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COMMISSION STAFF WORKING DOCUMENT
Accompanying the document

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment

{COM(2018) 673 final}

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1 AIM OF THE STAFF WORKING DOCUMENT

The present Staff Working Document accompanies the Communication from the European Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of Regions on "A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment" (hereafter, also the "Communication"). The Communication presents an update of the European Bioeconomy Strategy and Action Plan (hereafter, also the "Strategy"), which aim to drive the vision of a full deployment of a sustainable and circular European bioeconomy. In doing so, the Strategy aims to strengthen the connections between economy, society and the environment, thus maximising the contribution of a sustainable bioeconomy to the Commission priorities and to numerous of its policy objectives. These include in particular, the renewed Industrial Policy,[1] the Circular Economy,[2] and the Clean Energy for All Europeans Package,[3] all of which stress the need of a sustainable, circular bioeconomy to achieve their objectives. A sustainable bioeconomy will also underpin the objectives of the renewed Common Agricultural Policy and Common Fisheries Policy, as well as those of the Action Plan on Nature, People and the Economy, the EU Forest Strategy, Biodiversity Strategy, Plastic Strategy, and Soil Thematic Strategy (see 2.1). Delivering on all of the above objectives and policies will further accelerate the contributions of the EU bioeconomy towards the 2030 Agenda and its Sustainable Development Goals, to the EU's commitments under the Paris Agreement and to the targets of the 2030 Climate and Energy Framework.[4]

In Section 2, the Staff Working Document presents the background information, and supporting data, related to the European Bioeconomy Strategy and the current state of the bioeconomy in Europe. Section 3 of the Staff Working Document further details the background to, and expected impact of, the actions proposed in the Communication's Action Plan.

2 STATE OF THE EU BIOECONOMY

2.1. The European Bioeconomy Strategy

The European Bioeconomy Strategy and its Action Plan[5] emerged in 2012 from the Innovation Union[6] and Resource Efficient Europe[7] flagship initiatives of the EU 2020 strategy, recognising that the bioeconomy, currently worth EUR 2.3 trillion in turnover and accounting for 8.2% of the EU's workforce,[8] plays a central role in addressing a number of key interlinked challenges. The importance of this Strategy for Europe and its institutions, for the EU Member States and for their

1 COM(2017)47, Investing in a smart, innovative and sustainable Industry A renewed EU Industrial Policy Strategy, 13.09.2017

2 COM(2015)614, Closing the loop – An EU action plan for the circular economy, 02.12.2015

3 COM(2016)860, Clean Energy for All Europeans – unlocking Europe's growth potential, 30.11.2016

4 Regulation (EU) 2018/841 and Regulation (EU) 2018/842

5 COM(2012)60, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52012DC0060; SWD(2012)0011 final, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD:2012:0011:FIN

6 COM(2010)0546, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52010DC0546

7 COM(2011)0571, https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0571:FIN:EN:PDF

8 Ronzon, T. et al., Sustainability, 10, 6, 1745, (2018), doi: 10.3390/su10061745.

regions has been reiterated in several occasions.[9] The 2012 Strategy aimed to "*pave the way to a more innovative, resource efficient and competitive society that reconciles food security with the sustainable use of renewable resources for industrial purposes, while ensuring environmental protection*". The 2012 Strategy highlighted that the bioeconomy's cross-cutting nature offers a unique opportunity to comprehensively address inter-connected societal challenges, and identified five objectives to which the Strategy and its Action Plan were to contribute: (1) ensuring food security, (2) managing natural resources sustainably, (3) reducing dependence on non-renewable resources, (4) mitigating and adapting to climate change, and (5) creating jobs and maintaining EU competitiveness.

In 2017, a Review of the Bioeconomy Strategy[10] (hereafter, also the "Review") was carried out, with the support of independent external experts.[11] The Review concluded that the European Bioeconomy Strategy has substantially delivered during the past years on its objectives, through a wide array of actions ranging from the EU Framework Programmes for Research and Innovation, to the launching of the Bio-Based Industries Joint Undertaking (BBI JU)[12] leading to the creation of new bio-based value chains, to the development of several national bioeconomy strategies, of dedicated regional platforms and of stakeholder panels, all promoting the development of local bioeconomies valuing local resources and adapted to local needs. In particular, the Strategy succeeded in mobilising Research and Innovation funding in bioeconomy by a) doubling the EU Research and Innovation funding dedicated to the bioeconomy under Horizon 2020, b) increasing support to private investment and public-private partnerships through the launch of the BBI JU, and c) encouraging Research and Innovation investments in the Member States. Also, one of the key results of the European Bioeconomy Strategy has been to bring the bioeconomy principles and cross-cutting objectives to the attention of national and regional policy-makers, as demonstrated by the number of countries that have adopted bioeconomy policies since 2012.[13] A substantial number of European regions have also included bioeconomy-related priorities in their Research and Innovation Strategies for Smart Specialisation.[14] The importance of regional bioeconomy strategies, of rural renaissance and of sustainably managing natural resources, is also one of the points of the Bioeconomy Stakeholder Manifesto, which has been another significant achievement of the 2012 Strategy.[15]

9 P7_TA(2013)0302, http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P7-TA-2013-0302+0+DOC+XML+V0//EN; REPORT on cohesion policy and the circular economy (2017/2211(INI)); EUR-Lex - 52012AR1112 – EN (2013/C 17/09); https://cor.europa.eu/en/news/Pages/Towards-a-knowledge-based-bioeconomy.aspx;
https://dm.eesc.europa.eu/EESCDocumentSearch/Pages/redresults.aspx?LANG=EN&k=(documentsource:EESC)(dossiername:NAT)(dossiernumber:739)(documentlanguage:EN);
https://dm.eesc.europa.eu/EESCDocumentSearch/Pages/redresults.aspx?LANG=EN&k=(documentsource:EESC)(dossiername:CCMI)(dossiernumber:160)(documentlanguage:EN)

10 SWD(2017)374; ISBN 978-92-79-74382-5; https://ec.europa.eu/research/bioeconomy/pdf/review_of_2012_eu_bes.pdf

11 https://ec.europa.eu/research/bioeconomy/pdf/publications/bioeconomy_expert_group_report.pdf

12 https://www.bbi-europe.eu/

13 https://ec.europa.eu/research/bioeconomy/pdf/review_of_2012_eu_bes.pdf

14 https://ec.europa.eu/research/bioeconomy/pdf/publications/bioeconomy_development_in_eu_regions.pdf

15 http://ec.europa.eu/research/bioeconomy/pdf/european_bioeconomy_stakeholders_manifesto.pdf

Notwithstanding its positive outcome, the Review also identified several areas for further improvement of the Strategy and Action Plan, namely the need for:

a) further mobilisation of investments, including from the private sector;

b) increased predictability of the regulatory environment to facilitate further investments;

c) increased coherence among relevant EU policies;

d) increased involvement of Member States, regions and cities;

e) inclusion of fewer, focused actions to deliver on a circular bioeconomy;

f) better monitoring of progress of the bioeconomy as a whole and of the Strategy itself, including appropriate indicators;

g) updated alignment to recent EU and global policy developments.

In terms of the latter point, the Review concluded that *"…The current policy context highlights the need for a sustainable, circular bioeconomy. The policy context in which the bioeconomy operates has changed significantly since 2012, with EU and global policy developments such as the EU Circular Economy, the EU Energy Union, the Paris Climate Agreement and the 2030 Agenda for Sustainable Development. In consequence, the concept of a sustainable, circular bioeconomy is being proposed by various stakeholders. The scope of the 2012 Strategy and Action Plan and the relevance and focus of its objectives and actions have to be looked at in light of these developments.*"

Achieving sustainability is at the heart of the Commission's political priorities,[16] it depends upon the renewal of our industries, economies and energy systems, and as such it is central to EU policies related to different parts of the bioeconomy, such as the legislative proposals on the common agricultural policy (CAP),[17] the Strategic Approach to EU Agricultural Research and Innovation[18], the ongoing implementation of the EU Action Plan for the Circular Economy[19] and the new waste legislation,[20] FOOD 2030 Research and Innovation work stream,[21] the renewed EU Industrial Policy Strategy,[22] the Commission Work Programme for 2018-2020,[23] the EU Communication on Accelerating Clean Energy Innovation,[24] the Energy Union Framework Strategy[25] including the Renewable Energy Directive,[26] the Convention on Biological Diversity [27] and the EU Biodiversity

16 COM(2016)739 final, https://eur-lex.europa.eu/legal-content/DE/ALL/?uri=COM%3A2016%3A739%3AFIN

17 COM/2018/392 final; COM/2018/393 final; COM/2018/394 final/2

18 https://ec.europa.eu/programmes/horizon2020/en/news/final-paper-strategic-approach-eu-agricultural-research-and-innovation

19 COM(2015)0614, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52015DC0614

20 http://ec.europa.eu/environment/waste/legislation/

21 SWD(2016)319, http://ec.europa.eu/transparency/regdoc/rep/10102/2016/EN/SWD-2016-319-F1-EN-MAIN.PDF

22 COM(2017)0479 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52017DC0479

23 https://ec.europa.eu/info/publications/2018-commission-work-programme-key-documents_en

24 COM(2016)0763 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52016DC0763

25 COM(2015)080 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2015:80:FIN

26 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02009L0028-20151005&from=EN

27 https://www.cbd.int/

Strategy,[28] the Common Fisheries Policy,[29] the EU Forest Strategy,[30] the Blueprint for EU Forest-based Industries[31], the Blue Growth Strategy,[32] the European Commission Communication on International Ocean Governance[33] and the EU Action Plan for Nature, People and the Economy[34] (Table 1).

Strategies relevant to the bioeconomy	
Bioeconomy specific	➢ Commission communication 'Innovating for sustainable growth: a bioeconomy for Europe' (EC 2012a)
Sectors mainly supplying biomass	
Agriculture	➢ Commission communications: legislative proposals on the common agricultural policy (CAP) beyond 2020 (COM/2018/392 final; COM/2018/393 final; COM/2018/394 final/2) ➢ Commission communication 'Thematic Strategy for Soil Protection' (SEC(2006)620)
Forest-based sector	➢ Commission communication 'A new EU forest strategy: for forests and the forest-based sector' (EC 2013a) ➢ Commission staff working document 'Multiannual implementation plan of the new EU forest strategy' (EC 2015a) ➢ Blueprint for the EU Forest-based Industries (SWD(2013)343)
Fisheries, aquaculture and algae	➢ The Common Fisheries Basic Regulation (EU) No 1380/2013 ➢ Commission communication 'Blue growth: opportunities for marine and maritime growth' (EC 2012e) ➢ Report on the Blue Growth Strategy, Towards more sustainable growth and jobs in the blue economy, SWD (2017) 128 final ➢ Commission communication 'Strategic guidelines for the sustainable development of EU aquaculture' (EC 2013e) ➢ Joint communication "International ocean governance agenda for the future of our oceans" (EC 2016)
Waste	➢ See cross-cutting policies (below)
Sectors mainly using biomass	
Food and nutrition security	➢ Commission communication 'An EU policy framework to assist developing countries in addressing food security challenges' (EC 2010e) ➢ Commission communication ' Increasing the impact of EU development policy: an agenda for change' (EC 2011c) ➢ Commission communication 'Enhancing maternal and child nutrition in external assistance: an EU policy framework' (EC 2013b) ➢ Commission communication ' The EU approach to resilience: learning from food security crises' (EC 2012c)
Energy	➢ EU Renewable Energy Directive (2009/28/EC) ➢ Commission communication 'An energy policy for Europe' (EC 2007a) ➢ Commission communication 'A European strategic energy technology plan (SET-plan) — Towards a low carbon future' (EC 2007b) ➢ Commission communication 'Limiting global climate change to 2 degrees Celsius — The way ahead for 2020 and beyond' (EC 2007c) ➢ Commission communication 'Energy 2020 — A strategy for competitive, sustainable and secure energy' (EC 2010f)

28 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011DC024452011DC0244

29 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R1380

30 COM(2013)0659 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52013DC0659

31 SWD(2013)343

32 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM:02_2

33 JOIN(2016)049 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52016JC0049

34 COM(2017)0198 final , https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2017%3A198%3AFIN

	➢ Commission communication 'Energy roadmap 2050' (EC 2011d) ➢ Commission communication 'A policy framework for climate and energy in the period from 2020 to 2030' (EC 2014a) ➢ Commission communication: 'Accelerating Europe's transition to a low-carbon economy' (EC 2016k) ➢ Clean Energy Package (2016) ➢ Commission communication 'The role of waste-to-energy in the circular economy', (EC 2017a)
Bio-based industries	➢ Commission communication 'A lead market initiative for Europe' (EC 2007d) ➢ Commission communication 'Preparing for our future: developing a common strategy for key enabling technologies in the EU' (EC 2009) ➢ Commission communication: 'A stronger European industry for growth and economic recovery' (EC 2012d) ➢ Commission communication 'For a European industrial renaissance' (EC 2014f) ➢ Future strategy on plastics use, reuse and recycling (EC 2016l)
Cross-cutting policies relevant for the bioeconomy	
Environmental protection and Climate Change	➢ EU Action Plan for Nature, People and the Environment (COM(2017)0198 final) ➢ EU Biodiversity Strategy (COM/2011/0244 final) ➢ EU Strategy on adaptation to climate change (COM/2013/0216 final)
Circular economy — Waste	➢ Commission communication 'Towards a circular economy: a zero waste programme for Europe' (EC 2014e) ➢ Commission communication 'Closing the loop — An EU action plan for the circular economy' (EC 2015b) ➢ Commission communication 'The role of waste-to-energy in the circular economy' (EC 2017a) ➢ Future strategy on plastics use, reuse and recycling (EC 2016l) ➢ Waste package 2018 ➢ Fertiliser Regulation (Regulation (EC) No 2003/2003) ➢ A European Strategy for Plastics in a Circular Economy (EC 2018)
Regional policies — Smart specialisation	➢ Commission communication 'Regional policy contributing to smart growth in Europe 2020' (EC 2010g) ➢ Commission communication 'Strengthening Innovation in Europe's Regions: Strategies for resilient, inclusive and sustainable growth (EC 2017)
Research and innovation	➢ Commission communication 'Europe 2020 flagship initiative — Innovation union' (EC 2010a)
Industrial policy	➢ Commission Communication 'Investing in a smart, innovative and sustainable Industry- A renewed EU Industrial Policy Strategy' (COM/2017/0479 final)

Table 1: EU policies relevant for the bioeconomy

The Bioeconomy Strategy provides a coherent framework that cuts across various sectors and policies, allowing to build synergies (i.e. the exploitation of a service leading to the increased provision of another service), addressing trade-offs (i.e. the exploitation of a service to the detriment of another one) and delivering sustainability across various policy and sectoral objectives. In particular, the renewed Industrial Policy Strategy, the Circular Economy Action Plan and Accelerating Clean Energy Innovation refer to the bioeconomy as key for accelerating progress towards a circular, low-carbon economy.

The European Commission is therefore updating the European Bioeconomy Strategy in order to respond to the current policy priority needs. In line with the new EU policies, the evolved objectives of the updated European Bioeconomy Strategy are the following:

1. *Ensuring food security*. Food and farming systems are a fundamental part of the bioeconomy, but they urgently need to be transformed to become more sustainable, nutrition-sensitive, resilient and inclusive in view of a growing world population, climate

change and other environmental challenges, including water scarcity and loss of biodiversity and of productive land.[35]

2. *Managing natural resources sustainably,* as central for a bioeconomy whose parts are increasingly interlinked. More than ever, a circular bioeconomy depends on an efficient and sustainable use of biological resources, against the backdrop of an increasing demand for biomass. The European Bioeconomy Strategy aims to restore and enhance ecosystems, for instance addressing the root causes of the declining health of global oceans and the collapse of biodiversity.
3. *Reducing dependence on non-renewable resources,* including replacing fossil fuels. Today, bioenergy is the EU's largest renewable energy source, and it is expected to remain a key component of the energy mix in 2030.[36] Moreover, a scaled-up and strengthened bio-based sector can do more than non-renewable substitution: it can support the renewal of the EU industrial base; it can contribute to the greening of industrial products; and it can help to systematically turn bio-waste and discards into value, thus achieving circularity.
4. *Mitigating and adapting to climate change*, by combining enhanced ecosystems services with a renewed bio-based industrial base reducing energy demand and lowering emissions, and with the provision of a more resource efficient, sustainable primary production on land and sea. A sustainable bioeconomy has a pivotal role in reducing pressures on major ecosystems such as oceans, forests and soils to a level respecting all planetary boundaries, and support their pivotal role for balanced nutrient cycles and as carbon sinks.[37]
5. *Creating jobs and maintaining European competitiveness*. In 2015, the bioeconomy sectors employed nearly one in ten EU workers – 18 million people – and generated EUR 2.3 trillion turnover.[38] Deploying a sustainable bioeconomy will support competitiveness by capitalising on advances in life sciences and biotechnologies, as well as innovations merging the physical, digital and biological worlds, in some of the EU's most significant sectors and industries. A more proportionate sharing of the benefits of a competitive and sustainable bioeconomy among primary producers could benefit job creation at a local level.

Through this Strategy and Action Plan the European Commission further demonstrates its commitment to "*...mainstream the Sustainable Development Goals into EU policies and initiatives, with sustainable development as an essential guiding principle for all its policies*".[3940] It also aims to achieve a better integration of Bioeconomy with the Circular Economy, as called by the European Parliament in its report on Cohesion and Circular Economy.[41]

35 http://www.fao.org/publications/sofi/en/; https://www.nature.com/articles/s41558-018-0253-3

36 "Renewable Energy Prospects for the European Union", 2018

37 https://newclimateeconomy.report/2018/

38 Ronzon, T. et al., Sustainability, 10, 6, 1745, (2018), doi: 10.3390/su10061745

39 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A12012E%2FTXT

40 Eurostat EU SDG Monitoring Report

https://ec.europa.eu/eurostat/documents/2995521/9234939/8-18092018-AP-EN.pdf/888b182d-f6f9-4e0d-9e48-4b4e1561333e

41https://dm.eesc.europa.eu/EESCDocumentSearch/Pages/redresults.aspx?LANG=EN&k=(documentsource:EESC)(dossiername:NAT)(dossiernumber:739)(documentlanguage:EN)

2.2. The EU Bioeconomy

The 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, i.e. 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. It cuts across these sectors and systems, interlinking them and creating synergies. While biotechnology is at the heart of bio-based processes, health biotechnology and biological medicines are not included in the bioeconomy definition.

Sustainable bioeconomy activities are deemed central to meet the Sustainable Development Goals (Figure 1), from food and nutrition security to ensuring energy access and health.[42] What follows is an overview of the economic, social and environmental dimensions of the bioeconomy and its expected impacts towards 2030.

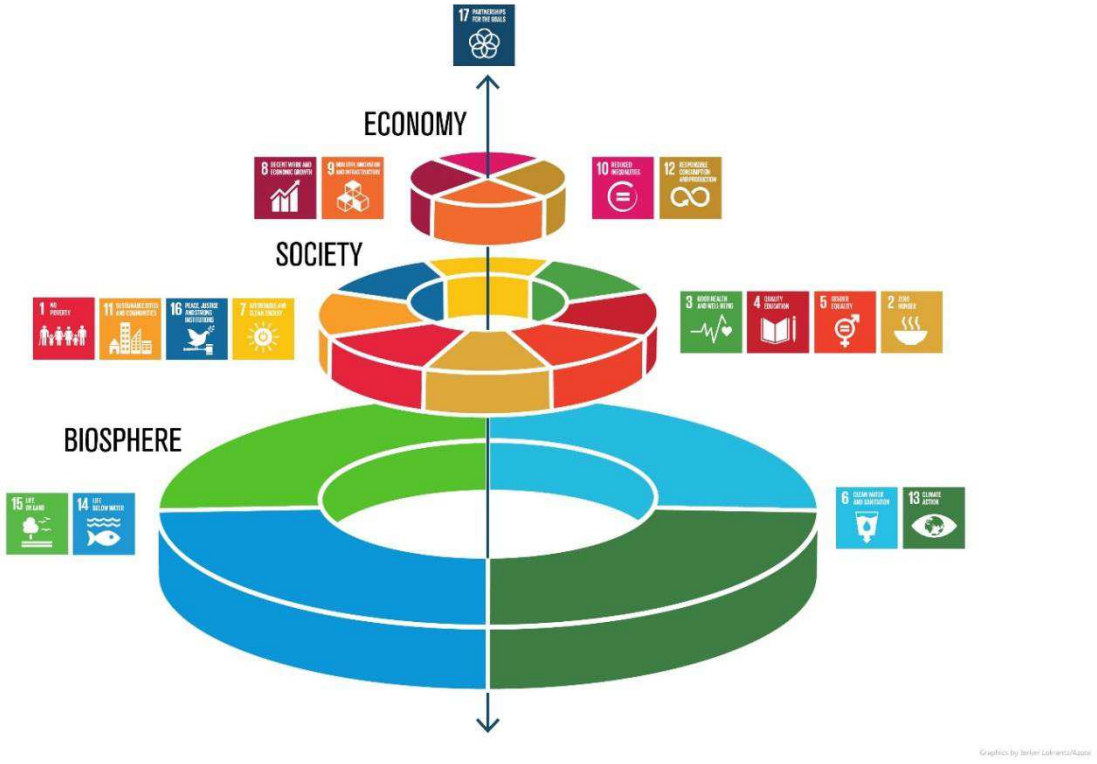

Figure 1. The Sustainable Development Goals "wedding cake": Source: Azote Images for Stockholm Resilience Centre.

42 El-Chichakli B. et al., Nature, 535, 221–223 (2016), doi:10.1038/535221a ; Philippidis G. et al. (2018), Joint Research Centre technical report, doi:10.2760/560977; Communiqués Global Bioeconomy Summits, Berlin 2015 and 2018, http://gbs2015.com/fileadmin/gbs2015/Downloads/Communique_final.pdf; http://gbs2018.com/fileadmin/gbs2018/Downloads/GBS_2018_Communique.pdf; http://iinas.org/tl_files/iinas/downloads/bio/IINAS_IFEU_2018_Linkages_SDGs_and_GSIs.pdf; SWD(2016) 390 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52016SC0390; Müller A.et al., IASS Working Paper, (2015), doi: 10.2312/iass.2015.010; https://sustainabledevelopment.un.org/content/documents/982044_Anand_Innovation%20and%20Sustainable%20Development_A%20Bioeconomic%20Perspective.pdf; http://www.bioeconomyalliance.eu/sites/default/files/EUBA%20SDGs%20final.pdf.

According to work from the European Commission's Joint Research Centre (JRC),[43] in 2015 the bioeconomy in the EU-28 generated approximately EUR 2.3 trillion of turnover,[44] which represents a 5% increase with respect to the previous year. In the same year, the bioeconomy created EUR 621 billion of value added in the EU (Figure 2), representing 4.2% of the EU's Gross Domestic Product and employing over 18 million persons in the EU,[45] mainly in agriculture and the manufacture of food and beverages (together 76% of bioeconomy employment). In 2015, the highest value added annual growth occurred in the manufacture of bio-based chemicals (excl. biofuels) (+26%), the production of bio-electricity (+15%) and the manufacture of rubber and bio-based plastics (+13%), generating altogether an additional EUR 3.5 billion of value added compared to the year before.

43 Ronzon, T. et al., Sustainability, 10, 6, 1745, (2018), doi: 10.3390/su10061745.

44 Included in the calculation are primary sectors (agriculture, forestry, fisheries and aquaculture), manufacturing sectors (food, beverage and other agro-manufacturing, bio-based textiles wood products and wooden furniture, paper, bio-based chemicals, bio-based pharmaceutical, bio-based plastics and rubber, and biofuels) and the production of bioelectricity. Estimates of jobs and growth created in the bio-based construction sector and bio-heat generation as well as in the management of bio-based wastes and bio-remediation are currently lacking.

45 This number includes primary production and biomass manufacturing. Data sources: EUROSTAT lfsa_egan22d for agriculture; EUROSTAT for_emp_lfs for forestry; STECF 2016 for fisheries; STECF 2014 Aquaculture; EUROSTAT Structural Business Statistics for all other sectors. The 18 million people working in the bioeconomy comprises 9.2 million agricultural workers as estimated in the Labour Force Survey (coded lfsa_egan22d) conducted by Eurostat, a source usually used when comparing employment data across different sectors of activities. It refers to people aged 15 years or over working in agriculture as their main activity (EU-28, 2015). The farm structure survey (FSS, coded ef_lflegaa), also conducted by Eurostat, reports 22.2 million persons employed in agriculture, as their first, secondary and minor activity, for the EU in 2013. According to the same source, 11.4 million persons are working on agricultural enterprises generating EUR 4 000 or more as an annual standard output.

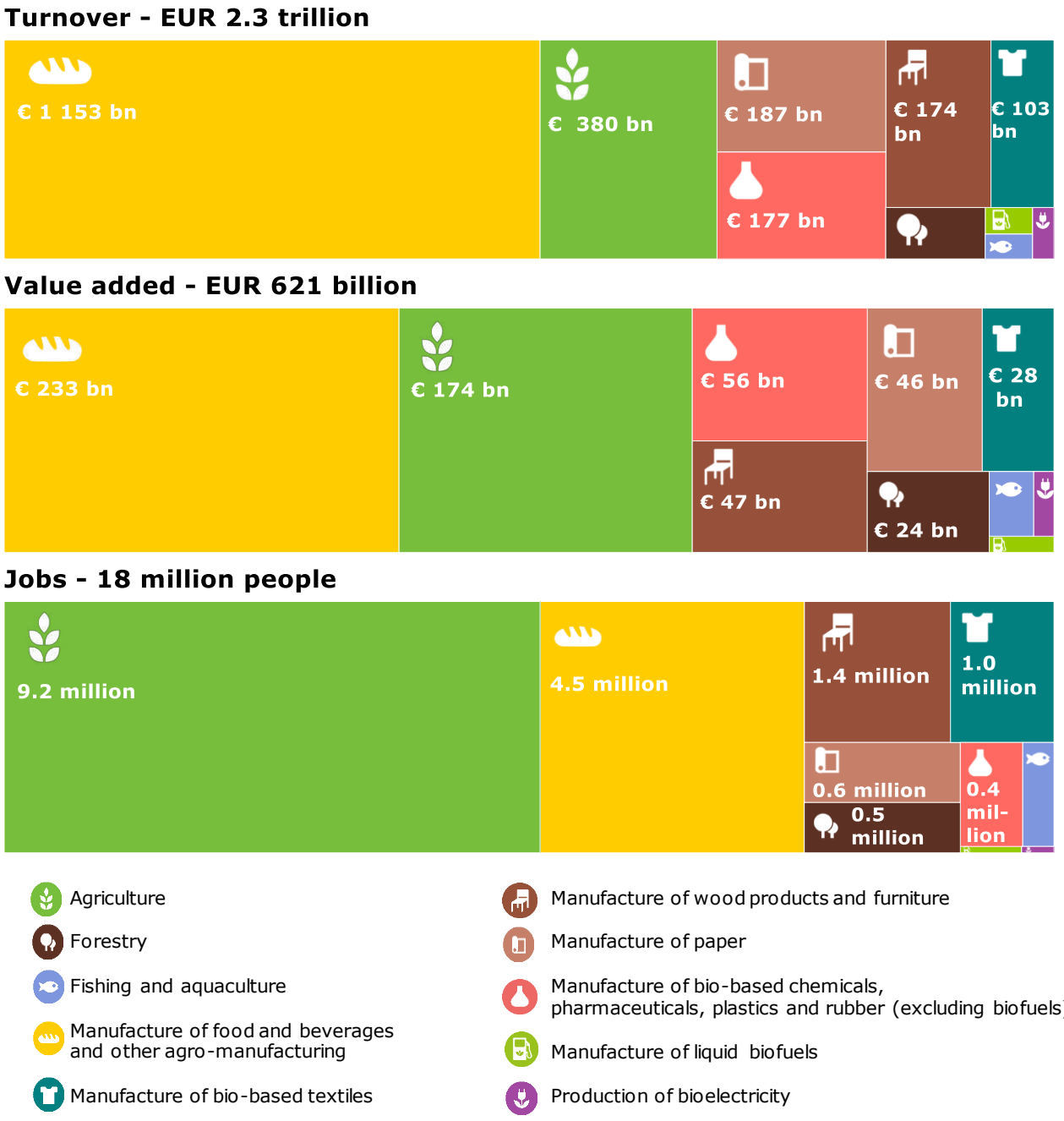

Figure 2. Turnover (billion EUR), value added (billion EUR) and employment (million people) in the EU-28 in 2015 by bioeconomy sector.[46] Adapted from: European Commission's Knowledge Centre for Bioeconomy (2018), Brief on jobs and growth of the bioeconomy 2009-2015. doi:10.2760/157298, JRC112875.

