biomass, processed goods and/or related technologies	Key component indicators currently not implemented in the EU-BMS: Export value; Trade balance (net export)					
	Comparative advantage	Key component indicators currently not implemented in the EU-BMS: Terms-of-Trade of biomass (export/import); Revealed comparative advantage of biomass (Balassa index); Number of enterprises in bioeconomy; Bioeconomy SME birth & death rates					

Figure 17: Scoreboard of indicators for Objective 5 of the EU bioeconomy strategy. Bold numbers in the average change per year indicate statistically significant trend (Mann-Kendall test).

Normative Criteria	Key components	Indicator name	Unit	Last year in the time series	5-year average change (%/year)	10-year average change (%/ year)	Trend of contribution towards bioeconomy objectives
Inclusive economic growth is strengthened	Employment in bioeconomy	Persons employed in bioeconomy	number of people	2021	-0.7%	**-0.7%**	Slightly negative
	Working conditions related to bioeconomy	Key component indicators currently not implemented in the EU-BMS: Occupation health and safety in bioeconomy sectors					
	Equality & inclusiveness in bioeconomy sectors	Key component indicators currently not implemented in the EU-BMS: Employment by age in bioeconomy sectors; Employment by educational level in bioeconomy sectors; Employment by gender in bioeconomy sectors; Income by gender by sector; Income distribution along bioeconomy value chains					
Resilience of the rural, coastal and urban economy is enhanced	Physical infrastructure (accessibility, services)	Key component indicators currently not implemented in the EU-BMS: Distance to logistics hubs (territorial dimension)					
	Bioeconomy investments in rural & coastal areas	Key component indicators currently not implemented in the EU-BMS: Bioeconomy investments in rural and coastal areas; Number of bioeconomy businesses developed with policy support					
	Rural income diversification	Key component indicators currently not implemented in the EU-BMS: Transformation of biomass at farm (or coop) level; Income diversification in rural areas, by farmer age for production and transformation at farm or coop level; Income diversification of rural and coastal biomass producers (other than agriculture)					
	Income of primary producers	Key component indicators currently not implemented in the EU-BMS: Income of primary producers (fish & seafood landing income, agriculture households, forest owners)					
Existing knowledge is adequately valued and proven sound technologies are fostered	Existing knowledge on bioeconomy technologies	Key component indicators currently not implemented in the EU-BMS: Adoption of new bioeconomy technology by primary producers for both production and transformation levels; Rolling-out of pilot projects; Investment in TRL8-9 bio-based products					
Knowledge generation and innovation are promoted	Knowledge generation/ (high level) education	Key component indicators currently not implemented in the EU-BMS: % persons employed with 3º education in bioeconomy sectors; Changes in University curricula (number); Investment in higher education related to bioeconomy					
	Research and innovation	Key component indicators currently not implemented in the EU-BMS: Number of patents by bioeconomy sectors; Investment in research and innovation (1000 eur); Open innovation; New non-food products produced from primary sources; Number of research outputs in the field of bioeconomy					
Demand and supply-side market mechanisms and policy coherence between supply and demand of food and non-food goods are enhanced	Market mechanisms (e.g. prices, consumer awareness)	Key component indicators currently not implemented in the EU-BMS: Market or consumers acceptance; Number of labelled or certified bio-based products					
	Resource competition among sectors of the bioeconomy and Biomass demand for new value chains	Key component indicators currently not fully implemented in the EU-BMS: Producer prices per primary production sector; Share of biomass used by primary sectors (Agriculture, Fisheries, Forestry)					

Source: own elaboration

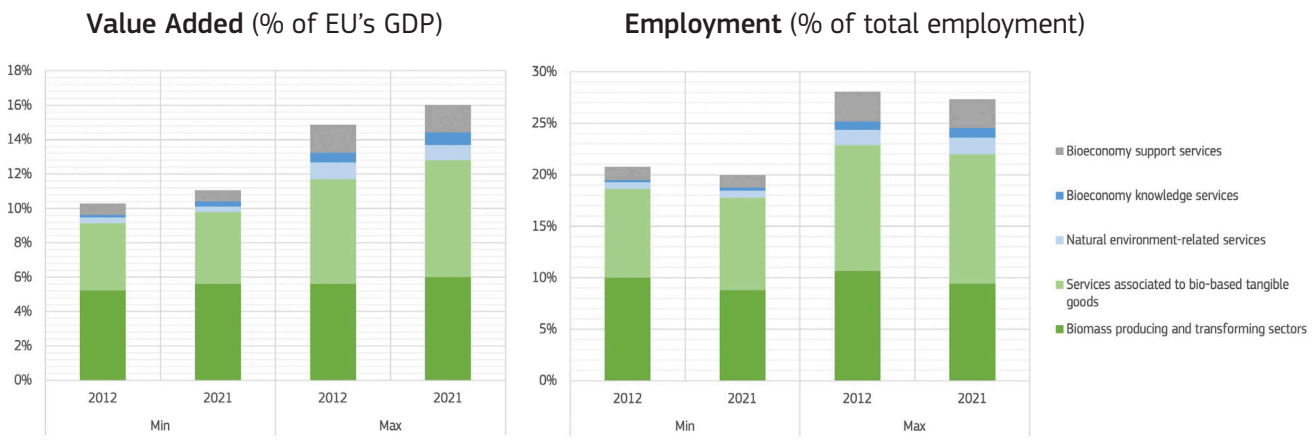
Focus box 8: The bioeconomy beyond biomass production and conversion: the economic importance of bioeconomy-related services

According to the latest data available in the EU-BMS, the bioeconomy accounted for 5.0 % of the EU's GDP in 2021 (EUR 728 billion) and created 8.2 % of total employment (around 17.2 million jobs). These figures inform only about the biomass-producing and -converting sectors, while the set of activities that are covered by the EU's definition can potentially include also bioeconomy-related services.

