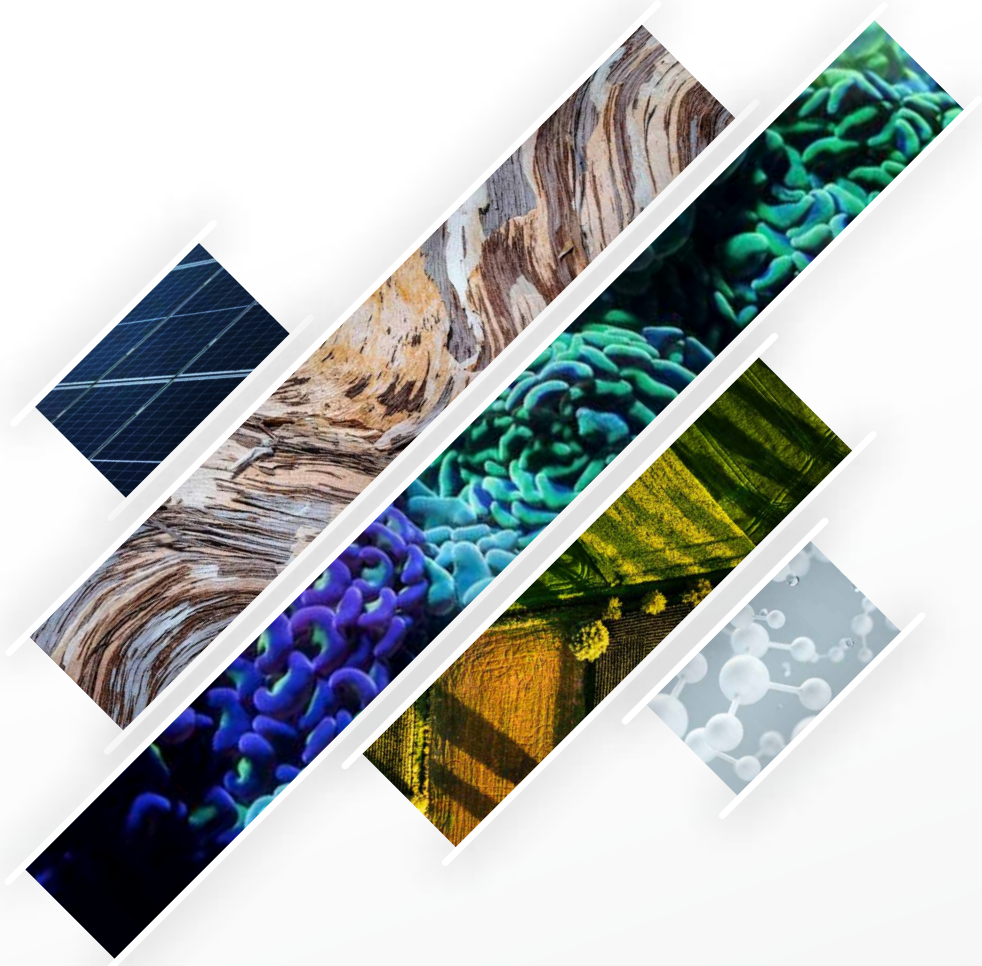

The Global Bioeconomy

Preliminary Stocktake of G20 Strategies and Practices: a contribution to the Brazilian G20 Presidency's Global Initiative on Bioeconomy

May 2024

NATURE FINANCE

FGV EAESP
CENTRO DE ESTUDOS EM SUSTENTABILIDADE

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Preliminary Stocktake of G20 Strategies and Practices:
a contribution to the Brazilian G20 Presidency's
Global Initiative on Bioeconomy

Prepared by NatureFinance and Getúlio Vargas Foundation for the G20 Initiative on Bioeconomy (GIB) on behalf of the following organisations:

AMAZON CONCERTATION

IPAM Amazônia

instituto arapyaú

cebds

CEBRI
CENTRO BRASILEIRO DE RELAÇÕES INTERNACIONAIS

BRAZILIAN COALITION ON CLIMATE, FORESTS AND AGRICULTURE

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Disclaimer: This Global Stocktake has been prepared as a contribution to the G20 Initiative on Bioeconomy. It takes stock of how G20 members are advancing the bioeconomy based largely on publicly available information. It is a preliminary work in progress and does not necessarily reflect the positions of the aforementioned organisations.

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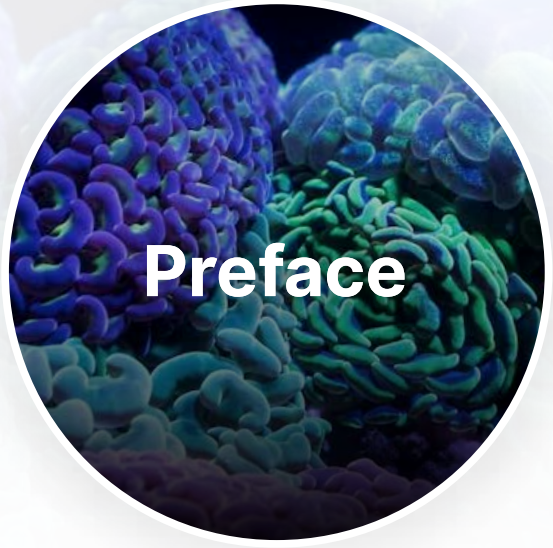

Preface

Ambassador André Corrêa do Lago
Vice-Minister for Climate, Energy and the Environment

Ministry of Foreign Affairs

The MFA chairs the G20 Initiative on Bioeconomy (GIB)

Brazil's presidency of the G20 comes at a time when the world is facing multiple social, economic and environmental challenges. There is growing evidence that climate change and environmental degradation are pushing humanity closer to potentially dangerous tipping points. However challenging, times of extreme difficulty often bring people together and allow new solutions to emerge.