Germany, France, Italy, the United Kingdom and Spain generated 64% of the total EU Bioeconomy value added in 2015. Additionally, specific features of national bioeconomies can be observed.[47] For instance, thet bioeconomy in Finland, Sweden, Estonia and Latvia is oriented towards the forest-based sector (i.e. forestry and the forest-based industries, including the manufacture of wood and paper). In Italy and Portugal, 14% and 16% of the bioeconomy value added, respectively, comes from the manufacture of bio-based textiles. Finland and Sweden generate 25% and 20%,

46 Some specific bioeconomy sectors are not covered in this figure, e.g. production of bio-heat and management of organic wastes

47 Ronzon, T. et al., Sustainability, 10, 6, 1745, (2018), doi: 10.3390/su10061745.

respectively, of their bioeconomy value added from the manufacture of paper. Finally, 36% of Ireland's and 35% of Denmark's bioeconomy value added were generated by the manufacture of bio-based chemicals, pharmaceuticals, plastics and rubber. This shows that there is not one single bioeconomy in Europe but several bioeconomies adapted to local contexts.

Between 2009 and 2015, employment has increased in bio-based chemicals, bio-based pharmaceuticals, bio-based plastics and bio-based rubber, notwithstanding the overall EU labour force decline in agriculture, which drove down the EU Bioeconomy jobs in a proportional fashion (Figure 3).[48] These employment trends are expected to continue to 2030.[49] Decentralised models, where at least the first transformation of biomass takes place as close as possible to the biomass provisioning areas, being them rural (agriculture, forestry), coastal (aquatic) or urban and peri-urban (biowaste and waste water), offer potential for reinvigorating local economies through the creation of skilled 'green' jobs. The use of biomass to produce materials can directly support 5-10 times more employment, and generate 4-9 times more value added, than energy uses, principally due to longer, more complex supply chains for material use.[50]

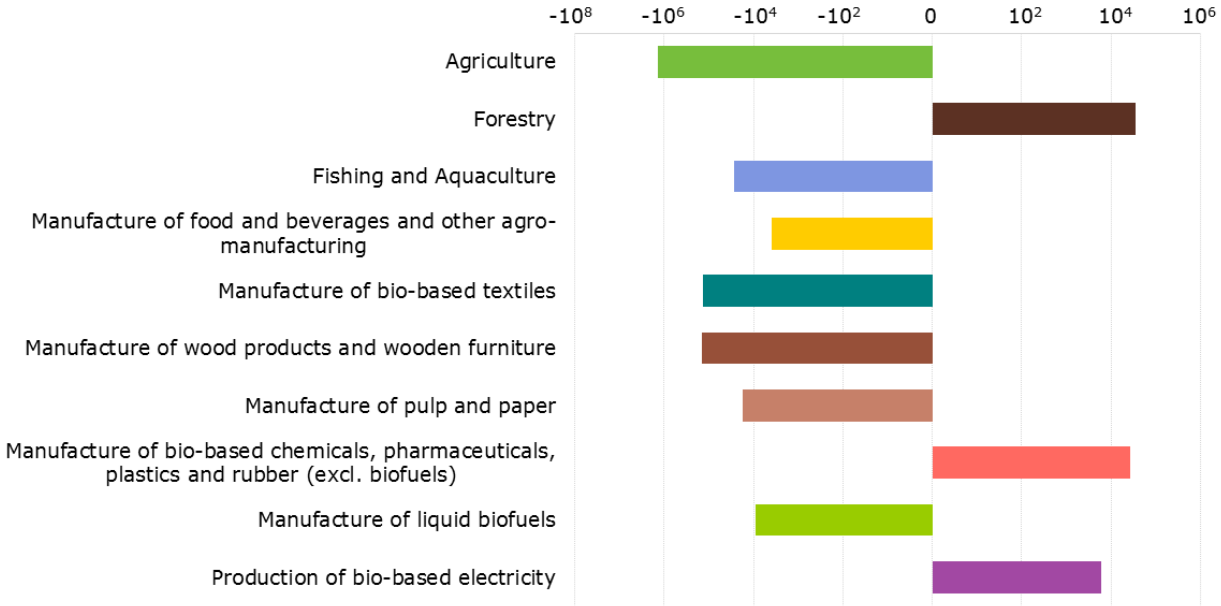

Figure 3. Change in number of jobs in the EU bioeconomy between 2009 and 2015, by sector (log scale). Source: Joint Research Centre, https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS.

The relative contribution of primary sectors to the EU Bioeconomy is significantly lower in terms of value added (33%) than in terms of the number of persons employed (55%). This is clearly reflected at national level too, where several EU countries have a high share of jobs in the bioeconomy, however with a comparatively low resulting added value (Figure 4), mainly due to a

48Joint Research Centre, https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS.

49 Philippidis G. et al. (2018), JRC technical report, doi:10.2760/560977

50 Carus et al., Bioplastics MAGAZINE, 6, 52-55, (2011)

predominance of employment in the less productive sectors.[51] Figure 4 reveals a rather heterogeneous geographical contribution to the EU Bioeconomy at Member State level. In particular, low bioeconomy added value in the Central and Eastern Europan countries is at odds with their high, and, compared to other European regions, yet underutilised biomass potential.[52] To address this gap, the BIOEAST Initiative's mission[53] is to assist Central and Eastern European countries to implement their bioeconomy vision for 2030,[54] offering opportunities for a sustainable increase of biomass production,, a circular processing of the available biomass and viable rural areas.

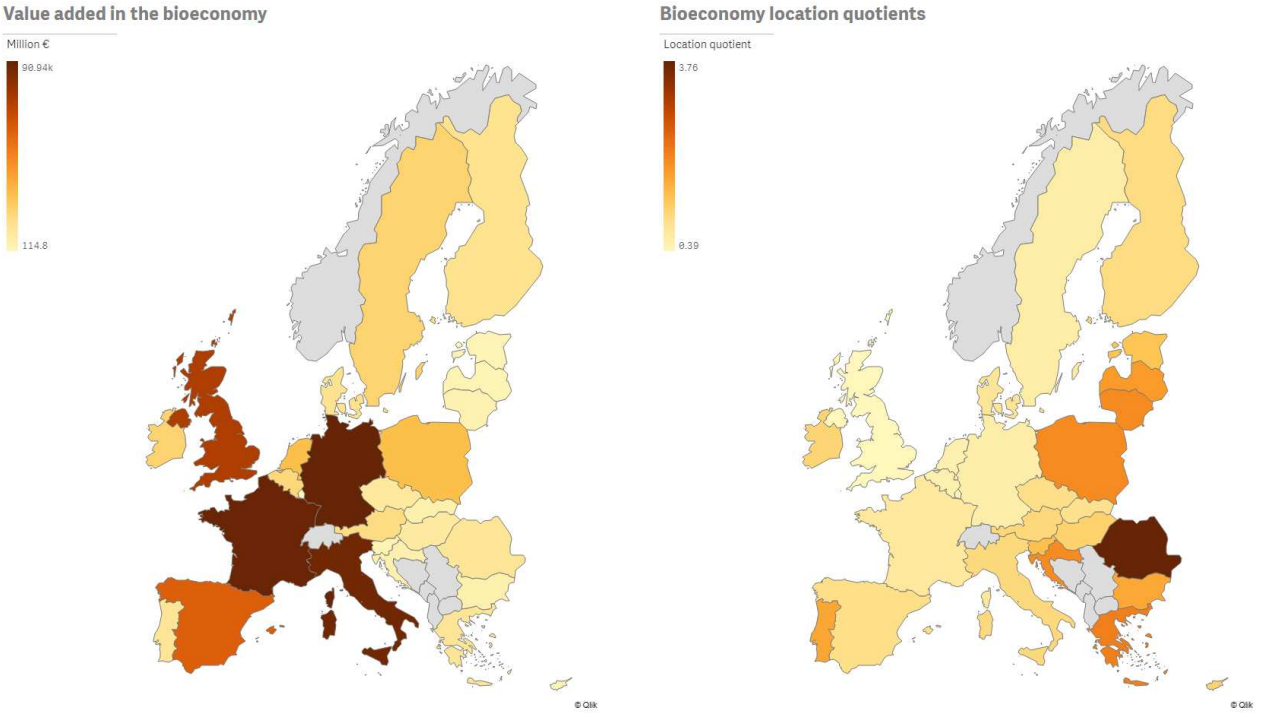

Figure 4. Left: Geographical distribution of bioeconomy added value across EU Member States (in million EUR, 2015). Right: Geographical distribution of bioeconomy location quotient across EU Member States (2015). The location quotient, or job concentration factor, is the indicator usually used to measure how 'concentrated' a sector is in a Member State compared with the EU, i.e. the share of Member State employment in the bioeconomy (or in a given sector of the bioeconomy) divided by the EU employment share in the bioeconomy (or in the same given sector). Source: Joint Research Centre, https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS.

In terms of its environmental benefits, the bioeconomy can contribute to the defossilisation of major industries, such as the energy and transport sectors, the chemical industry (e.g. plastics) and the construction sector (use of wood and its composites with other materials in the construction industry as a substitute for non-renewable building materials, such as steel and concrete with possibly lower use of energy and greenhouse gas emissions). Even though the production of biological renewable resources is also associated with greenhouse gas emissions,[55] resource

51 Less productive sectors are (in increasing order of productivity): Agriculture, Manufacture of bio-based textiles, Fisheries and Aquaculture, Manufacture of wood products and furniture (http://www.mdpi.com/2071-1050/10/6/1745). Ronzon, T. et al., Sustainability, 10, 6, 1745, (2018), doi: 10.3390/su10061745.

52 Conclusions of the project: www.s2biom.eu; see also de Wit M. et al., Biomass and Bioenergy, 34, 2, 188-202, (2009), doi: 10.1016/j.biombioe.2009.07.011); Salamon, P., Joint Research Centre Technical Report, (2017), doi 10.2760/363389; https://biconsortium.eu/sites/biconsortium.eu/files/downloads/Country-Report-Poland.pdf

53 http://www.bioeast.eu/

54 http://www.eu2016.sk/data/documents/160916-bratislava-declaration-and-roadmap-en16.pdf

55 https://www.epa.gov/ghgemissions/overview-greenhouse-gases

consumption and other environmental risks,[56] there is growing understanding that deep defossilisation and remaining under the 2°C limit will not be possible without sustainable bioeconomy activities, given their potential for carbon sequestration, the substitution of fossil resources with sustainable biomass-based resources, and their large greenhouse gas emission reduction potential related to more resource efficient and sustainable production patterns.[57] For example, wood products have significantly lower greenhouse gas emissions than fossil material alternatives over the complete life cycle of the product (including use and disposal), yielding an average saving of 1.5 to 3.5 tons of carbon dioxide emissions per 1 ton of wood products used, instead of construction materials such as concrete.[58] Moreover, the mix of industrial biotechnology with advanced chemistry can increase the efficiency of current production processes.

Notwithstanding the wealth of information available, significant data gaps remain, impeding fully assess the different impacts of the bioeconomy. Notably, information is still scarce on how much biomass is available and can be mobilised sustainably, how much is being used and for which purposes, and how the increased pressure on natural resources can be reconciled with environmental, economic and social sustainability in Europe and globally. Examples of potential competing demands for biomass are detailed in the 4th (and latest) foresight exercise[59] of the Standing Committee on Agricultural Research.[60] For instance, while Europe is self-sufficient in terms of food production, at a global level producing enough food for an increasing population is a central question, yet one that implies increasing cropping areas at the expenses of forests, which are indispensable for the future (see 2.2.1). Moreover, food that is produced directly for humans and feed that is produced for animals in order to feed humans are in competition for arable land. In industrial countries, more than 40% of the total land is used for feed production. Also, as fossil resources gradually phase out, crops cultivated for biofuel and bioenergy, and also for the production of materials, could take away land and calories from human nutrition, with the risk of increasing the pricesi of food commodities.

To help closing these knowledge gaps, the European Commission's Joint Research Centre (JRC) has been tasked with providing data, models and analyses of EU and global biomass potential, supply, demand and its sustainability on a long-term basis.[61] This work links in with international efforts, because examining biomass supply and demand without considering the global context, in particularly the rapidly expanding food demand of non-OECD countries, would underestimate

56 https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ%3AL%3A2018%3A156%3ATOC&uri=uriserv%3AOJ.L_.2018.156.01.0001.01.ENG; COM(2016)0767 final/2 - 2016/0382 (COD), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52016PC0767R%2801%29; COM(2016)0767 final/2 - 2016/0382 (COD), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52016PC0767R%2801%29

57 Dahiya S. et al., Bioresource Technology, 248 A, 2-12, (2017), doi: 10.1016/j.biortech.2017.07.176 ; Mirabella N. et al., Journal of Cleaner Production, 65, 28-41, (2014), doi: 10.1016/j.jclepro.2013.10.051 ; Giroto, F. et al., Waste Management 45, 32–41, (2015), doi: 10.1016/j.wasman.2015.06.008.

58 CLIMWOOD 2030: 'Climate benefits of material substitution by forest biomass and harvested wood products: Perspective 2030' 2016 ISBN 978-92-79-59947-7 http://europa.eu/!NN68bj

59 https://ec.europa.eu/research/scar/pdf/ki-01-15-295-enn.pdf#view=fit&pagemode=none

60 SCAR provides strategic policy advice to the European Commission, Member States and Associated Countries, on the European R&I3 strategies in agriculture and in the wider bioeconomy. It has developed joint foresights, common research agendas, mapping and analysis of SCAR Member States' research capacities, all of which feed into the development of the European Research Area, the Framework Programmes and joint initiatives such as ERANET Co-funds, Joint Programming initiatives (JPIs), European Innovation Platforms (EIPs) etc. See https://ec.europa.eu/research/scar/pdf/24-09_ce_scar_role.pdf#view=fit&pagemode=none for the role of SCAR.

61 https://biobs.jrc.ec.europa.eu/page/biomass-assessment-study-jrc

future competition for resources, resulting market effects, as well as possible global geopolitical and environmental repercussions that might well reach the local bioeconomies in the EU.[62]

Moreover, forecasts of future trends are required in order to steer Research and Innovation investments, to ensure a coherent policy approach that coordinates the demands for biomass from different sectors and to ensure an optimum contribution of the bioeconomy to defossilisation pathways.

2.2.1. Ecosystems and their services

Since 2012, climate change has accelerated, thus becoming a more pressing issue than ever before.[63] At the same time, biodiversity loss and land degradation have emerged as threats as serious as climate change.[64]

Biological resources, the vitality of ecosystems they inhabit and biodiversity are at the very heart of the manifold bioeconomy areas. Healthy ecosystems are essential to human wellbeing; they provide services including habitat maintenance, sustaining food and biomass production, pollination, regulation of freshwater quantity and quality, soil formation, balanced nutrient cycling and regulation of floods, not to mention climate regulation services, essential also to the provision of land and marine-based services. Soils are a fundamental factor in the transition towards a sustainable bioeconomy as society depends on fertile lands and their long-term maintenance because of their associated ecosystem services.[65] Biodiversity is at the base of robust ecosystem condition and functioning, which in turn ensures the continuous and dependable flow of services.

However, human activities exert increasing pressure on soils, oceans, water, air, biodiversity, climate and other natural resources.[66] Biodiversity has been shown to be a key determinant for productivity, as important as nutrients and climate, and biodiversity loss reduces ecosystems productivity and stability.[67] Nature's services to humankind are under threat due to the continuing loss of biodiversity, which has had negative consequences for the delivery of many ecosystem services over the last decades: In 2008, the cost of losing terrestrial biodiversity at global scale has been estimated to be just under 1% of Gross Domestic Product for the year 2010. These costs increase and are predicted to be 7% of global consumption by 2050.[68] The degradation of the Earth's land surface through human activities is negatively affecting the well-being of at least 3.2 billion people, and it costs the equivalent of about 10% of the world's annual gross product in 2010 through the loss of biodiversity and ecosystem services. [69]

62 OECD report "Biomass for a sustainable bioeconomy: technology and governance" (2017) [DSTI/STP/BNCT(2016)7/FINAL]

63 https://climate.nasa.gov/evidence/

64 https://www.ipbes.net/assessment-reports

65 https://naturalsciences.ch/uuid/a9c0c267-c1f6-59c5-9a25-e88c559349b2?r=20170706115333_1523540943_f3e5aeea-be69-5193-8d38-78d0ae65453d

66 https://www.ipbes.net/news/media-release-biodiversity-nature%E2%80%99s-contributions-continue-%C2%A0dangerous-decline-scientists-warn; http://www.resourcepanel.org/reports/global-material-flows-and-resource-productivity-database-link; https://esdac.jrc.ec.europa.eu/content/global-soil-biodiversity-atlas; http://www.un.org/Depts/los/global_reporting/WOA_RPROC/Summary.pdf; https://www.eea.europa.eu/data-and-maps/indicators/status-of-marine-fish-stocks-3/assessment.

67 https://www.nature.com/articles/nature16867. http://www.nature.com/articles/nature23886

68 http://ec.europa.eu/environment/enveco/biodiversity/pdf/ieep_alterra_report.pdf

69 https://www.ipbes.net/assessment-reports/ldr

Globally, these declines have occurred in part because of the intensive agriculture and forestry practices.

Major ecosystems, such as oceans, forests and soils are crucial carbon sinks, without which achieving the balance between emissions and removals of greenhouse gases will not be possible, as pointed out in the Paris Agreement. Oceans absorb up to 30% of the annual emissions of carbon dioxide generated by human activity, helping mitigate the rise in greenhouse gases.[70] However, this benefit comes at a steep ecological cost; the absorbed carbon dioxide alters the carbonate chemistry of the waters, leading to an increase in the acidity of seawater. Studies at open ocean and coastal sites around the world have revealed that current levels of marine acidity have increased on average by about 26% since the start of the Industrial Revolution (pH reduction of 0.1) and that marine life is exposed to conditions falling outside previously experienced natural variability.[71]

At a global level, between 2010 and 2015 the natural forest area has decreased by a net 6.5 million hectare per year.[72] Afforestation and natural expansion of forest do not compensate for these losses, and the continued overall loss of forest land contributes to water scarcity, unmitigated spring floods and climate change. However, against this trend, natural forest area in Europe is increasing, through natural regeneration, reforestation and afforestation practices. Moreover, the growing stock increases, as harvesting is lower than the yearly increment.[73] For this reason, European forests act as a considerable carbon sink whose carbon sequestration activity removes, on average, about 9% of total annual greenhouse gas emissions in the EU, [74] and has been doing so for the last decades.

Exploitation of certain ecosystem services may lead to unintended environmental consequences throughout the 'ecosystem services supply chain'. To this end, trade-offs and synergies in service provision must be carefully analysed.[75]

2.2.2. Primary sectors and biomass flows

The agriculture, forest-based and marine sectors (mainly aquaculture and fisheries) are the main primary producers/suppliers of biomass.[76] The average EU-28 annual domestic biomass production from the land-based sectors (forestry and agriculture, excluding pastures) is 1466 megatonnes of (above ground) dry matter. The breakdown by commodities and sectors is shown in Figure 5.

70 https://unstats.un.org/sdgs/files/report/2017/TheSustainableDevelopmentGoalsReport2017.pdf

71 https://www.eea.europa.eu/data-and-maps/indicators/ocean-acidification-1/assessment

72 http://www.fao.org/3/a-i4793e.pdf

73 Camia et al. 2018. Joint Research Centre, JRC Science for Policy Report, doi:10.2760/181536181536

74 https://www.eea.europa.eu/publications/european-union-greenhouse-gas-inventory-2017

75 http://www.openness-project.eu/library/reference-book/sp-ecosystem-service-trade-offs-and-synergies

76 Camia et al. 2018. Joint Research Centre, JRC Science for Policy Report, doi:10.2760/181536

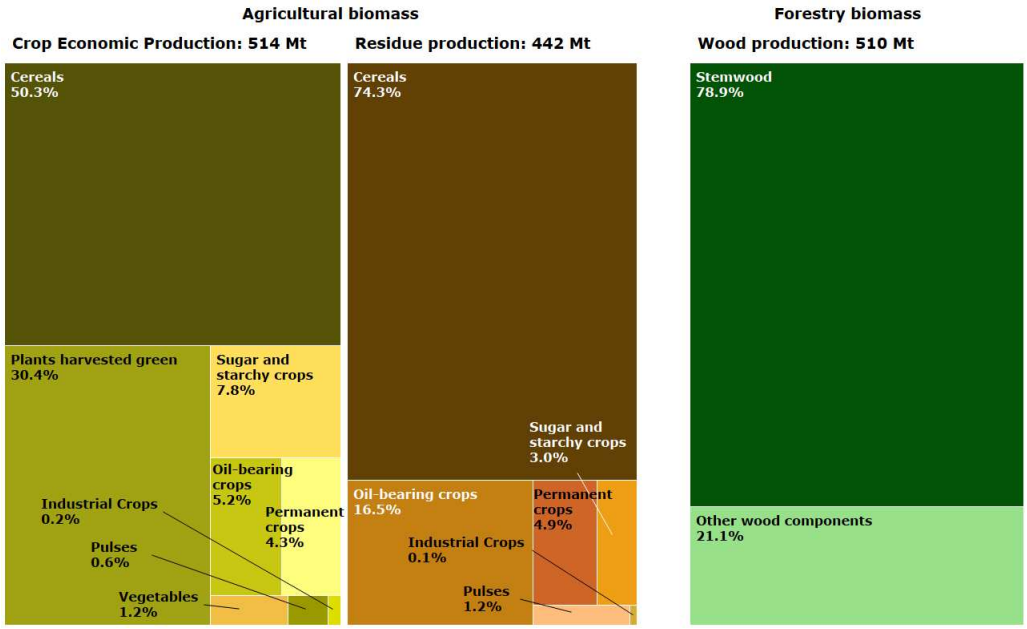

Figure 5. EU-28 annual biomass production from land-based sectors, excluding pastures (10-year average 2006-2015, in megatonnes dry matter). Adapted from Camia et al. (2018). Joint Research Centre Science for Policy Report, doi:10.2760/181536, JRC109869

In 2015, agriculture occupied about half of the land area of the European Union[77] and it employed 4.2% of the EU-28 working population.[78] Agriculture supplies the European economy with a diversity of essential products and services such as food, feed, material, energy and recreation.

According to the medium-term outlook for agriculture towards 2030, the EU's utilised agricultural area is expected to continue to decline.[79] As we approach 2030, EU per capita consumption of meat is expected to drop back to its current level, after increases in the first part of the outlook period 2017-2030. Nevertheless, EU feed use is expected to rise further over the outlook period, in response to more poultry and dairy production and more intensive beef production. Greenhouse gas emissions from agriculture are expected to decrease by 2030. Technological development, innovations and digitisation (e.g. precision farming, nature-based solutions, breeding) are significantly improving the potential for higher resource efficiency, decreased environmental and climate impact, increased resilience and decreased costs.[80] Nevertheless, system redesign is essential to deliver optimum outcomes as ecological and economic conditions change.[81] Although total agricultural income is expected to decrease considerably in real terms over the outlook period, income per worker is expected to increase slightly due to structural change and people leaving agriculture.

Forests and other wooded land occupy around 43% of EU land and are a source of wood and non-wood products, providing a wide range of ecosystem services, such as carbon storage and sequestration, habitat provision and water regulation.[82] Increasing the carbon storage in existing

77 https://data.worldbank.org/indicator/AG.LND.AGRI.ZS?year_high_desc=false

78 Eurostat, 2016d. Labour Force Survey (lfs_egan22d). http://ec.europa.eu/eurostat/statistics-explained/index.php/Labour_market.

79 https://ec.europa.eu/agriculture/sites/agriculture/files/markets-and-prices/medium-term-outlook/2017/2017-fullrep_en.pdf

80 cfr CAP Strategic plans. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2018%3A392%3AFIN

81 https://www.nature.com/articles/s41893-018-0114-0; https://link.springer.com/article/10.1007/s13593-018-0519-1

82 https://ec.europa.eu/agriculture/forest_en

forests is a cost-effective mitigation measure, but signs of decreasing carbon storage have been observed in recent years mainly due to the changing age structure of EU forests.[83] There is potential for increasing the carbon storage of European forests through sustainable forest management.

About 84% of the EU forest area is considered potentially available for wood supply. In this area 444 megatonnes of wood grow every year (wood net annual increment, i.e. excluding losses due to natural mortality of trees). The EU average wood harvest rate is around 65 % of the wood net annual increment, though such rates vary widely across the member states. This results in many cases in an increase of forest-based woody biomass stock over time[84] (around 100 megatonnes of carbon annually and approximately 9% of Europe's fossil fuel emissions). However, reported harvesting is likely to be consistently underestimated by up to 20%, meaning that biomass availability is actually higher than statistically recorded.

