Conceptual Framework and Key Terms

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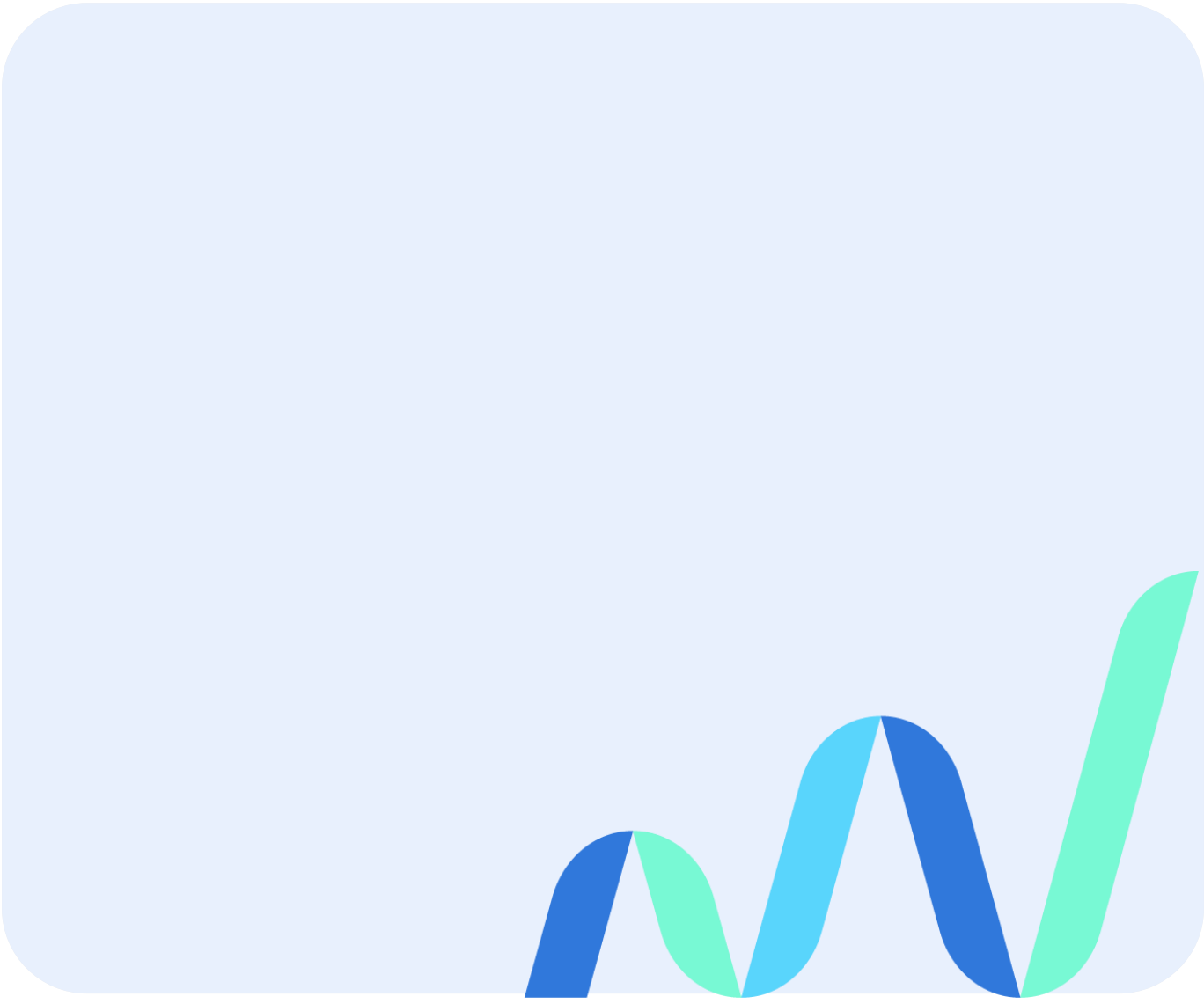
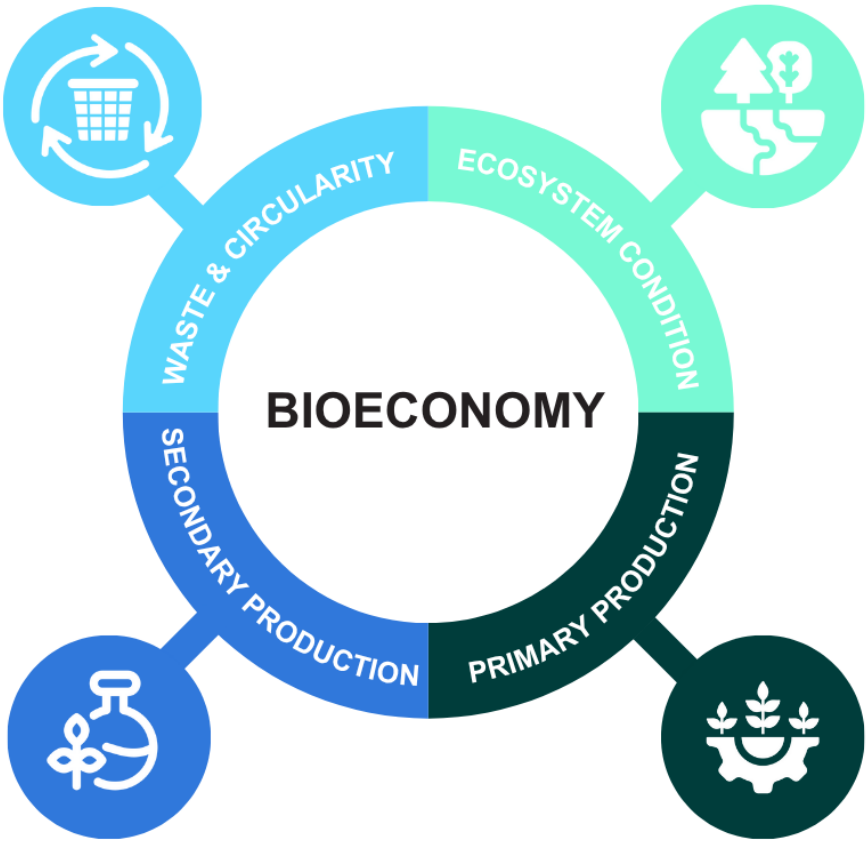


