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

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**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**

{SWD(2018) 431 final}

1. Introduction

We live in a world of limited resources. Global challenges like climate change, land and ecosystem degradation, coupled with a growing population force us to seek new ways of producing and consuming that respect the ecological boundaries of our planet. At the same time, the need to achieve sustainability constitutes a strong incentive to modernise our industries and to reinforce Europe's position in a highly competitive global economy, thus ensuring the prosperity of its citizens. To tackle these challenges, we must improve and innovate the way we produce and consume food, products and materials within healthy ecosystems through a sustainable bioeconomy.

Sustainable & Circular: Bioeconomy the European way

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 (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.¹ To be successful, the European bioeconomy needs to have sustainability and circularity at its heart. This will drive the renewal of our industries, the modernisation of our primary production systems, the protection of the environment and will enhance biodiversity.

The purpose of this update to the 2012 Bioeconomy² Strategy is to address these challenges through a set of 14 concrete actions which will be launched in 2019 at the latest.³ These actions reflect the conclusions of the 2017 review of the Strategy.⁴

2. How the Bioeconomy contributes to EU's priorities

This update to the 2012 Bioeconomy Strategy will maximise the contribution of the bioeconomy to major European policy priorities.⁵

Sustainability is not only a legal obligation, it is an opportunity for all parts of Europe and underpins most EU priorities.⁶ The EU is already a global leader in the sustainable use of

¹ Biomedicines and health biotechnology are excluded.

² COM(2012)60, Innovating for Sustainable Growth: A Bioeconomy for Europe, 13.02.2012.

³ 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.

⁴ SWD(2017)374, Review of the 2012 European Bioeconomy Strategy, 13.11.2017.

⁵ Letter of Intent, State of the Union, September 2018; https://ec.europa.eu/commission/sites/beta-political/files/soteu2018-letter-of-intent_en.pdf

⁶ COM(2016)739, Next steps for a sustainable European future: European action for sustainability, 22.11.2016.

natural resources within an efficient bioeconomy, which is essential to most of the Sustainable Development Goals.⁷

With a turnover value of €2.3 trillion and accounting for 8.2% of the EU's workforce,⁸ the bioeconomy is a central element to the functioning and success of the EU economy. The deployment of a sustainable European bioeconomy would lead to the **creation of jobs**, particularly in coastal and rural areas through the growing participation of primary producers in their local bioeconomies. In the bio-based industries **one million new jobs** could be created by 2030, according to industry estimates.⁹ The strong and fast-growing startup ecosystem in the biotechnology sector will play a leading role in realising this potential.

A sustainable European bioeconomy is necessary to build a carbon neutral future in line with the **Climate objectives of the Paris Agreement**. For instance, in the construction sector engineered wood offers great environmental benefits as well as excellent economic opportunities. Studies show that the average impact of building with 1 ton of wood instead of 1 ton of concrete could lead to an average reduction of 2.1 tons of carbon dioxide emissions over the complete life cycle of the product (including use and disposal).¹⁰ A sustainable bioeconomy is also essential to the reduction of emissions in the European Energy sector. Bioenergy, currently the EU's largest renewable energy source, is expected to remain a key component of the energy mix in 2030 and contribute to meet the EU renewable energy targets of 20% in 2020 and of at least 32% in 2030.¹¹ Sustainable primary production on land and sea underpins the overall sustainability of the bioeconomy and will provide 'negative emissions' or carbon sinks, in line with the commitments of the Paris Agreement.

A sustainable European bioeconomy supports the **modernisation and strengthening of the EU industrial base** through the creation of new value chains and greener, more cost-effective industrial processes. By capitalising on unprecedented advances in life sciences and biotechnologies, as well as innovations merging the physical, digital and biological worlds, the European industrial base can maintain and enhance its global leadership. Research and innovation and the deployment of innovative solutions for the production of new and sustainable bio-based products (such as bio-chemicals, bio-fuels, etc.) will also enhance our capacity to substitute fossil raw materials in very significant parts of European industry (e.g. construction, packaging, textiles, chemicals, cosmetics, pharma ingredients, consumer goods)

⁷ SWD(2016)390, Key European action supporting the 2030 Agenda and the Sustainable Development Goals, 22.11.2016 ; Eurostat SDGs monitoring report.