According to the Forest-Based Industries Blueprint,[85] over 95 % of roundwood used by the EU's wood-processing sector comes from EU forests. There is a potential for increasing harvest rates and wood mobilisation to provide additional quantities of woody biomass (as advocated by some stakeholders[86]) without exceeding the total annual increments, in order to maintain a domestic EU wood supply to the existing wood-processing industries, and also to service the growing demands from bio-based materials and products within the bioeconomy. Yet, trade-offs with other forest ecosystem services - e.g. carbon sink, nature conservation, recreation, soil and flood protection – need to be carefully assessed. The implementation of sustainable forest management principles, as enshrined in the EU Forest Strategy, must ensure sustainable wood mobilisation in the EU.

Another crucial source of biomass, which is increasing in importance as land ecosystems come under increasing pressure, is biomass from fisheries, aquaculture and from farming the seas and oceans for other types of biomass (e.g. algae). Fisheries and aquaculture are important sources of food and nutrition and have the potential to make a significant contribution to food security and adequate nutrition levels for a global population expected to reach 9.7 billion by 2050.[87] Moreover, they are an important source of income and support the livelihoods of hundreds of millions of people around the world.[88] Aquaculture is the fastest growing animal food producing sector in the world and is an increasingly important contributor to global food supply and economic growth.[89] The sector has increased production by 76% since 2004 and more than four times since 1990. However, in global terms the EU is still a relatively small player (Figure 6). Sustainable aquaculture

83 Pilli R. et al., Biogeosciences, 14, 2387-2405 (2017), doi:10.5194/bg-14-2387-2017

84 NB in fact the NAI (net annual increment) quoted is only for above-ground "merchantable woody biomass, i.e. "roundwood" that is bigger than a minimum specified top diameter, so smaller stem wood, small branches, leaves and below-ground biomass are not included.

85 SWD (2013) 343

86 http://simwood.efi.int/uploads/Presentations/final_conference/19_Schelhaas-Nabuurs_20171013.pdf;

http://www.forestplatform.org/system/attachments/files/000/000/072/original/FTP_renewed_Vision_2030.pdf?1472814337 (vision target 2)

87 SAM High Level Group Food from the oceans: how can more food and biomass be obtained from the oceans in a way that does not deprive future generations of their benefits? https://ec.europa.eu/research/sam/index.cfm?pg=oceanfood; OECD report "Biomass for a sustainable bioeconomy: technology and governance" (2017) [DSTI/STP/BNCT(2016)7/FINAL].

88 http://www.fao.org/3/a-i5555e.pdf

89 http://www.fao.org/3/a-i7989t.pdf

faces particular challenges in the EU, due to competition for space and markets and administrative constraints.[90]

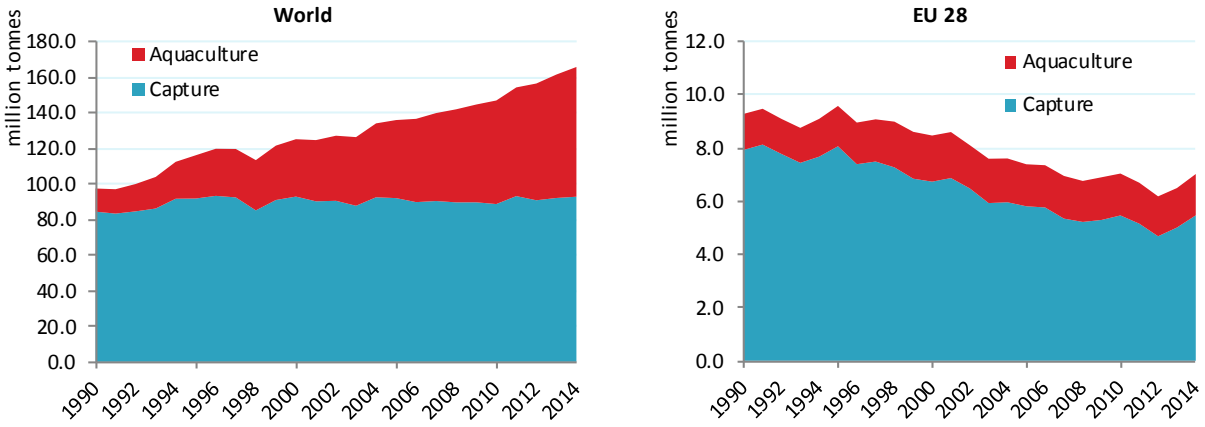

Figure 6. World and EU-28 seafood production (capture and aquaculture) from 1990 to 2014 in megatonnes. Source: Food and Agriculture Organization of the United Nations, 2016

A further source of biomass with increasing importance are the biological residues coming from the agricultural, forest-based and fishery sectors, and also the waste and sidestreams from other sources such as households, food production, and other biomass manufacturing (see 2.3).

When analysing biomass demand, currently ca. 50% of the biomass in the EU is used for feed and bedding, a significant fraction of which is needed for livestock production (Figure 7).

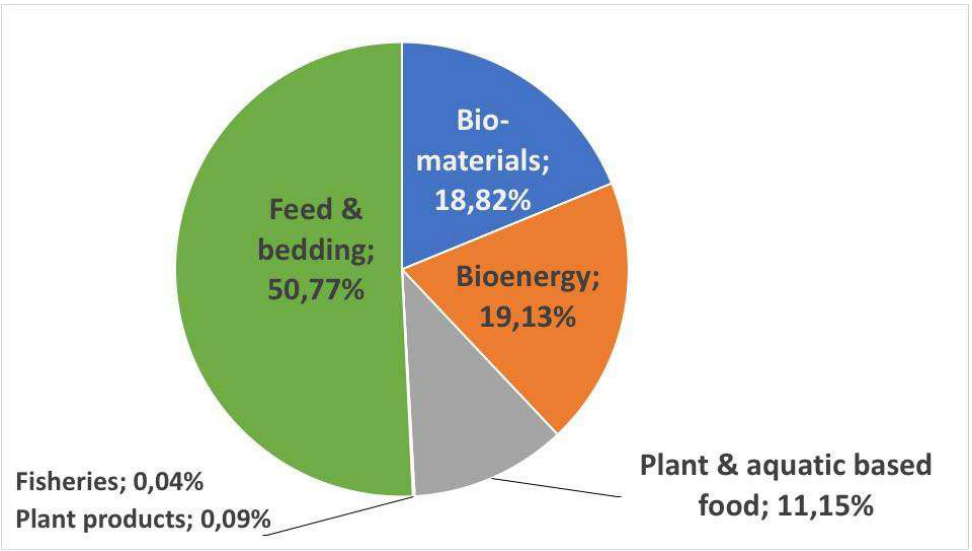

Figure 7: Biomass uses in the EU-28 in 2015. Adapted from Camia et al. (2018), Joint Research Centre Science for Policy Report, doi:10.2760/181536, JRC109869.

According to the Standing Committee of Agricultural Research Foresight on Sustainable Agriculture, Forestry and Fisheries in the Bioeconomy, the BIO-BOOM scenario foresees that the amount of biomass used globally for bio-based materials and chemicals could grow from 1.24 billion tons in 2012 to 5.7 in 2050,[91] while the BIO-MODESTY scenario assumes that the growth in

90 https://stecf.jrc.ec.europa.eu/documents/43805/1491449/STECF+16-19+-+EU+Aquaculture.pdf

91 4th SCAR Foresight Exercise https://ec.europa.eu/research/scar/pdf/ki-01-15-295-enn.pdf

demand for biomass for materials and energy will be relatively low. In line with Sustainable Development Goal 12, a sustainable supply and demand system of biomass requires that consumption patterns are also sustainable. Yet, this is not always the case today.[92,] For example, global livestock production currently accounts for one-third of the global cropland use and seven percent of the total greenhouse gas emissions,[93] besides consuming an important fraction of water both at global and at EU level.[94] Driven by an expected increase in world population, the demand for animal products is expected to increase by 70% by 2050,[95] which is likely to aggravate environmental pressure and to negatively impact climate mitigation measures.[96]

2.2.3. Oceans and the Blue Bioeconomy

Oceans cover more than two-thirds of the earth's surface and contain 97% of the planet's water.[97] The global ocean economy contributes significantly to economic output and employment. The Organisation for Economic Co-operation and Development (OECD) has estimated it at USD 1.5 trillion in value added in 2010, or approximately 2.5% of world gross value added.[98] Moreover, it identified emerging ocean-based industries as having a particularly high potential in terms of growth, innovation and contribution to addressing global challenges such as energy security, environment, climate change and food security. Traditional activities may also contribute to a sustainable growth of the Blue Economy, provided that they are put on a sustainable pathway.[99]

Marine and freshwater realms will be crucial to meet the demand for food caused by a rapidly growing world population. Marine resources already constitute an important source of protein worldwide, but they are not optimally used in the EU, where human consumption focuses on a small number of top predator species and other uses are not very widespread.[100] That translates into an untapped potential both for lower trophic levels and the various waste products. For the latter it has been estimated that for each tonne of fish eaten, an equal volume of fish material is discarded either as waste or as a low value by-product.[101] That is why farming the sea and harvesting its resources efficiently is a clear objective of the .European Bioeconomy Strategy Due to conservation efforts and scientifically informed management plans, in some areas, such as the North East Atlantic, over time conservation levels are increasing and exploitation levels are improving towards sustainability. Still, many stocks remain overfished (40% in 2016) and/or in biological risk (35% in 2016). Progress to achieve sustainable optimal exploitation to ensure that all stocks will meet EU policy objectives by 2020 seems too slow. The situation is much worse in the Mediterranean Sea, where 93% of fish stocks are overfished. Under the remit of the Common Fisheries Policy, the

92 https://academic.oup.com/bioscience/article/67/12/1026/4605229; Leip A., Environmental Research Letters, 10 (11) (2015); http://iopscience.iop.org/article/10.1088/1748-9326/10/11/115004/pdf

93 http://www.fao.org/docrep/018/ar591e/ar591e.pdf

94 Mekonnen M. et al., Ecosystems, 15, 3, 401-415 (2012), doi: 10.1007/s10021-011-9517-8; Mubareka S. et al., Ecosystem Services, 4, 139-145 (2013), doi: 10.1016/j.ecoser.2013.03.001

95 http://www.fao.org/ag/againfo/home/en/news_archive/2017_More_Fuel_for_the_Food_Feed.html

96 http://www.risefoundation.eu/images/files/2018/2018_RISE_LIVESTOCK_FULL.pdf; http://science.sciencemag.org/content/361/6399/eaam5324

97 http://www.un.org/depts/los/nippon/documents/Non_recurrent_e_publication_Oceans_final.pdf

98 http://www.oecd.org/sti/the-ocean-economy-in-2030-9789264251724-en.htm

99 https://ec.europa.eu/research/sam/pdf/sam_food-from-oceans_report.pdf#view=fit&pagemode=none

100 http://www.un.org/depts/los/nippon/documents/Non_recurrent_e_publication_Oceans_final.pdf

101 http://www.gov.scot/Publications/2005/03/20717/52862

Scientific Technical Economic Committee for Fisheries, together with the European Commission Joint Research Centre, is monitoring the status of the fish stocks, and also the performance of the Common Fisheries Policy (Art. 50 of (EU) 1380/2013), in order to provide the necessary scientific advice to ensure sustainable fisheries, thus contributing to reverse trends and restore ocean health.[102]

Next to fish, the extraction of algae biomass is becoming increasingly important, since this source is expected to represent an efficient alternative to increase the European biomass production potential, especially for protein generation. Algae are currently used mainly by the food and chemical industry as raw material for the extraction of hydrocolloids and for human nutritional products. Increased investment in sustainable farming of algae has become crucial, especially for commercially important species with identified susceptibility to ongoing stressors. In the EU, farming of algae is still at an early phase, however the production has increased by 66% between 2005 and 2014 (source: FAO fishstat). It requires further developments at the technological, operational, biological knowledge and economic levels.

Importantly, all Blue Bioeconomy activities depend on the broader macroeconomic environment and the complex and uncertain interactions with the rest of the marine and maritime activities. According to the World Wide Fund for Nature, up to 70% of the annual value of global ocean's activity depends on the health of the ocean,[103] and existing pressures would decimate the ocean's resources in a business as usual scenario. A critical uncertainty is linked to the observed declining health of the ocean which appears to be accelerated due to climate change. The United Nations Framework Convention on Climate Change, 21st Conference of the Parties highlighted that climate and the ocean are inseparable, and in ways still to be explored and understood. The ocean absorbed around 93% of the excess heat trapped by greenhouse gas during the period 1971-2010 and 26% of anthropogenic carbon dioxide since the beginning of the Industrial Revolution. Increase of sea temperatures, rise of sea levels and ocean acidification (the so called "other carbon dioxide problem")[104,105] may all bring an unbearable burden on the marine capital. However, just 4.1% of the ocean is classified as protected, but only part of this is effectively managed.[106] The Ellen McArthur Foundation and the World Economic Forum suggested that, current trend continuing, by 2050, seas and oceans might well contain more plastics than fish, by weight.[107] Experts at the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research have recently found higher amounts of microplastic in arctic sea ice than ever before.[108]

The Blue Bioeconomy can only flourish if managed sustainably. Yet, our knowledge about features below the sea surface remains limited, particularly when compared to what we know about the land. Therefore, efforts are needed, including scientific research, to better understand the impacts of maritime activities on marine ecosystems. A better understanding of ocean resources and the marine

102 https://ec.europa.eu/jrc/en/news/saving-our-heritage-worrying-state-mediterranean-fish-stocks

103 https://www.worldwildlife.org/publications/reviving-the-oceans-economy-the-case-for-action-2015

104 Doney S. et al., Annual Review of Marine Science, 1, 169-192, (2009), doi: 10.1146/annurev.marine.010908.163834

105 http://ec.europa.eu/eurostat/documents/3217494/8461633/KS-04-17-780-EN-N.pdf/f7694981-6190-46fb-99d6-d092ce04083f

106 https://wdpa.s3.amazonaws.com/Protected_Planet_Reports/2445%20Global%20Protected%20Planet%202016_WEB.pdf

107 https://www.ellenmacarthurfoundation.org/publications/the-new-plastics-economy-rethinking-the-future-of-plastics

108 Peeken I. et al., Nature Communications, 9, 1505 (2018), doi:10.1038/s41467-018-03825-5

environment is necessary to underpin sound policies and will allow to better assess and weigh opportunities and potential risks inherent to marine bioeconomic activities. The prevailing lack of knowledge about the marine realm impedes to tap into its value to tackle current global challenges.

The EU is stimulating action to provide better knowledge, ecosystem-based, cross-border and integrated spatial planning, management and surveillance. The Blue Growth Strategy and the circular economy offer opportunities to rethink growth models and extract more value out of our limited resources. Research and Innovation are progressing towards exploring the best possible ways that the ocean can continue to be both a healthy and productive life support system. Many scientific initiatives in place will enhance knowledge and help to push oceans and seas into sight as to improve governance and policymaking and to make the most of marine resources. With respect to the management of marine living renewable resources, the insistence on "best available scientific advice" stipulated in the Common Fisheries Policy basic regulation, could serve as a paradigm for other areas, to ensure the integration of scientific knowledge in policy and decision-making.

2.2.4. Bio-based sectors

The bio-based sector produces and uses renewable biological resources and/or applies innovative biological processes and principles to deliver bio-based products, processes and services. There are conventional bio-based products made traditionally from biomass (such as wood, cork, natural rubber, paper, textiles, wooden construction materials) and more recently developed products such as bio-based chemicals, bio-based plastics, etc. Biofuels are also bio-based products, however as they are energy applications, they are discussed in section 2.2.6.

Bio-based products can substitute fossil-based ones. They can be identical to their fossil alternative ("drop-in") or novel products with entirely new functionalities and potential for new markets (e.g. cellulose-based ones, bio-based plastics that are fit for industrial composting and biodegradable in the natural environment or "green" chemicals). Bio-based products go far beyond biomass processing. They capitalise on the unprecedented advances in life sciences and biotechnology (including microbiology, microbiomes and enzyme technologies) that, coupled with the digital revolution, allow to use nature's "biological assets" (its biochemicals and biomaterials) and its "biomimetic assets" (its functions and processes) to generate significant new sources of economic value and future revenue.

Bio-based processes are characterised by presenting high selectivity and operate under milder and more environmentally friendly conditions, compared with traditional processes. A typical example is the microbial-based production of vitamin B2 (one step process as compared to a six-step chemical production), which reduces the use of non-renewable raw materials by 75%, the emissions of volatile organic compounds to air and water decreases by 50% and operating costs to by 50%.

The transformation of biomass into a bio-based product takes place in biomass processing facilities. When a facility converts biomass into a spectrum of products, it is called a biorefinery.[109]

109 A biorefinery is intended as " an overall concept of a processing plant where biomass feedstocks are converted and extracted into a spectrum of valuable products". Source: US DOE, 1997, Energy, Environmental and Economics (e3) Handbook, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Washington D.C.

AGRICHEMWHEY Horizon 2020 project:
an integrated biorefinery for the conversion of dairy side streams into added-value products (e.g. lactic and polylactic acids).

AgriChemWhey aims at developing rural communities by creating local jobs (1,000 rural jobs within four years of project completion). It will secure the future for dairy farming by making milk production more sustainable and increase the amount that farmers can earn from their outputs and thus protect them against price volatility.

The bio-based sector has taken big strides in recent years. The interest in the transition from fossil to bio-based products has revitalised traditional sectors by bringing opportunities to diversify their product's portfolio. Innovation capitalises on the skills of making use of various biomass for the bio-based production, in traditional sectors such as pulp, woodworking, textiles and wood-based construction.

The pulp, paper and board developed new cellulose-based applications that can replace fossil-based textiles and plastics, boost the use of nanofibril applications in bio-based adhesives, laminates, 3D printing and flexible electronics, as well as use foldable corrugated cardboard for the large scale packaging business for Internet products. The revitalisation of pulp, paper and board has also brought solutions for the better utilisation of their side streams for the biofuel production and is also now seen increasingly in markets including fine and commodity chemicals, healthcare, automotive, consumer goods, construction, etc. Some low-tech products, such as composites, packaging materials, etc., have lower added value but also lower cost and risk, hence are interesting for their large potential for replication in a diversity of regions and contexts.

Another example of novel bio-based product comes from textile fibres made of microfibrillated cellulose from wood by mechanical processing and without harmful chemicals. For the textile sector, a gap of 180 million tons of textile fibres is expected by 2050, which could mainly be filled by man-made cellulose fibres, bio-based polymer fibres or petrochemical fibres — depending on the political and economic framework.[110]

The bio-based sector is a highly dynamic part of the bioeconomy in terms of jobs and turnover growth.[111] In the EU, between 2009 and 2015 the overall growth rate of the value added of bio-based sectors ranged between 14% for the manufacture of wood and wooden products and 23% for the manufacture of pulp, paper and cardboard. In the same period, the overall growth rate of EU value added of bio-based chemicals, pharmaceuticals, plastics and rubber has been 17%.[112]

Bio-based chemicals resulting from biomass processing are an important segment within the bio-based sector. In 2015, the sector of bio-based chemicals has created the highest number of jobs of all bioeconomy sectors (see 2.2). According to the preliminary results of a forthcoming Joint Research Centre 2018 study, the EU bio-based chemicals market is diverse and large differences can be found between product categories. For example, the bio-based solvents and platform

110 4th SCAR Foresight Exercise, https://ec.europa.eu/research/scar/pdf/ki-01-15-295-enn.pdf

111 https://ec.europa.eu/docsroom/documents/26451/attachments/1/translations/en/renditions/native

112 Joint Research Centre, https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS

chemicals both have a very small bio-based percentage, while on the other hand, surfactants and cosmetics already enjoy a large bio-based share. Even within the categories with similar bio-based share, the differences are large, where bio-based platform chemicals are expected to grow rapidly in the coming years, bio-based solvents are expected to grow much less.

A 1% increase of European wood-based products in the market share of the global construction, textile and plastics markets could generate a revenue for the European wood-based bioeconomy in the scale of EUR 10 to 60 billion (depending on the assumptions made – see Table 2). This would amount to 3% - 20% of the current total turnover of the EU forest industry. The additional industrial roundwood use of this 1% increase would be at least 83 million cubic metres, which would be 23% of the total industrial roundwood production in the EU in 2016 (355 million cubic metres, data FAOSTAT).[113] However, while the annual harvest would still be below the net annual increment, such an increase in the EU roundwood utilisation would reduce the EU's carbon sink, therefore trade-offs across all bioeconomy areas need to be carefully considered.

Market	Construction *(cement/concrete)*	Plastics	Textiles	TOTAL
Global market size in 2050	> 5 000 Mt	1 124 Mt	250 Mt	6 374 Mt
Growth rate *assumption*	Peaking soon	4x by 2050	4x by 2050	
Price* *(value per unit)*	80–2 650 €/ton	650–1 580 €/ton	600–2 300 €/ton	
Forest-based 1% solution *(European forest-based materials gain 1% share of the global market volume)*				
Production	13.7 Mt**	11.2 Mt	2.5 Mt	27.4 Mt
Revenue	– 1–36 billion €	– 7–18 billion €	– 1.5–6 billion €	– 10–60 bill. €
Wood use	68 Mm³	*(no primary use – based on side-streams)*	15 Mm³	> 83 Mm³

Table is modified from unpublished manuscript by Hurmekoski et al. (2017), Markets for new wood-based products, European Forest Institute.
*Based on Finnish customs statistic; ** Wood density (500 kg/m³) is different from that of concrete (1850 kg/m³) – 3–4 times less (tons) wood needed to substitute the same volume (m³) of concrete.

Table 2. Hypothetical example of 1% market share for forest-based products in different sectors.

In fact, the bio-based sector does not only contribute to growth and jobs but can also helps to sequestrate carbon through its long-term storage e.g. in wooden and woody biomass-based products. Moreover, the circularity and defossilisation of major economic sectors, including the agriculture and food sector, the chemical industry and the wooden construction sector, offer possibilities for long-term carbon sequestration and implementation of the low carbon economy. At the same time, forests are vulnerable to climate change, and enhancing their resilience and adaptive capacity will be key to ensuring a long-term supply of primary material and ecosystem services. Moreover, the future development and integration of Carbon Capture Storage or Use (CCS/U) technologies into industrial operations using biomass may offer the possibility for negative emissions, but after considerable infrastructure investments.

The chemical and petrochemical industries are partly using biomass as raw material. An important driver for using biomass as raw material is the objective to reduce the greenhouse gas emissions of

113 Leading the way to a European circular bioeconomy strategy, From Science to Policy 5. European Forest Institute, 2017.

this sector that account for 7% of greenhouse gas emissions of all industry.[114] According to the estimations of the European Chemical Industry Council (CEFIC), the total volume of organic raw materials used by the chemical industry in 2015 amounted to 77.7 megatonnes, of which about 10% (7.8 megatonnes) were renewable.[115] Out of the renewable raw material, carbohydrates (sugar and starch), vegetable oils, natural rubber and bioethanol for ethyl tert-butyl ether account for almost two-thirds of the quantities. Other important materials are animal fats, chemical pulp, tall oil, glycerol and others.

In the construction sector, greater use of wood as a substitute for more energy-intensive non-renewable building material can reduce greenhouse gas emissions.[116] According to a report from the Food and Agriculture Organization (FAO) of the United Nations[117] an analysis of 21 studies on mitigation potential of wood use in buildings and furnishing showed that most studies concluded that wood products have lower greenhouse gas emissions than alternatives over the complete life cycle of the product (including use and disposal). Meta-analyses of the average impact of using wood instead of concrete suggest an average reduction of 2.1 tons of carbon dioxide emissions per 1 ton of wood products used.[118]

Advances in bio-based innovation forter the circularity of the bio-based sector and the whole bioeconomy by enablinging the processing of current side-streams, residues and wates into products. For instance, side streams of both wood working industries and pulp, paper and board manufacturing can be converted into large number of new bio-based products with new functionalities (e.g. nanocellulose, carbon nanofibres, adhesives, normal and intelligent textiles, flexible electronics, 3D printing applications). The technologies also enable biowaste and residues from farms and forest-based sector, from cities or from the food sector to be transformed into bio-based products such as chemicals, organic fertilizers, biofuels and eventually heat and power, if a more circular use is not possible. The food-processing industries, for instance, are exploring the potential of converting residues into bio-based products such as chemicals and biofuels.New and/or more efficient ways of biomass processing, fractionation and extraction are key to recover complex molecules from biomass (e.g. polymers such as cellulose, hemicellulose and lignin derivatives), for new product value chains and to avoid the loss of value that results from breaking complex biomolecules down. Greater value can also be generated from unavoidable biological wastes and residues by efficient collection, sorting and conversion technologies and systems, as well as via development of upcycling technologies for them.

114 International Energy Agency (IEA), International Council of Chemical Associations, DECHEMA. Technology roadmap: energy and GHG reductions in the chemical industry via catalytic processes. Paris (France): IEA Publications; 2013.

115 http://www.cefic.org/Policy-Centre/Innovation/Bio-economy/

116 The cement industry is responsible for approximately 5% of global carbon dioxide emissions. Worrell et al, CARBON DIOXIDE EMISSIONS FROM THE GLOBAL CEMENT INDUSTRY, Annu. Rev. Energy Environ. 2001. 26:303–29.

117 http://www.fao.org/3/a-i5857e.pdf

118 http://www.efi.int/files/images/publications/efi_hurmekoski_wood_construction_2017.pdf

Multi-product biorefineries[119] can improve the efficiency of biomass utilisation by increasingly parallel exploitation of sideflows, reducing and/or recovering waste and residues, thereby boosting resource efficiency and waste prevention as well as recycling and circularity. The transformation of waste and residues into higher added value products will further link various sources of biomass (agri/forest-based sector residues; woodworking and pulp and paper processing sideflows, food production and household "biodegradable waste"; aquatic resources) with the production of an array of products such as food, feed, biotextiles, biopolymers, chemicals, bioplastics and eventually bioenergy/biofuels, thereby increasing the value creation, jobs and competitiveness as well as sustainability of biomass production and use as well as the value creation. As biomass is bulky and hence expensive to transport, these new transformation processes should ideally be located close to the primary production sites, hence bringing new added value generation into rural areas.

The development and deployment of biorefineries will depend heavily on the profit margins of bio-based products and the successful development and commercialisation of new technologies; availability of local and/or regional feedstock at competitive prices, suitable infrastructure including logistics, skilled personal, private and public support services, including utility companies facilitating financing and permitting; and fostered by a supportive policy and regulatory enabling environment. The commercialisation and large-scale deployment of the less mature technologies,[120] for instance, the material use of lignin and lignosulphonate currently transformed mostly into energy, represents a huge opportunity for e.g. lightweight materials deployment, phenol-based aromatics chemistry, for adding further value to this second most abundant biological resource beyond the current use as energy source.

For the bio-based sector to deliver its benefits across regions and actor groups, and to ensure a balanced distribution of its benefits, different technologies and business models need to be developed, offering a portfolio of options. These range from the large and/or sophisticated biorefineries to smaller and simpler facilities with large replication potential. In addition, solid methods for life-cycle assessments need to be in place to ensure high environmental standards (including resource efficiency) of processes and products in bio-based industries.

