

SCIENCE FOR GLOBAL TRANSFORMATION
BIOECONOMY: PUSHING THE WORLD TOWARD A SUSTAINABLE PLANET
Task Force 2 - Preliminary Document

Introduction

The world is coming to a point of non-return in the XXI century concerning:

- a) climate changes related to the effect of greenhouse gas emissions from fossil energy sources, burning and anaerobic fermentation of biomasses, methane from ruminants' digestion, and the use of soluble fertilizers rich in nitrogen.
- b) the global economy, from the onset of the Industrial Revolution on, is settled mainly on natural finite resources.
- c) ever-increasing consumption of industrial goods, which produces daily megatons of non-recyclables that cause an impact on human health and the environment, unbalancing soil health and aquifers.

The protection of the biodiversity has historically contrasted with an economic model based on the exploitation and extraction of natural resources, leading to the loss of substantial portions of different biomes. It seems that the current scenario of biome exploitation leads to severe losses in the biodiversity they harbor. It is in this scenario that researchers from various fields of knowledge are dedicated to discussing and modeling alternative forms of development that can combine these two tasks. These efforts appear to be coalescing around a concept that is still evolving: bioeconomy.

Science uniquely contributes to overcoming the world's challenges nowadays in different fields. Sequestration of CO₂ into biomass is a viable alternative. However, to increase the stock of stable carbon (C), it is urgent to find ways and means to develop knowledge and technology for C sequestration into chemicals with a long half-life. Biomass production in the ongoing technological packages requires soil amendments and mineral sources to produce soluble macro and micronutrients.

The world has limited sources for industrial production of soluble phosphorus and potassium fertilizers. This opens an avenue for international cooperation to build scientific knowledge to unravel the role of soil microbiota on soil remineralizers (rock dust). In doing so, a more sustainable agrifood system spearheaded by the private sector shall occur. Crop diversification using the potential of plant biodiversity is linked to improved nutrition and tackling the effects of global warming on food and bioenergy production.

Human health, nutrition and livelihood are hurdles to overcome at the global scale. In less developed countries, poverty, lack of housing and jobs, associated with tropical diseases and malnutrition, impair the social and economic development of the nations, creating an unbalanced world. In the long term, all countries should work together, looking forward to healthy and stable economies and building peace and well-being for human society.

The living systems are the way to build up chemicals of a distinct nature for different purposes using direct or indirect solar energy. Furthermore, they can recycle a vast range of biomasses for industrial purposes/or environmental health, besides having a central role in the bioeconomics related to human, animal, and plant health.

Bioeconomy Concepts

A standard definition of bioeconomy is a crucial step for bioeconomy deployment within the G20 countries, building up partnerships essential in meeting the UN requirements aiming at a long-lasting sustainable, economic, and social development coupled with an ever-healthy environment.

Looking at the bioeconomy programs and related policies of the countries members of the G20, it is clear that the concept of bioeconomy varies depending on the region's technological, social, and economic development. To make this point, let us look at a few cases:

- The International Advisory Council on Global Bioeconomy (IACGB) defines bioeconomy 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”¹.
- According to FAO, “bioeconomy is 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”².
- The European Commission defines a bioeconomy as “the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy”³. The bioeconomy is meant to be sustainable, as it promotes the responsible production and consumption of goods without causing detriment to the natural environment.
- In the United States, bioeconomy can be defined as “the portion of the economy based on products, services, and processes derived from biological resources (e.g., plants and microorganisms). (...) Executive Order 14081 prescribes a “whole-of-government approach to advance biotechnology and biomanufacturing towards innovative solutions in health, climate change, energy, food security, agriculture, supply chain resilience, and national and economic security”⁴.
- Germany defines bioeconomy as “the production, exploitation and use of biological resources, processes and systems to provide products, processes and services across all economic sectors within the framework of a future-oriented economy”⁵.
- The Brazilian Center for Strategical Studies (CGEE) understands that bioeconomy is “the economy based on the production and consumption of goods and products made from biological resources.