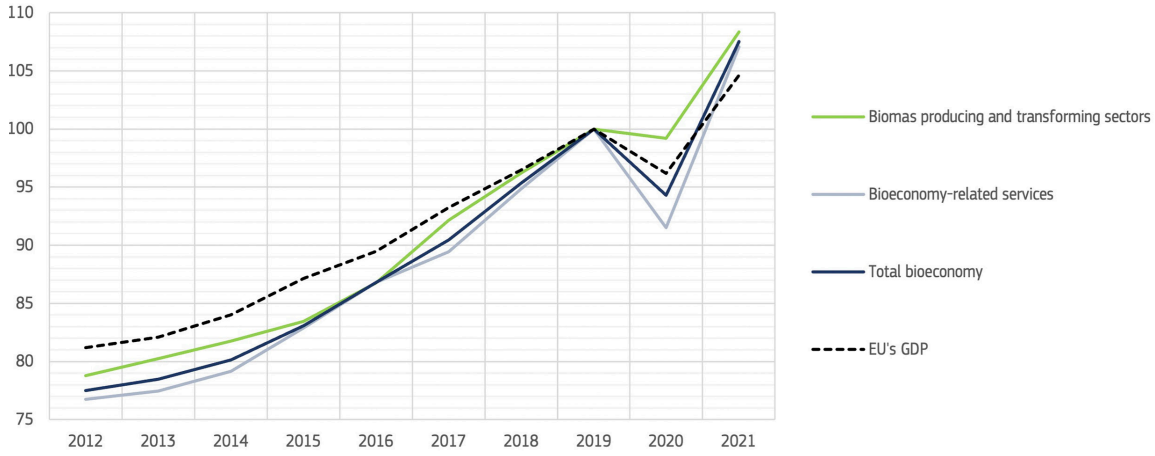
A methodology for quantifying the economic contribution of service activities to the bioeconomy in terms of employment and value added was proposed by Ronzon et al. (2022). This methodology follows an output-based approach, which makes the results comparable to those indicators already available in the EU-BMS. Four main categories of services are identified: (1) Services associated to bio-based tangible goods, such as food services or commercialisation of bio-based products; (2) Natural environmental-related services, such as rural tourism or landscape service activities; (3) Bioeconomy knowledge services, including scientific research and development, education or veterinary, and (4) Bioeconomy support services, such as public administration or activities of memberships organisations, among others.

The results of applying this methodology, providing a minimum-maximum value interval for each indicator, shows that the importance of the bioeconomy-related services is comparable to biomass-producing and processing sectors, with services associated with bio-based goods being the biggest category. According to our estimates, the total bio-based economy, including services, could account for 11-16 % of the EU's GDP and 20-27 % of employment. Similar to the biomass-producing and transforming sectors, in the 10-years period depicted, they have experienced higher growth than the EU's GDP, also during the COVID-19 crisis (see Figure 18 below). These trends highlight the key role of the bioeconomy to offer "biosolutions" to advance in the green and fair transition.

Figure 18. Value added and employment in the bioeconomy-related services in the EU



Note: The label "Min" identifies the minimum estimate provided by the Ronzon's approach, while "Max" refers to the highest value of the interval



Note: For simplification purposes, only the "Max" value is represented in this chart for the Bioeconomy-related services and the Total Bioeconomy.

Source: Own elaboration following the approach proposed by Ronzon et al. (2022)

4.7 Aggregated trends for the EU Bioeconomy Strategy objectives

In this chapter, we discuss the recent 5- and 10-year trends in the EU bioeconomy through aggregating the results observed for the individual indicators into key components under each criterion (*Figure 19 and Figure 20*). The aggregation is calculated through an arithmetic mean of the annual %-change of the indicators for each key component included in the EU-BMS. If a key component was represented by a single indicator, that indicator's trend was interpreted as the key component trend. Each indicator has the same weight in the analysis – this should be considered when interpreting the results.

It is worth recalling that the methodology used in the previous report on Trends in the EU Bioeconomy (Mubareka et al. 2023) was different, and the results shown here are not directly comparable with the composite scores presented in that earlier report.

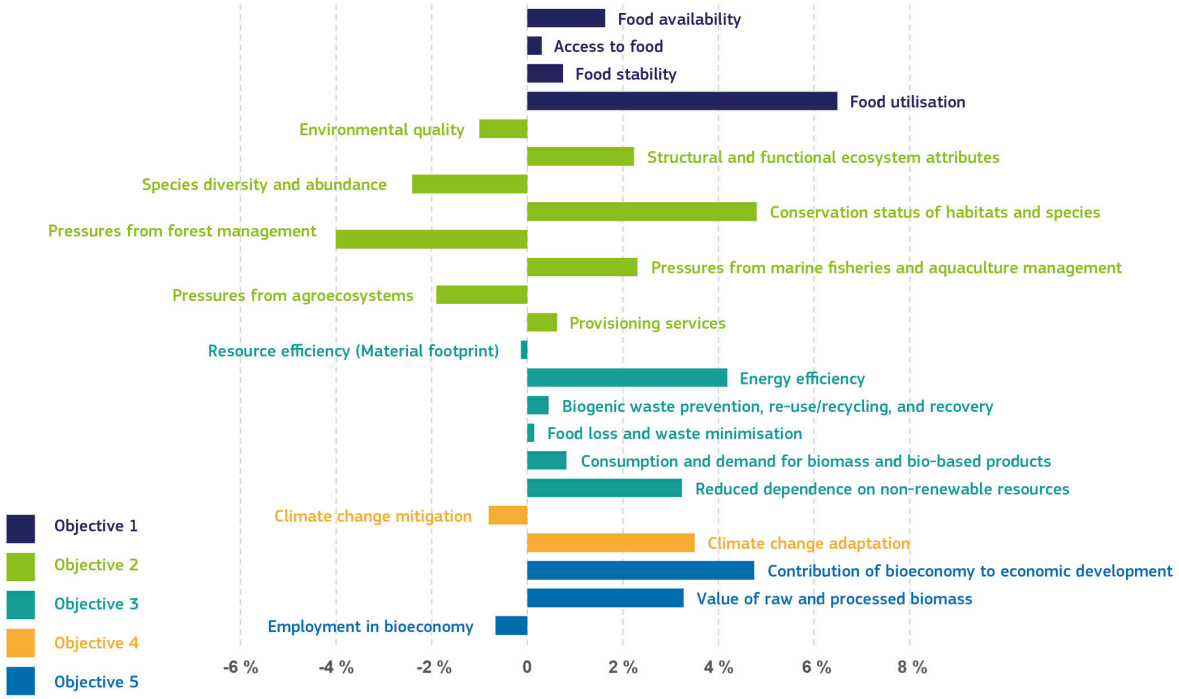
Overall, we observe that the recent trends for EU Bioeconomy Strategy objectives 1, 3 and 5 have been mostly positive both in the short-term (latest 5 years of the time series) and in the longer term (latest 10 years of the time series). It is worth noting that the COVID-19 pandemic may have strongly affected in particular the short-term trends. For Objective 1 (ensuring food and nutrition security), the positive trends are especially driven by improvements in agricultural factor income and in government support for agricultural research and development. For Objective 3 (reducing dependence on non-renewable, unsustainable resources), the trends are especially positive for the increased uptake of renewable feedstocks, where the EU-BMS monitors all renewables (also those beyond biomass). For Objective 5 (strengthening European competitiveness and creating jobs), the EU-BMS reports improved value added in the production from most activities, with especially strong increase in the profitability for biofuels and wood products production. In contrast, the value added in primary forestry and fisheries' production has declined in the short term.