2.2.5. Food systems

Europe's food and farming system on land and sea,[121] from primary production to consumption and disposal, has evolved over centuries and incorporates highly interlinked national and even local food and farming systems, embedded into a global system. Yet the European dimension is important, because many relevant policies, regulations and public support mechanisms are to a significant extent determined at EU level. Both the European fisheries and agri-food systems are characterised by a high diversity in terms of production, scale, intensity, labour input and supply chains. The European agri-food system, in particular, is based on a large number of small-scale

119 A biorefinery is intended as " an overall concept of a processing plant where biomass feedstocks are converted and extracted into a spectrum of valuable products" Source: US DOE, 1997, Energy, Environmental and Economics (e3) Handbook, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Washington D.C.

120 A number of projects are supporting the development of integrated biorefineries, in particular through the Bio-based Industries Joint Undertaking, BBI-JU (FIRST2RUN, BIOSKOH). https://www.bbi-europe.eu/

121 https://www.eea.europa.eu/publications/food-in-a-green-light

family-based producers, retailers, and food service outlets operating alongside large-scale globalised companies.[122]

Agriculture provides the basis for food and other bio-based production under a wide range of conditions. In doing so, farmers also drive development in rural areas, impact on ecological services and deliver wider public goods. These multiple functions are performed in the context of major demographic, economic and environmental challenges, which are changing the landscape of food and other bio-based systems in which land-based primary production is taking place.

The food and drink industry is one of the largest manufacturing sectors in the EU in terms of employment, turnover and value added.[123] Wholesalers, transport companies and retailers play a vital role in the EU's food system, in terms of logistics, handling and distribution. Together with food and beverage consumer service enterprises (restaurants, bars, etc.), they provide about twice the employment of the food and drink industry.

The largest proportion of food consumed in the EU is still produced within the EU and the majority of EU trade in food and drink products takes place between EU countries. The EU is a net exporter of food and drinks with a positive trade balance of EUR 30.1 billion.[124] Europe is a net importer of commodities such as tropical fruits, coffee, tea, cocoa, soy products and palm oil, used as food and feed. The EU is also the largest importer of seafood and fish products in the world. Its capacity to meet the demand for fish and aquaculture products from its own waters has been around 45% since 2008.[125]

The EU agri-food system generates 60% of all biomass demand in EU.[126] However, it is estimated that around 88 megatonnes of food are wasted annually in the EU – around 20% of all food produced, with associated costs estimated at 143 billion euros.[127] The energy necessary to cultivate, process, pack and bring food to European citizens' tables, accounts for 17 % of the EU's gross energy consumption, equivalent to about 26 % of the EU's final energy consumption in 2013.[128] Even though the agricultural sector has increased its productivity by nearly 9% since 2005 while cutting greenhouse gas emissions by 21% since 1990 and reducing fertiliser use, it remains the largest source of the greenhouse gases methane and nitrous oxide.[129] This suggests scope for further use of renewables and reduced greenhouse gas and pollution emissions, and for considering

122 http://www.fao.org/3/a-i5857e.pdf

123 http://www.fooddrinkeurope.eu/publication/data-trends-of-the-european-food-and-drink-industry-2017/

124 http://www.fooddrinkeurope.eu/publication/data-trends-of-the-european-food-and-drink-industry-2017/

125 https://www.eumofa.eu/documents/20178/66003/EN_The+EU+fish+market_Ed+2015.pdf/4cbd01f2-cd49-4bd1-adae-8dbb773d8519

126 https://ec.europa.eu/energy/sites/ener/files/documents/Final%20Report_GLOBIOM_publication.pdf

127 http://europa.eu/rapid/press-release_MEMO-16-3989_en.htm

128 http://publications.jrc.ec.europa.eu/repository/bitstream/JRC96121/ldna27247enn.pdf

129 https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_greenhouse_gas_emissionsemissions

agriculture, forestry, environmental protection of natural resources and climate change in an integrated manner.

Also, marine and freshwater realms will be crucial to meet the demand for food caused by a rapidly growing world population. The potential for sea and ocean farming to meet this demand has been discussed in 2.2.3.

In the EU today, the proportion of the population that is overweight and obese is increasing in all European countries and among all age groups, including pre-school and primary school-aged children. As a consequence related public health costs are likely to rise. Dietary recommendations have been developed to support healthy eating habits in most European countries.[130]

Research and Innovation investments by public and private actors are supporting the shift from a conventional consumption and mass production model to food system supporting sustainable food and nutrition security for all. For the agri-food system, this includes giving increased emphasis on principles of agroecology and the support to farming systems that make efficient use of ecosystems services (e.g. organic farming, mixed farming, agroforestry).[131] It also calls for a more personalised and customised food consumption model, while simultaneously improving sustainability, safety, resilience and resource efficiency of food production on land and sea. These investments drive solutions in the area of personalised nutrition, smart packaging, precision agriculture or smart local food systems to name just a few. At the same time, actors within the food system increasingly acknowledge that they need to engage more with citizens to design new solutions and to rebuild trust in the food systems.[132]

The EU agri-food sector is the main job and income source in many rural and remote areas, and relies on an agricultural sector capable of ensuring a steady supply of raw materials. European farming systems are characterised by fragmented structures and producer income levels, which remain significantly below income levels in the rest of the economy, and are facing significant structural adjustment. Hence, economic viability of farming and attractiveness to the younger generation are a prerequisite for food security. New food and bio-based value chains offer additional opportunities for agricultural and forestry production and activities in the rural economy. Avoiding additional pressure on resources will be necessary to seize these opportunities sustainably.

The territorial dimension of agri-food systems is also important. Rural areas, which still account as a whole for 55% of EU jobs and 46% of gross value added,[133] are going through a period of profound economic, demographic and institutional transformation. Globalisation, decentralisation, urbanisation, migration trends and the emergence of new product and service markets present new challenges and opportunities. Despite sustained growth in rural areas, there is still a gap with urban and intermediate areas. Recent research has however highlighted positive trends in rural growth and significant variations between rural areas. Encouraging cohesion and convergence among different regions is one of the EU's core objectives. Sustainable growth and a balanced territorial

130 http://www.fao.org/nutrition/education/food-dietary-guidelines/regions/europe/en/

131 https://www.nature.com/articles/s41467-017-01410-w

132 http://etp.fooddrinkeurope.eu/news-and-publications/publications/19-strategic-research-and-innovation-agenda-2016-food-for-tomorrow-s-consumer.html

133 Eurostat data

development are needed to achieve the objective of "jobs, growth and investments" of the European Commission. Working conditions on farms and forest holdings are evolving constantly and social conditions in the farming sector deserve appropriate attention.

2.2.6. Bioenergy

The European Commission's "Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy"[134] aims to bring about the transition to a low-carbon, secure and competitive economy. The key objective of the Energy Union Strategy is to promote a transition to a low-carbon economy, based on lower greenhouse gas emissions, increased energy efficiency and renewable energies, including bioenergy.

Bioenergy[135] is by far the largest of the EU's renewable energy sources (followed by hydropower, wind, solar and geothermal), supplying 12% of the EU final energy demand, and having a significant role for the achievement of the 2020 and 2030 energy and climate targets.[136] Bioenergy can have multiple benefits in terms of energy security, growth and jobs creation, particularly in rural development.[137] For instance, it provides the highest number of direct and indirect jobs in the EU of all renewable energies (489,000 in 2015). Bioenergy production is expected to play a major role in defossilisationdefossilisation in all scenarios of the Energy Roadmap 2050, with a potential contribution between 10.1 EJ and 12.6 EJ.[138]

Bioenergy can make a significant contribution to greenhouse gas emission reductions when produced sustainably and used efficiently (see 2.3 for a discussion on energy recovery from waste and residues) .[139] However, bioenergy production and use can also be associated to unintended environmental impacts, which need to be effectively mitigated by regulation and good practices at global and corporate level. These impacts were thoroughly analysed in the Impact Assessment on the Bioenergy sustainability,[140] accompanying the revised Renewable Energy Directive[141] for the period after 2020.[142]

Against this background, the EU bioenergy sustainability framework has been significantly reinforced under the updated Renewable Energy Directive, which final text was agreed at a political level between the Council and the European Parliament on 14 June 2018. For the period after 2020, the EU sustainability criteria will apply not only to biofuels and bioliquids but also to solid biomass and biogas for heat and power. The sustainability criteria applying to agriculture biomass have been further strengthened to protect highly biodiverse forest and soil quality and soil carbon. Specific

134 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0080

135 https://www.iea.org/topics/renewables/bioenergy/

136 SWD(2016) 418, Part 4/4, Impact Assessment on the Sustainability of Bioenergy. In 2016, about 67% of total primary energy production of renewable energy in the EU-28 was generated by biomass (solid, liquid and gaseous fuels), with a share of 7.1% specifically in the transport sector.[Eurostat, last update January 2018]

137 https://www.sciencedirect.com/science/article/pii/S2211464516302755

138 COM(2011)885, http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52011DC0885

139 EC (2014), SWD(2014)259 final, State of play on the sustainability of solid and gaseous biomass used for electricity, heating and cooling in the EU. Commission Staff Working Document;

140 https://ec.europa.eu/energy/sites/ener/files/documents/biosustain_report_final.pdf

141 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02009L0028-20151005&from=EN

142 https://ec.europa.eu/energy/sites/ener/files/documents/1_en_impact_assessment_part4_v4_418.pdf

new sustainability criteria have been set for forest-based biomass, with the view to prevent unsustainable harvesting and to protect forest carbon stocks. In addition, post-2020 large bioelectricity installations will need to apply stringent electrical efficiency standards. Furthermore, national renewable energy policies will need to take due regard of the waste hierarchy principles. Finally, Member States will not be able to support anymore incineration of organic waste for bioenergy generation in case they are not meeting the waste separation requirements set out in the Waste Framework Directive 2008/98/EC.

2.3. The Bioeconomy and Circular Economy: Adding value to bio-waste, by-products and resource flows

Circularity is a quintessential element of the European Commission's vision for an EU Bioeconomy. The Circular Economy is an economic system in which "*...the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised*".[143] The scopes of the Circular Economy and the Bioeconomy intersect in their common aim to add value to biological waste and residues. The Circular Economy aims to retain the value of different kinds of resources (not only biological) in the economic cycle as long as possible, including, but not limited to, renewable biological resources, focussing on the way products and materials are designed, produced, used and disposed of. The bioeconomy encompasses additional activities other than those adding value to biological waste and residue streams, such as the transformation of non-residual biological resources into higher value products and the efficient production of renewable biological resources.[144] The contribution of the bioeconomy to the circular economy has been assessed and recognised as very significant.[145]

Biodegradable waste (or biowaste) can be an important source of biomass, whose potential economic value is starting to be recognised by several sectors (e.g. the agricultural, forest-based, chemical and energy sectors). With the development of the bioeconomy, the demand for these secondary products is likely to increase, changing the economic conditions of production.

The lack of standardised definitions makes it difficult to truly assess the volumes of different waste[146] and residue streams that are not currently used but could be reasonably mobilised. Globally, more than 3300 megatonnes of residual biomass are estimated to be generated annually out of the six most important crops: barley, maize, rice, soybean, sugar cane and wheat.[147] In Europe alone, 900 megatonnes of waste paper, food, and plant material are generated every year.[148] In the fisheries sector, as much as 40 megatonnes of fish may be discarded each year during commercial fishing.[149] Other estimates of the waste produced in fisheries and aquaculture include

143 EC 2015 Closing the loop - An EU Action Plan for the Circular Economy

144 Carus M. et al., Nova Paper #9 on bio-based economy, 2018-01, (2018)

145 https://ec.europa.eu/research/bioeconomy/pdf/review_of_2012_eu_bes.pdf; https://www.eea.europa.eu/publications/circular-economy-and-bioeconomy

146 OECD (2018), Meeting Policy Challenges for a Sustainable Bioeconomy, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264292345-en

147 Bentsen, N.S. et al. (2014), "Agricultural residue production and potentials for energy and materials services", Progress in Energy and Combustion Science Vol. 40, Elsevier, Amsterdam, pp. 59-73.

148 IEEP et al. (2014), Wasted: Europe's Untapped Resource: An Assessment of Advanced Biofuels from Wastes & Residues, Institute for Environmental Policy et al., Brussels, http://europeanclimate.org/wp-content/uploads/2014/02/WASTED-final.pdf.

149 http://www.seafish.org/media/Publications/SR537.pdf

volumes as high as 130 megatonnes and up to USD 50 billion yearly losses as a result of poor management of seafood resources.[150,151] In forestry, woody biomass residues, such as branches and tree tops, have been estimated to account for 5100 megatonnes per year globally, of which logging residues, branches and tree tops in EU-28 account for 87 megatonnes.[152]

Every year, almost 300 megatonnes of biodegradable household and household-like wastes, industrial wastes and other wastes are generated in the EU and remain largely unexploited. Among this waste, 140 megatonnes (90 megatonnes in dry matter) are municipal waste.[153] About 82% of municipal solid waste is generated by households, the rest coming from commerce and trade, small businesses, yard and garden waste etc. (Eurostat, 2003).

The legal obligations included in the Circular Economy package[154] aim at increasing the availability of secondary materials (feed materials, biowaste) for further exploitation through conventional technologies (e.g. composting and anaerobic digestion), and very importantly, for innovative ways of extracting valuable substances or molecules before ultimately discarding the left-overs, if possible by using its inherent energy. With this view, innovation is expected to support the development of markets for bio-based products by creating industrial symbiosis for feed materials (one industry's waste becomes the starting material for another). An example is the use of plant residues such as wheat straw or maize stover for bio-based materials,[155] or the treatment of waste and residues for energy production, including the production of biogas through anaerobic digestion of biowaste and waste waters, as well as the integrated production of chemical products and bioenergy in biorefineries. The food processing industries are exploring the potential of recovering the energy contained in food residues on site, through biogas production or in dedicated combined heat and power plants.[156]

For biodegradable waste, the implementation of the requirements laid down in the Landfill Directive,[157] in combination with the proposed new rules to ensure separate collection of bio-waste, should result in greater use of this resource for the production of waste-derived products and energy. Proposed changes to the EU Fertiliser Regulation should support this trend by opening up the single market for waste-derived fertilisers.

According to FAO, one-third of food produced for human consumption is wasted or lost, which amounts to about 1300 megatonnes per year, and adds 3300 megatonnes of CO^2 equivalent GHGs

150 Ghosh P. et al., International Journal of Food Science, 1, 1-22, (2016), doi: 10.1155/2016/3563478

151 For instance, traditional processing of finfish such as Atlantic cod produces only the fillets for human consumption, but efforts are being increasingly made to retrieve as much value as possible by processing the remaining material (Rest Raw Materials, RRM) for human consumption. Given that in some fish, up to 70% is RRM (e.g. tuna), additional value could be extracted from the material other than turning it into fishmeal and fertiliser (European market Observatory for Fisheries and Aquaculture Products, Study on the Blue Bioeconomy, 2018).

152 Camia et al. 2018. Joint Research Centre Science for Policy Report, doi:10.2760/181536

153 Joint Research Centre Data 2018

154 Such as e.g. a mandatory obligation to separately collect the biowaste by the end of 2023; higher recycling targets for wood and paper packaging waste of 30% and 85%, respectively; and a landfill of municipal waste reduction rate of 10% by 2035

155 Thorenz A. et al., Journal of Cleaner Production, 176, 348-359, (2018), doi: 10.1016/j.jclepro.2017.12.143

156 http://publications.jrc.ec.europa.eu/repository/bitstream/JRC96121/ldna27247enn.pdf

157 Council Directive 1999/31/EC, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31999L0031

emitted to the planet atmosphere (third top emitter after the United States and China).[158] Food waste is generated along the entire food system, although there is considerable uncertainty about estimates related to different stages, including production and processing.[159] Nevertheless, the further use of food by-products and conversion of food waste is still limited. This is due to current limitation in its quantification along food supply chain, limited data on its quality and level of homogeneity, and to differences in national implementations of the waste legislation.

Human waste, such as waste recoverable through wastewater treatment, is also a potentially very valuable and large-scale source of energy, fertilisers and chemicals.

The EU Circular Economy Action Plan and the EU waste hierarchy consider important to keep the value of products, materials and resources in the economy for as long as possible, and the generation of waste minimised. The waste hierarchy is the cornerstone of EU policy and legislation on waste[160] and a key to the transition to the circular economy. Its primary purpose is to establish an order of priority that minimises adverse environmental effects and optimises resource efficiency in waste prevention and management. These processes have different environmental impacts and rank differently in the waste hierarchy. Where waste-to-energy processes are opted for, such as the common use of wood waste as a feedstock for incineration, there is a need to ensure that the most efficient techniques are used: this maximises their contribution to the EU's climate and energy objectives.[161] In fact, waste-to-energy processes encompass very different waste treatment operations, ranging from 'disposal' and 'recovery' to 'recycling'. For example, processes such as anaerobic digestion which result in the production of a biogas and of a digestate are regarded by EU waste legislation as a recycling operation. On the other hand, waste incineration with limited energy recovery is regarded as disposal. It is important to stress that the waste hierarchy also broadly reflects the preferred environmental option: disposal, in landfills or through incineration with little or no energy recovery, is usually the least favourable option for reducing greenhouse gas emissions; conversely, waste prevention, reuse and recycling have the highest potential to reduce greenhouse gas emissions.

The 2012 European Bioeconomy Strategy and its accompanying Staff Working Document[162] already emphasised the importance of the principle of cascading use of biomass. If it is applied as indicated in the Directive 2015/1513, all while taking into consideration the regional and local economic and technological circumstances, the maintenance of the necessary carbon stock in the soil and the quality of the soil and the ecosystems, the cascading principle may contribute to foster resource efficiency.[163] The Circular Economy encourages a cascading use of renewable resources, with several reuse and recycling cycles, where appropriate. Generally, appropriate management of

158 http://www.fao.org/docrep/014/mb060e/mb060e00.pdf

159 See Fusions-project (www.eu-fusions.org/) – project funded under European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 311972

160 Directive 2008/98/EC, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098

161 COM(2017)034 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52017DC0034

162 COM(2012)60, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52012DC0060; SWD(2012)0011 final, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD:2012:0011:FIN

163 DIRECTIVE (EU) 2015/1513 on certain fuels and the use of energy from renewable sources

biomass should ensure its exploitation towards measures to stimulate industrial symbiosis. While the conversion pathways towards added value products may exist, especially using homogenous by-products and waste coming from agriculture, forestry-based, marine and agri-food industry sectors, ensuring their profitability requires both a techno-economic analysis and that trade-offs are minimised, such as minimising environmental impacts and externalities due to logistics.[164]

3 ACTION PLAN: LEADING THE WAY TOWARDS A SUSTAINABLE, CIRCULAR BIOECONOMY

In February-March 2018, the European Commission published a Roadmap for the Communication updating the 2012 European Bioeconomy Strategy.[165] An important objective of the public consultation of the Roadmap was to get feedback on the scope of the update and the proposed indicative lines of actions. The number of public responses received was 92, both from the public and private sectors, as associations as well as individuals. Overall, the responses indicated that the stakeholders and civil society at large would welcome the update of the European Bioeconomy Strategy.

Many respondents stated that the European Bioeconomy Strategy and the Action Plan should further support strategic Research and Innovation. This latter is crucial for providing solutions to the challenges of our time. It delivers on citizens' priorities, as embodied in the Sustainable Development Goals and in the Paris Agreement on fighting climate change,[166] on growth and jobs, and to solve the global challenges we face today and will face tomorrow. Moreover, Research and Innovation determines the productivity and competitiveness of our economy: about two-thirds of Europe's economic growth over the last decades was driven by innovation.[167] The 2017 Review concludes that "*a direct result of the 2012 Action Plan is the over two-fold increase in dedicated EU funding for the bioeconomy under the Horizon 2020 programme […] compared to Framework Programme 7 […]. This financial envelope could exceed EUR 7 billion when also considering other actions under Horizon 2020 which are not labelled "bioeconomy" per se and which support - in an indirect manner – the development of the bioeconomy.*" Even though given the long-term nature of Research and Innovation only preliminary assessments of the funding's impact can currently be made, the 2017 Review states that "*there is already early indication that projects funded under the EU Framework Programmes are generating relevant excellent and multi-disciplinary research […]. Evidence from projects also shows that these are developing useful innovations aiming at for example reducing the environmental impact of food processing, generating food crops which are resource-efficient and high in protein, generating land-based and aquatic biomass for bio-based use, improving underwater observation to monitor the marine environment, fish stocks and pollution.*"

164 Cristóbal J. et al., Bioresource Technology, 259, 244–252, (2018), doi: 10.1016/j.biortech.2018.03.016

165 https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2018-975361_en

166 According to the 2017 Special Eurobarometer on Climate change, 92% of EU citizens see climate change as a serious problem, and 79% of Europeans believe fighting climate change can boost the economy and create jobs (https://ec.europa.eu/clima/sites/clima/files/support/docs/report_2017_en.pdf).

167 https://publications.europa.eu/en/publication-detail/-/publication/0635b07f-07bb-11e7-8a35-01aa75ed71a1/language-en

Europe's doubling of Research and Innovation investment in the bioeconomy (from EUR 1.9 billion in the 7th Framework Programme,[168] 2007-2013, to EUR 3.85 billion in Horizon 2020,[169] 2014-2020) has opened new pathways and solutions for sustainability. However, further mobilisation of EU and Member State Research and Innovation investments are needed to deal with the coming challenges of a sustainable bioeconomy, and they could benefit from increased synergies, partnership and leverage. Horizon 2020 is now entering its crucial last years, when the results it produced will be harnessed and their impact on European societies and economies maximised. Furthermore, the EU Budget for the Future 2021-27 foresees that EUR 10 billion is invested for research and innovation in food, agriculture, rural development and the bioeconomy,[170] as compared to the current EUR 3.85 billion in Horizon 2020 Societal Challenge 2 (Food, sustainable agriculture and forestry, marine, maritime and inland waters research, and the bioeconomy). This unprecedented level of commitment needs an equivalent level of responsibility in ensuring that these investments deliver a sustainable bioeconomy across the EU. These EU investments will be closely co-ordinated with and ideally complemented by the European Regional Development Fund and similar efforts at national and regional level, as well as with the public and private sectors. Importantly, the Action Plan will promote the involvement of stakeholders across the entire value chain in Research and Innovation to ensure that research and innovation are co-designed with the future users of its results.

Many stakeholders stated that the European Bioeconomy Strategy and the Action Plan should further support training for a skilled workforce for all areas of the bioeconomy. Mobilising investments was considered to be a crucial step. Many respondents called for better data and more knowledge of the environmental, social and economic impacts of the bioeconomy, as a basis for dealing with possible trade-offs. In view of the development of regional bioeconomy strategies, the potential of interregional cooperation was highlighted. Largely emphasised was the need for coherence of the European Bioeconomy Strategy with other EU policies, especially in the field of Circular Economy, agriculture, forestry, energy and climate.

There was consensus that raising public awareness and broadly engaging stakeholders is of utmost importance for the future development of the bioeconomy. Also, there was a clear indication of a need for a space where regular and strategic international cooperation at multi-partner level can take place with a focus on building policy coherence and on exploiting synergies between countries and regions taking into account existing mechanisms. In this respect, the European Commission has set up the International Bioeconomy Forum in 2017. The International Bioeconomy Forum is expected to develop a global policy dialogue on selected aspects of the bioeconomy through international co-operation for coherent, joint and impactful delivery of the world bioeconomies on Sustainable Development Goals, align research funding programmes and increase Research and Innovation cooperation and international awareness of the central role of bioeconomy.

168 DECISION No 1982/2006/EC, concerning the Seventh Framework Programme of the European Community for research, technological development and demonstration activities (2007-2013), 18 December 2006

169 REGULATION (EU) No 1291/2013, establishing Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020) and repealing Decision No 1982/2006/EC, 11 December 2013; https://ec.europa.eu/research/horizon2020/pdf/press/fact_sheet_on_horizon2020_budget.pdf

170 COM(2018)321 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2018%3A321%3AFIN

The 2017 Review also emphasised the complementarity between the circular economy and the bioeconomy. However it also pointed out that the links, synergies and coherence between the two were not fully developed (see 2.1). The purpose of this update to the 2012 Bioeconomy Strategy is to address these challenges through a set of 14 concrete actions which will be launched in 2019 at the latest.[171] These actions reflect the conclusions of the 2017 Review.

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

The 2017 Review concluded that "*...Further mobilisation of investments is still needed, which requires a stable regulatory environment" and that "...Funding of high risk investments is not well supported by current EU instruments*".

Matching the financing needs of the EU sustainable bioeconomy relies heavily on private investment which should be extensively further mobilised.[172] As an illustration, according to some estimates approximately 300 biorefineries will need to be deployed in Europe by 2030 in order to meet the growing EU market demand in this sector.[173]

There are on-going efforts to map the number and location of existing biorefineries in the EU. An initial study identified 224 biorefineries operating in the EU at the end of 2017 and reports several dozens more biorefineries currently under construction.[174] The raw material and main end product differs according to location and market focus. On the other hand, work by the Joint Research Centre (Figure 8) mapped more than 800 facilities producing bio-based products of which more than 500 are dedicated to the production of bio-based chemicals. Discrepancies are due to different definitions of biorefineries being used in the respective studies.

171 These actions will not entail any budgetary or legislative commitments for the next Commission while the concrete implementation of these actions may run until 2025.

172 http://www.eib.org/attachments/pj/access_to_finance_study_on_bioeconomy_en.pdf

173 According to BIO-TIC project, by 2030 in the EU there would be a need for 310 biorefineries: 185 2nd generation ethanol, 50 bio-based jet fuel, 30 bio-based chemical building block and 45 bio-based plastics (The bioeconomy enabled - A roadmap to a thriving industrial biotechnology sector in Europe (2015) http://www.industrialbiotech-europe.eu/wp-content/uploads/2015/08/BIO-TIC-roadmap.pdf). A recent report of the OECD indicates that in order to make the industrial bioeconomy a success, the number of biorefineries, both in the United States and Europe, would have to be increased to between 300 and 400 (OECD (2018), Meeting Policy Challenges for a Sustainable Bioeconomy, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264292345-en).

