



Food and Agriculture
Organization of the
United Nations

BIOECONOMY

BIOECONOMY FOR A SUSTAINABLE FUTURE

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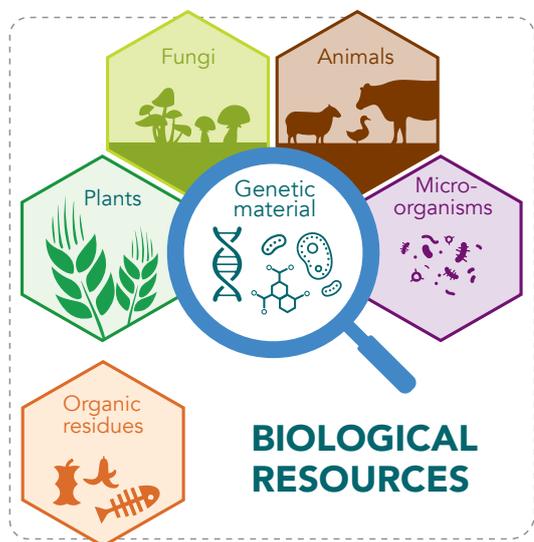
This information brief describes what the bioeconomy is. It looks at how the bioeconomy can contribute to sustainable production and consumption and resource-use efficient agri-food systems in an economically, socially and environmentally sustainable manner and what the Food and Agriculture Organization of the United Nations (FAO) is doing to support this.

1 What is the Bioeconomy?

The bioeconomy is commonly referred to as the “production, utilization, conservation, and regeneration of biological resources – including related knowledge, science, technology, and innovation – to provide sustainable solutions (information, products, processes and services) within and across all economic sectors and enable a transformation to a sustainable economy” (IACGB, 2020).

FAO promotes the bioeconomy because it plays a fundamental role in achieving the Sustainable Development Goals (SDGs), including those related to sustainable production and consumption, food security and nutrition, climate change, biodiversity, and the environment.

By integrating evidence-based policies and practices, and using technological, organizational and social innovations, the bioeconomy can deliver economic value while improving environmental and social outcomes.



2 Biological resources and biomass

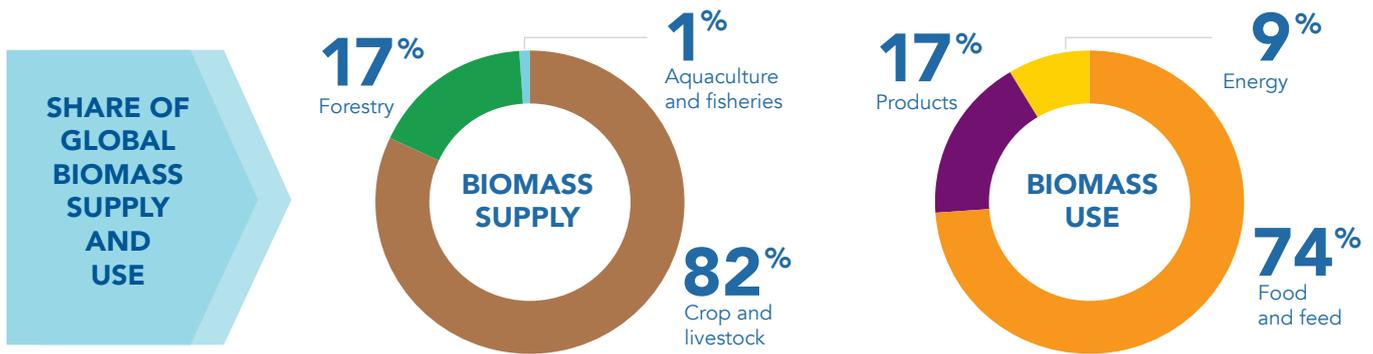
Biological resources are at the heart of the bioeconomy. These resources include genetic resources, organisms or parts thereof, populations, or any other biotic component of ecosystems with actual or potential use or value for humanity (CBD, 1992).

Biomass, which refers to the mass of living organisms, is an important element of the world’s biological resources and the basis of global agri-food systems. Biomass is used in the production of food, feed, agricultural products, chemicals, textiles, energy and a range of different bio-based services.

3 Global biomass supply and use

As of 2018, the total global biomass supply from crops, livestock, forests and aquatic resources is estimated at about 23.2 billion tonnes annually. This figure is expected to increase to 26.7 billion tonnes in 2030 (WBCSD, 2020).