<https://ec.europa.eu/eurostat/documents/2995521/9234939/8-18092018-AP-EN.pdf/888b182d-f6f9-4e0d-9e48-4b4e1561333e>; JRC Report, The MAGNET model framework for assessing policy coherence and SDGs – Applications to the bioeconomy, 2018, ISBN 978-92-79-81792-2.

⁸ Ronzon, T. et al., Sustainability, 10, 6, 1745, (2018), doi: 10.3390/su10061745; annual figure (data relative to 2015).

⁹ EuropaBio Report, Jobs and growth generated by industrial biotechnology in Europe, 09.2016.

¹⁰ How can wood construction reduce environmental degradation?, Elias Hurmekoski (2017) http://www.efi.int/files/images/publications/efi_hurmekoski_wood_construction_2017.pdf

¹¹ Directive of the European Parliament and the Council on the promotion of the use of energy from renewable sources (recast), formal adoption expected by the end of 2018 following the agreement at political level by the European Parliament and the Council on 13 June 2018.

in line with the renewed Industrial Policy objectives.¹² According to the projections of the industry, the demand for industrial biotechnologies is expected to almost double within the next decade.¹³

A sustainable bioeconomy is the renewable segment of the **circular economy**. It can turn bio-waste, residues and discards into valuable resources and can create the innovations and incentives to help retailers and consumers **cut food waste by 50%** by 2030. For example, in the livestock sector innovations increasingly allow to safely turning certain food waste into feed for animals, provided the applicable rules and legal requirements are observed.¹⁴ It is estimated that the land - currently used to feed animals - that could be saved through these innovations could feed three billion additional people.¹⁵ **Cities should become major circular bioeconomy hubs.** Circular urban development plans could translate into very significant economic and environmental gains. For instance, 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 annually.¹⁶ For Europe's 50 largest cities, representing 11% of EU population, combined effects would be at least 50 times higher.

Supporting **healthy ecosystems** is a European priority. The bioeconomy can contribute to restoring ecosystems, for instance achieving **plastic-free seas and oceans**. The European Environmental Agency already advises that bio-based, biodegradable materials alternative to plastics should be used where the risk of dispersion into the ecosystem is high, such as lubricants, materials subject to wear and tear, and disposable products.¹⁷ Furthermore a sustainable bioeconomy will contribute to the Sustainable Development Goals target of achieving **land degradation neutrality** by 2030 and to the ambition of restoring at least 15% of degraded ecosystems by 2020.¹⁸

Realising this potential will not happen on its own. It requires investments, innovation, developing strategies and implementing systemic changes that cut across different sectors (agriculture, forestry, fisheries, aquaculture, food, bio-based industry). It means enhancing our capacity to translate opportunities from all types of innovation into new products and services on the market, creating new jobs locally. And it means doing it the European way: being economically viable with sustainability and circularity in the driver's seat.

¹² COM(2017)479, Investing in a smart, innovative and sustainable Industry A renewed EU Industrial Policy Strategy, 13.09.2017.

¹³ EuropaBio Report, Jobs and growth generated by industrial biotechnology in Europe, 09.2016.

¹⁴ Guidelines for the feed use of food no longer intended for human consumption; [https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018XC0416\(01\)&from=EN](https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018XC0416(01)&from=EN)

¹⁵ <https://eu-refresh.org/eu-panel-experts-concludes-feeding-treated-surplus-food-pigs-viable-provided-certain-safety-0>

¹⁶ "Circular Amsterdam: a vision and action agenda for the city and metropolitan area", Circle Economy, Fabric.two and Gemeente Amsterdam, 2016.

¹⁷ EEA Report No 8/2018 - The circular economy and the bioeconomy Partners in sustainability, ISSN 1977-8449.

¹⁸ Decision no. 1386/2013/ EU on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet', 20.11.2013.

Maximising the impact of EU Research and Innovation is key in this respect¹⁹. Regulation and financing must be innovation friendly for Europe to become a front-runner in market creating innovation. This was stressed by the recent Renewed European Agenda for Research and Innovation.²⁰ Horizon 2020 and the European Regional Development Fund, in a complementary fashion, will continue to deliver important Research and Innovation outputs that can address cross-cutting challenges and opportunities in the bioeconomy. The Commission proposals for the next Multiannual Financial Framework for 2021-27 intend to give a significant boost for systemic research and innovation in the areas and sectors covered by the bioeconomy, in particular with EUR 10 billion foreseen²¹ for the Horizon Europe cluster for "Food and Natural Resources".²² This recognition is also reflected in many Smart Specialisation Strategies that identified bioeconomy related priorities, and in the teaming up of regions in bioeconomy-related Smart Specialisation Platforms and partnerships with a view to facilitating the involvement of EU regions²³. Research and innovation in the bioeconomy is also an important domain for cooperation at the global level.