Overall, the employment in the bioeconomy sectors has remained rather stable, with a slight downward trend observed both in the short- and the long-term periods tracked here.

In contrast, there is considerable variability in Objective 2 of the Bioeconomy Strategy (managing natural resources sustainably) and Objective 4 (mitigating and adapting to climate change). On sustainability indicators, we observe clear improvement especially in marine sites: the area of conserved marine areas has increased, fish stocks are reported to have increased, and mortality of commercially exploited fish has decreased. In contrast, the land-based habitats show adverse development, as indices for common birds and butterflies on agricultural lands have deteriorated, the share of low input farms has declined (suggesting more fertiliser and pesticide use in agriculture), and the amount of phosphate detected in rivers has turned into a slight increase, after several years of improvement in the early 2000s. On climate change, the negative trend is driven by the deteriorating LULUCF sink. Even though LULUCF is still a substantial sink on the EU level, the development is negative in terms of climate change mitigation. The main driver behind the decreasing LULUCF sink is the intensified forest harvesting (increasing ratio between fellings and increment), together with an increase in frequency and severity of natural disturbances, such as wildfires, windfall, droughts and insect outbreaks.

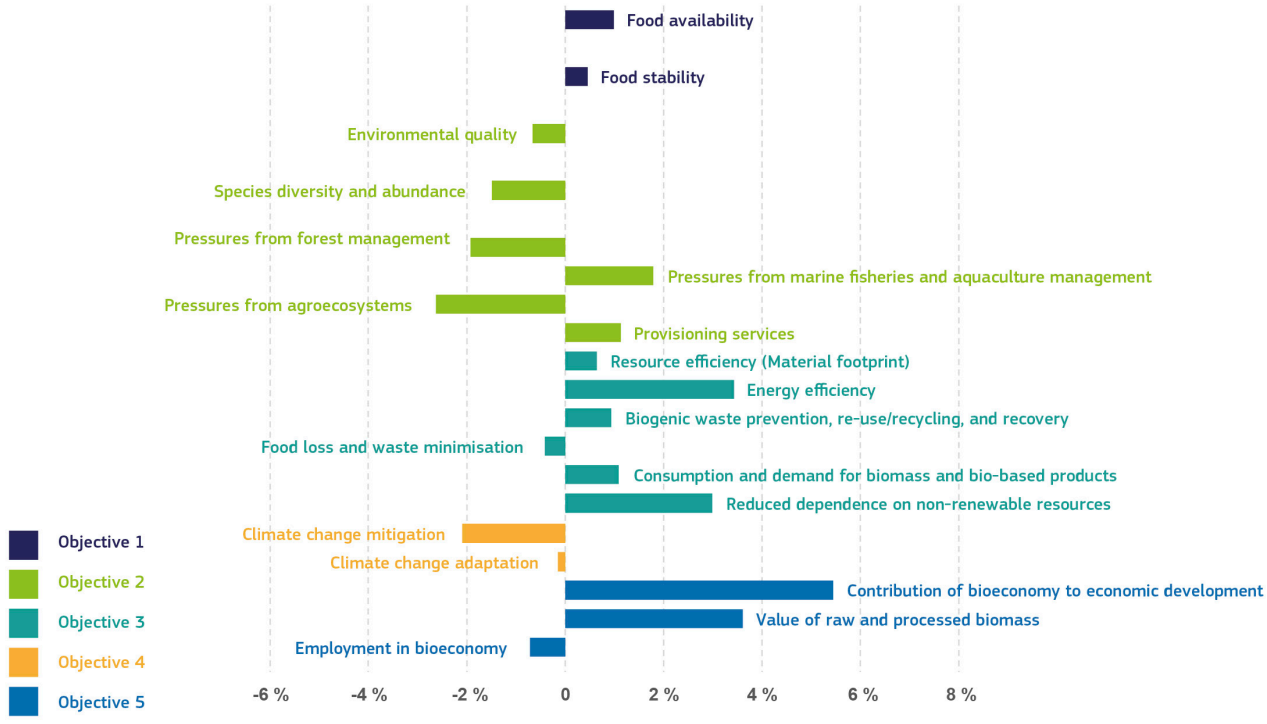
Clear interdependencies and trade-offs emerge between the bioeconomy strategy objectives: while the provisioning services – especially production of roundwood from the EU forests – have increased, this has contributed to more pressure on forest habitats (under Objective 2) and a less pronounced increase of the forest standing stock, and consequently a decreasing LULUCF sink (under Objective 4).

Figure 19. Contribution of the average 5-year trend of the key components towards the bioeconomy objectives.



Source: own elaboration

Figure 20. Contribution of the average 10-year trend of the key components towards the bioeconomy objectives.



Source: own elaboration

5 Discussion and concluding remarks

With a view to the upcoming update of the EU's bioeconomy strategy by the end of 2025 , this report, prepared by the European Commission's Knowledge Centre for Bioeconomy (KCB), provides a consolidated overview of the most up-to-date information on the bioeconomy in the EU. More specifically, this document describes the European, national, and regional policy landscapes and summarises the EU-level results from the EU Bioeconomy Monitoring System (EU-BMS) regarding the different aspects of the EU bioeconomy and their latest trends.

The European bioeconomy is one of the enablers of the green transition. As outlined in the Strategic Agenda 2024–2029 by the European Council[92], the EU will reap the full benefits of the bioeconomy, contributing to a more circular and resource-efficient economy. Bioeconomy is shaped by various policies and initiatives at different levels and builds on all sustainability dimensions: management of land and biological resources within ecologic boundaries; sustainable value chains and consumption; social fairness and just transition[93]. Covering almost the whole of EU's territory and therefore impacting and being impacted by the environment, the bioeconomy has a strong socioeconomic weight, with up to 27 % of all employment and 16 % of contribution to the overall GDP in the EU, when taking into account also related services. The strategic importance of the bioeconomy became even more visible during the COVID-19 pandemic and, still as of today, as a consequence of the geopolitical turmoil. In the meantime, bioeconomy and its development need to carefully consider the scarcity of biological resources and the impact that the use and extraction of biomass has on the environment, the ecosystems and the natural processes. Europe's biodiversity is declining, with intensifying land management practices as one of the main drivers. Climate change is already having a profound impact on the environmental conditions in Europe, and the occurrence and severity of extreme weather events such as storms, heatwaves and flooding are expected to increase in the future. Bioeconomy has a key role in addressing climate change, both in mitigation through land-based systems and providing renewable feedstocks to substitute for fossil-based raw materials, as well as in adapting to climate change-induced risks and environmental changes through management choices.