4 Biomass in a circular economy

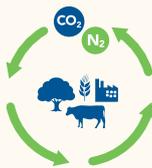
About 22 percent of the total market size of the bioeconomy has been estimated to come from food and feed loss and waste (WBCSD, 2020). Food loss and waste is equivalent to about 1.6 billion tonnes of food yearly, and it is expected to grow to 2.1 billion tonnes by 2030 (UNEP, 2021; FAO, 2021a).

However, biomass coming from food loss and waste can still be used in a productive and regenerative way. For example composting, which supports soil health, helps optimize the value of discarded food and other forms of biomass over time, leading to the notion of a “circular bioeconomy”, where biological materials are repurposed, reused, recycled and renewed.

Here are just **five bio-innovations that contribute to a circular bioeconomy**:

- 1** Insect protein for animal feed can be safely produced from food loss and waste.


- 2** Bioremediation that relies on the soil microbiome can provide organic nutrients to the soil and help restore degraded land and ecosystems.


- 3** Biologicals, such as biopesticides, biofertilizers and biostimulants can improve crop protection and enhance plant health, contributing to reduce food losses.


- 4** Micro-organisms such as microalgae can be used in wastewater treatment processes to recover nitrogen and phosphorous that can be used as fertilizers.


- 5** Biodegradable and compostable products, such as food packaging made from fermented cheese whey and filter material from almond shells, can make separation and management of organic waste easier and reduce the amount of plastics disposed in landfills and waterways.





5 Beyond biomass – bio-based processes and biotechnology

The bioeconomy is not only about biomass, it also promotes bio-based processes and tools carried out by and with the help of micro-organisms, animal and plant cells and their components. These processes and tools include breeding, bioinformatics, technologies and methods for data analysis and production processes for industrial biotechnology.

Biotechnology includes traditional, low-tech approaches, such as microbial fermentation, to more advanced technology-driven approaches such as bionics, artificial intelligence, and carbon capture (WBCSD, 2020; Gomez San Juan and Bogdanski, 2021). Examples include:

- **Fermentation**, where micro-organisms convert sugars from plants, animals or residues into alcohol or acid for the production of food additives, bioethanol, biopharma, or bioproducts, such as biofertilizer. For instance, today, 100 percent of vitamin B2 on the global market is produced by fermentation using industrial biotechnology (WBCSD, 2020);
- **Carbon capture**, where micro-organisms such as microalgae capture carbon emissions from farms, landfills or heavy industry, and convert atmospheric carbon into valuable materials; and
- **Digital sciences and data analysis** tools, which can optimize and upscale all these applications – e.g. biotechnology is used for plant and animal disease diagnosis, cell culture, bio-based sensors and for the characterization and conservation of genetic resources for food and agriculture (Gomez San Juan and Bogdanski, 2021; FAO, 2021b).



6 Bioeconomy across the economic sectors

The bioeconomy encompasses all three economic sectors:

- The primary sector, such as agriculture, forestry, fisheries and aquaculture.
- The secondary sector, including the food and beverages sector and the so-called bio-based industries, such as those producing chemicals, pharmaceuticals, paper and paper products, wood-based materials, textiles, biofuels and bioelectricity.
- The tertiary sector, such as food service activities, ecotourism, water supply, waste and water treatment, retail as well as biological research, development and innovation.

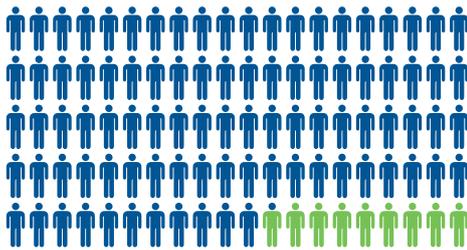




7 Value, turnover and employment (European Commission, 2020)

While there is no estimate for the global value of the bioeconomy, regional and national calculations show that the bioeconomy adds significant economic value and generates employment.