174 http://news.bio-based.eu/media/2017/11/17-11-27-PR-Mapping-European-Biorefineries1.pdf

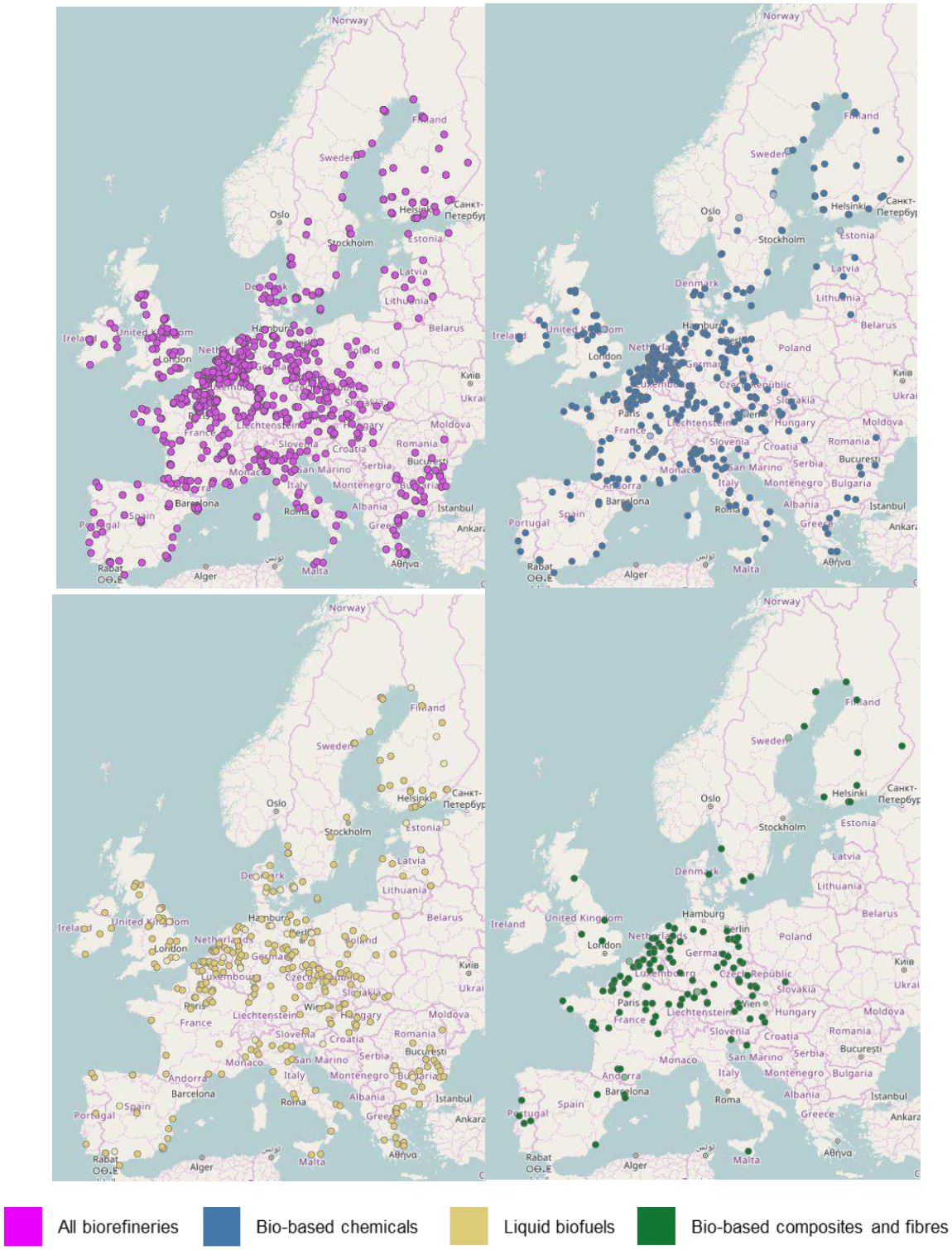

Figure 8. Biorefineries distribution in the EU as of March 2018. Purple dots indicate all biorefineries (803 in total) Blue dots indicate the 507 biorefineries producing bio-based chemicals, yellow dots indicate the 363 biorefineries producing liquid biofuels and the green dots indicate the 141 biorefineries producing bio-based composites and fibres. It has to be noted that some biorefineries produce more than one product category and are thus shown in more than one map. Dots in lighter colour in the three last figures indicate facilities that are currently inactive (but not necessarily as permanent status). Most biorefineries correspond with location of chemical industry clusters and location of ports. Highest density of facilities is in Belgium, Netherlands and some highly industrialised regions of Germany, France and Italy. Source: Parisi, C. 2018. Research Brief on biorefineries distribution in the EU. Joint Research Centre.

However, private investors are often reluctant to invest in Research and Innovation bioeconomy projects because of uncertainties and risks in terms of regulation and policy, technology, market demand as well as feedstock supply issues amongst others. For instance, a major bottleneck is the large capital expenditure required for certain bioeconomy projects, such as new biorefineries. To address these issues, a financial instrument dedicated to the bioeconomy - the Circular Bioeconomy Thematic Investment Platform - will be established by the European Commission, and implemented in the context of enhancing synergies and complementarities between the various EU funding schemes available for supporting innovation in the bioeconomy, such as the Common Agricultural Policy (post-reform), the InvestEU Programme, the future European Innovation Council and the ETS Innovation Fund.[175]

Large, sophisticated biorefineries are only viable under certain circumstances and in certain locations and the number of actors capable of promoting and running them is limited. To achieve a wide deployment of sustainable bio-based value chains, it is necessary to develop in parallel business models that can be replicated and adapted to a variety of locations and contexts, with lower levels of investment, risk and technical sophistication, which can be plugged into established food and bio-based value chains or to stimulate new alternatives, taking advantage of the benefits of the particular location (resource availability, socio-economic factors, etc.). A wider range of actors need to get involved, including farmers and forest owners (alone or in association), small businesses, etc. By operating at local / regional level, these models will also facilitate circular approaches between exploitations and across sectors. To achieve these objectives, small-to-medium scale solutions seem to be most appropriate. Innovative organisational models should also be developed, to promote cooperation within and outside the primary sector.

The EU bio-based sector needs to be reinforced to capitalise on its potential to contribute to greenhouse gas savings, the Circular Economy, reindustrialisation and decentralised manufacturing.[176] The latter is particularly important for the European wood working, pulp, paper and board and bio-based chemical industry to stay competitive on an international level[177] by modernising their business models and partners, their technological basis, reducing greenhouse gas emissions and generating more sustainable products through the exploration of alternative sustainable feedstock, industrial symbiosis and clean technologies.[178] In this context, EU regions constitute key actors that help combining industrial modernisation and sustainability in a decentralised manner, and providing rural jobs. They play a pivotal role in keeping the woodworking, pulp, paper and board and chemicals industry in Europe and boosting their growth, as they can support the establishment of (regional and local) innovative value chains and are best situated to deploy locally available feedstocks (from agriculture, agri-food, the forest-based sector, residual and side streams, etc.) that can trigger the bio-based economy. Further, regions are very well placed to attract investments through local demonstration or flagship projects by benefitting

175 The ETS Innovation Fund will cover the low-carbon innovation in sectors regulated by the ETS Directive (EY) 2018/410 (Annex1), by focusing on the energy intensive industry, Carbon capture and storage, energy storage and innovative renewables.

176 OECD (2018), Meeting Policy Challenges for a Sustainable Bioeconomy, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264292345-en

177 http://fr.zone-secure.net/13451/451623/#page=1

178 http://www.cefic.org/Documents/RESOURCES/Reports-and-Brochure/Competitiveness-of-the-European-chemical-industry-2014.pdf

from the cohesion policy funds, thus creating jobs, economic growth and new opportunities for the primary sector.

For realising the existing opportunities and scale up, the bio-based sector should have equal footing on market and regulatory conditions vis-à-vis the fossil-based industries. Some important messages from OECD on the bioeconomy policy challenges are as follows:[179]

1) Bioeconomy policies have to be stable and long-term so that the private sector has the confidence to invest.

2) Removing fossil fuel subsidies and pricing in the environmental damage caused by those industries, would put a completely different complexion on their economics, and would create a level playing field for bio-based industries. The Communication "Accelerating Clean Energy Innovation (Nov 2016)" indicates that in 2012 annual direct fossil-fuel subsidies stood at around EUR 41.9 billion, rising to EUR 300 billion when including environmental externalities.

3) Support measures for renewable energy are reported as a problem for some industries seeking to process some forms of biomass for material and chemical use. Value added, employment, innovation and, in many cases, the environmental footprint do speak in favour of supporting industrial use of biomass-based materials, products, and chemicals in the majority of economic sectors.

Standards, certification schemes, labels and public procurement can serve as further powerful instruments to support emerging markets for innovative products.[180] According to market studies, products that included declarations on the sustainability of the product grew by 7%, as opposed to non-declaration products which only grew by 1%.[181] Despite the launch of a number of initiatives in standardisation, certification, labelling and public procurement,[182] progress on the issue of the voluntary uptake and on the regulatory framework for the development of new markets for the bioeconomy has remained limited in the European Union.[183] A wider application of available standards for bio-based products, e.g., Life Cycle Analysis including carbon accounting tools, [184] sustainability criteria,[185] business-to-business and business-to-consumer communication[186] will facilitate certification and labelling. This can improve the visibility of bio-based products and help

179 OECD (2018), Meeting Policy Challenges for a Sustainable Bioeconomy, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264292345-en

180 http://www.biobasedeconomy.eu/projects/open-bio/; http://innprobio.innovation-procurement.org/home/

181 The sustainability imperative – new insights on consumer expectations, Nielsen, 2015

182 e.g. CEN mandates, pre-normative research, EMAS, EU Ecolabel on biolubricants, organic labelling, InnProBio-project generating a toolbox and catalogue as well as the COSME-Project on Guidance for bio-based products in procurement including main guidance document, training material and factsheets on the innovation potential of various bio-based product groups; http://ec.europa.eu/growth/content/guidance-bio-based-products-procurement_en; https://biobasedprocurement.eu/

183 It is noteworthy that relevant measures are currently proposed in the Circular Economy Action Plan, for example amendments to EU waste legislation that aims to increase the availability of quality bio-waste, measures that facilitate industrial symbiosis, in particular to exploit plant based feed materials, and the proposal for the revised Fertilising Product Regulation that provide specific measures for nutrient recovery from waste.

184 EN1676:November 2015 on Bio-Based Products Life-Cycle Assessment and CEN/TR16957:September 2016 on Bio-Based Products – Guidelines for Life-Cycle Inventory (LCI) for the End-of-Life Phase

185 EN16751:April 2016 on Bio-Based Products Sustainability Criteria

186 EN16848 on Bio-Based Products – Requirements for Business-to-Business communication of characteristics using data sheets; EN16935:May 2017 on Bio-Based Products – Requirements for Business-to-Consumer Communication and claims

with public perception and acceptance. Additionally and building upon the availability of guidance and training materials for bio-based products in procurement for different product groups,[187] specific requirements promoting bio-based materials and products could be included during the development of EU Ecolabel and Green Public Procurement (GPP) criteria for new or other existing product groups not yet addressed and further innovative procurement activities.

The bioeconomy can contribute solving the problem of plastic litter in seas and oceans via the support to research and innovation for the development of alternatives to fossil-based plastics and bioremediation methods. Plastic substitutes could include bio based, recyclable and/or biodegradable alternatives. In addition, the development and promotion of standards (including through research and innovation actions addressing marine biodegradability of bio-based products) and related labelling is crucial.

This set of actions aims to strengthen and scale-up the bio-based sector to deliver more environmental benefits, value-added and job creation, by mobilising stakeholders and investments, and by supporting the creation of markets for novel and sustainable bio-based products and processes, including through existing and emerging regulatory frameworks. It responds to the Strategy's objectives of reducing the dependence on non-renewable resources, as well as creating jobs and maintaining European competitiveness.

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

This action will further engage with stakeholders (Member States, regional authorities, biomass primary producers, the private sector and wider public) to align strategies and visions to further strengthen and upscale the bio-based sectors (dealing with bio-based value chains in e.g. agriculture, forestry, marine, bio-waste, food), including innovative solutions that can be deployed in small scale, and which are suitable for direct adoption by primary producers, either individually or through cooperative business models, by exploring the various instruments available, including under the EU Research and Innovation Framework Programme, and also leveraging on private funds.

Indicators: Number and financing volume of bioeconomy projects benefitting from financial advisory support; Number of regions having adopted the Self-Assessment tool to support investment readiness of the EU regions; Inventory of most promising technologies and innovations; Roadmap of demonstration activities and outreach activities; Number of demonstration projects and publicity materials and activities; Number of projects matched with potential investors; Number of EC match-making events between projects & investors; Inclusion of the bioeconomy in the existing EC initiatives on Distributed Ledger Technologies (DLTs) / blockchain (H2020; EU Blockchain Observatory and Forum).

The bio-based sector has recently experienced accelerated technological development.

187 http://ec.europa.eu/growth/content/guidance-bio-based-products-procurement_en; https://biobasedprocurement.eu/

The Bio-Based Industries JU has been instrumental to kick-start the demonstration and deployment of a number of first of a kind biorefineries and new value chains in the EU.[188]

Nevertheless, there is still a need to 1) make investment opportunities in the bio-based economy more appealing, transparent, secure and visible vis-à-vis investors, in the view of mobilising investment in the bioeconomy, and 2) helping EU regions using available tools to evaluate their investment readiness level for the production of more sustainable chemicals, including the usage of alternative raw materials for their production.

To this end, this action aims at the development of a toolbox of solutions for biomass processing into bio-based products. It will deliver the following:

1) Further engagement with stakeholders, including Member States, the private sector and the wider public, to further align strategies and visions in scaling up the bio-based sector, exploring the various instruments under Horizon Europe and leveraging on existing EU-funded initiatives and private funds.

2) In respect to rural small-to-medium bio-based solutions, building on results from research and innovation, identification of technologies that are suitable to operate at small scale and easy to replicate and/or to adapt to local conditions, and promote demonstration activities. Successful demonstration projects will then be ready for deployment, which will be supported through action on the Strategic Deployment Agenda for food, farming, forestry and biobased production in a circular bioeconomy. They could also benefit from support from national or regional instruments, EU financial instruments (e.g. action 3.1.2), or feed into EIP-AGRI activities. (e.g. action 3.2.1)

3) Exploration of ways to increase the EU financial advisory support for Research and Innovation bioeconomy projects, as recommended by the European Investment Bank on 'Access-to-finance conditions for Investments in Bio-Based Industries and the Blue Economy'.[189] Such financial advisory support would improve access-to-finance of projects, for instance by helping them to improve their bankability and investment-readiness, structuring their financing and liaising with private investors.

4) Exploration of the main Distributed Ledger Technologies (DLTs/blockchain) opportunities, challenges, barriers, potential applications and use cases in the bioeconomy sector, as well as raising awareness, and stimulating ideas and studies related to the DLTs possible impact in the bioeconomy. DLTs are globally drawing significant attention, resources and investments, and the bioeconomy sector is in a unique position to look into and benefit from the potential of DLTs.[190]

Finally, it is expected that investment in the bioeconomy may benefit from the clarification for investors on which economic activities can reliably be considered sustainable for climate change

188 https://www.bbi-europe.eu/

189 http://www.eib.org/attachments/pj/access_to_finance_study_on_bioeconomy_en.pdf

190 https://www.wur.nl/upload_mm/d/c/0/b429c891-ab94-49c8-a309-beb9b6bba4df_2017-112%20Ge_def.pdf;
http://www.europarl.europa.eu/RegData/etudes/IDAN/2017/581948/EPRS_IDA(2017)581948_EN.pdf

and environmental protection more broadly.[191] It is expected that the outcome of the European Commission's Action Plan on 'Financing Sustainable Growth'[192] will lead amongst others to a harmonised EU classification system (taxonomy) of environmental activities, which will be integrated into EU legislation and therefore spur investment in the bioeconomy.

3.1.2. Launch of the EUR 100 million Circular Bioeconomy Thematic Investment Platform

This action will support a financial instrument dedicated to the Circular Bioeconomy under the InnovFin scheme (Horizon 2020).

Indicators: EUR leveraged from the private sector for projects financed by the Thematic Investment Platform; Number and financing volume of bioeconomy projects benefitting from Thematic Investment Platform Financing.

This action aims to tackle the funding gaps faced by innovative bioeconomy projects in the demonstration and commercial development phases through the launching of a new EU thematic financial instrument: the Circular Bioeconomy Thematic Investment Platform.

The launching of this new EU thematic financial instrument follows a recommendation made in the InnovFin Advisory study by the European Investment Bank on access-to-finance conditions for investments in two key areas of the EU Bioeconomy – the bio-based industries and the blue economy.[193] The study has identified gaps in private capital funding in these areas for projects seeking to scale up from pilot to demonstration phases, and from demonstration to flagship and industrial-scale phases. This stems from the inherent risks of investing in innovative projects in the bioeconomy and the often large capital expenditure needs of such projects. Insufficient access-to-finance makes it difficult for projects to reach the later development phases and might even push some to deploy outside the EU.

The Circular Bioeconomy Thematic Investment Platform will aim to tackle these access-to-finance issues by de-risking innovative projects vis-à-vis private investors, leveraging EU funds to help mobilise private investment in them. In addition to the bio-based industries and the blue economy, it will also cover closely related sectors, such as agriculture and forestry. The deployment of funded projects is expected to contribute to the Sustainable Development Goals, as well as to the EU priorities on climate, the Circular Economy and sustainable finance. It is also expected to help foster industrial, rural, coastal and offshore development, and to open new avenues for the primary sector, creating jobs and growth in the EU.[194]

This action aims to provide funding for innovative bioeconomy projects in the demonstration and commercial development phases. This financial instrument will be launched under the InnovFin scheme and will receive an already adopted EU budget of EUR 100 million from Horizon 2020.[195] It will focus primarily, but not exclusively, on innovative circular bioeconomy projects. This

191 Millar R. et al., Nature Climate Change, 8, 1, (2018), doi: 10.1038/s41558-017-0042-4

192 COM(2018) 97 final, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0097&from=EN

193 http://www.eib.org/attachments/pj/access_to_finance_study_on_bioeconomy_en.pdf

194 http://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-food_en.pdf

195 Total EU funding dedicated to the financial instrument, including to its administrative costs.

financial instrument is delivering on the Pillar III of the broader Circular Economy Finance Support Platform.[196]

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

Provide, guidance, identify bottlenecks, enablers, and gaps that influence synergies and deployment of bio-based innovations.

Indicators: Report on regulatory landscape delivered

The bio-based sector has important segments (e.g. bio-based alternatives to fossil-based chemicals, textiles, plastics, composites, etc.) which are only emerging and therefore still fragmented. According to some experts, regulation and incentives have not followed the pace of the technological progress. [197] Therefore, there is still a need to (1) Take stock, map and identify the Research and Innovation still needed to realise the full potential of the bio-based sector; (2) Identify bottlenecks, enablers, and gaps that hamper the market uptake and industrial exploitation of bio-based innovations, including in relevant EU policy areas such as Research and Innovation, circular economy, environmental and human health protection, construction, textiles, plastics, waste, fertilisers, CAP, Industrial Policy, etc.[198]

By 2021, this action will:

1) Map the full range of potential bio-based innovations in the agricultural, forest-based and marine sectors. It will also cover the full range of bio-based products, such as those coming from woodworking, pulp, paper and board industries and advanced biorefineries; side streams and waste-based ones and how these can support circularity, as well as classical ones such as construction, furniture, textiles, etc.

2) Identify the research needed to unlock the innovation potential in these areas, Building on existing reports and analyses, including process-related innovations and social innovations, as well as possible enablers and bottlenecks to the market uptake and industrial exploitation of bio-based innovations, including standardisation and labelling gaps and opportunities in the emerging bio-based sector. The objective is to provide guidance, knowledge and analysis on how to include and feed bioeconomy in the preparation and proper implementation of Union policy initiatives, and legislative and programme proposals..

The action will be implemented through a publicly procured service contract.

196 http://europa.eu/rapid/press-release_IP-17-104_en.htm

197 Commission Expert Group for Bio-based Products – Working Group Public Procurement of Bio-based Products – Recommendations 2016 and ANNEX 1 to the Recommendations 2016. The group calls for alignment of the European Bioeconomy Strategy with the EU policy framework.

198 Commission Expert Group for Bio-based Products – Working Group Public Procurement of Bio-based Products – Recommendations 2016 and ANNEX 1 to the Recommendations 2016.

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

This action will provide support through relevant funding programmes (e.g. LIFE, Horizon or other programmes) to develop country-based Life Cycle Inventories, prioritising products most relevant for the bioeconomy. This data could be considered by the Commission in the framework of product policies, such as the EU Ecolabel and Green Public Procurement, and shall be compliant with the latest version of the Environmental Footprint methods and supporting guidance as far as products, services and organisations are concerned. The Member States are called to contribute to the creation, update and maintenance of such datasets. Furthermore, This action will explore how to leverage environmental performance information to boost the market of bio-based products by potentially integrating the Environmental Footprint methods into a wide range of relevant tools.

Other tools, including carbon accounting, would also provide evidence on the contribution of bio-based products and services to lower GHG emissions in a wide range of sectors (agriculture, services, SMEs, domestic sector).

This action will therefore promote the use of existing standards and labels and emerging market-based incentives for bio-based products.

Indicators: High quality, Environmental Footprint compliant secondary life cycle inventory datasets developed for each EU Member State on bio-based materials ; € invested in the development of such secondary data and related projects; Development of Product Environmental Footprint Category Rules (PEFCRs) for product groups relevant to the bio-based economy. Uptake of existing standards to include elements on bio-based content

In order to boost market uptake and consumer confidence, it is necessary to use multiple instruments, such as environmental performance information based on reliable and comparable background data in policy instruments (e.g. the EU Ecolabel and green public procurement), as well as standards related to bio-based products, which will ensure accountability and foster consumer's trust.

Product policy environmental oriented instruments such as Green Public Procurement (GPP) and the EU Ecolabel should only promote the increased market uptake of bio-based products and processes if they are proven to be beneficial also from an environmental perspective. One of the key elements in determining their potential superiority is that their life cycle environmental performance is better than existing alternatives.

EU methods for measuring life cycle environmental performance in a comparable way exist: these are the Product and Organisation Environmental Footprint methods (PEF and OEF, respectively), adopted by the Commission in 2013.[199] The methods were developed based on existing standards with the aim of making results comparable, reproducible and reliable. They accommodate a broader suite of relevant environmental performance criteria, allowing to calculate in a harmonised way 16

199 SWD(2013)0112 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52013SC0112

different impacts (including climate change, direct land use, water use, acidification, eutrophication and resource use, of a product, a service or an organisation by looking at the entire value chain (from cradle to grave). The methods were field tested in collaboration with Member States, NGOs and 25 industry sectors, including 11 pilots related to feed and food products.[200] For these product groups, the European Commission made freely available more than two thousand Life Cycle Inventory data, which are adequate for comparing similar final products and are used in combination with primary data to do so.

However, a wide range of products is not covered by these 11 pilots, and the data needed that is appropriate for comparing alternatives is lacking or is not sufficiently detailed. These data need to be available possibly at country level and, for some impacts like water and land use, ideally even at regional/watershed level. These high-quality data are currently not sufficiently available in existing commercial databases. Furthermore, if a comparison between bio-based products and alternatives, mainly fossil-based products is to be made, it is essential that all the datasets used are Environmental Footprint (EF)-compliant and Carbon Footprint compliant, in order to guarantee full interoperability and comparability of results.

One recent analysis aiming at comparing the Environmental Footprint (EF) of bio-based products and fossil-based alternative indicates that nowadays the assessment cannot be made relying entirely on EF compliant data due to a partial lack of such data.[201] There is also a lack of data covering the Indirect Land Use Change (ILUC) effects of bio-based feedstock in a harmonised manner. The study also concluded that more transparent fossil-based products data would be helpful to conduct more reliable and transparent comparisons. The secondary data made available in the framework of the Environmental Footprint pilot phase covers this gap related to fossil-based products.

As an additional point, a proper comparative Environmental Footprint analysis between the different alternatives will also mean in some cases overcoming some of the current limitations shared by current life cycle assessment and other assessment methods[202] for example related to biotic resource use, impacts beyond climate change due to indirect land use change (ILUC), toxicity, biodegradability or littering. The Commission should take action to overcome these limitations.

These challenges and gaps could be addressed by concerted action between the EU and Member States.

By 2025, this action will:

1) Address methodological and data challenges, through EU funds such as LIFE, the Horizon programmes and other funding opportunities would contribute to their development. Covering these developments with EU funds would also help to make them available for free to any user in the world, further reducing the cost of access to users and strengthening the environmental assessment

200 For results of the Environmental Footprint pilot phase and resulting product category rules, see: http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm#final

201 https://www.ecologic.eu/sites/files/publication/2018/3513-top-emerging-bio-based-products.pdf

202 EU Ecolabel on Lubricants, http://ec.europa.eu/ecat/category/en/48/grease-and-stern-tube-gre

of bio-based products and their supply chain. Member States should contribute to the creation, update and maintenance of such datasets. The number of datasets to be developed will depend on the type of bio-based products and their supply chains that will be identified as priority. Considering that biomass is an important environmental hotspot, it could be one of the priorities for data development.

2) Propose, whenever relevant and possible, to consider the inclusion of specific requirements promoting bio-based materials and products during the development of EU Ecolabel and GPP criteria for new or existing product groups, according to Environmental Footprint[203] results, and in line with available EU standards and technical reports,[204] as well as with the strategic approach for EU Ecolabel and GPP. The action will contribute to the Circular Economy and potentially to the Plastics Strategy.

3) Promote and/or develop existing standards and labels and emerging market-based incentives for bio-based products.

These combined actions will allow for the full exploration of the potential of bio-based products, analyse their Environmental Footprint in comparison to alternative fossil-based products, and allow their promotion on markets, boosting consumer confidence and their uptake.

3.1.5. Facilitate the development of new sustainable biorefineries and confirm the type and estimated potential

This action will consider measures to incentivise private investment in biorefinery deployment and market developments of bio-based products (including bio-based chemicals) while ensuring the sustainability of biomass supply and public acceptance.

Indicators: Targeted policy measures and regulations relating to biorefining; Number and financing volume of biorefinery investments; Outlook for biorefinery deployment in the EU; Public reports on best practice; Number of New sustainable biorefineries; Number of workshops/ events delivered and number of participants.

Development of the circular local bioeconomy depends on the availability of sustainable feedstock, including residues and urban biowaste. Schieb et al. (2015) suggest the need to increase the number of biorefineries to 300-400, both in the United States and Europe, for the industrial bioeconomy to succeed.[205] That represents a very large investment, most of which will need to come from the private sector.[206] Other studies estimate that by 2030 more than 100 megatonnes of unutilised biomass could be exploited, assuming that all market demand is met by EU production of both feedstock and products. In this context, our market demand is estimated to equate to a number of

203 COM(2013)196 final, https://eur-lex.europa.eu/procedure/EN/202530; Recommendation 2013/179/EU, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013H0179

204 EN16751:April 2016 on Bio-Based Products – Sustainability Criteria; EN1676:November 2015 on Bio-Based Products Life-Cycle-Assessment; CEN/TR16957:September 2016 on Bio-Based Products – Guidelines for Life-Cycle Inventory (LCI) for the End-of-Life phase.