The creation of the G20 Bioeconomy Initiative aims to contribute to such unity and collective work. Although it is a concept with no internationally agreed meaning, the bioeconomy could be ascribed as an economic paradigm that focuses on the sustainable use of renewable biological resources to produce goods, services, information and energy. Brazilian and international experience shows that the bioeconomy has the potential to promote social equity, environmental protection and economic growth, while keeping global warming below 1.5°C.

For this to happen, the bioeconomy must be an integral part of global economic discussions and cooperation, with a view to integrating its inherent environmental and social aspects. The G20 countries, representing 80% of global GDP and a similar share of global greenhouse gas emissions, are well placed to promote such integration.

The Brazilian government is committed to strengthening the broader participation of civil society in the G20. In this context, we encourage contributions that can enrich the debates among countries and provide valuable and up-to-date information.

The stocktaking exercise presented in this document brings together experiences from around the world on how to promote the bioeconomy in different contexts. As the following pages show, bioeconomy strategies can benefit countries with different levels of biodiversity and technological development. Their potential can be realized in a wide range of climates, biomes and environments.

The Brazilian Presidency of the G20 is therefore grateful to the Support Group that has brought together 19 entities from different regions. The Group provided valuable elements that deserved to be shared for the growing importance of bioeconomy in the global debates. Even though this document is not an outcome of the G20 Brazilian Presidency, it deserves wide disclosure to enrich the global debate on bioeconomy.

Executive Summary

This Global Stocktake objective is to provide a preliminary stocktake of how G20 members are advancing the bioeconomy as a basis for (a) facilitating members' learning and engagement, (b) enabling G20 members' action and (c) increasing cooperation in areas of common interest.

In addressing this objective, the Global Stocktake highlights some common themes on the bioeconomy emerging from the stocktake, which the G20 Initiative on Bioeconomy (GIB) might take forward during the Brazilian G20 Presidency in 2024, or that could be explored beyond 2024 through other fora.

The Global Stocktake is a response to the highly significant growth potential of the bioeconomy.

In its report 'A Status of the Global Bioeconomy', the World Bioeconomy Forum estimates the total value of the bioeconomy from various announcements around the world to be of the order of US$4 trillion. The Forum predicts considerable growth in the global bioeconomy. For example, China assesses that its bioeconomy will be valued at US$3.3 trillion by the end of 2025, whereas India is registering double-digit growth rates in recent years. The World Bioeconomy Forum concludes that "...its value will rise to US$30 trillion by 2050, which is a third of the global economic value" (World Bioeconomy Forum, 2022).

This Global Stocktake aims to represent an initial framing exercise by the G20 Initiative on Bioeconomy for advancing a bioeconomy that is equitable, regenerative of biodiversity, supportive of climate action and an enabler of the sustainable transition of the real economy.

Currently, there is a wide range of views on the definition of the bioeconomy existing. This is due to G20 members having diverse priorities and strategies, contexts and drivers. The approaches to the bioeconomy show however some underlying commonalities. It would be beneficial to foster comparability, complementarity and, in some instances, convergence of these approaches to support learning, integration and mutually beneficial cooperation among the G20 members.

The preliminary analysis indicates that G20 members' approaches are closely aligned across three thematic axes: (a) biotechnology (research, development and innovation); (b) bioresources (sustainable use of biodiversity) and (c) bio-ecology (sustainable development more broadly).

The comprehensive stocktaking has not been exhaustive and draws exclusively on secondary, publicly available materials. It covers the following seven dimensions:

1 Definitions, frameworks and metrics

2 Research, development and innovation

3 Sustainable use of biodiversity

4 Bioeconomy as enabler of sustainable development

5 National and regional bioeconomy strategies

6 Financing of the bioeconomy

7 International cooperation to foster the bioeconomy

Our research showed that G20 members are largely aligned in their objectives in advancing the bioeconomy, despite differences in their priorities given differing contexts. We suggest that Brazil's G20 Initiative on Bioeconomy agrees on the identified objectives and consolidates them in a common set of high-level principles on the bioeconomy.

The principles could take into account that the future global bioeconomy should:

deliver equitable economic and other positive outcomes;

be regenerative of biodiversity;

support action on climate; and

underpin the broader real economy transition towards sustainable development.

Five related themes have been identified through the stocktaking exercise, which could serve as the foundation for a G20 Initiative on Bioeconomy program of work aimed at promoting learning and, when applicable, fostering collective approaches and collaboration.

1. Bioeconomy integration into economic, industrial and green growth plans: Exploring how G20 members have integrated bioeconomy elements into national, regional and sector plans would enable learnings as to how the bioeconomy fits into wider development planning and policies.

2. Livelihoods and equity outcomes and opportunities: Deepening shared understanding of the livelihoods and equity dimensions and opportunities of bioeconomy development experiences and associated policy options, particularly for the most vulnerable populations such as small-scale farmers, indigenous peoples and local communities and others, would help ensure the long-term sustainability and resilience of bioeconomy strategies.