92 https://www.consilium.europa.eu/media/yxrc05pz/sn02167en24_web.pdf

93 COM (2022) 283. EU Bioeconomy Strategy Progress Report European Bioeconomy policy: stocktaking and future developments

The overarching and cross-sectoral nature of bioeconomy is reflected in the diversity with which European countries have translated and adapted the concept to local conditions, while maintaining an overall common conceptual framework grounded on the EU approach to bioeconomy. This report takes stock of the bioeconomy policies and initiatives existing or being developed in the EU MS and their regions, which have been growing since the adoption of the first EU bioeconomy strategy in 2012. Today most EU MS have adopted or are developing national or macro-regional strategies dedicated or related to bioeconomy. The report also covers bioeconomy policy development at macro-regional level, such as the BIOEAST group that encompasses 11 EU MS and is becoming instrumental also for the Eastern accession countries. At national level, eleven EU MS have dedicated bioeconomy strategies (as of September 2024); seven others have national strategies under development; another five MS have other policy initiatives dedicated to the bioeconomy; and the remaining four MS have strategies related to the bioeconomy. Among the national bioeconomy strategies already adopted, a few actions have been adopted by all MS such as those related to investments in bioeconomy research and innovation, investments in communication and awareness raising campaigns, promotion of the principles of cascading use, circularity and resource efficiency for biomass.

The EU Bioeconomy Monitoring System (EU-BMS) is designed to track the progress towards the five objectives of the 2018 EU Bioeconomy Strategy and through these towards the overarching goal of a sustainable and circular bioeconomy. This report provides a EU-level overview of the recent developments and trends of the quantitative indicators implemented in the EU-BMS to reflect those objectives. The indicators informing Objectives 1 (ensuring food and nutrition security), 3 (reducing dependence on non-renewable, unsustainable resources) and 5 (strengthening European competitiveness and creating jobs) reveal a broadly positive development towards the objectives both in the short-term (latest 5 years of the time series) and in the longer term (latest 10 years of the time series).

Overall, trade-offs between bioeconomy objectives remain key issues to be addressed. Whereas food security, reduced dependency on non-renewable resources with substitution by bio-based sources, and socio-economic indicators exhibit positive trends, the environmental and climate change indicator trends remain reasons for concern. Despite some relatively positive signals regarding nature conservation efforts and the status of marine habitats, the pressure on inland natural resources remains high, affecting negatively environmental quality and species diversity, as well as threatening the climate change mitigation potential of forests. The positive trends in ecosystem services are due to the improvement of provisioning services mostly driven by increased biomass extraction, which in turn is negatively affecting the forest habitats and depleting the LULUCF carbon sink. In agriculture, the clearly positive signs from the increasing trends of agricultural factor income, coupled with the marked increase of the share of organic farming and the slight decrease in livestock density, are counterbalanced by an increase of more intense farming practices, with overall signs of negative impacts on water quality and species diversity. On a general positive note, trends regarding biogenic waste re-use, recycling and recovery are overall improving, the fractions of biowaste recycling and recovering are increasing with time.

For Objective 1, the positive trends are especially boosted by the improvements in agricultural factor income and in government support for agricultural research and development. For Objective 3, the trends are principally positive for the increased uptake of renewable feedstocks. For Objective 5, the EU-BMS reveals improved value added in the production from most activities, in particular with strong increase in the profitability of biofuels and wood-based products manufacturing. In contrast, the value added in primary forestry and fisheries' production has declined in the short-term. Overall, the employment in the bioeconomy sectors has remained rather stable, with a slight downward trend observed both in the short and the long-term periods tracked here.

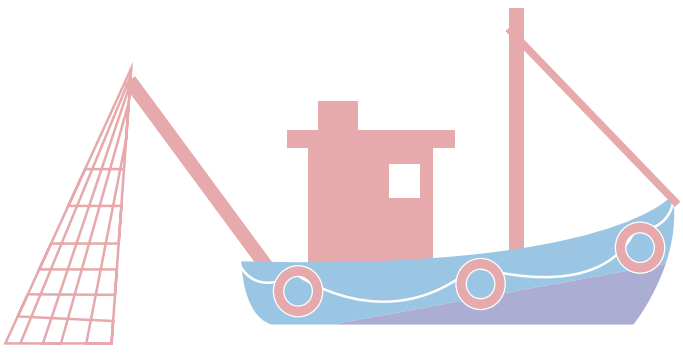
In contrast, there is considerable variability in the indicators tracking Objective 2 (managing natural resources sustainably) and Objective 4 (mitigating and adapting to climate change). Regarding environmental sustainability indicators, we observe clear improvement in marine sites: the area of conserved marine areas has increased, fish stocks are reported to have increased, and mortality of commercially exploited fish has decreased. In contrast, the inland habitats show adverse development, as indices for common birds and butterflies on agricultural lands have deteriorated, the share of low input farms has declined (suggesting more fertiliser and pesticide use in agriculture), and the amount of phosphate detected in rivers has turned into a slight increase, after several years of improvement in the early 2000s. For climate change mitigation, the development has been especially adverse on the LULUCF sector, in particular in forests. As shown in the ratio of harvests to increment, forest harvest levels have increased more than the forest increment, thus reducing the rate of increase of carbon stock in the forest. In the meantime, severe droughts, windfalls and wildfires have strongly affected several MS. As a result, the key role of forests as carbon sink is significantly declining. On a positive note, the pressure on renewable freshwater resources – an indicator used to reflect climate change adaptation – shows only little water stress on the average EU-level. However, the assessment regarding Objective 4 should be taken as preliminary, since the coverage of indicators available in the EU-BMS to measure climate change mitigation and adaptation is rather limited.