205 P.-A. Schieb et al. (2015), Biorefinery 2030, doi 10.1007/978-3-662-47374-0_5

206 OECD (2018), Meeting Policy Challenges for a Sustainable Bioeconomy, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264292345-en.

biorefineries of 185 for 2nd generation ethanol, 50 for bio-based jet fuel, 30 for bio-based chemical building block and 45 for bio-based plastics.[207]

The investment decisions for an advanced biorefinery project depend largely on the maturity of the technology, its inherent efficiency, the market conditions for its products and the feedstock cost and availability, in particular at the commercialisation stage. The public understanding and awareness of such investments is of key importance, and this depends on the reliability of sustainability data for an entire value chain including on bio-based products and their related standards (link with action 3.1.4). Concrete action to help public regional authorities to understand how to attract more chemical industry investments through a focus on use of biomass and waste to produce high value sustainable chemicals has already taken place (such as a self-assessment tool for sustainable chemical production)[208] but it needs to be replicated more widely. Concretely, it is critical to ensure that the newly established biorefineries are fully in line with the objectives of the environmental, economic and social sustainability, circular economy and zero-waste concepts and do not create undesired environmental pressure and societal rejection.

By 2024, this action will

1) Develop an outlook and roadmap for the deployment of biorefineries in Europe. The action includes all sources of biomass, and focuses also on promotion and development of active and sustainable management of natural resources, deployment of innovative technologies for conversion of biomass into long-life bio-based products and their use to increase the contribution of the bioeconomy to climate change mitigation and renewable transition. It includes biorefining in rural setting (linking with action 3.2.2.ii), to support the use of local renewable resources and rural revival (link with action 3.2.1) and to help establish attractive job opportunities for both the primary producers and young skilled entrepreneurs in the rural territory. Furthermore, it supports lowering transportation costs of biomass and can be expected to result in a lower environmental footprint (e.g. low water use).[209]

2) Assess ways of increasing EU policy support to biorefining via environmental, social, economic and technical aspects of the bioeconomy projects, to facilitate the deployment of new sustainable biorefineries. It will be implemented by the European Commission taking into account input from biomass value chain stakeholders including civil society and will result in periodic public reports describing the best practice.

207 BIO-TIC, A roadmap to a thriving industrial biotechnology sector in Europe, 2015

208 https://ec.europa.eu/growth/tools-databases/escss

209 e.g. the Crescentino biorefinery (using 270,000 tons biomass per year) applies 100% water recycling on all operations http://www.betarenewables.com/en/crescentino/here-comes-the-green-revolution

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

This action will contribute to plastic-free seas and oceans by supporting Research and Innovation through the Framework Programme for the following interlinked aims to : i) for the development of substitutes to fossil-based plastics, such as in particular those that are at the same time bio-based, recyclable and biodegradable in the marine environment , and ii) the development of further bio-remediation methods.

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

Indicators: EUR invested in relevant research and innovation projects; report from industry forum

Worldwide, an estimated 10 megatonnes of litter, mostly plastics, enter the seas and oceans each year, some of it as macro-plastics, but also micro-plastics. It is estimated that only 30% stays at or close to the surface,[210] and that open ocean floating plastics account for less than 1% of the total that has reached the seas and oceans since plastic began to be produced.[211] The plastics may persist for hundreds of years before eventually degrading completely. During this time they adsorb toxins, concentrating them before getting into the food chain and affecting animal and human health.

The plastics pollution in seas has raised demands for the already existing bio-based, mostly cellulose based, materials and questioned the use of excessive packaging.

Bioeconomy can provide various options to address this fundamental problem by encouraging the deployment of already existing functional substitutes and development of new materials and processes to ease the recycling of most plastics to long term applications where the waste management meets the quality standards. In the Commission's legislative proposal on Single Use Plastics, Art. 15 stipulates that a report shall be submitted, in a certain timeline, indicating whether "sufficient scientific and technical progress has been made and criteria or a standard for biodegradability in the marine environment applicable to single - use plastic products within the scope of this directive and their single-use substitutes have been developed". Research and Innovation activities across the whole innovation chain will be essential in achieving this objective. Activities will be underpinned by the 6Rs framework: redesign-reduce-remove-reuse-recycle-recover.

<u>This action will:</u>

210 Marine plastic debris and microplastics: global lessons and research to inspire action and guide policy change, UNEP, 2016

211 It is estimated that open ocean floating plastic accounts for less than 1% of the total that has reached the oceans since it began to be produced by Marine Litter Vital Graphics, UNEP / GRID-Arendal, 2016

1) Support further research and innovation activities contributing to the elaboration of European (CEN) standards for biodegradability in the marine environment, in particular pre- and co-normative research. The substitute materials should be compostable or biodegradable in the marine environment, and based on sustainable production cycles. Furthermore, the Bioeconomy can support the development of bio-based solutions to recycle and re-use the plastics removed from the oceans, seas and in-land waters.

2) Include the development of substitutes to fossil-based plastics such as those that are at the same time bio-based, recyclable and marine biodegradable.

3) Build clear synergies with the many actions related to the Circular Economy Package, the Single Use Plastics legislation, the Marine Strategy Framework Directive, the Plastics Strategy and international cooperation schemes and activities, for example the EU International Ocean Governance, the Galway and Belém Statements, the BLUEMED, G7 and G20 initiatives.

3.2. Deploy local bioeconomies rapidly across Europe

One aim of the European Bioeconomy Strategy is to deploy the bioeconomies across Europe to ensure that the bioeconomy as a whole is a vehicle for inclusive and sustainable growth at the local level. This includes local development in Member States and their territories, such as their regions, rural areas, cities and coastal areas.

In 2017, the Review of the European Bioeconomy Strategy concluded that "*...the opportunities that the bioeconomy offers and the importance of the Bioeconomy Strategy coordination are increasingly recognised by EU Member States and regions. […] However, there is still room for further development in Member States, and also the potential contribution of cities to the bioeconomy remains largely unexploited.*"

A deployment agenda for sustainable food and, farming systems, forestry and bio-based production in a circular economy will provide a long-term vision on pathways to development of the bioeconomy and its sustainability. It will be complemented by open innovation spaces, which will allow, on a shorter term, integrating actors across value chains to experiment and work together on new solutions that will provide enhanced sustainability and circularity, and which are adapted to local conditions.

Specific areas that could benefit from deployment strategies in this context include:

- Future proofing food and farming systems (terrestrial and aquatic) by addressing e.g. food waste, losses and by-products (including nutrient recycling), more food from the oceans, with increased share of EU aquaculture production and market uptake, rising levels of obesity and malnutrition.

- Exploiting the potential of bio-based innovations including in farming sectors. Develop new products, processes and value chains for bio-based markets as well as new avenues for primary producers to develop rural and coastal areas. This includes high value added bio-based chemicals and materials, turning farm-waste and sea-weeds into valuable bio-based products or exploiting crop innovations materials.

- New opportunities arising from the forestry sector in view of replacing less sustainable resources in construction, packaging and for providing new, more sustainable innovations in classical sectors such as textiles, furniture and chemicals.

- Exploiting the potential of ocean farming - algae and other marine resources - for a sustainable bioeconomy, with scaling up and market uptake of marine bio-based industries, as well as further integration of marine and land-based farming.

Exploiting the potential of ocean farming - algae and other marine resources - for a sustainable bioeconomy, with scaling up and market uptake of marine bio-based industries, as well as further integration of marine and land-based farming.

The bioeconomy should harness opportunities to improve its sustainability and circularity, for example those offered by advances in the bio-based technologies to turn residues and by-products into new valuable bio-based materials and energy, or to recycle nutrients. Research and innovation at EU and Member State level have provided important solutions in the last years that would allow responding adequately to these challenges and opportunities; however these are not being deployed as fast as it is needed.

This set of actions aims to encourage the adoption, update and coherence of national and regional bioeconomy strategies throughout Europe. It equally supports the EU coastal, rural and urban areas in exploiting bioeconomy opportunities. It addresses the need to ensure an equitable sharing of the benefits of the EU bioeconomy and responds to the Strategy's objective of creating jobs and increasing European competitiveness. It aims to support the further development of the bioeconomy at all levels.

The actions related to the Strategic Deployment Agenda and to open innovation spaces aim at creating a framework for exploiting synergies across the bioeconomy and for coordinating instruments and actors at EU, national and regional level to develop more sustainable, circular and resilient bioeconomies. Furthermore, activities will help to build new partnerships and cooperation models between the different stakeholders including citizens.

Terrestrial and aquatic food and farming systems will be analysed as well as the exploitation of the potential of ocean farming and the market uptake of innovative marine bio-based products (cosmetics, nutrition, textile…), including by improving integration of marine- and land-based farming into value chains. Environmentally sustainable, resource efficient, competitive maritime activities to increase employment and territorial cohesion in coastal communities will be supported. In addition, financial support will be provided to a pilot group of five EU cities to draft their urban circular bioeconomy strategies, to be further extended in a longer term to up to 30 bioeconomy cities across Europe.

An EU support mechanism will be devised to support the Member States that are developing or updating their dedicated national bioeconomy strategy. Moreover, a forum will be facilitated to spur cooperation and mutual learning between Member States that are planning or implementing their dedicated national bioeconomy strategies. These actions will also respond to the need to raise public awareness about the opportunities presented by a sustainable bioeconomy.

All areas of the bioeconomy will require skilled professionals with specific skill sets along the value chains. Education and training programs need to be adjusted and developed to enable the labour force to gain relevant skills. In order to address these challenges, Member States in partnership with the EU will be called to further develop bioeconomy skills in higher and vocational education curricula, including through EU mechanisms such as the Sector Skills Alliances, across all areas relevant for the bioeconomy, taking into account their diverse needs and also including entrepreneurial training.

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

This action will, together with Member States and the private sector, develop a Strategic Deployment Agenda (SDA) for sustainable food and farming systems, forestry and bio-based production in a circular bioeconomy. This SDA will provide a coherent framework for the deployment of new knowledge, technologies and practices to connect these sectors in a systems approach in the framework of a circular, and sustainable bioeconomy.

Indicators: Number of public and private partners participating in the development of the roadmap; Leverage effect (in €) outside the EU R&I Framework Programme; ; Number of stakeholders participating in innovation actions; Geographic coverage of innovation actions; Number of innovative practices/technologies deployed; Impact reported by participating stakeholders

This action addresses challenges and opportunities of circular and sustainable food systems, primary production and bio-based sectors in an integrated manner. It will provide a coherent framework for the deployment of new knowledge, technologies and practices to connect these sectors in a systems approach in the framework of a circular and sustainable bioeconomy. It will look at processes and instruments and have a strategic approach to the deployment of innovations that is problem-oriented, that overcomes fragmentation in the landscape of research and innovation programming and deployment across sectors, policies and territories.

For this purpose, by 2021 the SDA will identify instruments and initiatives that can contribute to spreading knowledge and facilitating technology deployment at EU, national and regional level. At EU level, this may include optimising synergies between the Common Agricultural Policy (CAP) and the Common Fisheries Policy (CFP), and instruments such as the European Maritime and Fisheries Fund (EMFF), Horizon 2020 and the proposed Horizon Europe, the European Agricultural Fund for Rural Development (EAFRD) and other European Structural and Investment Funds (ESIF). Links with other policies (e.g. education) and instruments (e.g. financial instruments) will also be explored. Importantly, relevant instruments and initiatives at national and regional levels will also be identified. Possible interactions and complementarities will be analysed, providing a clear and complete picture of the support framework.

Building on existing platforms and initiatives such as EIP-AGRI, this action will bring together primary producers (agro- and aqua-farmers, foresters, fishermen), citizens, innovators, educators, SMEs, industry, national authorities and other actors to define needs and long-term approaches [to systemic challenges and opportunities related to sustainability, resilience and circularity] that mobilise knowledge, approaches, social innovations and technologies that are mature for

deployment, as well as relevant market mechanisms, investment, and regulations. It will identify needs and propose deployment pathways, which will combine the most appropriate means and instruments and harness synergies. It will also support primary producers, SMEs and other actors through advisory services, platforms and guidelines.

3.2.2. Pilot actions to support local bioeconomy development (rural, coastal, urban) via Commission instruments and programmes

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

This action will support the marine bioeconomy through the "Blue Economy grants" of the European Maritime and Fisheries Fund and a Blue Bioeconomy Forum. Coastal development will be boosted through the use of Sea Basin Strategies - including through dedicated Strategic Research and Innovation Agendas for the Mediterranean, the Black Sea, the Atlantic and the Baltic, as well as through public partnerships across European Sea Basins - to unlock the potential of the Blue Bioeconomy (Research and Innovation Framework Programmes). Member States and regions are called on to boost sustainable coastal bioeconomies through their Smart Specialisation Strategies.

Indicators: Number of sea basin strategies adopted, implemented, reviewed; Number of relevant projects funded; EUR invested in relevant projects.

The objectives of this action are to support environmentally sustainable, resource efficient, competitive maritime activities and to increase employment and territorial cohesion in coastal communities.

This action aims to support the development of coastal areas and their blue bioeconomies. Coastal areas are at the crossroads of land, sea and air ecosystems. They are strongholds of the emerging offshore economy and link ocean with land-based economies. Almost half of the EU population lives less than 50 km from the sea; the majority is concentrated in urban areas along the coast. In 2011, 206 million people, or 41% of the EU population, lived in Europe's coastal regions.[212] Coastal communities host the majority of jobs related to fishing activities, sometimes being fairly dependant on them.[213]

However, the resilience of coastal areas has been under much stress with sea-level rise and storm surge due to extreme effects of climate change as well as diminishing protection from the ocean given the progressive deterioration of coral barriers.[214]

By 2024, this action will:

1) Provide funding for the marine bioeconomy through the "Blue Economy grants" of the European Maritime and Fisheries Fund.[215] These grants will finance, among others, viable solutions to

212 http://ec.europa.eu/eurostat/statistics-explained/index.php/Archive:Coastal_regions_-_population_statistics

213 Natale F. et al., Marine Policy, 42, 245-252, (2013), doi: 10.1016/j.marpol.2013.03.018

214 Nicholls J. et al., OECD Environment Working Papers, (2008), doi: 10.1787/011766488208

address pollution at sea, develop value added products and services from underused biomass, increase the eco-friendliness of aquaculture, address the labour needs of maritime sectors and bridge the gap between innovative solutions and their establishment in the market.

2) Support the creation of a Blue Bioeconomy Forum, bringing together a partnership of industry, public authorities, academia, and finance in order to strengthen Europe's competitive position in the emerging blue bioeconomy. The aim of the forum will be to develop a shared understanding of the current status of the emerging blue bioeconomy in Europe and to collectively identify strategic developments, market opportunities, appropriate financial assistance, regulatory actions and research priorities to advance the blue bioeconomy in Europe. The forum will seek to exploit synergies between blue bioeconomy sectors that can benefit from innovative uses of aquatic biomass. It will look into biomass sourcing for novel purposes, such as animal feed and feed additives, food products (functional, fermented or fried), pharmaceuticals or cosmetics. Particular attention is also given to using and adding value to residues for other applications (e.g. adding value to chitin, shells and other bioactive components). By the end of 2019, the Forum will also produce a pipeline of viable blue bioeconomy projects to bring them closer to investments. The European Commission will organise matchmaking events under the #BlueInvest for these and other promising blue economy projects.

3) Establish, implement and review of sea basin strategies for the development of the Blue Economy, which include all marine bio-based sectors. Member States and regions are encouraged to boost coastal bioeconomies development through their Smart Specialisation Strategies. Sea basins strategies will be implemented including through dedicated Strategic Research and Innovation Agendas for the Mediterranean, the Black Sea, the Atlantic and the Baltic, and through public partnerships across European Sea Basins (EU Research and Innovation Framework Programmes). Sea basin strategies are a structured framework of cooperation in relation to a given geographical area, developed by EU institutions, Member States, their regions and where appropriate third countries sharing a sea basin. They take into account the geographic, climatic, economic and political specificities of the sea basin.

ii. Support the deployment of inclusive bioeconomies in rural areas through the European Rural Development Fund

This action will facilitate awareness raising, best practices and capacity building through workshops, seminars or meetings with Member States, and relevant private and public stakeholders. This action enables Member States to incorporate the bioeconomy in their Common Agricultural Policy Strategic Plans in a way that adequately integrates primary producers, adding to the aim of specifically supporting the setting up of sustainable bioeconomy businesses in rural areas.

Indicators: Initiatives to encourage Member States to invest Common Agricultural Policy funds in bioeconomy such as workshops, meetings with national representatives and stakeholders; Number

215 The European Maritime and Fisheries Fund focuses on the long-term objectives of the Europe 2020 strategy for a smart, sustainable and inclusive growth over the 2014-2020 period. It will contribute to sustainable and competitive fisheries and aquaculture, to a consistent framework for the Integrated Maritime Policy and to a balanced and inclusive territorial development of fisheries and aquaculture areas.

of events on the bioeconomy potential especially for primary producers and rural areas; Number of participants to events; Number of materials provided to Member States about existing good practices in supporting the deployment of the bioeconomy.

The on-going reform of the Common Agricultural Policy aims, among other things, to further simplify its implementation by providing more flexibility to Member States in choosing the types of policy interventions to include in their national Common Agricultural Policy strategic plans. In this framework, this action consists of streamlining good and best practices on how to better integrate the bioeconomy in the future national Common Agricultural Policy strategic plans to be developed by the Member States, using the opportunities available under the Common Agricultural Policy to support the development of the bioeconomy. Taking into account that several Member States do not yet have a national bioeconomy strategy, it is vital that awareness is raised about the opportunity to have a bioeconomy strategy and the importance of the bioeconomy for primary producers and rural areas alike. This should be complemented by more capacity building in their public administrations in order to translate these opportunities into effective interventions in their future national Common Agricultural Policy strategic plans. As a result of the successful implementation of this action, Member States will more adequately reflect bioeconomy in their future Common Agricultural Policy strategic plans, based also on information about existing good practices across the board in the EU. In this way policy coherence will be achieved by linking national bioeconomy strategies and national Common Agricultural Policy strategic plans.

By 2024, this action will:

1) Raise awareness of Member States about the importance of the bioeconomy for rural areas through targeted meetings and high-level discussion (e.g. AGRI/FISH meeting at the Council of Ministers). The use of Common Agricultural Policy support and financial instruments to streamline good practices to foster the deployment of the bioeconomy will therefore be encouraged, enabling primary producers and rural area to benefit from these opportunities.

2) Streamline the exchange of good and best practices across EU Member States public administration and other relevant stakeholders through capacity building events (workshops, seminars, presentations). This exchange should also cover existing good practices and opportunities in the use of financial instruments as part of future Common Agricultural Policy Strategic plans, national schemes, and EU schemes on the bioeconomy (financed through the European Investment Bank).

iii. Develop urban bioeconomies through piloting circular bioeconomy cities through Horizon Europe

This action will provide support to a pilot group of 5 up to 10 EU cities to draft their Urban Circular Bioeconomy Strategies, through a service contract. It will also support the introduction of a system to assess the implementation and success of each strategy.

This action will also promote the rehabilitation of urban brownfields and stimulate the application of nature-based remediation solutions and green infrastructure to reduce the urban pressure on agricultural and forest land. The rehabilitated land could serve to install urban farms, community gardens, green infrastructure or bio-based economic activity. This action will identify possible

implementation barriers for the use of EU funding in cooperation with national, regional and local authorities.

Indicators: Number of urban bioeconomy strategies adopted; Number of urban bioeconomy strategies implemented.

Today, cities produce about 1.3 billion tonnes of solid waste per year. Around half of it is organic.[216] Urban biowaste is often perceived as a challenge for urban agendas due to its potential pressure on the environment and human health. At the same time, biowaste flows in cities contain substances that could be used for the production of bio-based products such as chemicals, plastics, nutrients, etc. The city of Amsterdam estimates that the better recycling of high value organic residue streams could generate EUR 150 million in added value per year, create new 1.200 jobs in the long run and save 600.000 tonnes of carbon dioxide per year.[217] If Europe's 50 largest cities were to copy this vision, then the scaled-up impacts could be between EUR 7.5 and 12 billion in economic added value, between 60.000 and 100.000 new jobs, and carbon dioxide emissions savings of 30 to 50 megatonnes. Today, there are conventional technologies to process urban biowaste into compost and biogas, the latter mainly used as an energy carrier. There are, therefore, opportunities for further exploiting its potentials in a smart and innovative fashion. Furthermore, the EU urban strategies on sustainability policies (such as Circular Economy, climate mitigation, renewable energy production, sustainable transport, etc.) rarely refer to circular bioeconomy. This action will build on the work of the EU Urban Agendas Partnership on "regulatory obstacles and drivers to boost an urban circular bioeconomy".

In addition, the new EU regulation on waste should lead to an increase of the amount of bio-waste in EU cities that could be available also for biorefining. According to the new Waste Framework Directive, by 31 December 2023 bio-waste shall either be separated and recycled at source or collected separately. The directive aims also to reduce landfilling and promote other uses of this feedstock, including the production of materials from bio-waste.

The 2017 Review of the Bioeconomy Strategy highlighted that there are only a few cities that have bioeconomy-related priorities in their policies, despite the potential of municipal bio-waste for nutrient recovery, bio-based products and energetic use. This shortcoming is significant, considering that cities and urban areas now house more than 70% of all Europeans.[218] Cities are drivers of innovation and the economy but also the battleground for many of the societal challenges of the 21st century, as emphasised in the UN 2030 Agenda on Sustainable Development and the UN New Urban Agenda.[219]

An important step in further exploiting urban biowaste is the launch and implementation of Urban Circular Bioeconomy Strategies in EU cities. These strategies provide the basis for the implementation of concrete territorial measures contributing to key EU policies including: (i) Circular Economy and bioeconomy: preventing and reducing avoidable urban biowaste and turning

216 http://www3.weforum.org/docs/WEF_Project_MainStream_Urban_Biocycles_2017.pdf

217 "Circular Amsterdam: A vision and action agenda for the city and metropolitan area", Circle Economy, Fabric Tno and Gemeente Amsterdam, 2016.

218 https://ec.europa.eu/futurium/en/system/files/ged/pact-of-amsterdam_en.pdf

219https://sustainabledevelopment.un.org/post2015/transformingourworld; https://unhabitat.org/new-urban-agenda-adopted-at-habitat-iii/

unavoidable urban biowaste into valuable resources management; (ii) Climate change mitigation: Reducing greenhouse gas emissions from biowaste and capture by avoiding landfilling and capturing its carbon in biowaste-based products; (iii) Industrial symbiosis: Linking biowaste and wastewater sectors with others such as bio-based, chemicals, plastics, food & feed, etc.; (iv) Resource efficiency and security: Turning urban biowaste into valuable substances, including valuable and critical materials such as Nitrogen (N), Phosphorus (P), and Potassium (K), (v) Sustainable food and nutrition security: Improving local food systems through bio-based solutions, such as the production of feed (and eventually food) ingredients from urban biowaste.

Urban circular bioeconomy measures, if adapted and replicated by other cities, can multiply the local contributions for boosting an EU Bioeconomy with significant economic, social and environmental benefits. Furthermore, testing this pilot group of urban circular bioeconomy cities can potentially open the door to future and more systemic initiatives such as an EU-wide initiative to directly engage cities and regions in the EU bioeconomy policies.[220] The implementation of this action will take into account the cooperation and synergies with related EU and international initiatives. It will also examine the synergies and complementarities with EU funds such as URBIS.[221]

Cities are the centres of the local bioeconomy, but their growth at the same time puts pressure on the forests and the agricultural, and (semi-)natural land that surrounds them. Tackling soil contamination, which is mainly a problem in urban and heavily industrialized regions, offers opportunities for the reactivation of land including for bio-based economic activity and for the reduction of urban sprawl.

The availability of fertile soils and land is crucial in the transition towards a sustainable bioeconomy. Land use changes in favour of artificial surfaces and urban development negatively affect the availability of productive land for the bioeconomy and the delivery of ecosystem services by the soil. Between 2000 and 2012, the average area of land taken for development in the EU was with 926 km² above the 800 km^2 per year for 2000–2020 that was identified in the Roadmap to a Resource Efficient Europe as an upper benchmark in order to stay on target to achieve the objective of no net land take by 2050.[222] Soil sealing through artificial surfaces is not only increasing across the EU, it is also accelerating. While artificial areas grew by 3.7 % between 2009 and 2012, this rate increased to 4.0 % between 2012 and 2015, indicating an acceleration of land use change towards artificial and urban land use.[223] It is unlikely that a drastic reduction in the rate of land take will take place in the near future, because key land take drivers such as urban population, economic activity and transport activity have been on the increase since 2012.

220 An EU-wide initiative on urban and regional bioeconomy can provide a unique instrument to actively engage local and regional actors in the EU Bioeconomy and obtain their significant territorial contribution to achieve its targets. This initiative could be based on: (i) a voluntary and formal commitment by mayors or presidents of provinces/counties and regions to draft, launch and implement bioeconomy strategies in their territories; (ii) an interactive online free-of-charge website for the initiative, including a platform for exchange of information and good practices and the profiles of each signatory (presenting, for example, their urban bioeconomy strategies with the respective targets, action plans and implementation reports); and (iii) a system for monitoring, reporting and verification (MRV) to assess the implementation and achievements of the strategies' targets.

221 http://eiah.eib.org/about/initiative-urbis.htm

222 EEA (2017), Environmental indicator report, Urban land take briefing

223 EEA (2017), Ecosystem coverage

One way to reduce the rate of land take is through the redevelopment of brownfields to make better use of neglected land. Brownfield sites are derelict and underused or even abandoned former industrial or commercial sites, which may have real or perceived contamination problems. Redevelopment of these sites has many environmental advantages: relieving pressure on rural areas and greenfields, reducing the risks for environment and human health, allowing more effective use of natural resources and facilitating economic diversification. Brownfield redevelopment applies the principles of the circular economy on land-use.

Despite different national legislative approaches and definitions to address soil contamination in Europe, the number of contaminated sites that needs remediation in the EEA-39 was estimated to approximate 340.000 in 2014. About one third of these sites has been identified while only 15% has been remediated. The costs related to the remediation of the remaining contaminated sites are huge: in 40% of the cases the cost lies between 50.000 and 500.000 euro but for some outliers the financial impact can exceed 5 million euro.[224] These sites are mainly found in urban areas of industrialized regions.

Academic research and pioneering industrial projects already demonstrated the effectiveness of nature-based solutions that replicate and simulate the ecosystem's natural restorative capacity to solve complex soil pollution. Technologies such as phytoremediation, bioremediation or phytostabilization use the ability of specific plants, fungi or bacteria to degrade, stabilize or capture pollutants. A nature-based approach can replace the use of energy intensive and sometimes environmentally invasive remediation technologies to provide a cost-effective solution for the rehabilitation of degraded land. Conversion of remediated brownfields into urban farms, bio-based economic activity, community gardens or green infrastructure can result in a double win for the bioeconomy: the nature-based solution delivers biomass, the land is rehabilitated and the urban pressure on agricultural and forest land reduces.[225]
In line with the on-going work of the EU Urban Agenda's Partnership on Circular Economy (UAPCE)[226] and as a concrete contribution to its Action Plan, by 2022 this action will:

1) Provide financial support to a pilot group of up to 10 EU cities to draft their Urban Circular Bioeconomy Strategies.