3. Bioeconomy-enabling finance: Understanding how developments in sustainable finance could broadly or specifically support bioeconomy developments, would enable learnings as to how to fund growth, drawing from and informing the work of the G20 Sustainable Finance Working Group.

4. Facilitating biotrade: Better understanding of the evolving importance of 'biotrade' arising from the development of a global bioeconomy would facilitate consideration of enabling policies, regulations and incentives.

5. Bioeconomy measurement: Sharing experience on the methodologies, indicators and data sources for measuring the bioeconomy would enable a greater understanding of the dynamics of the bioeconomy, its potential and also its usefulness in different contexts.

We suggest using the above key themes as a basis for the G20 Initiative on Bioeconomy to explore the experiences of the G20 members and develop an enabling analytical framework to support learning and develop common understanding.

Finally, given the current dynamic developments of the bioeconomy – and practical constraints that can limit research during the Brazilian G20 Presidency – the G20 Initiative on Bioeconomy could usefully highlight other key themes that might be valuable to consider in the future, whether through the G20 itself or other international cooperation platforms and initiatives.

Preamble

The Government of Brazil is establishing an Initiative on Bioeconomy in the G20[1] under its Presidency in 2024 and wishes to ensure that the resulting work and outcomes are aligned with and mutually reinforcing with other G20 workstreams, particularly those in the finance track such as the working group on sustainable finance.

To support the bioeconomy is vital, given the dependence of the global economy on biodiversity and more broadly on nature. The bioeconomy is essentially a two-way interaction between nature and society, which puts both biodiversity and equity at the centre of sustainable growth. Without fair access to resources, opportunities and benefits, the bioeconomy may exacerbate existing inequalities and social tensions, leading to social and environmental instability and ultimately biodiversity loss.

The breadth of resulting considerations creates challenges in how the bioeconomy can best be pursued by the G20. It ranges from the span of possible definitions (on what the bioeconomy is) to its relevance (how and in what ways it is important to each G20 member) and the breadth of possible policy dimensions to implement it (from economic strategies to food security, financial regulation and monetary policy).

Important in the context of the G20 is that the approach is both inclusive and focused. It should take account of diverse interests, visions and contexts and at the same time provide a basis for the G20 to converge on key points of common analysis and understanding, and potentially support the members in progressing on some agreed areas. An important first step in achieving this balance is to provide a stocktake of how each of the G20 members approaches the bioeconomy and to identify potential synergies and acceptable pathways that could be undertaken by the G20.

1

Introduction

In its annual 'State of the Global Bioeconomy' report, the World Bioeconomy Forum estimates the total value of the bioeconomy at US$4 trillion (World Bioeconomy Forum, 2022)[2], and according to a study by Boston Consulting Group's Henderson Institute (BHI), its value could rise to US$30 trillion by 2050[3] (BCG Henderson Institute, 2022). In its 14th Five-Year Plan (2021–2025), China predicts its bioeconomy will rise to CNY22 trillion, or US$3.3 trillion, by 2025. According to the India Bioeconomy Report (BIRAC, 2022), India's bioeconomy registered a 14% growth rate, and a study by the Brazilian BioInnovation Association, in partnership with Embrapa, estimated that the bioeconomy in Brazil could generate an annual industrial revenue of US$284 billion by 2050 (ABBI, 2022).

This growth in the bioeconomy is coupled with a range of economic benefits, such as strengthening the resilience of supply chains, creating jobs and diversifying the economy. One study estimated that the U.S. bioeconomy has generated more than US$48 billion in revenue and 285,000 jobs (Rogers et al., 2016).

It is important to note that countries may use different definitions and metrics to estimate the growth of the bioeconomy, hindering comparability. Notwithstanding, by many accounts, the transition to the bioeconomy is at a pivotal point today.

As bio-based production systems expand, reconciling bioeconomy growth with ecosystem conservation and restoration will become critical. This is because the bioeconomy relies on healthy and diverse ecosystems for the raw materials needed for bio-based products (e.g. food, fibre and biofuels), as well as other vital ecosystem services, such as regulation of air and water quality. Without these services, the bioeconomy would not be able to function sustainably (Bastos Lima and Palme, 2022).

Furthermore, as global populations grow and natural resources become increasingly scarce, equity remains an integral part of ensuring sustainable growth. This includes access and opportunity, inclusivity, fair distribution of benefits, and environmental and social justice. Without equity, bioeconomy expansion risks benefiting some populations at the expense of others, thereby strengthening conventional patterns of economic growth, and in turn, reinforcing existing inequalities and biodiversity loss. Furthermore, rewarding the stewards of nature, particularly indigenous peoples and local communities, incentivises the protection and restoration of natural resources that the bioeconomy depends on (Bastos Lima, 2022; Bastos Lima and Palme, 2022).

This Global Stocktake was prepared by NatureFinance and Fundação Getúlio Vargas (FGV) on behalf of 19 organisations[4] to support the Brazilian federal government during its G20 Presidency and the G20 Initiative on Bioeconomy (GIB) held on the Sherpa Track. It aims to sum up the *status quo* of bioeconomy conceptions worldwide, especially in the G20 countries, raising challenges and opportunities around it, and highlighting the emerging themes that could be the focus of further research by the GIB.

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[1] Currently, it's a group with the African Union (AU) in its composition.

[2] Based on a bottom-up analysis by the World Bioeconomy Forum of national bioeconomy programmes in selected countries: Brazil, USA, Canada, EU, Sweden, Finland, India and China (see https://wcbef.com/tuote/a-status-of-the-global-bioeconomy/).