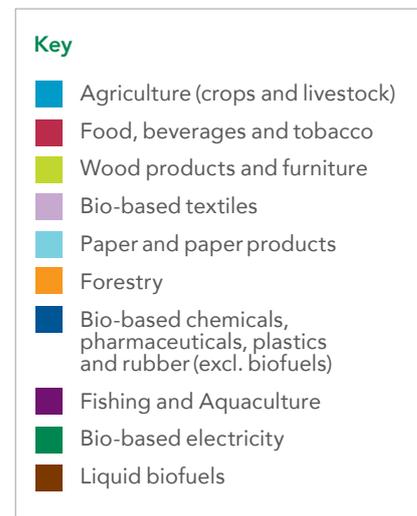
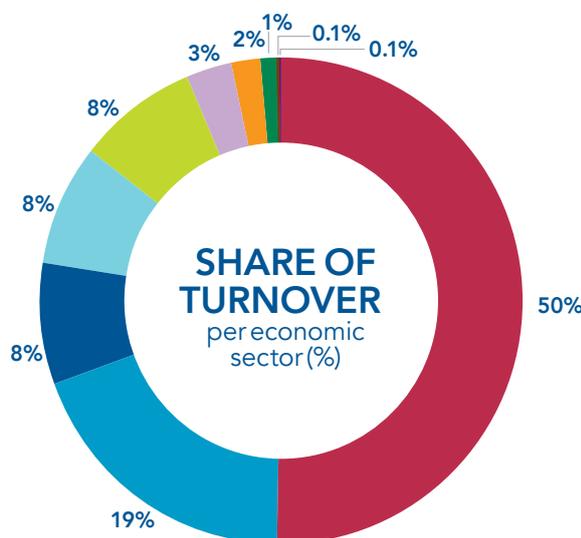
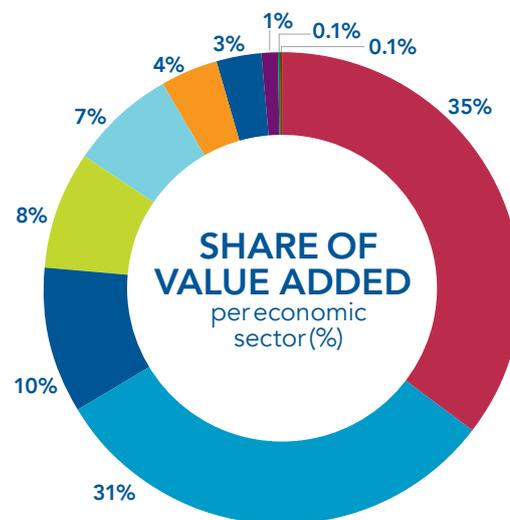
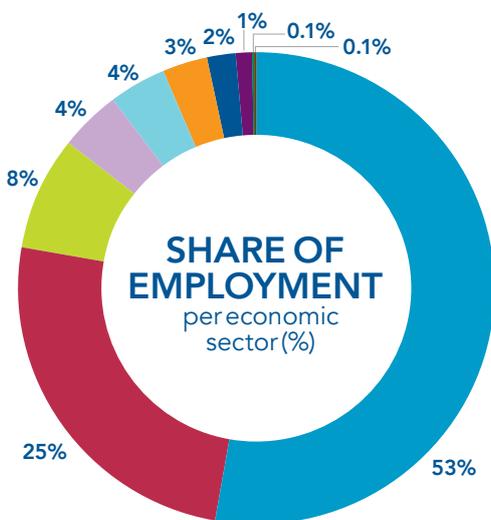
For instance, the bioeconomy within the 27 states of the European Union (EU-27) created up to EUR 614 billion of value added in 2017, which represents 4.7 percent of GDP of the EU-27. This was based on a turnover in the bioeconomy of EUR 2.2 trillion in the EU-27 in 2017. The bioeconomy within the EU-27 also employed 17.5 million people in 2017, representing 8.9 percent of the total labour force.



The bioeconomy within the EU-27 in 2017 employed **17.5 MILLION PEOPLE**

8.9% OF THE TOTAL LABOUR FORCE

Share of employment, value added, and turnover per economic sector of the EU Bioeconomy in 2017 (Ronzon et al., 2020)





8 **FAO's role in promoting bioeconomy strategies**

FAO supports countries to access data, information and knowledge on environmental and social opportunities and risks of bio-based innovations in agri-food systems.

FAO provides policy guidance and technical support to assist policymakers in establishing and implementing national and regional strategies, action plans, and programmes to develop a sustainable and circular bioeconomy in line with the SDGs.

FAO also promotes science-based policy dialogue to develop coherent strategies across and within economic sectors. It facilitates communication on sustainable circular bioeconomy for food and agriculture, partnerships and knowledge-sharing between governments, development partners, civil society and the private sector at global, regional and national levels.

Many countries and regions have developed bioeconomy strategies to promote the sustainable production and consumption of biological resources in recent years and many more are following suit.