However, it is necessary to move beyond research and innovation and have a strategic and systemic approach to the deployment of innovations to fully reap the economic, social and environmental benefits of the bioeconomy. Such an approach should bring together all actors across territories and value chains to map the needs and actions to be taken. It will require addressing the systemic challenges that cut across the different sectors, including synergies and trade-offs, to enable and speed up the deployment of circular economy models. And this approach will have to make the most of all tools and policies available; exploiting synergies with other EU and national funds and instruments, in particular the Common Agricultural Policy, Common Fisheries Policy as well as the cohesion policy and Financial Instruments under the InvestEU Programme.

3. Unlocking the potential of the bioeconomy

The 2012 Bioeconomy Strategy's aim 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" still holds today. The Review of this Strategy²⁴ recognised success, notably at mobilising research and innovation, boosting private investments, developing new value chains, promoting the

¹⁹ COM(2018)2, Horizon 2020 interim evaluation: maximising the impact of EU research and innovation, 11.01.2018.

²⁰ COM(2018)306, A renewed European Agenda for Research and Innovation – Europe's chance to shape its future, 15.05.2018.

²¹ COM(2018)321, A Modern Budget for a Union that Protects, Empowers and Defends – The Multiannual Financial Framework for 2021-2027, 02.05.2018.

²² COM(2018)435 Establishing Horizon Europe – the Framework Programme for Research and Innovation, laying down its rules for participation and dissemination, 07.06.2018.

²³ <http://s3platform.jrc.ec.europa.eu/s3-thematic-platforms>

²⁴ SWD(2017)374, Review of the 2012 European Bioeconomy Strategy, 13.11.2017.

uptake of national bioeconomy strategies and involving stakeholders. The review concluded that the five objectives of the 2012 Bioeconomy Strategy remain valid.

While it acknowledged the contributions of the Bioeconomy Strategy to both the Circular Economy and the Energy Union, it also highlighted that the scope of its objectives needs to be adapted, in line with the overall European priorities. The actions should consequently be refocussed to maximise their impact on these priorities - in particular as set out in the renewed Industrial Policy,²⁵ the Circular Economy Action Plan,²⁶ and the Clean Energy for All Europeans Package.²⁷

The first objective, *ensuring food and nutrition security*, remains critical. Food and farming systems account for about three quarters of the overall bioeconomy employment and about two thirds of bioeconomy turnover. However their sustainability is challenged by a growing world population, changing consumption practices and nutrition, unsustainable biomass use and waste, and climate change threats.²⁸ The transformation towards sustainable, healthy, nutrition-sensitive, resource-efficient, resilient, circular and inclusive food and farming systems needs to accelerate. This includes turning organic waste, residues and food discards into valuable and safe bio-based products, for instance by deploying small-scale biorefineries, helping farmers, foresters and fishermen to diversify their revenue sources and better manage market risks, all while achieving the goals of the Circular Economy.

The second objective, *managing natural resources sustainably*, is more important than ever in the current context of increasing environmental pressures and biodiversity loss.²⁹ Timely action is needed to avoid ecosystem degradation, restore and enhance ecosystem functions, which can increase food and water security, and contribute substantially to the adaptation and mitigation of climate change through “negative emissions” and carbon sinks.³⁰ In particular, the preservation and productivity of healthy ecosystems in seas, oceans, forests and soils depends on biodiversity. We also need to improve our capacity to monitor and forecast the state and development of our natural resources.

The third objective, *reducing dependence on non-renewable, unsustainable resources whether sourced domestically or from abroad*, is vital to deliver the EU’s energy and climate targets, as bioenergy, currently the EU’s largest renewable energy source, is expected to remain a vital component of the energy mix in 2030.³¹ A stronger bio-based sector can accelerate the substitution of non-renewable resources in line with the EU’s commitments under the Paris Agreement. Moreover, industrial symbiosis and innovative industrial bio-

²⁵ COM(2017)479, Investing in a smart, innovative and sustainable Industry A renewed EU Industrial Policy Strategy, 13.09.2017.