[3] Based on the projected growth of synthetic biology in manufacturing industries that account for more than a third of global output.

[4] Amazon Concertation; Amazon Environmental Research Institute (IPAM); Arapyaú Institute; Brazilian Business Council for Sustainable Development (CEBDS); Brazilian Centre for International Relations (CEBRI); Brazilian Coalition on Climate, Forests and Agriculture; Brazilian Tree Industry (IBÁ); CDP Latin America; Climate Policy Initiative (CPI); Dom Cabral Foundation (FDC); Getúlio Vargas Foundation (FGV); Igarapé Institute; Insper Agro Global; Interstate Consortium for the Sustainable Development of the Legal Amazon; Natura & Co; NatureFinance; The Brazilian Federation of Banks (FEBRABAN); The Institute for Climate and Society (iCS); The Nature Conservancy (TNC)

2

Definitions, Frameworks and Metrics

2.1 Definitions of Bioeconomy

G20 members have developed and adopted differing and yet often complementary definitions of the bioeconomy. The term "bioeconomy" is commonly used to describe the process of converting renewable biological resources (inputs) into different materials, chemicals and energy (outputs) (Ferraz & Pyka, 2023; Mittra & Zoukas, 2020; Wei et al., 2022). As such, the bioeconomy relies on nature to provide the necessary biological resources or raw materials. It can be seen as a two-way interaction between nature and society, which includes: i) the dependence of people, the economy and society on biodiversity; and ii) the impacts of human activities on biodiversity (de Schutter et al., 2019; Ramcilovic-Suominen et al., 2022).

The concept of the bioeconomy has different meanings depending on the underlying worldviews it represents, either from academic research or indigenous peoples and local communities. In academia, much of the literature refers to three major approaches: 1) biotechnology, which emphasises innovation and utilisation of biotechnology at a commercial scale, 2) bio-resources, which focuses on upgrading biomass-based value chains, and 3) bio-ecology, which seeks to address ecosystem health and sustainability issues more broadly (Johnson et al, 2022; Bugge et al, 2016).

The approaches are not mutually exclusive, and differences are rooted in diverse priorities and strategies, contexts and drivers of the G20 members. For example, within the bio-ecology approach, the concept of socio-biodiversity has emerged, which refers to the interconnectedness of biological diversity and cultural diversity. In Brazil, Uma Concertação pela Amazônia (Amazon Concertation) offers a classification of three approaches to the bioeconomy in the Amazon:

1. Socio-biodiversity: Refers to the interconnectedness between biological diversity and cultural diversity and focuses on inclusive value chains of non-timber forest products owned and produced by indigenous peoples and local communities.[5]
2. Forest bioeconomy: Refers to management methods such as silviculture of native forests, livestock-crop-forestry production systems, agroforestry systems and restoration of degraded areas.
3. Agrobioeconomy: Refers to intensive production processes, such as planted forests and commercial agriculture (Uma Concertação pela Amazônia, 2023).

[5] Socio-biodiversity generated BRL4.24 billion in local income in the Brazilian state of Pará in 2019, according to a study by The Nature Conservancy, Inter-American Development Bank and Natura, available at https://www.tnc.org.br/conecte-se/comunicacao/noticias/estudo-de-bioeconomia/

This Global Stocktake considers the bioeconomy as it has developed in G20 countries so far. However, new visions and approaches continue to emerge. For instance, in Brazil, the 'New Economy for the Brazilian Amazon' report, published in 2023, states that the bioeconomy in the Amazon should evolve in harmony with the forest and the rivers. The Amazon bioeconomy must be able to adjust to the biome's biocapacity, building upon economic activities that do not disrupt the complex ecological balances that guarantee the health of the forest and rivers on which the population depends (Nobre et al., 2023). Moreover, the debate related to the bioeconomy is increasingly coupled with agrifood system transformation.

The literature also provides examples of bioeconomy approaches in other countries. For instance, in South Africa, one major component of the bioeconomy is the wildlife economy, including value chains around wildlife activities such as tourism and the management of protected areas (DEA, 2016; Förster et al., 2021). This is in addition to the other key sectors (agriculture, health and industry) outlined in the South Africa Bioeconomy Strategy (DST, 2013) (see Annex 2.1 for a more detailed literature review of various bioeconomy definitions).

This landscape of definitions, which is not exhaustive, points to the bioeconomy as an emerging and prominent field, offering various transformation pathways for countries depending on the socio-economic and ecological context. While the pathways may differ, the bioeconomy can be framed around three thematic axes that align with different approaches by G20 members:

- Research, development and innovation (biotechnology)
- Sustainable use of biodiversity (bioresources)
- Bioeconomy as an enabler of sustainable development (bio-ecology)

These thematic axes are described in further detail in sections 3, 4 and 5 of this report.

2.2 Frameworks in Common Use

When it comes to conceptualising the bioeconomy, two cross-cutting frameworks are commonly used:

The Circular Bioeconomy: This framework emphasises the integration of renewable biological resources, such as agricultural and forestry products and waste streams, in a circular system. It promotes sustainable production, resource efficiency and minimising waste by reusing, recycling and recovering biological resources (MoEFCC & TERI, 2023; Tan & Lamers, 2021).

In a circular bioeconomy, technology enables the valorisation of organic waste streams. For example, China has been actively promoting the concept of "waste-to-wealth" through the integration of biotechnology and biomanufacturing processes. Examples of this include the conversion of agricultural residues into biofuels or bioplastics, and the use of biotechnology to transform waste streams into valuable products like enzymes or specialty chemicals.