Figure 1. Four Pillars of the Bioeconomy



Source: adapted from EU Bioeconomy Monitoring System, 2025

Waste and circularity are the processes of recovering and managing biowaste and food waste. It includes waste management services that recover or recycle these materials so that they can be transformed into new products or energy.

Ecosystem condition describes the quality of freshwater, marine, agricultural, forest and urban ecosystems. It includes ecosystem management services, which help maintain ecosystems in a healthy and well-functioning state.

Primary production is the part of the economy that produces biomass. Included within this sector are the agricultural, forestry, fishing and aquaculture industries.

Secondary production transforms raw biomass into value-added products. This sector includes the food, bioenergy, biochemical and biomaterial industries.

Key Terms

Term	Definition
Agricultural (green) biotechnology	A range of scientific techniques (e.g. gene editing, molecular diagnostics) aimed at improving plants, animals and microorganisms in order to achieve sustainable farming with the best yield potential (e.g. breeding more resistant crops and plants) and minimal negative environmental impacts (e.g. minimising the use of chemical fertilisers). Biotechnologies are also used to address environmental problems (e.g. to purify pollutants with enzymes or microorganisms).[1]
Agri-food sector	The overall sector combines agriculture and food production, emphasizing a sustainable food and agricultural production system, and encompasses the entire food supply chain.[2]
Alternative proteins	Proteins that are available as an alternative to meat, fish, eggs and dairy products, extracted or produced from plants, animal cells (see cultured meat) or by fermentation using microorganisms (bacteria, yeasts, fungi). Proteins extracted from insects, macro and microalgae are also considered alternative.[3]
Anaerobic digestion	Process in which microorganisms break down biodegradable material in the absence of oxygen.[4]
Bio-based	Derived from biomass. Biomass can have undergone physical, chemical or biological treatment(s).[5]
Bioeconomy	The sustainable production of renewable biological resources and the recycling of those resources and waste streams into value-added products (food, feed, biotechnology products and bioenergy).[6] The