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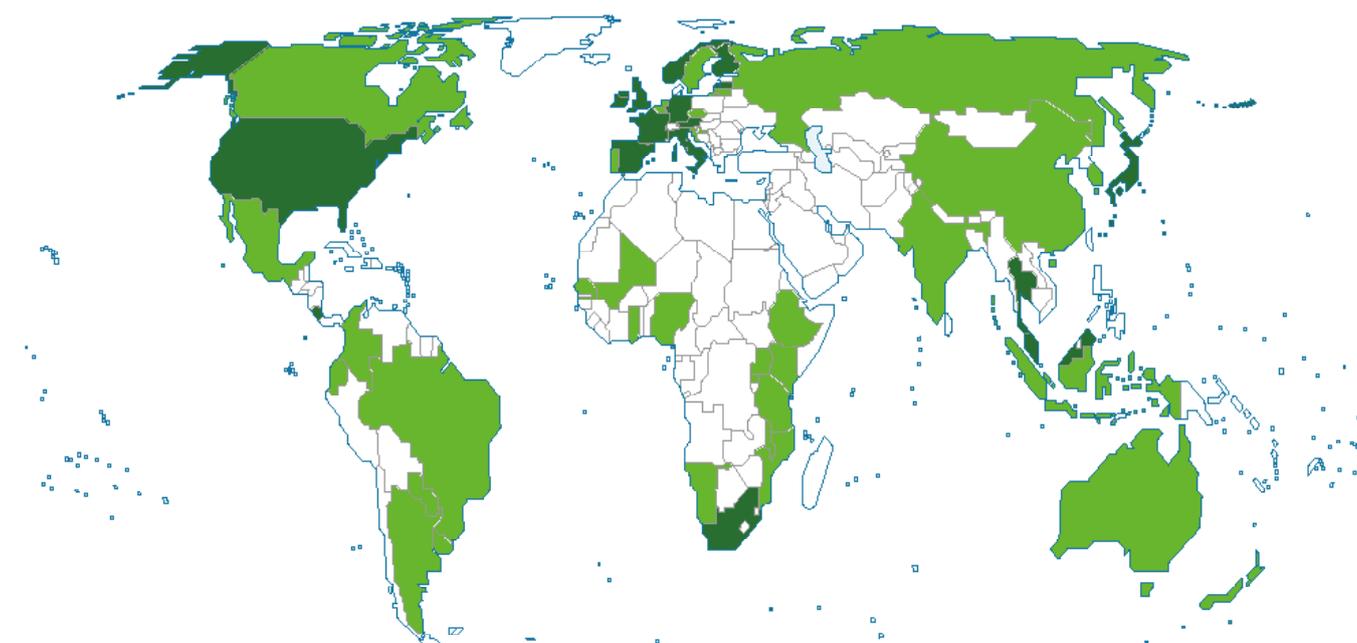
countries and regions have bioeconomy or bioscience-related strategies

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of which have published dedicated bioeconomy strategies, including in Africa, Asia, Europe, Oceania and the Americas.

Not one bioeconomy is the same. There are many bioeconomies in the world and even in the same region or country, as the variety of different bioeconomy strategies clearly shows:

Bioeconomy strategies around the world (German Bioeconomy Council, 2021)



- Dedicated bioeconomy strategy
- Related bioeconomy strategy

Map conforms to United Nations World Map 4621, Feb 2021.

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

9 Sustainability

The bioeconomy can contribute to a more sustainable future with greener, safer and more equitable societies. Agri-food systems in particular have great transformational potential since they occupy the biggest share of the bioeconomy from an economic value-added perspective. Nevertheless, the cross-cutting nature of the bioeconomy poses challenges with regards to different sustainability goals and aspirations, inclusivity and governance.

To address this, FAO developed a set of **Aspirational Principles and Criteria for Sustainable Bioeconomy**, with the support of the International Sustainable Bioeconomy Working Group (ISBWG), a multi-stakeholder group established in 2016.

The **ten Principles** provide a reference list of issues to be addressed when developing and implementing a sustainable bioeconomy at international, national and local levels. They ensure that bioeconomy strategies embed different local priorities and sustainability goals, while addressing global issues and contributing to the achievement of the SDGs.

Aspirational Principles and Criteria for Sustainable Bioeconomy (FAO, 2021c)





10 Bioeconomy monitoring and evaluation

Economic, social and environmental criteria guide monitoring and evaluation (M&E) systems and keep countries on track to meet global goals. Reliable and holistic M&E systems are an essential component of good governance and to assess the progress of bioeconomy strategies and their strategic objectives (Giuntoli *et al.*, 2020; Bracco *et al.*, 2019).

Natural capital accounting¹ has been proposed as a tool to measure the changes in the stock of natural capital at a variety of scales and to integrate the value of ecosystem services into bioeconomy M&E systems. Beyond M&E, natural capital accounting can support decision-making on policies and investments.

¹ Natural capital accounting systems can enable to explicitly account for the range of ecosystems and their services and demonstrate in monetary terms the benefits of investing in nature and the sustainable management of resources (EC, 2021).

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