The Bioeconomy and Agenda 2030: The United Nations' Sustainable Development Goals (SDGs) provide a comprehensive framework for sustainable development across various sectors, including the bioeconomy. The SDGs related to the bioeconomy focus on areas like food security, clean energy, responsible consumption and production, and climate action (Calicioglu & Bogdanski, 2021; Rodriguez et al., 2019). In addition, Diaz-Chavez et al. (2019) emphasise the relevance of SDG 5 (Gender Equality) in the bioeconomy, given the significant role women play in agriculture and other bioeconomy sectors.

Many countries and regions view the bioeconomy as an engine to achieve not only economic growth but also policy objectives under the UN 2030 Agenda. For example, the East African Community (EAC) Regional Bioeconomy Strategy positions itself as “a compelling framework for putting in place agreed goals and interventions, which countries in East Africa can use to achieve the continental aspiration of integrating its Agenda 2063 and the UN 2030 Agenda for Sustainable Development into intersectoral national development plans ...”.

2.3 Metrics in Common Use

A common framework for bioeconomy indicators does not exist today but work on indicators is ongoing among several G20 members (Robert et al, 2020; Bracco et al, 2018). Monitoring progress in the bioeconomy and its economic, environmental and social impacts is difficult for many reasons. One key issue is that official economic statistics rarely differentiate between bio-based and non-bio-based products. Progress is being made, however, through efforts by the UN Conference on Trade and Development (UNCTAD) to develop the TraBio database and product classification systems for bio-based products.[6]

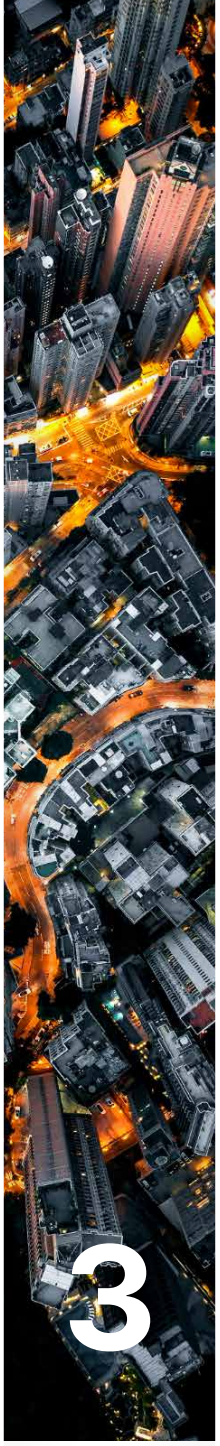
When monitoring the bioeconomy, countries typically use economic indicators such as value added, turnover, job creation, foreign sales and investments. Many countries use the United Nations System of Environmental-Economic Accounting (SEEA), a standardised methodology for measuring the interactions between the economy and the environment. For example, the Australian System of National Accounts (ASNA) applies the SEEA methodology to include the economic value of environmental assets, such as land and timber, in its national balance sheet.

It is also worth noting the ongoing efforts to better understand, monitor and measure the impacts and dependencies of economic activities on nature. Initiatives such as The Economics of Ecosystems and Biodiversity (TEEB) and the Taskforce on Nature-related Financial Disclosures (TNFD) continue to influence reporting regulations, such as the EU's Corporate Sustainability Reporting Directive (CSRD).

Indicators to monitor the contribution of the bioeconomy to meeting social goals, such as poverty alleviation or income inequality, are most rarely used (see Annex 2.4 for further examples of indicators across different categories).

As measuring the bioeconomy and its scope are key emerging themes, going forward, the G20 Initiative on Bioeconomy (GIB) has opportunities to share knowledge of how such methodologies meet environmental and social sustainability goals.

[6] https://unctadstat.unctad.org/EN/Biotrade.html



3

Research, Development and Innovation

3.1 Agriculture and Animal Technology

Technology has had a significant impact on transforming traditional industries such as agriculture, forestry, fisheries and aquaculture. In recent years, frontier technologies including Artificial Intelligence, the Internet of Things (IoT), remote sensing, geographic information systems (GIS), and global positioning systems (GPS) have been deployed to improve overall production output while minimising costs and conserving resources.

By improving efficiency, productivity and sustainability in primary production, technological advances can lead to the creation of more bio-based products and renewable resources, promoting the development of the bioeconomy.

Technology has enabled farmers to adopt precision agriculture techniques, which complement regenerative agricultural practices focused on soil health, water retention, nutrient recycling and carbon sequestration (see examples in Annex 3.1). Through the use of sensors, drones and satellite imagery, farmers can gather real-time data on soil conditions, moisture levels and crop health.

For example, the Modern Agriculture Platform (MAP), developed by China's largest agriculture input enterprise Sinochem Agriculture, provides farmers with comprehensive services to help facilitate precision agriculture across seven provinces in China. The Platform combines online and offline elements that cover the entire agriculture production and sales process. This data-driven approach allows for the precise application of fertilisers, pesticides and irrigation, leading to higher yields, reduced costs and more sustainable practices.

Overall, agriculture and animal technologies have the potential to enhance productivity, sustainability and efficiency in farming operations. However, smallholders, indigenous people and marginalised rural communities are likely to have limited access to these technologies due to various factors such as cost, availability and infrastructure limitations. They may also lack the necessary training or education to effectively use these technologies, limiting their ability to harness their full potential.