2) Support the introduction of a system to assess the implementation of each strategy and the achievement of its targets as well as support the setting up and maintenance of an ad hoc website for presenting relevant data and information on the implementation of these strategies and facilitating the exchange of good practices among the policy-makers involved. Moreover, the Member States are encouraged to support the development of bioeconomy strategies at the local level (bio-regions, bio-cities, etc.) through the Forum mentioned in Section 2.1.2.

224 JRC, 2014. Progress in the Management of Contaminated Sites in Europe

225 European Commission. 2015. Towards an EU Research & Innovation Policy Agenda for Nature-Based Solutions & Re-Naturing Cities

226 https://ec.europa.eu/futurium/en/circular-economy

iv. Support pilot carbon farming initiatives through LIFE

This action will encourage Member States to establish (on a voluntary basis) a fund to buy carbon credits from farmers and forest owners who implement specific on-farm projects aimed at increasing soil/biomass carbon sequestration and/or reducing emissions in the livestock sector or related to fertilizer use.

Indicators: Number of pilot projects on carbon farming; EUR invested; Number of sectors/farmers/forest owners covered by carbon farming; Tonnes of CO2/equivalent sequestered.

Carbon farming would provide result-based payments to farmers and forest owners, ensuring a clearly defined public payment to the farmer for the provision of a public good by making carbon sequestration and emission reduction a profitable farming/forestry activity. It would be highly visible in enhancing emission reductions, carbon sequestration, resilience and farm productivity (thanks to increased fertility). It is coherent with the Paris Agreement objective of increasing carbon sinks with a view to reaching a balance between emissions and removals in the second half of the century.

The objectives of this action are: (1) a more effective use of natural and financial resources (2) to reduce greenhouse gas emissions in the life cycle of the agricultural and agro-food supply chains, and (3) to test innovative financial incentive schemes for farmers to take actions for reducing GHG emissions.

This action will help to comply with different policies, regulations and programmes, at EU Level (CAP and climate related measures, LULUCF Regulation (EU)2018/841, Climate benefits of the future Bioeconomy strategy, the EU Action Plan for a Circular Economy) and at global level (Paris Agreement, Global Alliance for Climate Smart Agriculture by FAO).

The impact of this action by 2024 will include (1) the reduction of GHG emissions, (2) the adoption of market-based incentives for reducing greenhouse gas emissions and (3) the adoption of climate smart practices.

This action could be supported from the LIFE Programme.

v. Set-up "living labs" to develop and test place-based innovations based on ecological approaches and circularity in primary production and food systems

Living labs will be set-up and tested for their contribution to open, multidisciplinary and multi-stakeholder innovation in primary production on land and sea and its interfaces with bioeconomy value chains (food and bio-based products). They will serve to develop solutions based on ecological and circular approaches and help the shift to a more sustainable and resilient bioeconomy. By adapting innovations to site-specific needs and involving the relevant stakeholders, they will allow and facilitate their further adoption and deployment.

Indicators: Number of living lab pilots established; Number of stakeholders from primary production and from bioeconomy value chains (including consumers) actively involved in living lab activities; Number of outreach activities and solutions tested

As primary production (agriculture, forestry and aquatic) and value chains are becoming more and more knowledge intensive, attention is turning to open innovation as a means to tap more efficiently into various types of knowledge, promote efficient ways of cooperation and sharing experiences between different players such as farmers, forest owners, advisors, researchers, businesses, policy-makers, citizens. The interaction between science and practice is particularly relevant where a) innovations cannot be applied in a uniform manner but need to be adapted to local conditions and b) a thorough understanding of complex solutions is needed. This is the case for example in farming systems such as agro-forestry or agri-aqua farms: they make use of biodiversity-based ecosystems services, develop a range of products for multiple purposes and value chains (food and bio-based products) and exploit synergies within farms and across sectors through the circular use of water, nutrients and biomass.

By 2024, this action will:

1) Develop and test living labs as place-based, local infrastructures where multiple disciplines and stakeholders can exchange ideas, co-create, test and replicate solutions on different scales (e.g. from pilot to landscape). Activities will be based on ecological approaches and circularity in primary production and their links across bioeconomy value chains (food and bio-based products).

2) In addition to guiding new approaches in primary production and food systems, the ambition is that living labs also provide spaces where information and datasets are integrated, can be open-accessed and mined to understand complex interactions and find solutions.

Relevant EU instruments, such as EIP-AGRI and EIT Food, will help to connect living labs working on different themes and in different locations, support outreach activities and create a dynamic network. While focusing on Europe, work will capitalise on international experiences and initiatives.

3.2.3. Set up an EU Bioeconomy policy support facility and a European Bioeconomy Forum for Member States

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

This action will provide support to develop and implement bioeconomy strategies across Europe (Horizon 2020). This will include a focus on Central and Eastern Europe through the BIOEAST initiative.

Indicators: Number of bioeconomy strategies adopted under the BIOEAST Initiative; Number of bioeconomy strategies adopted by Member States

One of the key results of the 2012 Bioeconomy Strategy is to have brought the bioeconomy principles and cross-cutting objectives to the attention of national and regional policy-makers. This is reflected in the number of countries and regions that have adopted bioeconomy policies since 2012 (Figure 9).

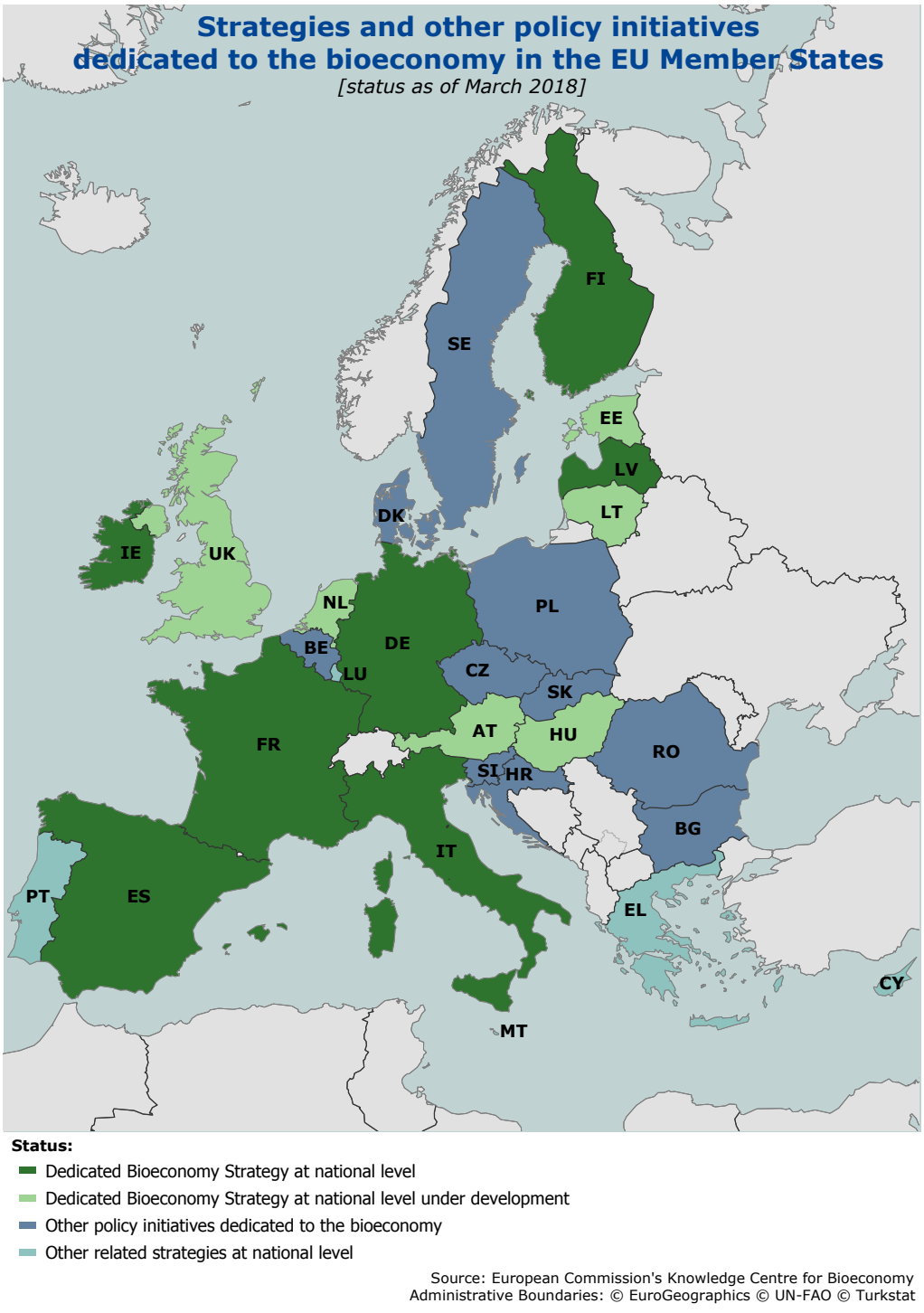

Figure 9. Bioeconomy strategies and other policy initiatives dedicated to the bioeconomy in the EU as of March 2018. Source: European Commission's Knowledge Centre for Bioeconomy.

Dedicated bioeconomy strategies or other policy initiatives exist or are being developed in many of the Member States and their regions. So far, seven Member States have a dedicated bioeconomy strategy (Finland, France, Germany, Ireland, Italy, Latvia and Spain) and six Member States (Austria, Estonia, Hungary, Lithuania, the Netherlands and United Kingdom) are in the process of developing a dedicated strategy at national level.[227] Other Member States are involved in macro-

227 https://ec.europa.eu/knowledge4policy/bioeconomy/topic/policy

regional bioeconomy initiatives (e.g. Denmark, Sweden)[228] and sub-national strategies (e.g. Belgium). As aligned to the 2012 European Bioeconomy Strategy, these strategies go beyond Research and Innovation and have been developed jointly by various ministries covering bioeconomy-relevant policy areas, such as agriculture, forest-based sector, industry, environment, regional, etc. The diversity of focus chosen by the Member States for their national bioeconomy strategies indicates that there is no single "bioeconomy blueprint" to be followed. Instead there is rather a variety of "bioeconomies" to be developed at national and regional levels, depending on the type and form of biomass available, infrastructures, markets, know-how and investment capacity. The variety of "bioeconomies" in the EU and the diversity of focus of the national bioeconomy strategies urge for alignment of strategies and policy coherence.[229]

Most EU-15 Member States have developed or are developing dedicated national bioeconomy strategies, while the new Member States lag behind, despite their huge biomass potential.[230] To address this gap, several high-level initiatives call for more action at EU, national and regional levels, including initiatives rooted in the Central and Eastern European (CEE) countries such as the BIOEAST[231] and the Lodz Bioregion and Bioregions declaration.[232] In particular, the BIOEAST initiative has recently set the vision and highlighted opportunities for 2030 to develop knowledge and cooperation based circular bioeconomies in CEE.[233] As part of this initiative, 10 CEE countries (Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Lithuania, Poland, Romania, Slovakia, Slovenia) plan to develop a dedicated bioeconomy strategy or other national Circular Economy strategies.

In order to support Member States in developing and implementing their dedicated bioeconomy strategies, this action aims to

1) Activate a support mechanism for Member States, drawn among others on good practices and independent high-level expertise and guidance, peer reviews, and/or other customised support.

228 http://www.norden.org/en/theme/nordic-bioeconomy

229 Alignment and coherence of national bioeconomy strategies with the objectives of the European Bioeconomy Strategy are necessary in order to best promote the development of the Bioeconomy in the European Union.

230 See, e.g. Salamon, P., Joint Research Centre Technical Report, (2017), doi: 10.2760/363389; https://biconsortium.eu/sites/biconsortium.eu/files/downloads/Country-Report-Poland.pdf

231 www.bioeast.eu

232 a) http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+REPORT+A7-2013-0201+0+DOC+PDF+V0//EN; b) Council of the European Union – Note AGRI 115 / RECH 93 (5/3/2018): Letter from Mr Rumen PORODZANOV, President of the Agriculture and Fisheries Council, to Commissioner MOEDAS, Commissioner for Research, Science and Innovation; c) www.consilium.europa.eu/en/press/press-releases/2016/06/20-envi-conclusions-circular-economy; d) http://www.bioeconomybratislava2016.eu/; e) The Central-Eastern European Initiative for Knowledge-based Agriculture, Aquaculture and Forestry in the Bioeconomy – BIOEAST – is an open initiative started by the Visegrad Group Countries (http://www.bioeast.eu/); f) Annual conference on Bioeconomy "European Bioeconomy Congress in Lodzkie region (EBCL 2016)" organised on 6-7/10/2016, by the Lodzkie region Marshal's Office / Poland with the support of the EC. The Lodz Bioregions Declaration, endorsed by 8 Polish regions, establishes closer cooperation among various Polish regions aiming to specialise in Bioeconomy.

233 Joint Declaration of the Ministers of Agriculture of the Visegrad Group, Bulgaria, Croatia , Slovenia and the Baltic States on the Vision of the Central and Eastern European Initiative for Knowledge-based Agriculture, Aquaculture and Forestry in the Bioeconomy "BIOEAST", 13 June 2018. BIOEAST (2018) Vision Paper http://www.bioeast.eu/article/bioeastvisionpaper23022018

2) Increase the number of EU Member States with a dedicated bioeconomy strategy– especially in moderate/modest innovator[234] Member States where there is not yet such a strategy.

ii) Support a European Bioeconomy Forum of Members States implementing bioeconomy strategies

This action will facilitate networking of Member States and regions, also capitalising on existing groups, to exchange knowledge and best practices, facilitate interaction and mutual learning, and enhance interregional cooperation to support bioeconomy developments at national, regional and local level.

This action will facilitate bioeconomy communication initiatives, such as awareness raising campaigns and debates, also at regional level in the context of its cohesion policy, by for example using the smart specialisation platform. This includes the deployment of a European Bioeconomy Network (Horizon 2020). Member States, regions and stakeholders are called on to support similar bioeconomy communication activities at national, regional and local level.

Indicators: Number of actions launched by the Forum members; Number of campaigns/events delivered; Number of stakeholders reached

When providing feedback to the EU Bioeconomy Roadmap 2018, the Member States have advocated for increased cooperation through networks of Member States and regions, with the aim to exchange knowledge and good and best practices,[235] facilitate interaction and mutual learning, and enhance interregional cooperation to deliver joint actions in support of bioeconomy developments at national, regional and local levels.

As a result, at the first meeting of national bioeconomy coordinators organised by the EC (16/3/2018, Brussels, 22 Member States present), the creation of a strategic mutual learning Forum of Member States that have already adopted, or plan to adopt/update a national Bioeconomy strategy was considered useful.

This action will:

1) Provide a stable and operational format for networking/interaction and knowledge exchange to facilitate the promotion and implementation of their bioeconomy strategies;

2) Increase the visibility and potential of the various areas of the bioeconomy in all Member States using existing networks and platforms;

3) Put Member States in the driving seat to shape a concrete agenda of joint actions strengthening the development of the bioeconomy areas in the EU as a whole and in Member States;

4) Act as a channel to provide recommendations to the EU for evidence-based future actions that take into account regional and urban aspects.

234 European Innovation Scoreboard http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en

235 A result of the first meeting of national bioeconomy coordinators organised by the EC (16/3/2018, Brussels, 22 Member States present).

This action will also support communication strategies to raise awareness about the environmental and socio-economic impacts of activities on all bioeconomy areas and for bio-based products.

The successful transition towards the bioeconomy requires a profound transformation both on the supply and the demand side of the economy. On the demand side, consumers and their behaviour play a major role in this transformation process. As demonstrated by a number of studies,[236] consumer awareness and knowledge are important factors determining responsible consumption behaviour. Additionally, raising awareness is also important to accelerate the implementation of Bioeconomy strategies at national, regional and community level, and also to allow the citizens to have their say and provide their feedback on bioeconomy-related issues, such as through the EU Citizens' Initiatives tool.

The Review of the 2012 Bioeconomy Strategy concludes that "*...A number of EU-funded research and innovation projects have contributed to the development of markets for bio-based products [...], by addressing, amongst other things, the development of standards, awareness-raising, and public procurement.*" Yet, as the public consultation on the Roadmap for the Communication updating the 2012 European Bioeconomy Strategy showed,[237] increasing public awareness and knowledge about all areas of the bioeconomy remains one a major challenge, which the European Commission aims to address by supporting communication initiatives to raise awareness of the environmental and socio-economic impacts of the bioeconomy and bio-based products, and its benefits, such as more green jobs.

To this end, this action will strengthen the European Bioeconomy Network, i.e. a network of projects and initiatives currently funded by the European Commission to promote, communicate and support all bioeconomy sectors at the national, regional and local level. The projects belonging to the European Bioeconomy Network will define a joint consolidated action plan of communication activities to initiate or reinforce the existing synergies, and maximise the opportunities to, and the impact of, promoting the bioeconomy.

The communication activities of the European Bioeconomy Network are expected to take place at least yearly not only in those countries/regions which have adopted a bioeconomy strategy, but also in those where the bioeconomy potential has not yet been exploited. The action will complement existing European Platforms (such as Urban Agenda, Circular Economy Platform, and European Rural Development Network), Member States networks and projects or programmes supported by EU funds.

The objective of this action is not only to share information and best practices but to engage all actors to promote all bioeconomy sectors and bio-based products through communication and engagement activities (events and tailored campaigns) at the national, regional and community level. It will build upon sectoral communication activities and will also involve engaging citizens through awareness-raising and education on sustainable production, consumption and lifestyles.

236 See e.g. Buerke A. et al., Review of Managerial Science, 11, 4, 959-991, (2017), doi: 10.1007/s11846-016-0211-2; Stöckigt G. et al., Journal of Retailing and Consumer Services, 43, 188-199, (2018), doi: 10.1016/j.jretconser.2018.03.018.

237 https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2018-975361_en

3.2.4. Promote education, training and skills across the bioeconomy

This action will support networking of education and training providers and labour market actorsi n the bioeconomy, for the development of education and training content that responds to the diverse needs of stakeholders and sectors (Horizon 2020 and Erasmus+ Sector Skills Alliances). Member States are encouraged to integrateof dedicated curricula and training programmes in the bioeconomy areas in their education and training systems.

Indicators: Skills intelligence on the occupations in a specific sector up-to-date and available; European occupational 'core' profiles reviewed and updated; as necessary new occupational core profiles established; Vocational core curricula and teaching/training methods updated; as necessary new vocational core curricula established; Vocational core curricula and teaching/training methods integrated in national vocational training systems; Number of researchers working in bioeconomy relevant training & education projects; Number of networks/programmes supported (Sector Skills Alliances, CSA, EIC ecosystems).

In 2017, the Review of the European Bioeconomy Strategy highlighted that "*...whilst efforts have been deployed to reinforce the human capacity for the bioeconomy, the scope and level of ambition of the strategy and of the actions implemented have remained limited (e.g. vocational training is largely absent and needs to be addressed, so as to have a workforce equipped for the bioeconomy such as in the maritime sector where steps have been taken to address this issue)".*

For instance, the EU agricultural sector has in general lower level of training and education than other economic sectors. In 2016, more than 40% of people working in the agricultural sector had at most completed a low level of education while this proportion was 18% of the total working population.[238] Additionally, anecdotal evidence indicates that even existing levels of wood supply to the forest-based industries will be difficult if not impossible to maintain if the ongoing rate of evaporation of skilled but ageing wood-supply personnel (e.g. technicians, support engineers, ground-staff) is not matched by new recruitment.[239]

Beyond vocational training however, the bioeconomy job market will need all sort of professionals, including some that possess multidisciplinary, managerial and cross-sectoral expertise acquired in a higher education setting. Graduates, for example, who have an in-depth knowledge in a certain domain (e.g. engineering, ecology, agronomy, food systems and food science, social science, economy, etc.), but also an understanding of the broader bioeconomy and supporting and emerging fields (information and communication technology, robotics, remote sensing, new materials, etc.) are needed.

Finally, stimulating entrepreneurship in bioeconomy will be key to foster local developments in the European regions and cities. As part of the Multiannual Financial Framework and the activities foreseen for the European Innovation Council, entrepreneurship skills training will be supported, such as through a potential "Bioeconomy Innovation Bootcamp" for researchers. The action should include practical presentations of entrepreneurial practices and new business approaches, evidence

238 http://ec.europa.eu/eurostat/statistics-explained/index.php?title=Farmers_in_the_EU_-_statistics

239 e.g. from CEETAR (a member of the EU Forest-based Industries Expert Group, representing also wood-harvesting contractors), http://www.ceettar.eu/

of enhancing biodiversity and ecosystems, and examples of positive synergies with local communities, Bioeconomy and ecosystem-based principles, a study visit to problem owners (company, site, protected areas), and work in teams on the problem with inter and trans-disciplinary expertise input.

The Skills Agenda, launched in 2016, already addresses several skills needs crucial to the bio and low-carbon economy. For instance, the Digital Skills and Jobs Coalition and the Blueprint for Sectoral Cooperation on Skills address digital skills and green skills. Some Blueprint projects also provide valuable skills intelligence information from sectors relevant to the bioeconomy, including the maritime sector. The EU has already provided significant funding for skills in the period 2014-2020. In particular, more than €27 billion of the European Social Fund budget has been allocated to "education, training and vocational training for skills and life-long learning" and a significant proportion of that has gone to digital skills. This represents a third of ESF resources. In the same period, Erasmus+ with a budget of €11.4 billion has supported the development of education and training.

The activities proposed under this action will deliver further vocational, higher education and entrepreneurship training to upskill the next generation of bioeconomy workforce. In turn, Member States in partnership with the EU will be called to embed the necessary bioeconomy skills in higher and vocational education curricula.

The development of skills in the agricultural sector will be fed by activities in the context of the EIP AGRI and the development of Agricultural Knowledge and Innovation Systems.[240] Furthermore, "Bioeconomy, New Technologies, and Innovation in Agriculture" will be one of the eligible sectors for a Blueprint Alliance to be proposed following the Erasmus+ call for 2019.

This action will:

1) Map personnel structures and existing skill sets, as well as those foreseen to be needed for 2030 and 2050 in relevant bioeconomy sectors

2) Support subsequent projects under the Blueprint for Sectoral Cooperation on Skills,[241] with a view to possibly initiating pilot training networks, e.g. as those foreseen by the "Blueprint for the EU Forest-Based Industries".[242] In the framework of the EU Erasmus+ programme, calls for proposals for Sector Skills Alliances implementing the Blueprint could be launched to address skill mismatches and gaps across bioeconomy sectors.

3) Deliver up-to-date skills intelligence on the occupations in bioeconomy and specific occupational core profiles, based on which bioeconomy vocational core curricula and teaching and training methods will be updated and new vocational core curricula in bioeconomy established.

240 https://ec.europa.eu/eip/agriculture/

241 http://ec.europa.eu/social/main.jsp?catId=1415&langId=en

242 SWD(2013)0343 final, http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:52013SC0343

4) Generate a pipeline of talented entrepreneurs and innovators and by promoting an entrepreneurial mind-set and culture for the bioeconomy through the contribution of the EIT KICs (and, in particular, EIT Raw Materials, EIT Food, EIT Climate-KIC and EIT InnoEnergy).

5) Consider supporting collaborative networks, involving academic educational institutes (Higher Education Institutions) that have or are preparing bioeconomy Bachelors' degrees, Masters' degrees and / or doctoral programmes, as well as the private sector. This can help to collect and share best practice and to organise information for the development of bioeconomy curricula in higher education.

3.3. Understand the ecological boundaries of the bioeconomy

The objective of the following actions is to strengthen the resilience of land and sea ecosystems, ensuring their contribution to climate mitigation, and enhancing their biodiversity. In addition, they should help us move towards sustainable, circular and post-waste food systems and mobilise the full potential of biological resources from primary production on land and sea. Promoting connections between sectors of the bioeconomy, including the bio-based sector, will also be addressed. It responds to the need to operate the European bioeconomy within the limits of our planet and supports all objectives of the Strategy.

The environment, natural resources, ecosystems and biodiversity are under severe pressure at global and local scale (see 2.2). It is therefore imperative that the bioeconomy is developed in a way that helps reduce environmental pressures, values biodiversity and contributes to enhance the provision of all ecosystem services. Sustaining nature's contribution to humanity requires the maintenance of a healthy planet, resilient ecosystems, an efficient use of natural resources, and conservation and sustainable management of biodiversity. Yet, European biodiversity is in continuous decline.

It is therefore necessary to have at any time the required data, information, and knowledge to judge if the observed developments are in the right direction and to anticipate if possible actions are likely to promote the desired trends.

These actions should improve the knowledge base (data, information and tacit knowledge) on all areas of the bioeconomy and a forward-looking capacity (modelling, foresight exercises, scenarios), as essential elements for providing the evidence needed to support policy makers and for underpinning policy coherence. Moreover, a comprehensive monitoring is needed in order to provide policy makers with transparent and harmonised (across the EU and over time) descriptions of status and trajectory of change in the environmental, social and economic dimensions of the bioeconomy. Significant work in these fields has already been done by the European Commission and its advisory bodies as well as by the general research community.[243] Moreover, as laid down in the Action Plan accompanying the 2012 European Bioeconomy Strategy, a Bioeconomy Observatory was set up in 2013 by the Joint Research Centre with the aim to provide data and

243 https://ec.europa.eu/research/scar/pdf/ki-01-15-295-enn.pdf#view=fit&pagemode=none

information on the current bioeconomy.[244] In 2017 it was integrated into the Commission's Knowledge Centre for Bioeconomy,[245] coordinated by the Joint Research Centre. The Commission's Knowledge Centre for Bioeconomy collects, structures and makes accessible data and information on the bioeconomy from different sources, bringing together the knowledge and expertise needed to assess the status, progress and impact of the bioeconomy. It develops and makes available forward-looking tools and results of foresight exercises. These actions will respond to the need to monitor and communicate progress towards a sustainable bioeconomy, through further generation and dissemination of bioeconomy knowledge. It will inform policy making and underpin all the objectives of the Strategy, as an enhanced knowledge base is essential to support policy coherence(i.e. cross-sectoral and cross-policy) and achieve the bioeconomy objectives. It is crucial to ensure that biological resources are used within their sustainability thresholds so that they can recover and replenish, and that ecosystems are not pushed beyond safe boundaries e.g. through exceeding the capacity of specific provisioning ecosystem services. Research is needed on the opportunities, trade-offs and potential risks of developing the bioeconomy, in particular for the ecosystem services and the biodiversity. Further knowledge needs to be developed on the synergies and trade-offs between various ecosystem services – both for terrestrial and marine ecosystems, and how to reconcile economic activities and social needs with sustainable management of ecosystems, primary production and biodiversity. This involves developing knowledge about risks and opportunities of working with biological resources, sustainability thresholds and the values of biodiversity (including economic, cultural and intrinsic values). The development of innovative solutions, new business models and alternative value chains that are centred on biological resources, ecosystems and biodiversity, should be done with the participation of local communities and stakeholders.