²⁶ COM(2015)614, Closing the loop – An EU action plan for the circular economy, 02.12.2015.

²⁷ COM(2016)860, Clean Energy for All Europeans – unlocking Europe’s growth potential, 30.11.2016

²⁸ COM(2017) 713, The Future of Food and Farming, 29.11.2017; SWD(2016)319: European Research and innovation for Food and Nutrition Security, 21.09.2016.

²⁹ COM(2015)478, The Mid-term Review of the Biodiversity Strategy to 2020, 02.10.2015; European Environment Agency, The European environment: state and outlook 2015.

³⁰ Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Summary for policymakers of the thematic assessment of land degradation and restoration, 2018.

³¹ SWD(2016) 418, Part 4/4, Impact Assessment on the Sustainability of Bioenergy, 30.11.2016.

based processes³² contribute to the greening of industries and development of circular bioeconomies and products, for instance by innovating the way cities add value to their significant share of bio-waste.

The fourth objective, *mitigating and adapting to climate change*, has established itself as the global challenge of this generation. Within the Long Term Greenhouse Gas Emission Reductions Strategy, a sustainable and circular bioeconomy is key to achieve a greenhouse gas neutral Europe. Furthermore, a sustainable bioeconomy has large potential to reduce greenhouse gases emissions by promoting more resource efficient, active and sustainable primary production practices on land and sea, as well as by enhancing the capacity of ecosystems to regulate climate, for instance through the deployment of carbon farming innovations.

The fifth objective, *strengthening European competitiveness and creating jobs*, is a core policy objective of the bioeconomy. Providing frameworks for developing and deploying innovations and fostering the development of markets for bio-based products, e.g. through public procurement,³³ creation of standards, renewable energy policies and carbon pricing, will support the global competitiveness and transformation of European industries.⁵ The bioeconomy offers important opportunities for new jobs regional economic development and improved territorial cohesion, also in remote or peripheral areas. It has the potential to provide an important source of income diversification for farmers, foresters and fishermen, and to boost local rural economies through increased investment in skills, knowledge, innovation and new business models, as recommended in the 2016 Cork 2.0 declaration.³⁴

4. Actions leading the way towards a sustainable, circular bioeconomy

To support the five objectives in the context of evolved policy priorities, this updated strategy proposes three main action areas:

1. strengthen and scale-up the bio-based sectors, unlock investments and markets
2. deploy local bioeconomies rapidly across Europe;
3. understand the ecological boundaries of the bioeconomy.

The proposed actions capitalise on and go beyond previous successful Research and Innovation investments. The action plan applies a systems-approach in order to develop and scale up the bioeconomy and ensure its overall sustainability and circularity. It embraces multiple sectors and policies related to the bioeconomy, interlinks them, facilitates coherence and synergies, addresses trade-offs such as competing use of biomass, and provides a blueprint that will help the Union to develop the potential of bioeconomy and use it to effectively deliver on many of its policy objectives. The actions will be implemented within

³² EuropaBio Report, Jobs and growth generated by industrial biotechnology in Europe, 09.2016

³³ https://ec.europa.eu/growth/content/guidance-bio-based-products-procurement_en and <https://biobasedprocurement.eu/>

³⁴ Cork 2.0 Declaration - A Better Life in Rural Areas, 2016.

the existing international context of the International Bioeconomy Forum³⁵ and the Global Bioeconomy Summit³⁶ to foster synergies with like-minded actions by partners.

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

To accelerate the development and deployment of sustainable and circular bio-based solutions, on which the modernisation, strengthening and competitiveness of our industrial base depend, the EU will intensify the **mobilisation of public and private stakeholders, in research, demonstration and deployment of bio-based solutions** (Action 1.1). This includes, for example, the promotion of technologies such as artificial intelligence and innovative solutions that are suitable for small scale deployment and easy to replicate. Under Horizon 2020, the EU public-private partnership on Bio-Based Industries has been instrumental in the development and deployment of new bio-based value chains, based on the use of renewable resources including waste.³⁷ This action will result in the development of a tool-box of solutions to process biomass into bio-based products that will support the modernisation and the renewal of our industries in a number of areas.