Meanwhile, the bioeconomy can benefit from centuries of wisdom from smallholders. By integrating traditional knowledge into technology development and decision-making processes, the bioeconomy can contribute to sustainable development, cultural preservation and the well-being of indigenous communities. See Annex 3.1 for further information on advances in agricultural and animal technologies, and examples of integrating traditional knowledge into technology development, as well as broader approaches to ensuring inclusiveness and equity.

3.2 Bio-refineries

Biorefining is a process that involves converting biomass, such as agriculture and forestry residues, into a range of products, including biofuels, chemicals and materials. Biorefineries utilise various techniques, such as fermentation, enzymatic hydrolysis and thermochemical conversion, to extract valuable components from biomass and transform them into products.

For example, Raizen, a Brazilian integrated energy company, uses a combination of fermentation and enzymatic hydrolysis to convert agricultural waste, such as sugarcane bagasse and straw, into ethanol. In August 2023, Raizen became the world's first ethanol producer certified to make sustainable aviation fuel (SAF), a key in the airline industry's search to reach net-zero emissions by 2050.[7]

Additionally, advances in biotechnology and genetic engineering have allowed bio-refineries to develop and optimise enzyme cocktails and microorganisms tailored to specific processing requirements. For example, Ginkgo Bioworks in the U.S. leverages synthetic biology techniques to engineer microorganisms with enhanced capabilities for biorefining.

Annex 3.2 showcases further examples of advanced bio-refineries around the world utilising advanced extraction technologies, process automation, fermentation, anaerobic digestion, synthetic biology and genetic engineering, biocatalysis and algae.

Overall, technology advancements enable more sustainable and economically viable utilisation of natural resources while also reducing the environmental footprint of the biorefinery industry.

Examples of Biorefinery Research & Development

Brazil: The Brazilian Agricultural Research Corporation (EMBRAPA) plays a crucial role in promoting research and development in biorefining in Brazil. It focuses on bioenergy and biomass projects, investigating the use of various feedstocks for biorefinery processes.

India: The Advanced Biofuel Centre (ABC) is involved in biorefinery research and development, particularly in the areas of biofuel crops and biomass conversion technologies. It works on improving crop yields and developing sustainable methods for biomass processing.

European Union: The Bio-based Industries Consortium (BIC) is a public-private partnership that aims to accelerate the development of biorefineries and bio-based industries in Europe. It provides funding and support for research and development projects across multiple countries.

Germany: The Fraunhofer Institute for Interfacial Engineering and Biotechnology is a research institute working on various aspects of biorefining, including the development of efficient conversion processes and the utilisation of different biomass feedstocks.

United States: The National Renewable Energy Laboratory (NREL) is a leading research institution focused on advancing renewable energy technologies, including biorefineries. It conducts extensive research on biomass conversion, biofuels and bioproducts.

[7] https://www.nasdaq.com/articles/brazils-raizen-gets-certification-for-ethanol-based-saf

3.3 Bio-based Materials

There have been several technological advancements in bio-based materials in recent years. Bioplastics – derived from renewable sources such as corn, sugarcane, lignin or cellulose from planted forests – continue to evolve as a more environmentally friendly alternative to traditional plastics derived from fossil fuels. These new materials reduce the reliance on fossil fuels and non-renewable resources, help mitigate environmental pollution and reduce carbon emissions associated with traditional plastics.

Innovations in biodegradable materials have made it possible to design products that can naturally decompose at the end of their lifecycle, reducing their environmental impact. For instance, a UK startup, Notpla, has developed a sustainable packaging material derived from seaweed that composts completely within weeks. In Brazil, Bracell (with two factories, in São Paulo and Bahia) and LD Celulose in Minas Gerais, a joint venture between Dexco and the Austrian company Lenzing, have developed viscose from soluble cellulose, generating innovative, sustainable and high-tech fabrics. Another example is nanocellulose, a versatile category of materials derived from cellulose fibres found in plant cell walls. It has extraordinary strength, and lightweight properties and can serve as an eco-friendly alternative to traditional materials like plastics or metals. In Canada, the company CelluForce has played a significant role in the development and commercialisation of cellulose nanocrystals derived from pulpwood.

Overall, technology empowers industries to transition to bio-based materials, offering ecological benefits, waste reduction and economic advantages, and contributing to a more sustainable and environmentally conscious future (see Annex 3.3 for further details on the sectors that are most quickly adopting bio-based materials).

3.4 Biotechnology, Bioinformatics and Computational Biology

Advancements in biotechnology, bioinformatics and computational biology have also significantly contributed to the growth of the bioeconomy.

In biotechnology, genetic engineering has led to the development of new and improved medicines, agronomic traits, bioinputs and industrial processes. For example, scientists have created genetically modified organisms with enhanced traits, such as disease resistance in crops or valuable pharmaceuticals.

For example, the Brazilian Biorenewables National Laboratory (LNBR) is one of four national laboratories that is funded by the Ministry of Science, Technology and Innovation (MCTI). The LNBR utilises synthetic, structural and computational biology to engineer and customise biotechnology platforms for the production of biofuels, biochemicals and biomaterials (see Annex 3.4 for additional examples of biotechnology research).

Bioprospecting is a term used for the search of new plant species, animals, microorganisms, or other biological materials that have potential applications in fields such as medicine, agriculture, cosmetics and biotechnology. Bioinformatics is used to complement bioprospecting, by providing tools and methods for the analysis, processing, and interpretation of biological data. Together, bioprospecting and bioinformatics expand the economic potential of the bioeconomy.