As outlined in the EU Bioeconomy Strategy Progress Report[94], the EU-BMS was launched online in 2020, relying on extensive and in-depth stakeholder consultations and a stocktake of other initiatives to map and monitor bioeconomy. At the time of the Progress Report in 2022, the system had 39 published indicators, 43 in the pipeline, and 74 aspirational indicators in various stages of completion. As of September 2024, the EU-BMS hosts 49 published indicators, while 29 are in the pipeline, and 76 remain as placeholders for future implementation (Patani et al. 2024, Kilsedar et al. 2023, Kilsedar et al. 2021). In particular, aspects connected to the social, justice and equity dimensions of the EU Bioeconomy are lacking from the current dashboard (Giuntoli et al. 2023). Furthermore, the representation of climate change mitigation and adaptation is rather limited with the current indicator set. The data availability to monitor these aspects will likely improve notably in the future, through developments in the reporting under legislative frameworks such as the LULUCF Regulation[95], Regulation on Nature Restoration[96],

94 COM (2022) 283. EU Bioeconomy Strategy Progress Report European Bioeconomy policy: stocktaking and future developments

95 Regulation (EU) 2023/839 of the European parliament and of the council of 19. (April 2023 amending regulation (EU) 2018/841 as regards the scope, simplifying the reporting and compliance rules, and setting out the targets of the member states for 2030, and regulation (EU) 2018/1999 as regards improvement in monitoring, reporting, tracking of progress and review

96 Regulation (EU) 2024/1991 of the European Parliament and of the Council of 24 June 2024 on nature restoration and amending Regulation (EU) 2022/869

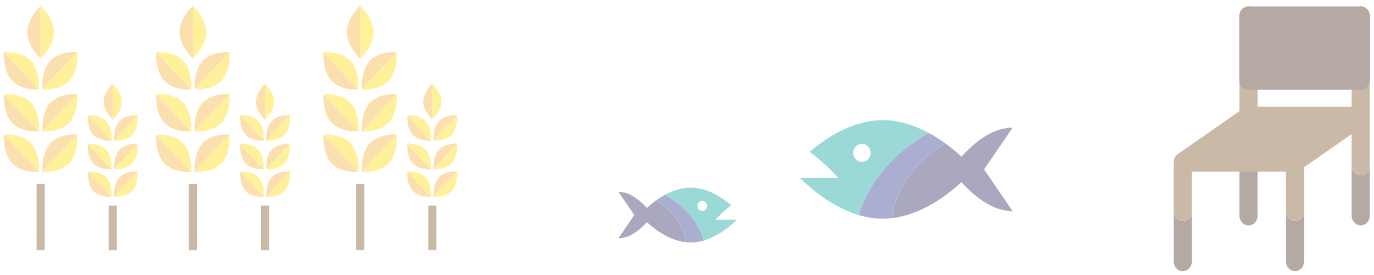


the EU Food System Monitoring under preparation[97] and the EU framework for Forest Monitoring[98], the latter not adopted at the time of writing.

The present report provides an overview on the evolving and dynamic policy landscape of and related to the bioeconomy. It depicts an overall positive picture of the bioeconomy trajectory towards its objectives, even if challenges still remain, especially in ensuring sustainability with respect to environmental condition and under climate change. Acknowledging the complexity of the bioeconomy, further improvements should be envisaged in cooperation with ongoing bioeconomy monitoring initiatives from macro-regions such as BIOEAST, the MS and regions, considering also the developments underway in other parts of the world. In addition, synergies with other topical monitoring systems in the EU are desirable. Given the multifaceted and evolving policy landscape related to bioeconomy, it is of utmost importance to ensure also in the future that the monitoring system is agile enough to consider all sustainability dimensions of the bioeconomy, and monitor their development in as comprehensive and balanced way as possible.

97 https://datam.jrc.ec.europa.eu/datam/area/FS_MONITORING?rdr=1729803986654

98 https://environment.ec.europa.eu/topics/forests/forest-monitoring_en



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List of abbreviations

AT	Austria
AWU	Agricultural Factor Income per annual work unit
BBI-JU	Bio-Based Industries Joint Undertaking
B	Billion
BIOEAST	Central and Eastern European Initiative for Knowledge-based Agriculture, Forestry and Aquaculture in the Bioeconomy
BCE	Butterfly Conservation Europe
BOD	Biochemical Oxygen Demand
CBE JU	Circular Bio-Based Europe Joint Undertaking
CEE	Central and Eastern European countries
CF	Cohesion Fund
CH_4	Methane
CO_2	Carbon Dioxide
CO_2 eq	Carbon Dioxide Equivalent
DataM	JRC Data-Modelling Platform of Resource Economics
DE	Germany
DG AGRI	Directorate-General for Agriculture and Rural Development
DG CLIMA	Directorate-General for Climate Action
DG ENER	Directorate-General for Energy
DG ENV	Directorate-General for Environment
DG GROW	Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
DG INTPA	Directorate-General for International Partnerships
DG MARE	Directorate-General for Maritime Affairs and Fisheries
DG MOVE	Directorate-General for Mobility and Transport
DG REGIO	Directorate-General for Regional and Urban Policy
DG RTD	Directorate-General for Research and Innovation
DG TRADE	Directorate-General for Trade
EGD	European Green Deal
EUSBSR	EU Strategy for the Baltic Sea Region
EAFRD	European Agricultural Fund for Rural Development Fund
EC	European Commission
EEA	European Environmental Agency
EMFF	European Maritime and Fisheries Fund
ERDF	European Regional Development Fund
ES	Spain
ESIFs	European Structural and Investment Funds
EU	European Union (in this report, the EU refers to the EU-27 composition after 2020)
EU-BMS	EU Bioeconomy Monitoring System
EUR	euro
Eurostat	Statistical Office of the European Union
FADN	Farm Accountancy Data Network
FAO	Food and Agriculture Organization of the United Nations
FAO FRA	FAO Global Resources Assessment
FAOSTAT	Food and Agriculture Organization Statistics
FI	Finland
FP7	7th Framework Programme
FR	France
G20	Group of Twenty
GDP	Gross Domestic Product

GHG	Greenhouse Gas
H2020	Horizon 2020 Framework Programme
ha	hectare(s)
HE	Horizon Europe Framework Programme
IE	Ireland
IT	Italy
JFSQ	Joint Forest Sector Questionnaire
JRC	Joint Research Centre of the European Commission
JRC-Biomass	JRC Biomass Mandate
KCB	Knowledge Centre for Bioeconomy
k ton	kilotonnes
L	Litre
LV	Latvia
LULUCF	Land Use, Land Use Change and Forestry
m^3	cubic metre
mg	milligram
MS	Member State(s) of the European Union
MSY	Maximum Sustainable Yield
Mt	Megatonnes
N_2O	Nitrous Oxide
NAI	Net Annual Increment
NE	North-East
NL	the Netherlands
NO_3	Nitrate
NUTS2	Nomenclature of Territorial Units for Statistics, level 2
O_2	Dioxygen
o.b.	over bark
PO_4	Phosphate
PPP	Public-Private Partnerships
PT	Portugal
R&I	Research and Innovation
R&D	Research and Development
Q3	Third quarter of the year
SG	Secretariat-General of the European Commission
STECF	Scientific, Technical and Economis Committee for Fisheries
UAA	Utilised Agricultural Area
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
WEI	Water Exploitation Index

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Annex – Bioeconomy in the EU Framework Programmes for Research and Innovation

In the last two decades, in line with the bioeconomy strategy developments described in Chapter 2 of this report, there has been a constant increase in the EU investments for research and innovation projects dedicated to the bioeconomy, through the related Research and Innovation (R&I) Framework Programmes.