In addition to research and innovation grants under Horizon 2020, the EU will deploy a targeted financial instrument - the **EUR 100 million Circular Bioeconomy Thematic Investment Platform**³⁸ (Action 1.2) - to de-risk private investments in sustainable solutions. This will build on and reinforce synergies with on-going and future EU initiatives, such as the Capital Markets Union, the InvestEU Programme, the Common Agricultural Policy and the ETS Innovation Fund.

To realise its potential, the bio-based sector needs to be further promoted for its positive impacts, and to be on equal footing with market and regulatory conditions vis-à-vis fossil-based industries. This action will **identify bottlenecks, enablers, and gaps affecting bio-based innovations, provide voluntary guidance on** their deployment at scale, with a view to promoting existing standards and labels and assessing the need for developing new ones, particularly for bio-based products (Action 1.3).

In order to boost market uptake and consumer confidence, it is necessary to use multiple instruments. This requires the availability of reliable and comparable **environmental performance information** and their application to environmental oriented policy instruments (e.g. the EU Ecolabel and green public procurement), when proven beneficial from an environmental perspective. The generation and use of data shall be compliant with the **Product Environmental Footprint** method. Other aspects to be covered include the

³⁵ <https://ec.europa.eu/research/bioeconomy/index.cfm?pg=policy&lib=ibf>

³⁶ <http://gbs2018.com/home/>

³⁷ Interim Evaluation of Bio-Based Industries Joint Undertaking (2014-2016) operating under Horizon 2020, 10.10.2017, ISBN 978-92-79-67438-9.

³⁸ This financial instrument is delivering on the financial pillar of the Circular Economy Finance Support Platform: http://europa.eu/rapid/press-release_IP-17-104_en.htm

promotion and development of **standards**, which can serve to verify the products' properties, as a basis for existing voluntary labels (Action 1.4). Overall, actions will contribute to the diversification, development and deployment of bio-based solutions. In addition, they will seek to facilitate the **development** of new sustainable biorefineries and confirm the type and estimated potential, current estimates being around 300 new **biorefineries** (Action 1.5).³⁹ This will be done based on the availability of sustainably sourced resources.

Finally, in an effort to contribute to the global challenge of **plastic-free-oceans** whilst offering growth prospects for innovative bio-based business models and products, actions will channel the potential of the bioeconomy to contribute to tackling plastic pollution⁴⁰ in European seas and oceans, and in inland waters, and to restore water quality and ecosystems (Action 1.6). The action will, for example, mobilise the key actors in the plastics value chain to support the development of substitutes to fossil resources, in particular bio-based, recyclable and marine biodegradable substitutes for plastic.

4.2 Deploy local bioeconomies rapidly across Europe

The European Commission will actively support and promote all types of innovations and practices **for sustainable food and farming systems, forestry and bio-based production** through a systemic and cross-cutting approach linking actors, territories and value chains. It will develop a Strategic Deployment Agenda (Action 2.1) which will provide a long-term vision on pathways to deploy and scale up the bioeconomy in a sustainable and circular manner. This systemic approach will address, amongst others, the following areas:

- Future proofing food and farming systems (terrestrial and aquatic) by addressing e.g. food waste, losses and by-products (including nutrient recycling), resilience, the need for nutrition-sensitive food production, more food from the sustainable use of seas and oceans⁴¹ with increased share of EU aquaculture production and market uptake.
- Bio-based innovations including in farming, to develop new chemicals, products, processes and value chains for bio-based-markets in rural and coastal areas, with involvement and increased benefits for primary producers.
- New opportunities arising for the forestry sector in view of replacing non-sustainable raw materials in construction, packaging with bio-based materials and for providing more sustainable innovations in sectors such as forestry-based textiles, furniture and chemicals, and new business models based on the valuation of forestry ecosystem services.

³⁹ OECD, Meeting Policy Challenges for a Sustainable Bioeconomy, 2018, ISBN 9789264292345 ; BIO-TIC, A roadmap to a thriving industrial biotechnology sector in Europe, 2015.

⁴⁰ Building on and feeding into the EU Plastic Strategy, COM/2018/028, A European Strategy for Plastics in a Circular Economy, 12.01.2018.

⁴¹ SAM Scientific Opinion No. 3/2017, Food from the Oceans, 2017, ISBN 978-92-79-67730-4.