For example, Australia's national science agency, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), leverages bioinformatics to understand biological systems, identify unique traits and discover new genetic resources. Using bioinformatics, they have made several notable marine bioprospecting discoveries with pharmaceutical applications, such as anti-inflammatory compounds from marine sponges, antimicrobial agents from marine bacteria and novel cancer therapies from various marine organisms (see Annex 3.4 for additional examples in bioinformatics).
Computational biology combines mathematical modelling, computer science and statistical analysis to understand complex biological systems. It has contributed to advancements in genomics, proteomics, drug discovery and synthetic biology. It has also paved the way for personalised medicine, where genetic information is used to tailor treatments to individual patients.

While the positive impact of technology on the bioeconomy is undeniable, ethical and biosafety concerns are emerging simultaneously. Additionally, biotechnology advancements may be accompanied by concerns regarding equitable access to benefits, such as healthcare and agricultural improvements. Ensuring benefits are distributed fairly and do not exacerbate social or economic disparities is crucial.

3.5 Technological Horizons of the Bioeconomy

The technological horizons of the bioeconomy are diverse and dynamic. With continuous research and innovation, we can expect technological breakthroughs that drive the transition towards a more sustainable, resource-efficient and resilient economy.

The most promising breakthroughs are those that combine technologies and take a systems approach. For example, integrated smart agricultural systems combine various technologies, such as precision agriculture, remote sensing and data analytics to optimise farming practices. Similarly, aquaponics combines aquaculture and hydroponics, and incorporates technologies such as Recirculating Aquaculture Systems (RAS), which use beneficial microbes, biofilters and mechanical filters to maintain water quality.

Technologies that increase circularity and involve innovative approaches to waste and by-product utilisation have the potential to link value chains and transform industries. For example, the most advanced integrated biorefineries aim to maximise the value obtained from biomass by using multiple conversion technologies in a cascading manner. They optimise resource use and minimise waste. Furthermore, ongoing research and development efforts aim to make bio-based hydrogen production a viable component of the energy transition.

Collaborative networks will bring more technological innovation to the bioeconomy. These networks will consist of various stakeholders, including researchers, industry partners, policymakers and local communities. They will facilitate the exchange of knowledge, expertise and resources to address complex bioeconomy challenges, foster innovation, create synergies and promote sustainable development (see Annex 3.5).

4

Sustainable Use of Biodiversity

4.1 Interdependence between Biodiversity and Bioeconomy

The bioeconomy depends on biodiversity as its foundation. Biodiversity is the "variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (CBD, 2011). Biodiversity, thus, embraces different levels of ecosystems,[8] species and genetic material.[9]

Beyond its economic value, biodiversity holds deep social, ethical and cultural significance. Biodiversity provides important benefits to people and society's well-being in the form of ecosystem services. These services, as defined by the Millenium Ecosystem Assessment in 2005, can be grouped into four fundamental types:

- Provisioning services are the products directly obtained from ecosystems such as water, food, medicinal plants and fibre.
- Regulating services are the benefits obtained from the regulation of ecosystem processes, such as climate regulation, pollination and flood protection.
- Cultural services are the non-material benefits obtained from ecosystems, such as stress relief, sightseeing as well as spiritual and research uses.
- Supporting services are those that make it possible for all other ecosystem services to exist, such as habitat for species, soil formation and nutrient cycling.

More recently, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) developed the Nature's Contributions to People (NCP) framework. It recognises the central role of culture in shaping the nature-people relationship and integrates a wider range of perspectives and stakeholders, from social sciences to indigenous peoples and local communities (see Annex 4.2).

[8] Ecosystem is defined as "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit" according to the CBD.

[9] According to CBD Article 2, "'Genetic material' means any material of plant, animal, microbial or other origin containing functional units of heredity".

Furthermore, the bioeconomy can be seen as a two-way interaction between nature and society: i) the dependence of people, the economy and society on biodiversity; and ii) the impacts of humans' activities on biodiversity (de Schutter et al., 2019; Ramcilovic-Suominen et al., 2022). The socio-biodiversity approach to the bioeconomy highlights the intertwined relationship between biodiversity, culture and ways of living, especially as seen among indigenous peoples and local communities.

The excessive use of biological resources can also have negative effects on biodiversity and ecosystems. This can, in extreme cases, lead to an overshooting of the safe operating limits of key earth system processes, as represented in the planetary boundaries (Ramcilovic-Suominen et al., 2022). At the same time, an expanding bioeconomy could also lead to conflicts arising from competing demands for food security, energy security and the availability of bioresources (Zilberman et al., 2018). Therefore, the sustainable use[10] of biodiversity is a precondition to avoid such conflicts and establish a fair and equitable bioeconomy (Bastos Lima and Palme, 2022).

The sustainable use of biodiversity entails the management of natural resources in a manner that safeguards ecosystems, minimises pollution and guarantees that every individual, regardless of their socioeconomic status or location, has fair access to opportunities within the bioeconomy.

Thus, a key theme for the G20 Initiative on Bioeconomy (GIB) to consider is livelihoods and equity within the bioeconomy. This would provide an opportunity to share knowledge and experience on how sustainable use of biodiversity can contribute to an inclusive and equitable bioeconomy, particularly for the most vulnerable populations such as small-scale farmers and indigenous peoples and local communities.

[10] "Sustainable use' means the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations" (CBD, 2011).