As the concept of bioeconomy has evolved over time, from knowledge-based bioeconomy to a sustainable and circular bioeconomy (Aguilar and Twardowski, 2022), the focus of R&I efforts has evolved accordingly. The first Framework Programme where the concept of the bioeconomy, focused on the increased use of, and processes for, biological resources (Patermann and Aguilar, 2018), was the 7th Framework Programme (FP7), starting in 2007. Under theme 2 'Food, agriculture and fisheries, and biotechnology, it aimed to establish and promote a European 'Knowledge-based bio-economy'[99]. The Horizon 2020 Framework Programme (H2020) for the timeframe 2014-2020[100], firstly introduced the bioeconomy in Societal Challenge 2 'Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the *bioeconomy',* followed by Horizon Europe Framework Programme (HE, 2021-2027), where the funding for bioeconomy related research features prominently in Cluster 6: Food, Bioeconomy, Natural Resources, Agriculture and Environment[101].

From 2007 to 2024, the EU R&I investments funded in total 1772 projects[102] related to bioeconomy, with topics ranging from bio-based innovation to bioeconomy governance, blue-economy to biotechnology, food systems transformation to circular economy transition, and many more. *Figure 21* shows the distribution of such projects over time (starting year). The projects have been markedly increasing since 2007.

99 https://cordis.europa.eu/article/id/27728-new-cordis-service-for-the-european-knowledgebased-bioeconomy

100 SWD(2024) 29 final, Ex-post evaluation of Horizon 2020, the EU Framework Programme for Research and Innovation

101 https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/cluster-6-food-bioeconomy-natural-resources-agriculture-and-environment_en

102 See methodological note on how these projects were selected

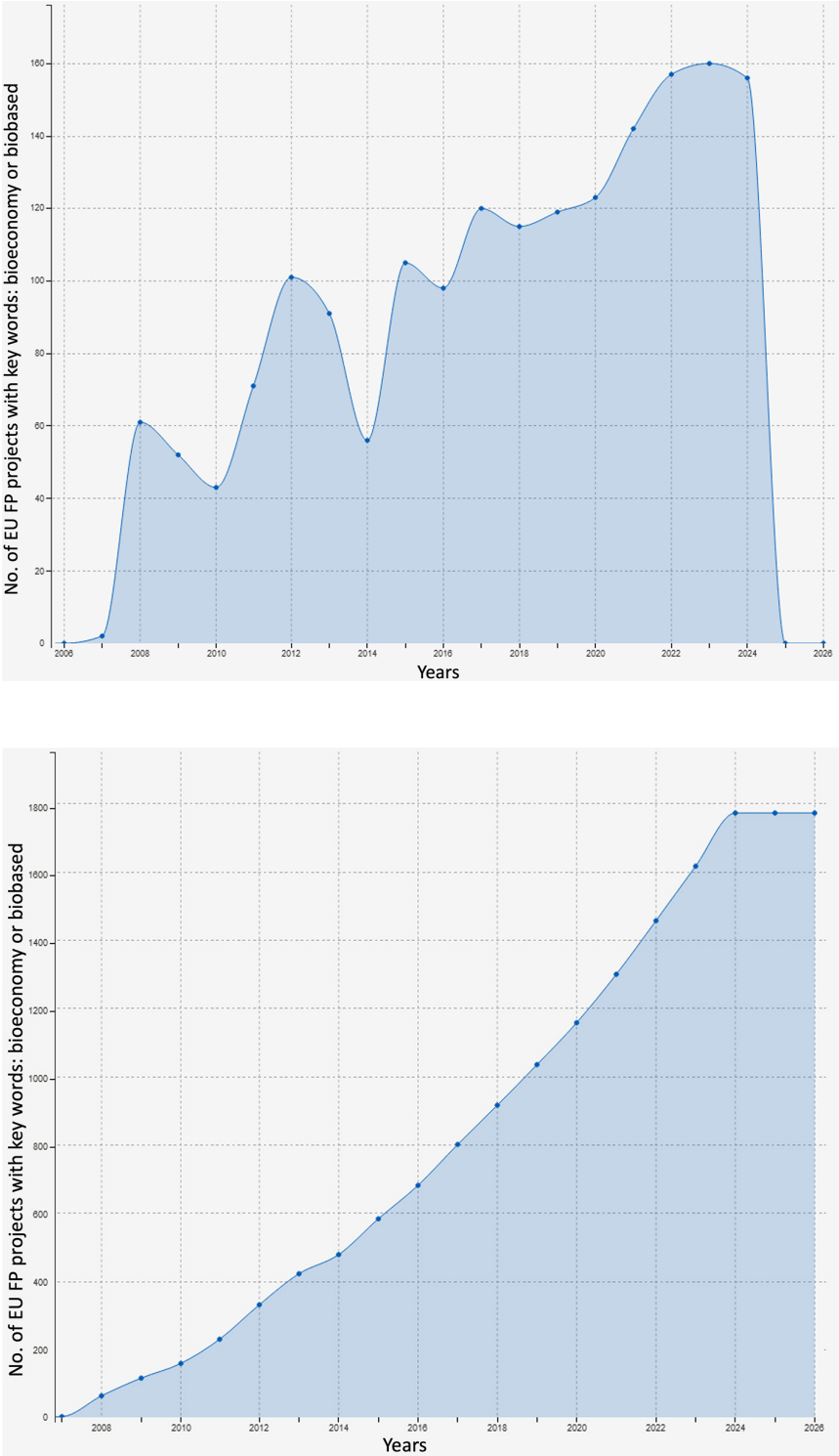
In terms of the total EU grant by Funding programme for these selected 1772 projects, EUR 1.17 billion were invested in FP7, EUR 2.54 billion in H2020 and EUR 1.69 billion in HE (until 2024).