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

Concrete actions to develop this Strategic Deployment Agenda will showcase the vast potential of the **bioeconomy for rural, coastal, and urban areas development**. Pilot actions will be implemented (Action 2.2), which will enhance synergies between **existing EU instruments to support local activities**, introducing a more explicit focus on the bioeconomy. In a first round, five pilot actions will be launched:

- A "Blue Bioeconomy" pilot will unlock the potential of blue bioeconomy approaches in coastal areas and islands. The EU Strategy for the Baltic Sea region has proven to be a good bottom-up vehicle to direct existing funds towards locally adapted bioeconomy models⁴². Similar actions are proposed to be extended to other sea basins, as well as coastal and maritime areas, including through the use of the European Maritime and Fisheries Fund.
- Specific interventions will be developed under the Common Agricultural Policy to support **inclusive bioeconomies in rural areas**. The aim is to better link national bioeconomy strategies and national strategic plans under the Common Agricultural Policy. Dissemination of good practices to foster the deployment of the bioeconomy will enable primary producers to benefit from the opportunities that new systemic bioeconomy approaches offer.
- The **Urban bioeconomies pilot** will enable 10 European cities to turn organic waste from a societal problem into a valuable resource for the production of bio-based products. Furthermore, the rehabilitation of brownfields and application of circular-bioeconomy processes and technologies within urban areas should be further developed to diversify the sustainable sourcing of biomass and to create new business opportunities.
- The **pilot on carbon farming** will encourage Member States to establish a fund to buy carbon credits from farmers and forest owners who implement specific projects that aim at increasing soil and biomass carbon sequestration and/or reducing emissions in the livestock sector or that are related to fertilizer use.
- **"Living labs" will be set-up to develop and test place-based innovations based on ecological approaches and circularity in primary production and food systems**. This will allow adapting innovations to site-specific needs, involving the relevant stakeholders and facilitating their further adoption and deployment.

In order to ensure that all territories of the Union have the opportunity to develop their bioeconomy potential, an **EU bioeconomy policy support facility for Member States** (Action 2.3) will be set up under Horizon 2020. It will support the development of

⁴² SWD(2017)128, Report on the Blue Growth Strategy Towards more sustainable growth and jobs in the blue economy, 31.03.2017; SWD(2017)118, European Union Strategy for the Baltic Sea Region, 20.03.2017.

national/regional bioeconomy strategies, including remote areas and candidate and accession countries.⁴³

The systemic and cross-cutting nature of new and emerging bioeconomy approaches and new value chains will need new **education and skills** (Action 2.4). These must be adapted to different needs across bioeconomy sectors (e.g. at the interface of agronomy, biorefining, ecology and other disciplines), to be capable of responding quickly and flexibly to the emerging and ever-growing needs of the bioeconomy. The piloting of vocational and higher education curricula, the involvement of social partners and the development of entrepreneurship programmes will contribute to this action.

4.3 Understand the ecological boundaries of the bioeconomy

For the bioeconomy to deliver on sustainability, we must be able to better understand and measure its effects and impacts on the ecological boundaries of our planet. This is necessary to develop the bioeconomy in a way that attenuates pressures on the environment, values and protects biodiversity and enhances the full range of ecosystem services. The following actions aim at increasing the overall knowledge and monitoring of the bioeconomy. All of them respond to the need to have an in depth knowledge of the sustainable biomass supply limits at the local, regional and global level. This knowledge will feed into the other operational actions of this strategy. These actions will provide the foundation to reinforce the resilience of land and marine ecosystems, enhance their biodiversity and ensure their contribution to climate mitigation while transforming our fossil-based economy into a bio-based economy.

Enhancing the **knowledge base** and **understanding** of specific bioeconomy areas (Action 3.1) will be based on acquiring **more data**, generating **better information** and **systemic analysis** (for example through artificial intelligence) of **data and information** including:

- The status and resilience of terrestrial (agricultural and forest) and marine ecosystems and their biodiversity. This includes their related socio-economic costs and benefits, and their capacities to serve as a sustainable domestic biomass source, to sequester carbon and to increase climate resilience.
- The sustainable biomass availability as well as public and private bioeconomy investments.

Enhancing the knowledge base will include forward looking, cross-sectoral assessments, modelling and scenarios. Progress in the bioeconomy will be systematically monitored for a responsible and inclusive governance and coherent policy-making. The **status of biodiversity, ecosystem, degraded land areas and land at risk of climate change impacts**, such as desertification will also be monitored, to restore land based and marine ecosystems.