[1] Prospects for the development of the bioeconomy in Europe and Lithuania

[2] https://monitor-industrial-ecosystems.ec.europa.eu/sites/default/files/2020-09/ATI%20Technological%20trends%20in%20the%20agri-food%20industry.pdf

[3] Defining alternative proteins

[4] https://task39.ieabioenergy.com/wp-content/uploads/sites/37/2013/05/IEA-Task-39-Current-Status-and-Potential-of-Algal-biofuels0.pdf; Darzins, A., Pienkos, P. and Edye, L., 2010, Current status and potential for algal biofuels production. A report to IEA Bioenergy Task 39, Report T39-T2, August 2010.

[5] EN 16575:2014, European Committee for Standardisation, Technical Committee 411 (CEN TC/411), Bio-based products – Vocabulary, Mandate M/492, August 2014.

[6] Innovation for sustainable growth. Bioeconomy for Europe (2012)

	bioeconomy encompasses all sectors and systems that use biological resources (animals, plants, microorganisms and their biomass, including organic waste), their functions and principles.[7] Sustainability and circularity are identified as key principles of the bioeconomy.
Biofertilser	Formulation of microorganisms, mostly bacteria, fungi, or cyanobacteria, which on application to plants or soil helps in improved plant growth, development and soil quality.[8]
Biogas	Gas, rich in methane, which is produced by the fermentation of animal dung, human sewage or crop residues in an air-tight container. It is used as a fuel to heat stoves, lamps, run small machines and to generate electricity.[9]
Biomass	Renewable organic matter composed of living organisms: plants, animals, microorganisms. Biomass is used for food, feed, biotechnological products (e.g. bioplastics) and as an energy source (heating, electricity, fuel). Examples of biomass as a raw material can be agricultural crops, algae, wood, sawdust, straw, manure, paper waste, household waste and wastewater.[10]
Biomass valorisation	A process by which biomass (e.g. plant biomass),[11] its by-products, residues and waste are converted into energy and high value-added materials and products.
Bioplastic	An umbrella term for plastics (polymers) that are made from biomass (see bioplastics) and/or are biodegradable (see biodegradable plastics). Bioplastics are usually made from biopolymers.[12]
Biopolymer	A broad term that includes polymers that are produced from biological raw materials (e.g. plants) or that are produced by microorganisms.[13] A distinction is made between natural biopolymers (cellulose from wood, silk from silkworms, collagen from animals) and synthetic

[7] A sustainable European bioeconomy. Strengthening the economic, societal and environmental nexus (2018)

[8] Nidhi Bharti, Mangesh Suryavanshi, Chapter 10 - Quality control and regulations of biofertilizers: Current scenario and future prospects, Biofertilizers, 2021, Pages 133-141, ISBN 9780128216675,

[9] EEA, European Environment Agency, Glossary, accessed 22 November 2023.

[10] Bioeconomy: Biomass and biomass-based energy supply and demand

[11] Recent advances in the valorisation of plant biomass

[12] What are "Bio-plastics"?

[13] Biopolymer - an overview | ScienceDirect Topics

	biopolymers developed as analogues of natural polymers. Petroleum products are not used for the production of biopolymers.
Bioreactor	A vessel in which controlled, favourable conditions are created for biological reactions and desired biological processes to take place. They create a favourable environment for enzymes, microorganisms, plant and animal cells, and tissues to grow.[14]
Biorefinery	Where biomass is converted into food, food ingredients, flavours, chemicals, bioproducts, materials, fuels and energy through the integration of a wide range of technologies. The goal of biorefineries is to use raw materials as efficiently as possible, i.e. adding the greatest economic value and minimizing the impact on the environment. Three generations of biorefining plants are distinguished according to the raw materials that are processed.[15]
Biotechnology	The application of science and technology to living organisms, as well as their parts, products and models, in order to replace living or inanimate substances for the creation of knowledge and services, for the production of products. The definition includes not only all modern biotechnology, but also many traditional or marginal activities. For statistical calculations, the *The Organisation for Economic Co-operation and Development* (OECD) recommend adding a biotechnology-based definition to this definition (example in the document). Biotechnology, due to its diversity and different applications in the scientific literature, is divided according to colours (example). The following are definitions of those biotechnologies whose application corresponds to the scope and theme of the project.[16]
By-product	An incidental product deriving from a manufacturing process or chemical reaction, and not the primary product or service being produced. A by-product can be useful and marketable, or it can have negative ecological consequences.[17]
Blue economy	All economic activities related to the oceans, seas and coasts. The European Union's Blue Economy Report (2023) also includes the blue