Most of the EU beneficiaries are from Spain, Germany, Italy, France, Netherlands, United Kingdom (when part of the EU), and Belgium (Table 2. Organisations with highest participation in EU Horizon projects with keyword Bioeconomy – 2007-2024 (more than 40 projects)). In total, 5344 organisations participating to bioeconomy related projects in the timeframe 2007-2024 are from EU-27 (2020), while 1281 are from outside the EU (*Figure 22*).

Along the 17 years, half of the organisations involved in EU R&I projects were companies, with the other half composed mostly by universities and research centres combined. Other types of organisations represent a residual part of the R&I project consortia. The relative proportion among the types of participating organisations remain relatively stable across the years (*Figure 23*). Table 2. Organisations with highest participation in EU Horizon projects with keyword Bioeconomy – 2007-2024 (more than 40 projects)*Table 2* gives an overview of the top organisations involved in EU R&I projects between 2007-2024, with organisations from Germany, Spain, France, Italy and the Netherlands leading the group, followed by Denmark, Finland, Belgium and United Kingdom.

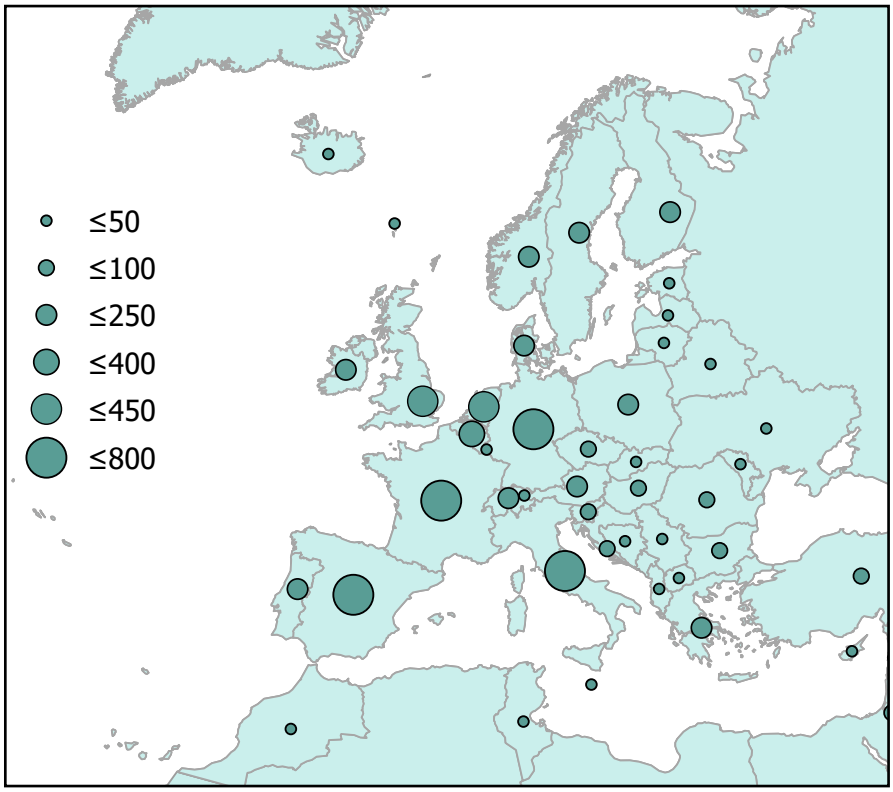
Among the 1772 projects, the most used keyword is of course 'bioeconomy' followed by 'bio-based' 'valorisation', 'biorefinery', 'industry partner', 'multiactor'. Interestingly, the term 'circular bioeconomy' appeared from 2016, while 'resource efficiency' was used already as of 2008, and 'waste stream' from 2009 (*Table 3*).

Figure 21. Number of EU FP projects with keywords "biobased" or "bioeconomy" since 2007 (frequency and cumulative distributions). Projects starting in a given year.



Source: Tim Technology on Cordis data

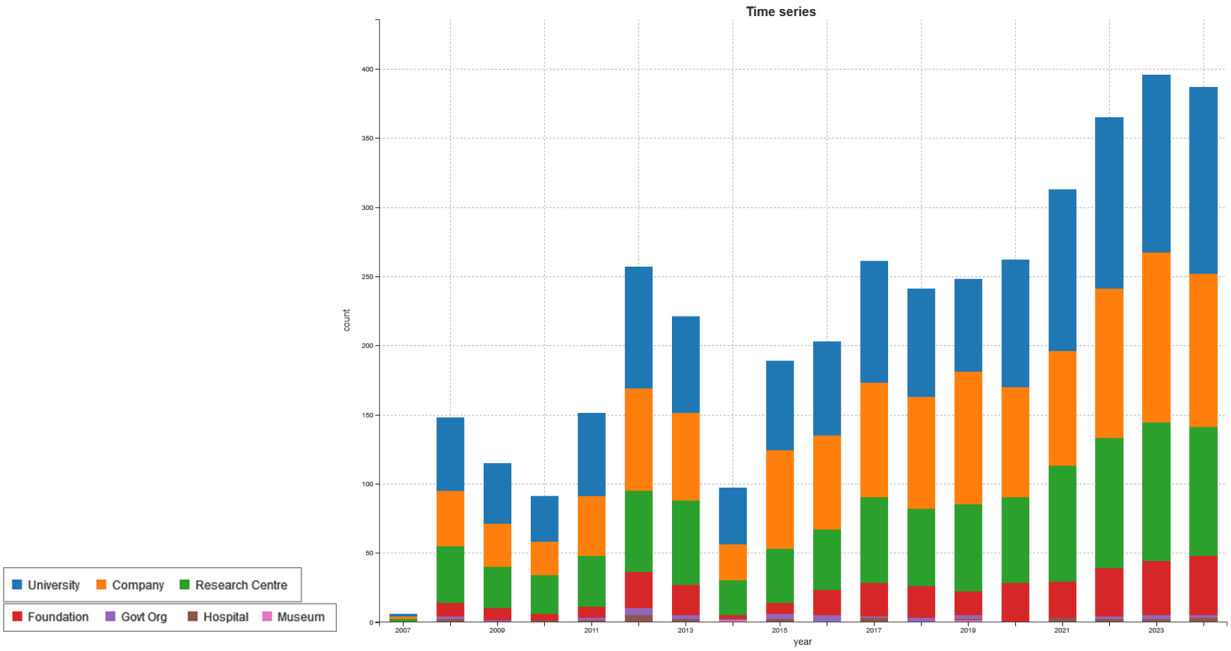
Figure 22. No. organisations participating in FP7/H2020/HE projects per country – 2007-2024 – focus on Europe