¹ The International Advisory Council on Global Bioeconomy (IACGB) – What is Bioeconomy (<https://www.iacgb.net/GLOBAL>).

² Food and Agriculture Organization of the United Nations – Sustainable bioeconomy and FAO (<https://www.fao.org/documents/card/en?details=cb7445en#:~:text=Bioeconomy%20is%20the%20production%2C%20utilization,enable%20a%20transformation%20to%20a>).

³ Publications Office of the European Union – Blue Bioeconomy Forum (<https://op.europa.eu/en/publication-detail/-/publication/c8b2f69f-4314-11ea-b81b-01aa75ed71a1/language-en>).

⁴ Congressional Research Service – White House Initiative to Advance the Bioeconomy, E.O. 14081: In Brief (<https://crs-reports.congress.gov/product/pdf/R/R47274>).

⁵ The Federal Government – National Bioeconomy Strategy (https://www.bioeconomy-international.de/lw_resource/datapool/_items/item_169/summary_bioeconomy_strategy.pdf).

Modern bioeconomy emerges as a new paradigm of development needed to ensure the sustainable development of life on Earth because it is based on renewable biological resources, the advancement of science and technology, the discovery of new materials and processes capable of regenerating nature and restoring the resilience of ecosystems”⁶.

Bioeconomy is present today in the production of vaccines, industrial enzymes, fertilizers, biofuels, cosmetics, among many other examples. Furthermore, it should seek to value the role that local communities play in the conservation of territories, studying their traditional modes of production and resource management to find sustainable solutions for production chains in dialogue with science and technology.

In general, we can say that a bioeconomy model should aim to meet certain criteria:

- 1) Preserve and protect natural resources. The natural resources present in any biome are the result of long geoevolutionary processes that provide the foundations for more sustainable and inclusive production chains. Drastically interrupting these processes can lead to irreversible losses.
- 2) Adopt appropriate technologies. Using natural resources efficiently requires technologies for the main production bottlenecks without causing environmental harm. Importing technologies is not enough, as some of these solutions were developed for other contexts with different specificities and are not universal. Therefore, it is necessary to invest in local science and technology designed for local problems.
- 3) Respect local communities. Traditional communities possess profound knowledge about the environments and their natural resources, and their involvement is essential in building an inclusive and sustainable economy.

Based on the mentioned above, ABC proposes the following definition: bioeconomy is based on the production and commercialization of goods derived from renewable biological resources for the production of bio-based products, food, feed, and bioenergy, in compliance with the United Nations Sustainable Development Goals.

International Bioeconomy Strategies

- European Union: “The EU bioeconomy strategy envisions a transition towards a low-carbon, resource-efficient economy. It focuses on leveraging biomass, fostering research and innovation, and promoting sustainable production and consumption. Europe's strengths lie in its strong policy frameworks, robust research and development infrastructure, and collaborative networks. However, limitations include the need for improved coherence among diverse policy areas, scaling up bio-based industries, and addressing potential conflicts between food and non-food uses of biomass”⁷.
- United States: “The US economy strategy emphasizes the economic potential of bio-based products, energy, and manufacturing. It aims to drive rural development, reduce dependence on fossil fuels, and promote environmental sustainability. The strengths of the U.S. strategy include

⁶ The Brazilian Center for Strategical Studies (CGEE) – Bioeconomy in the Americas 2030 (https://www.cgEE.org.br/documents/10195/734063/3445_Bioeconomy+in+the+Americas+-2030.pdf).

⁷ Iluminem – Bioeconomy strategies in the Global South should not copy those of the Global North (<https://illuminem.com/illuminemvoices/bioeconomy-strategies-in-the-global-south-should-not-copy-those-of-the-global-north>).

its innovation-driven approach, strong private sector engagement, and abundant biomass resources. However, challenges stem from fragmented governance across states and inconsistent policy support”⁸.