The mid-term review of the Biodiversity Strategy[246] identified important knowledge and data gaps, in particular in marine ecosystems, ecosystems health and resilience. To understand the impact of the bioeconomy on land and sea we need to increase our observation, measurement, monitoring and reporting capacities. Improved insights and better data collection and management can form the basis for active management of biological resources and ecosystems marine environments. Ecosystem accounts can reflect the condition of key ecosystems, their capacity to deliver services sustainably, as well as their contributions to the sustainable bioeconomy.

The EU and its Member States have recently launched initiatives in order to contribute to global conservation efforts of pollinators.[247] The bioeconomy action plan can contribute to these efforts amongst others by: better understanding how businesses depend on pollinators and integrating this into risk-management strategies, in particular for those higher up the biomass chain; raising awareness about the importance of pollinators amongst relevant bioeconomy sectors; and promoting

244 BISO operated as a Framework Programme 7-funded project (2013-2016) that provided a website with bioeconomy-relevant S&T, policy and market data as well as research on bio-based industries and environmental aspects. It was followed (2016-2017) by the Joint Research Centre institutional project-funded EU Bioeconomy Observatory.

245 https://ec.europa.eu/knowledge4policy/bioeconomy

246 COM(2015)0478 final; https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52015DC0478

247 Commission Communication on the EU Pollinators Initiative http://ec.europa.eu/environment/nature/conservation/species/pollinators/index_en.htm

their engagement in improving the knowledge base and supporting monitoring activities on pollinators and pollination as a service.

Recent key discoveries on microbiomes[248] offer the potential to improve primary production and food systems, to protect our crops, to restore and better manage soils, to improve human and planetary health, and to spawn new sustainable solutions and economic opportunities for growing bioeconomies, while preserving the intrinsic value and biodiversity of our ecosystems. Having recognised the key importance of microbiomes, the international community has called for a global initiative on microbiomes.[249] The International Bioeconomy Forum established by the European Commission in 2017, together with several international partners, includes a working group in microbiomes, which plans further collaborative activities to harness the potential of microbiomes for the sustainable bioeconomy.

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

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

This action will continue to enhance the knowledge base of the bioeconomy, which will be publicly disseminated via its Knowledge Centre for Bioeconomy (KCB). It will build on tools and methods, including those established by the Joint Research Centre, which address sustainable biomass availability and also enable forward-looking policy analysis with a specific focus on sustainability and trade-offs (Horizon 2020 and Horizon Europe Proposal).

Indicators: Standard bibliographic metrics (incl. number of articles in peer-reviewed journals); Technical reports published; Publications shared (incl. through the Knowledge Centre for Bioeconomy and at conferences)

Bioeconomy as defined in the introduction is a highly complex system with many interacting elements and stakeholders. To which extent its potential can be realised depends on many local and global factors, including the impact that a bioeconomic activity has on the environment and the socio-economic system.

To ensure that the bioeconomy operates within the planetary boundaries, first and foremost a robust assessment of the amounts, types, qualities and impacts of the sustainable production and use of biomass from all sources is needed. Impacts include the implications of land use (and its changes) on biodiversity and other essential parameter of ecosystems on land and sea, as well as on the local, regional and sometimes global socio-economic systems. In that context the competition and synergies between bio-based sectors (food and other bio-based) is of central importance. A good

248 Microbiomes are communities of micro-organisms with their genomes that inhabit a particular environment

249 Create a global microbiome effort. Nature 29 Oct 2015: 526, 631–634

way to visualise these interdependencies are biomass flows that should include by-products and residues.

A better understanding of the status of terrestrial and aquatic ecosystems, the biomass demands and supplies and their drivers, their costs and their associated impacts (economic, environmental and social), would help to better understand the synergies and potential trade-offs between the various uses of biomass with regard to climate change mitigation, food security, raw materials and energy security, natural capital conservation, cohesion, trade, environmental services, etc.

Examining separately the specific needs of each bio-based sector without considering the whole bioeconomy system could lead to wrong conclusions. Accumulating needs of different sectors without considering their interactions could lead to either overexploitation (possibly resulting in exacerbating climate change but also in greater food insecurity and environmental degradation) or a sub-optimal use of available natural resources (potentially resulting in lost economic opportunities, as well as lost opportunities for climate mitigation and adaptation, substitution of non-renewable resources, etc.).

Through the development of data, models and analyses on EU and global biomass flows and their sustainability, the Joint Research Centre has already contributed to the common knowledge base on biomass supply and demand.[250] The Joint Research Centre furthermore carried out studies on the land-use impacts, direct and indirect, resulting from increasing demand for different biomass feedstocks. Even though data are lacking in some areas (waste, bio-based products), significant progress has been achieved with regard to different supply and demand scenarios and their economic, social and environmental impacts. The Joint Research Centre has also established tools that enable forward-looking policy analysis with a specific focus on trade-offs.[251]

The aim of the modelling activities of this action is to provide the assessment and the anticipatory capacity needed to analyse policy scenarios and trade-offs of policy options. This will be based on relevant data, knowledge and intelligence generated in the JRC and from external sources, including through other actions in section 3.3.

<u>This action will:</u>

1) Enhance the knowledge base on EU and global biomass supply, uses and flows.

2) Assess the environmental and socio-economic dimensions of the bioeconomy.

3) Develop and implement modelling tools to support elaboration of scenario development that take into account interaction of different policy fields, to help drive policy coherence across different bioeconomy sectors.

250 Camia et al. (2018). Joint Research Centre Science for Policy Report, doi:10.2760/181536, JRC109869

251 Sector-specific models are extended to capture in detail the impacts of increased biomass usage. In a second step, these models are connected through a modelling framework. The MAGNET model as described in Philippidis G. et al. (2018), Joint Research Centre Technical Report, doi:10.2760/560977, JRC111508. Includes various features for assessing policy coherence in the context of the bioeconomy and SDGs.

4) Make this information available to EU policymakers and any other interested stakeholder in a transparent, tailored, concise and accessible manner through the Commission's Knowledge Centre for Bioeconomy.

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

Complementing existing work, the assessment of ecosystem services will be strengthened and ecosystem service accounts will be developed by the Commission in partnership with Member States to reflect key bioeconomy sectors, in particular for the marine environment and the forests. This will be complemented by further knowledge and research on linkages between biodiversity, ecosystems and their services, sustainability thresholds, and consequences for the resilience of ecosystems.

Indicators: Number of relevant publications; Key recommendations developed; Development of key indicators reflecting: improvement in conservation status of species and habitats; Improvement in good environmental status for marine ecosystems; Increase in area of ecosystems in good condition; contribution of Mapping and Assessment of Ecosystems and their Services (MAES); ecosystem accounts developed in support of the bioeconomy; Input to key IPBES and UN documents and guidelines; Map and statistics of ecosystem state and change; inputs to ecosystem assessments and accounts

Compared to other areas, such as waste and recycling, significantly more knowledge and data are still needed on biodiversity and ecosystems. Ecosystems are complex; there are many different ecosystem types operating at different scales; and they are difficult to measure. Yet this is an urgent need, since ecosystems are being degraded and in some cases in danger of collapse. Without developing this knowledge base, the bioeconomy could end up further putting unsustainable pressures on nature, and destroying the foundations upon which it is built on.

For these reasons, significant and extensive research and development is needed on: Real world experimentation on roles of biodiversity and specific species in ecosystem functioning, reactions to pressures and ability to recover; rapid and effective approaches for measuring ecosystems, biodiversity and resilience; new ways of *working with* nature; Critical behaviour such as tipping points, degree of irreversibility or ecosystem collapse; development of key restoration parameters. Relationship to conservation objectives; research on a range of ecosystems both land-based and aquatic / marine ecosystems. Finally, all this knowledge also needs to be rendered into practical forms for future policy development and natural resource management. This research and development should form a corner stone of this action.

The European Bioeconomy Strategy strives to support the implementation of an ecosystem-based approach to natural resources management, valuing the provision of ecosystem services and stimulate synergies and complementarities with environmental policies on protection of water, soil,

biodiversity and habitats.[252] Ongoing Commission and Member States work on the Mapping and Assessment of Ecosystems and their Services (MAES)[253] and on ecosystem accounting can increasingly support the analysis of trade-offs and synergies amongst ecosystem services and help consider sustainability aspects of biomass production and of the bioeconomy.

The objective of MAES is to provide the evidence and knowledge base on ecosystems and their services in an integrated way to inform land- and sea-based policy and decision-making, linking socio-economic systems with ecosystems via the flow of services, and through the drivers of change that affects ecosystems either as a consequence of using the service or as indirect impacts due to human activities in general. It supports the integration of ecosystems and their services into decision-making, and impact assessment of land and sea-related policies.

Ecosystem accounts at EU level are being developed under the Knowledge Innovation Project on an Integrated accounting system for Natural Capital and ecosystem services (KIP INCA). First pilot ecosystem services accounts have been developed by the Joint Research Centre[254] and further work is planned, with the intention of having a representative set of accounts by 2020. To complement existing work, further ecosystem accounts will be developed under this Action Plan to reflect key ecosystems and their services, their capacity to deliver services sustainably, as well as their contributions to the bioeconomy.

Furthermore, the bio-economy can have large scale effects at EU and global levels. The recent IPBES report points to consumption and production as one other greatest threats to biodiversity next to climate change.

IPCC assessment reports have been successful in outlining key features of risks and opportunities based on extensive modelling and assessments and scenarios. We need the same for biodiversity and ecosystems. The World Economic Forum increasingly features biodiversity loss and ecosystem collapse in the lists of top global risks. The Stockholm Resilience Centre (Rockstrom et al.) places biosphere integrity alongside climate change as key global boundaries that are already being transgressed. Effects of consumption – in the EU – and production – outside the EU – of bio-based products (e.g. palm oil, excessive timber harvesting) is having huge effects of ecosystem degradation.

Further action in this area will be an important contribution of EU knowledge and know-how at global level, of how to tackle these issues at a global and systemic level.

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

As part of the development of the Forest Information System for Europe, specific sections in the system will address the data and information needs to support the sustainable development of the

252 For instance, DG ENV is examining, through a tender study, the implementation of sustainable forest management according to the EU biodiversity strategy and the European Bioeconomy Strategy.

253 http://biodiversity.europa.eu/maes

254 Vallecillo Rodriguez, S. et al. (2018), Joint Research Centre Technical Report, doi:10.2760/619793, JRC110321.

bioeconomy, to support assessing the sustainable availability of domestic biomass resources in the context of climate change and biodiversity loss

Indicators: Forest Information System for Europe (FISE) launched; Technical reports delivered; Solutions identified

A large and growing number of EU and national policies draw on, or affect directly and indirectly, Europe's forest ecosystems and their services. As the need for renewable materials and energy increases, the demand for various types, dimensions and qualities of woody biomass is on the rise as well.[255]

There is hence a need for improved efforts to provide more accurate, frequent and harmonised data and assessment tools on the status and management of forest ecosystems through the FISE, to support the sustainable availability of domestic biomass resources in the context of climate change and biodiversity loss for Europe's bioeconomy. The FISE therefore needs to provide a holistic picture of forest ecosystems as an important part of Europe's natural capital, supporting the required strategic approach that cuts across sectors and policy areas.

In particular, this action would help the European Commission and all other relevant players to a) analyse economic, social and environmental impacts of the future development of the EU's and global bio-based economy on the EU's forest-based and related industries; b) support policy initiatives at EU and Member States levels to mitigate negative impacts but also enable or enhance positive impacts; c) identify other necessary and/or desirable enabling and/or mitigating actions and their actors; d) inform the EU's long-term forest growth and biomass availability scenarios and assessments.

As a basis for this, action is also needed at Member State level to support the activities of national forest inventories and international forest-related data surveys, so as to maintain existing data sets into the future and add new ones emerging, also to help service the bioeconomy and international data surveys, such as the annual Joint Forest Sector Questionnaire (JFSQ), carried out by Eurostat, together with FAO-UNECE and the International Tropical Timber Organization.

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

i) *Increase observation, measurement, monitoring and reporting capabilities on the condition of biodiversity, ecosystems and ecosystem services, to underpin ecosystem conservation and restoration*

This action will advance observation, measurement, monitoring and reporting capabilities on the state and the condition of biodiversity, ecosystems, and ecosystem services through better use of

255 https://publications.europa.eu/en/publication-detail/-/publication/358c6d4b-1783-11e8-9253-01aa75ed71a1/language-en; http://www.efi.int/files/attachments/publications/wsctu_8_2017.pdf

Copernicus services, Sentinel satellite data, INSPIRE in-situ data and other relevant spatially explicit data sources. This will help to better detect and assess trends in biodiversity and ecosystems and progress towards restoring degraded ecosystems. Moreover, it will help provide a sound basis for identifying and prioritising restoration actions.

Indicators: Map and statistics of ecosystem state and change; inputs to ecosystem assessments and accounts.

There is currently a shortage of timely and comprehensive data to adequately assess the condition of ecosystems. It is important to have better and more timely data to be able to quantify the pressures (e.g. land-use change, pollution …) and measure the impact of the bioeconomy on ecosystems and their services (e.g. habitat fragmentation, biodiversity loss …) and how this might affect the basis for economic activities in the long term. This action will help support the provision of timely spatially explicit information on the state and condition of biodiversity and ecosystems. Such action will help populating ecosystem accounts and may contribute to a European monitoring system for the bioeconomy.

This action will be primarily built on the Copernicus program, data and services and the spatial data covered by the INSPIRE Directive, 2007/2/EC, and will make use of other relevant data sources such as citizen science or in situ monitoring networks managed by the Member States. The objective is to strengthen geospatial intelligence capabilities to interpret satellite data to measure the state and condition of biodiversity and ecosystem services in a more timely and comprehensively manner, through better calibration with ground data.

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

This action will develop and implement a comprehensive bioeconomy monitoring framework covering economic, environmental and social dimensions, and make it publicly available via its Knowledge Centre for Bioeconomy. Member States are called upon to collaborate for ensuring that the monitoring systems developed and used at different levels are compatible and complementary.

Indicators: Monitoring framework and set of indicators delivered; Online interface created

The 2017 Review of the 2012 European Bioeconomy Strategy concluded that "*better monitoring and assessment frameworks are needed to assess progress" and that "new actions are needed to develop relevant indicators and scientific evidence for policy making, and to implement a more holistic monitoring and assessment framework*".

This action will:

1) Deliver and implement a simple and comprehensive monitoring framework, covering all aspects of sustainability (economic, social and environmental), with indicators building upon existing and emerging, internationally shared, monitoring and assessment frameworks.[256] This monitoring

256 Eurostat EU SDG Monitoring Report

https://ec.europa.eu/eurostat/documents/2995521/9234939/8-18092018-AP-EN.pdf/888b182d-f6f9-4e0d-9e48-4b4e1561333e

framework will be periodically reviewed. When appropriate, new indicators will be incorporated whilst ensuring continuity of the monitoring.

2) Present the monitoring indicators online, in a visual form, via the Commission's Knowledge Centre for Bioeconomy. A synthesis will be provided periodically in a dedicated report.

The monitoring framework will be developed through a consultative process led by the Joint Research Centre in close collaboration with Member States, other Commission services and key stakeholders. It will rely upon data published and periodically updated by authoritative statistical sources and existing internationally recognised monitoring and reporting frameworks. Thus, the action is not meant to imply additional reporting burdens.

The monitoring framework will also integrate existing Key Performance Indicators and other indicators, including those used for monitoring the Sustainable Development Goals in an EU context. The use of common indicators will ensure the consistency with other international monitoring processes and allow comparability between different Member States and between EU and Member States level assessments.

Knowledge gaps may be identified resulting in suggestions to improve existing data collection exercises, including proposals for new indicators to relevant statistical sources (e.g. EUROSTAT, Food and Agriculture Organization of the United Nations, etc.), and proposal for new research topics.

ii) Increase monitoring of degraded land areas or land at risk of climate change impacts such as desertification, to underpin action for restoration of land based systems

This action will advance spatially explicit mapping of land change primarily by using Copernicus services and Sentinel satellite data, and the space-borne estimation of biomass change. This action will put emphasis on vulnerable and degraded land (e.g. Mediterranean, Eastern Europe).

Indicators: Maps and statistics of land change and biomass; Emissions and removals of greenhouse gasses.

Landscapes often undergo slow directional processes of transformation, often leading to biomass loss. Degraded landscapes may be particularly vulnerable to natural disturbances such as floods or fires, windbreaks which have increased in frequency and/or severity due to climate change and continue causing higher damages to humans and infrastructure. The objectives of this action are: (1) a more effective and appropriate use of natural resources, (2) to reduce GHG emissions, (3) to guide land use practices and objectively informed land use decision making, (4) to take appropriate actions in land management, and (5) to contribute to a uniform European monitoring system from Space.

This action will:

1) Increase knowledge by providing timely spatially explicit information on biomass and (annual) biomass change.

2) Contribute to a European monitoring system for land serving needs across various policy areas and as a basis for forecast and risk maps in the future.

3) help to comply with different policies, regulations and programmes, at EU Level (CAP and climate related measures, LULUCF Regulation (EU)2018/841, INSPIRE) and at global level to land monitoring actions under international conventions and bodies.

This action will be primarily built on the Copernicus program, data and services and make use of space-borne satellites, ground segments and data processing platforms (clouds). Involvement of Member States and private sector is needed for development of new or extended services as well as risk assessment and forecasting.

3.3.3. Provide voluntary guidance to operate the bioeconomy within safe ecological limits

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

Indicators: Improved conservation status of species and habitats under the Nature Directives; Improved environmental status for marine ecosystems under MSFD; Increase in area of ecosystems in good condition following the MAES methodology.

Bioeconomy policy and business need to operate within ecological limits. Increase demand from bioeconomy sectors will lead to increased pressure on nature if it is not properly balanced by the supply of sustainably produced biomass.

Bioeconomy needs to embrace new ways of working with nature. Applying knowledge of ecosystems and services can lead to improved productivity and resilience, such as through crop mixing that improves crop yield, resilience and reduces need for pest control. Guidance is needed on how to make use of ecosystem approaches and function rather than working against them and how to work within safe ecological limits.

Without such guidance that can guide bioeconomy development there is a danger of augmenting pressures on ecosystems. If on the other hand one can guide bio-economy development to more sustainable and ecologically based approaches one can create new "win-win" scenarios.

Guidance on integrating ecosystem services into decision making to be published this year will be developed under the EU Action Plan for People, Nature, and the Economy by 2022, to facilitate the integration of ecosystems and their services into planning and decision-making, taking into account the mitigation hierarchy (avoid-reduce-compensate) that should be followed in order to allow healthy ecosystems to keep providing a range of services.

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

i. Increasing the understanding of microbial biodiversity with a view to develop microbiome-based solutions

This action will foster biodiversity for diverse and sustainable food and primary production systems focussing on microbial biodiversity in the context of agro-, forest- and marine ecosystems and developing microbiome-based solutions. It will build on existing initiatives and projects such as the International Bioeconomy Forum or ongoing Horizon 2020 and national projects. Cooperation across disciplines and with stakeholders across sectors and borders will be sought.

Indicators: Roadmap development, number of EU R&I projects on microbiomes; Number of international partners in EU R&I microbiomes projects (development of an R&I community); Enlargement of the IBF partners (consolidation of networks); Establishment of test cases for practices in primary production which make use of benefits from microbial diversity; EUR invested in relevant research projects; Number of relevant research projects

The microbiome is commonly defined as a community of microorganisms (e.g. bacteria, fungi, viruses) and their genomes that inhabit a particular environment (e.g. body, plants and animals, soil, water). Even though current knowledge on existing microbiomes is limited, unravelling their complexity offers enormous potential for finding sustainable ways to manage our planet, develop bioeconomy potential, understand and preserve biodiversity in natural systems and primary production, and address multiple Sustainable Development Goals. The resulting knowledge, discoveries and enabling technologies and practices can help to develop applications within or across human, plants and animal health, food production, consumption and safety, and the environment—all contributing to robust and sustainable bioeconomies while preserving the intrinsic value and biodiversity of our terrestrial and aquatic ecosystems.[257]

The scientific community has logged the difficulties and dimensions of the challenge and has called for an interdisciplinary international initiative[258] to complement ongoing efforts.[259]

This action will:

1) Promote coordination, exchange of practices and Research and Innovation in this domain, thereby contributing to sustainable food system transformation. Activities will furthermore contribute to biodiversity-rich practices in primary production. The active participation of Member States, International partners, Industry, Academia, farming, forestry, fisheries, NGOs and other relevant stakeholders will be sought.

257 http://mbio.asm.org/content/7/3/e00714-16.full

258 A unified initiative to harness Earth's microbiomes. Science 30 Oct 2015: 507-508; Create a global microbiome effort. Nature 29 Oct 2015: 526, 631–634

259 http://www.earthmicrobiome.org/

2) Promote coordination with existing Horizon 2020, microbiome consortia and national initiatives and cross-disciplinarity. This will take into account on-going and upcoming microbiome activities of the International Bioeconomy Forum.

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

This action will step up efforts to increase knowledge about drivers of agro-biodiversity and to enhance (bio)diversity in agricultural production by mobilising instruments (such as the EU R&I FP, EIP AGRI, LIFE) in a synchronised way.

Indicators: Action plan established; number of projects/activities funded; number of demonstration activities; number of stakeholders from farming community involved; Enhance biodiversity protection (% of species and habitats of Community interest related to agriculture with stable or increasing trends); CAP biodiversity indicators; MAES indicators on the condition of agro-ecosystems

Agricultural biodiversity (including functional biodiversity) underpins the delivery of ecosystems services and plays a significant role in conferring stability, resilience and adaptability to farming systems.[260] Despite its importance, diversity in agriculture is declining as manifested by the decline of pollinators and other insects or the limited use of genetic resources in plant and animal production.

This action will:

1) Step up efforts to increase knowledge about drivers of agro- ecology (such as nutrient flows) and enhance more diverse production systems. Due attention will be given to promoting the integration of diversity into farming practices (inter and intraspecific diversity) and creating incentives for wider biodiversity management. A better use of genetic resources will benefit the creation of new food and non-food value chains.

2) Create a roadmap for action on agro-ecology bringing together different instruments (e.g. EU R&I, EIP AGRI, LIFE) and use them in complementary ways towards common action lines. Work under the various instruments will bring together a range of actors from the agricultural, environmental and other domains and allow to better link research, demonstration, innovation and testing activities. A main ambition is to promote a community of practice and a strategy on agro-ecology, the latter one complementing the EU Biodiversity strategy. While having a focus on Europe, activities will capitalise on international expertise and initiatives.

260 http://teebweb.org/agrifood/wp-content/uploads/2018/06/Foundations_vJun26.pdf

iii. Developing tools for the integration of pollinators and pollination service into the design of sustainable biomass supply value chains

Member States are called on to strengthen investments into knowledge base on pollinators and pollination by supporting the deployment of an EU scheme for monitoring pollinators, in line with the EU Pollinators Initiative. This action will provide technical support to Member States in implementing the monitoring scheme. Based on acquired monitoring data, this action will develop tools for policy makers and land managers, such as an atlas of pollinators and pollination service, and explore options to build an early warning system for pollination deficit.

The private sector is called upon to use these tools to evaluate their dependency on pollinators, assess future risks and develop risk mitigation strategies in regards to pollination deficit.

Indicators: Full extent of pollinator decline in the EU assessed; systemic monitoring of the status and trends of pollinators established; Number of sectoral policies developed to mitigate causes of pollinator decline; number of bioeconomy companies undertaking actions on pollinators

In the EU wild pollinators have seriously declined in occurrence and diversity: According to the European Red List almost one in ten bee and butterfly species is facing extinction and around one-third of species has a declining population.[261] For bumblebees, the best studied group of wild bees, nearly one in four species is facing extinction and almost half of the species experience negative population trends. Around 4 in 5 crop and wild flowering plant species depend, at least in part, on animal pollination.

The pollinator decline will have far-reaching consequences not only on insect-pollinated plants, but also on the health of terrestrial ecosystems, therefore posing fundamental risks not only to food security, but to all the economic activities that depend directly or indirectly on those ecosystems. Agriculture and related industries are particularly dependent. The value of the direct contribution of insect pollinators to the EU agricultural output has been estimated at around EUR 15 billion per year.[262] For particular crops, the impact of insect pollination on profit margins and viability of businesses is very significant. For example, 20% of the market value of oilseed rape can be attributed to insect pollination and half of the market value of strawberries,[263] blueberries or apples[264] can depend on insect pollination.

In June 2018 the Commission adopted the first-ever EU initiative[265] to tackle the decline of pollinators and avoid its negative consequences. Strong knowledge base is a key prerequisite for the conservation of pollinators and the initiative lists a number of actions to this aim. Monitoring of pollinators and their habitats is particularly important. It provides data that makes possible to assess the status and trends of pollinators, and based on that the sustainability of the pollination service. As this service is critical for maintaining the natural resources base on which bioeconomy depends, monitoring of pollinators in effect provides information on the sustainability of bioeconomy.

261 http://ec.europa.eu/environment/nature/conservation/species/redlist/bees/status.htm

262 Gallai N. et al., Ecological Economics, 68, 3, 810-821, (2009), doi: 10.1016/j.ecolecon.2008.06.014

263 Klatt B. K. et al., Proceedings of the Royal Society: Biological Sciences, 281, 2013-2440, (2014), doi: 10.1098/rspb.2013.2440

264 De Groot G. et al., De bijdrage van (wilde) bestuivers aan de opbrengst van appels en blauwe besse. Alterra, Wageningen UR, Alterra rapport 2636.

265 https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1531117569875&uri=CELEX:52018DC0395

Moreover, coupling pollinator data with information on land use (available through for example LUCAS[266] or the CAP's management system IACS[267]) makes it possible to develop tools for policy makers and land managers (such as an atlas) and build an early warning system for pollination deficit. Such system would be able to predict future risks and guide effective targeted mitigation actions in nature conservation and land management sectors to ensure sustainable pollination.

Through the pollinators initiative this action will devise an EU-wide monitoring scheme for pollinators. The links to bioeconomy are inherent and the strategy will showcase the importance of this process and facilitate its development and implementation. Member States will play an indispensable role in deploying the scheme on the ground. It will be important to secure adequate technical capacity in Member States to ensure smooth and harmonized implementation of the scheme across the EU. The private sector across the biomass supply chain should be encouraged to use the information acquired though the monitoring to assess risks of the pollinators decline to their businesses. This will increase the sector's awareness about the problem and support development of risk mitigations strategies in this regard.

266 http://ec.europa.eu/eurostat/statistics-explained/index.php/LUCAS_-_Land_use_and_land_cover_survey

267 https://ec.europa.eu/agriculture/direct-support/iacs_en