⁴³ For example, the BIOEAST initiative offers a shared strategic research and innovation framework for sustainable bioeconomies in Central and Eastern Europe; <http://www.bioeast.eu/>

The Commission will implement an EU-wide, **internationally coherent monitoring system** (Action 3.2) to track the progress towards a sustainable, circular bioeconomy in Europe and to underpin related policy areas. Knowledge gained will be used to provide voluntary guidance for **operating the bioeconomy within safe ecological limits** (Action 3.3).

The benefits from biodiversity-rich ecosystems will be better integrated in primary production through a specific support to agro-ecology, the development of microbiome-based solutions, new tools to integrate pollinators in value chains and specific support for agro-ecology (Action 3.4).

The data and information generated in these actions will be made publicly available through the Knowledge Centre for Bioeconomy.

5. Conclusion

The finite biological resources and ecosystems of our planet are essential to feed people, provide clean water and affordable and clean energy. A sustainable bioeconomy is essential to tackle climate change and land and ecosystem degradation. It will address the growing demand for food, feed, energy, materials and products due to an increasing world population, and reduce our dependence on non-renewable resources.

Deploying a sustainable and circular bioeconomy will boost the competitiveness of the bioeconomy sectors and support the creation of new value chains across Europe while enhancing the overall status of our natural resources. Such a bioeconomy will rely and capitalise mainly on domestically available sustainable renewable resources, and on advances in sciences, technologies and innovations merging the physical, digital and biological worlds, in some of the EU's most significant sectors and industries.

This Strategy proposes actions to support rural and coastal development, also in remote areas, ensuring a more proportionate sharing of the benefits of a competitive and sustainable bioeconomy across European territories and value chains. These actions will ensure that the bioeconomy respects the limits of our planet. A sustainable bioeconomy must value natural resources and diminish environmental pressures and increase the use of sustainable renewable products, restore and enhance ecosystems' functions and biodiversity. It will promote more sustainable, circular and post-waste food systems and primary production on land and sea.

Delivering a sustainable circular bioeconomy means that our economic prosperity and the health of our environment will mutually reinforce one another. To ensure the effective delivery of the proposed policy goals, the Commission will report regularly on the progress of the Action Plan and is committed to adapting or discontinuing activities that do not contribute to the objectives of the Strategy in a satisfactory manner.

Action Title	Who
1 Strengthen and scale-up the bio-based sectors, unlock investments and markets	
1.1 Mobilise public and private stakeholders, in research, demonstration and deployment of sustainable, inclusive and circular bio-based solutions	Commission, Member States and Regions, stakeholders
1.2 Launch of the EUR 100 million Circular Bioeconomy Thematic Investment Platform	Commission
1.3 Study and analysis of enablers and bottlenecks and provide voluntary guidance to the deployment of bio-based innovations	Commission
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	Commission and Member States/stakeholders
1.5 Facilitate the development of new sustainable biorefineries and confirm the type and estimated potential ⁴⁴	Commission and Member States
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	Commission, stakeholders

⁴⁴ Some reports estimate this potential with up to 300 new biorefineries by 2030

Action Title	Who
2 Deploy local bioeconomies rapidly across Europe	
2.1 A Strategic Deployment Agenda for sustainable food and farming systems, forestry and bio-based production in a circular bioeconomy	Commission, Member States, private sector, stakeholders
2.2 Pilot actions to support local bioeconomy development (rural, coastal, urban) via Commission instruments and programmes	Commission, Member States, regions, municipalities and other stakeholders
2.3 Set up an EU Bioeconomy policy support facility and a European Bioeconomy Forum for Member States	Commission and Member States
2.4 Promote education, training and skills across the bioeconomy	Commission and Member States
3 Understand the ecological boundaries of the bioeconomy	
3.1 Enhance the knowledge on the bioeconomy, including on biodiversity and ecosystems, to deploy it within safe ecological limits and make it accessible through the Knowledge Centre for Bioeconomy	Commission, Member States, International Organisations, IPBES
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	Commission , Member States, private sector
3.3 Provide voluntary guidance to operate the bioeconomy within safe ecological limits	Commission
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	Commission, Member States, private stakeholders