Number of organisations participating to FP7/HE/H2020 projects per country
Timeframe 2007-2024

Source: Tim Technology on Cordis data, own elaboration

Figure 23. Distribution of organisations involved in the selected projects by type, timeline 2007-2024



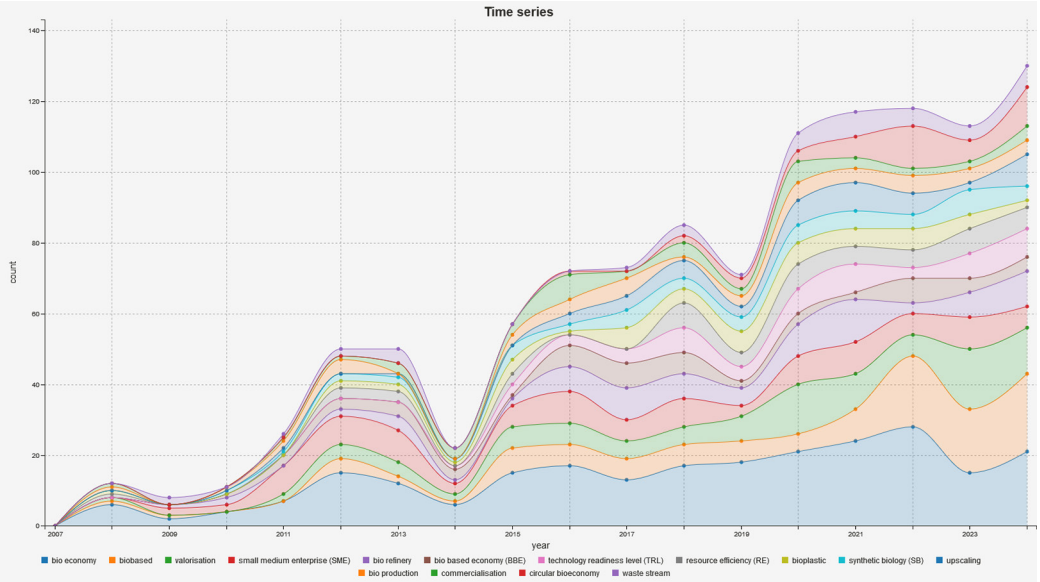
Source: Tim Technology on Cordis data, own elaboration

Table 2. Organisations with highest participation in EU Horizon projects with keyword Bioeconomy – 2007-2024 (more than 40 projects)

TOP 20 ORGANISATIONS	No.Projects	Org_type	Country
Fraunhofer-Gesellschaft Zur Forderung Der Angewandten Forschung	119	Company	Germany
Agencia Estatal Consejo Superior De Investigaciones Cientificas	117	Research centre	Spain
Stichting Wageningen Research	110	Foundation	Netherlands
Cnrs	109	Research centre	France
Cnr	84	Research centre	Italy
Danmarks Tekniske Universitet	75	University	Denmark
Teknologian Tutkimuskeskus VTT Oy	75	Company	Finland
Institut National De Recherche Pour L'agriculture, L'alimentation Et L'environnement	73	Research centre	France
Universiteit Gent	64	University	Belgium
Wageningen University	60	University	Netherlands
Alma Mater Studiorum-Universita Di Bologna	59	University	Italy
Bio Base Europe Pilot Plant Vzw	48	Company	Belgium
Imperial College London	47	University	United Kingdom
Katholieke Universiteit Leuven	46	University	Belgium
Kobenhavns Universitet	45	University	Denmark
Vito (Vlaamse Instelling Voor Technologisch Onderzoek)	41	Research centre	Belgium
(Certh) Ethniko Kentro Erevnas Kai Technologikis Anaptyxis	41	Research Centre	Greece
Fundacion Tecnalia Research&Innovation	41	Foundation	Spain
Rise Research Institutes Of Sweden Ab	40	Research centre	Sweden
Novamont Spa	40	Company	Italy
Aarhus University	40	University	Denmark
Stiftelsen Sintef	40	Research centre	Norway
AIMPLAS Instituto Tecnológico Del Plástico	40	Research centre	Spain

Source: Tim Technology on Cordis data

Figure 24. Most used keywords in bioeconomy related projects – 2007-2024



Source: Tim Technology on Cordis data

Table 3. Keywords most used EU Horizon projects relevant to the bioeconomy– 2007-2024

KEYWORD	First Occurrence	Last Occurrence	Number of occurences
bio economy	*2008*	*2024*	*240*
biobased	*2008*	*2024*	*111*
small medium enterprise (SME)	*2007*	*2024*	*102*
valorisation	*2008*	*2024*	*102*
bio refinery	*2009*	*2024*	*81*
industry partner	*2007*	*2024*	*65*
multi actor	*2016*	*2024*	*59*
bio based economy (BBE)	*2010*	*2024*	*56*
technology readiness level (TRL)	*2014*	*2024*	*53*
bioplastic	*2008*	*2024*	*50*
resource efficiency (RE)	*2008*	*2024*	*50*
synthetic biology (SB)	*2010*	*2024*	*50*
upscaling	*2011*	*2024*	*48*
overall objective	*2007*	*2024*	*46*
bio production	*2007*	*2024*	*45*
commercialisation	*2008*	*2024*	*44*
circular bioeconomy	*2016*	*2024*	*44*
research and innovation	*2012*	*2024*	*42*
waste stream	*2009*	*2024*	*40*
sustainable production (SP)	*2010*	*2024*	*40*
side streaming	*2009*	*2024*	*39*
european research area (ERA)	*2008*	*2024*	*38*

Source: own elaboration

METHODOLOGICAL NOTE

The statistics explained in this Annex have been retrieved with the TIM Technology tool[103], based on the CORDIS[104] database, using a simple query[105] looking at the occurrence of the terms “bioeconomy” and “bio-based” in title, abstracts and keywords of the database. It is worth to note that the above statistics are indicative and not comprehensive, as based on this basic query, which might exclude some additional relevant items. A more detailed analysis of the selected projects would give the opportunity to understand better and more precisely the current landscape.

103 https://knowledge4policy.ec.europa.eu/text-mining/topic/tim_analytics_en

104 https://cordis.europa.eu/, including comprehensive information about EU research and Development projects

105 topic:(bioeconomy OR bio-economy OR bio-based OR biobased) AND emm_year:[2007 TO 2024] AND class:euproject AND emm_programme:(fp7 or h2020 or he2027)

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