- China: “To promote the integration and innovation of biotechnology and information technology, as well as accelerate the development of biomedicine, biological breeding, biomaterials, bioenergy, and other industries to enhance the bioeconomy in scope and strength. Under the plan, the bioeconomy will become a key driving force to boost high-quality development by 2025”⁸.
- Global South: “Bioeconomy strategies (...) must explicitly be anchored in a strong sustainability paradigm, combining alternative visions of the bioeconomy, alongside the bioresource vision; these include the biotechnology and bioecology visions. The former emphasizes the application of advanced biological technologies, including genetic engineering and synthetic biology, to develop innovative bio-based products, processes, and services for various sectors”⁸.
- South Africa: “Envisaged outcomes within the next five years, and beyond, are to carve a niche for South Africa in the globally competitive pharmaceutical industry”⁹.
- Brazil: Brazil is leading food and feed production in the tropics based on the continuous investment in science and technology within the national institutes, the universities, and the Brazilian Agricultural Research Corporation (Embrapa). Since the beginning of 1970, Brazil has developed industrial expertise in bioethanol production, followed by biodiesel production, expanding its circular bioeconomy, and linking energy generation with food and feed production.

Perspectives on Bioeconomy

- Fostering bioeconomy innovations in biogenic raw materials is crucial to transitioning from fossil energy to a biological way of “harvesting the sun” to produce bioenergy.
- Investment in new sources of food, energy, chemicals, and medicines derived from plants and microorganisms from native biodiversity in different biomes will create a more sustainable bioindustry.
- Research, development, and innovation in the agrifood system worldwide aiming at new inputs, such as biofertilizers, biological control, plant protection, and post-harvesting, will have a tremendous impact on local economies, generation of new jobs, and the health of the population and the environment.
- Health bioeconomy has enormous challenges in providing good health conditions for the world population at an accessible cost. To achieve this goal, basic scientific research, technology, and innovation in different areas are mandatory.
- Strategic investment in the perspective of a more sustainable bioeconomy will reduce the pressure on land for food, feed, and energy production.

In a recent meeting in Poland (6-8 November 2023), the Environmental Biotechnology Division of the European Federation of Biotechnology invited scientists from academia and industry to discuss the

⁸ The State Council The People’s Republic of China – Bioeconomy prominent on growth agenda (https://english.www.gov.cn/policies/policywatch/202205/11/content_WS627b169ec6d02e533532a879.html).

⁹ Republic of South Africa Department Science and Technology – The Bio-Economy Strategy (https://www.gov.za/sites/default/files/gcis_document/201409/bioeconomy-strategyva.pdf).

“Green Deal Biotechnology” focusing on circular bioeconomy, stating seven significant challenges related to the Green and Blue Bioeconomy¹⁰:

- Recovery of resources, including rare resources and novel bio-based value chains
- Healthy soil and food security
- Bioelectrochemistry for energy and water recovery
- Wastewater treatment
- Nanotechnology in environmental biotechnology
- Marine biotechnology
- Emerging micropollutants in aquatic and terrestrial environments

Final Remarks

The Amazon bioeconomy, together with the bioeconomy from other biomes around the world, should aim to address the challenges of intersectional inequalities and poverty in the regions, aiming to sustainability that implies the protection of the biodiversity, diversification of production, and equitable benefit sharing. There is still a path to other innovations that can indeed combine environmental conservation, respect for cultural diversity, and prosperity.

By revealing mechanisms of interaction among living beings in various biomes, pathways are opened to develop bioproducts and technologies that increase plant tolerance to pests, diseases, flooding, etc. Detailing interactions among living beings also allows for identifying the vocation of each biome and the strategies that should be adopted to maximize production, including replacing chemical fertilizers and pesticides.

The G20 should create a consensus on the role of bioeconomy as one of the strategies for tackling the world's challenges in this century concerning global warming, poverty, and human and animal health.

Research, innovation, and dissemination of knowledge in bioeconomy among the key stakeholders are critical steps in the ongoing transition from the actual industrial development model to a more sustainable model meeting the UN Sustainable Development Goals.

¹⁰ Environmental Biotechnology Division of the European Federation of Biotechnology – Green Deal Biotechnology (https://www.efbiotechnology.org/green_deal/).