[14] Bioreactor - an overview | ScienceDirect Topics

[15] BIC fact sheet: Biorefineries

[16] Revised proposal for the revision of the statistical definitions of biotechnology and nanotechnology

[17] https://sor.epa.gov/sor_internet/registry/termreg/searchandretrieve/termsandacronyms/search.do; US EPA, 2015, Terminology Services. U.S. Environmental Protection Agency, accessed 4 December 2023.

	biotechnology sector (see marine biotechnology). Algae (macro and micro), bacteria, fungi and invertebrates are important raw materials in the blue economy.[18]
Carbon capture, utilisation and storage	The term CCUS comprises a chain of technologies, with each of the steps (capture, transport, utilization and/or storage) being independent from the other ones and containing several sub-technology choices.[19]
Carbon footprint	A measure of the total amount of CO_2 and CH_4 emissions of a defined population, system or activity, considering all relevant sources, sinks and storage within the spatial and temporal boundary of the population, system or activity of interest. Calculated as CO_2e using the relevant 100-year global warming potential (GWP100).[20]
Cascading use	The efficient utilisation of resources by using residues and recycled materials for material use to extend total biomass availability within a given system. From a technical perspective the cascading use of wood takes place when wood is processed into a product, and this product is used at least once more either for material or energy purposes.[21]
Cellular agronomy	The use of cell cultures (plants, animals, microorganisms) for the production of agricultural products. It can be considered an alternative to traditional animal husbandry and crop production. Sustainability in food production and food safety are important aspects in this area.[22]
Circular bioeconomy	A regenerative industrial system in which end-of-life is replaced by the idea of restoration or regeneration. The circular bioeconomy aims to use renewable energy sources, eliminate the use of toxic chemicals and waste generation through the use of superior design materials, products, systems and business models.6 Circular bioeconomics includes sustainable, resource-efficient recovery of biomass (see biomass valorisation) in integrated, multi-production chains (e.g. biorefineries) that utilise residues and waste and optimise the value of biomass over time.[23]

[18] The EU blue economy reports 2023

[19] https://www.tandfonline.com/doi/full/10.4155/cmt.10.39

[20] Laurence A Wright, Simon Kemp & Ian Williams (2011) 'Carbon footprinting': towards a universally accepted definition, Carbon Management, 2:1, 61-72, DOI: 10.4155/cmt.10.39

[21] Vis M., U. Mantau, B. Allen (Eds.) (2016), Study on the optimised cascading use of wood. No 394/PP/ENT/RCH/14/7689. Final report. Brussels 2016. 337 pages

[22] Cellular agriculture — industrial biotechnology for food and materials - ScienceDirect

[23] The circular bioeconomy: Its elements and role in European bioeconomy clusters

Circular economy	An economic system that aims to completely avoid waste and pollution throughout the life cycle of materials, from their extraction to their transformation in industry and their availability to end-users in all relevant ecosystems. At the end of the operational phase, the materials are returned to the industrial process or, in the case of organic waste, back to the environment as part of a natural regenerative cycle, while maintaining their highest possible value.[24]
Cultivated meat	Meat that is made from cultured animal cells. This method of production is a potential alternative to animal husbandry. The structure of cultivated meat at the cellular level is very close to or the same as that of traditional meat.[25]
Green economy	An umbrella term[26] that encompasses circular economy and bioeconomy concepts such as renewable resources, environmentally friendly use of resources.
Industrial (white) biotechnology	Industrial biotechnology that is applied to the industrial processing and production of chemicals, materials and fuels, using microorganisms (yeasts, bacteria, fungi) or their components (enzymes). The aim of industrial biotechnology is to produce products more efficiently on an industrial scale (e.g. using less energy, creating fewer by-products) or to develop materials and chemical compounds with properties that the traditional petrochemical industry cannot offer. Industrial biotechnology is applied in different sectors, such as chemical, pharmaceutical, textile, energy industries, in the production of food and feed, materials and polymers from renewable raw materials. Industrial biotechnology also includes cellular agronomy (see cellular agronomy).[27]
Life cycle assessment (LCA)	A structured, comprehensive, and internationally standardised method for evaluating environmental impacts associated with goods or services ("products"). It quantifies all relevant emissions, resource use, and related impacts across the entire life cycle — from raw material extraction, production, and use, to recycling and waste disposal. LCA

[24] Compass for the transition of Lithuanian industry to a circular economy (2021)

[25] The science of cultivated meat | GFI

[26] Green Economy; Green, circular, bio economy: A comparative analysis of sustainability avenues

[27] Industrial Biotechnology; The colours of biotechnology: general overview and developments of white, green and blue areas

	serves as a key decision-support tool for sustainable production and consumption in the EU bioeconomy.[28]
Marine (blue) biotechnology	Studies marine biodiversity (organisms, cells, genes) with a view to developing new useful products (e.g. enzymes used in the food and pharmaceutical industries, biopolymers). Marine biotechnology can help strengthen sustainable and safe food sources, environmental protection, energy security, and contribute to green growth in many sectors.[29]
Nature-based solutions (NBS)	Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions.[30]
Novel food	Novel Food is defined as food that had not been consumed to a significant degree by humans in the EU before 15 May 1997, when the first Regulation on novel food came into force. 'Novel Food' can be newly developed, innovative food, food produced using new technologies and production processes, as well as food which is or has been traditionally eaten outside of the EU.[31]
Precision fermentation	A fermentation process that is optimized by using modified microorganisms as "cell factories" for the production of high-value functional food ingredients (e.g. proteins, enzymes, lipids, carbohydrates, vitamins, etc.).[32]
Product environmental footprint (PEF)	The Product Environmental Footprint (PEF) is a lifecycle assessment-based method to quantify the environmental impacts of products (goods or services). It builds on existing approaches and international standards. The overarching purpose of PEF information is to enable to

[28] https://eplca.jrc.ec.europa.eu/uploads/ILCD-Handbook-General-guide-for-LCA-DETAILED-GUIDANCE-12March2010-ISBN-fin-v1.0-EN.pdf

[29] Smart Specialisation and Blue biotechnology in Europe

[30] https://research-and-innovation.ec.europa.eu/research-area/environment/nature-based-solutions_en

[31] https://food.ec.europa.eu/food-safety/novel-food_en

[32] Fermentation for future food systems: Precision fermentation can complement the scope and applications of traditional fermentation: EMBO reports: Vol 22, No 5 (embopress.org)

	reduce the environmental impacts of goods and services taking into account supply chain activities (from extraction of raw materials, through production and use and to final waste management).[33]
Technology readiness level (TRL)	A scale from 1 to 9 used to assess the maturity of a technology—TRL 1 is basic principles observed, TRL 9 is fully deployed, and industrial production has started. In the EU, it's used to determine readiness, guide funding calls, and benchmark innovation progress.[34]
Upstream processes	The sequence of processes aiming at growing, harvesting and drying the microalgae biomass, as well as producing the lipids, carbohydrates and proteins that will be further processed in downstream processes.[35]

Note: The table is adapted from the project "Lietuvos biotechnology sektoriaus konkurencingumo pasaulinėje bioeconomic vertinimas" developed by Rasa Mončiunskaitė. The original document can be found here.

[33] Zampori, L. and Pant, R., Suggestions for updating the Product Environmental Footprint (PEF) method, EUR 29682 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-00654-1, doi:10.2760/424613, JRC115959.

[34] https://euraxess.ec.europa.eu/career-development/researchers/manual-scientific-entrepreneurship/major-steps/trl

[35] The impact of Biofuels on transport and environment, and their connection to the agricultural development in Europe