4.2 Indigenous and Local Knowledge (ILK) and Indigenous People and Local Communities (IP&LCs)

Much of the world's biodiversity lies within the territories of indigenous peoples and local communities (Díaz et al., 2018). Indigenous peoples and local communities possess extensive and intricate knowledge about how to conserve and utilise biodiversity sustainably. It is knowledge which has been developed and passed down through generations. The bioeconomy benefits from valuing and learning from such knowledge, allowing indigenous peoples and local communities to be key players in the bioeconomy through value chain participation, community businesses, asset ownership and other innovative means (Bastos Lima and Palme, 2022).

For example, the Brazilian government has developed a series of policies and programmes designed to promote the sustainable exploitation of the country's socio-biodiversity product chains. These are non-timber forest products produced by indigenous peoples and local communities that reflect the biological diversity and cultural diversity of the region. Pará is one of the leaders in the production and export of Brazil's socio-biodiversity products, with over 30 value chains generating an estimated BRL5.4 billion in local income (Costa et al., 2021).

In turn, the bioeconomy can provide livelihoods for indigenous peoples and local communities and maintain their traditional ways of life. Particularly, this allows local communities residing in or on the outskirts of forests to generate income; people who would otherwise face limited economically viable alternatives than destructive practices (Bastos Lima and Palme, 2022).

Thus, integrating science and Indigenous and Local Knowledge (ILK), plays an essential role in advancing the bioeconomy, by providing valuable insights into conservation and management practices, biodiversity preservation, agricultural techniques, medicinal and herbal knowledge and inclusive governance structures (see Annex 4.4).

Furthermore, the adequate sharing of benefits, as established by the Nagoya Protocol, is an important element of the bioeconomy.

The Nagoya Protocol

The Nagoya Protocol was a fundamental step towards regulating the use of genetic resources and access and benefit sharing around the world. It was an enabler of the bioeconomy by promoting legal certainty and fair distribution of benefits. In Brazil, for instance, Law No. 13.123 /2015 regulates access to the country's genetic heritage and associated traditional knowledge for research and technological development. The law guides the sharing of the benefits arising from the economic exploitation of products or reproductive material developed from these genetic resources, including plants, animals or microorganisms and secondary metabolites. It also establishes a benefit sharing fund, where indigenous peoples and local communities are members of the board and actively participate in decision-making on the destination of benefit-sharing resources, including for the development of the bioeconomy.

4.3 Climate Change and Biodiversity

Climate change and biodiversity are inherently connected and interdependent in their natural processes, as affirmed by the COP28 Joint Statement on Climate, Nature and People.[11]

Nevertheless, over the past three decades, the norms and institutional focus on climate change and biodiversity have evolved separately, with different speeds, players and milestones. For example, the topics are addressed by different UN conventions, namely the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD).

The global challenges of climate change and biodiversity have a reciprocal impact on each other, both exacerbating the problem but also presenting opportunities for mutual solutions (Pörtner et al., 2021). For instance, land use change is one of the main drivers of biodiversity loss (IPBES, 2019) and responsible for a quarter of the global greenhouse gas emissions (Shukla et al., 2019). In some tropical countries, land use change is the greatest source of greenhouse gas emissions. Thus, it is important to recognise that the perception of separate climate and biodiversity agendas in international governance creates a risk that the two indeed operate independently (Pörtner et al., 2021).

The IPCC has shown that efforts to restore ecosystems help to mitigate and adapt to climate change. This is achieved through the improvement of ecosystem services, positive economic returns, benefits for poverty reduction and improvement of livelihoods. Furthermore, the IPCC emphasises that successful adaptation and mitigation strategies involving ecosystems require strong cooperation and the active involvement of indigenous peoples and local communities in decision-making processes. Thus, the bioeconomy has the potential to go beyond solely addressing climate change to encompass a more holistic approach that also promotes the health of nature's various components, including biodiversity, on which the bioeconomy is highly dependent.

The Kunming-Montreal Global Biodiversity Framework adopted during COP15 outlines 23 targets for urgent action until 2030 and establishes four long-term goals for 2050 (CBD, 2022). Target 8, which aims to minimise the impacts of climate change on biodiversity and build resilience, could benefit from experience-sharing among G20 countries, especially considering the global cooperation required for climate change mitigation (see Annex 4.7 for further information on the links between the bioeconomy and the Kunming-Montreal Global Biodiversity Framework).

[11] https://www.cbd.int/article/climate-nature-people-statement-climatecop28-2023

4.4 Biodiversity Conservation and Restoration

The bioeconomy also offers a new paradigm where economic growth helps to preserve and enhance nature, rather than harming it. First and foremost, by recognising and quantifying the benefits of nature in economic terms, more resources and efforts can be allocated towards the conservation and restoration of biodiversity. The valuation of biodiversity is fundamental – a process considering its many possible forms (monetary, sociocultural, etc.) and followed by its integration into policy, regulations, planning and development processes, strategy and assessments. This is a core objective outlined in Target 14 of the Kunming-Montreal Global Biodiversity Framework (CBD, 2022) and by IPBES (2022).

Secondly, the restoration of native species leads to the expansion of the ecosystem base and fosters sustainability. Restoration can be understood as "'the return to a previous or original state'", which aligns with the concept of a circular economy. It is considered an essential activity within the field of bioeconomy, specifically known as restorative bioeconomy. "Restoration has become key given the extent of ecosystem degradation in the past decades," according to Bastos Lima and Palme (2022). "Therefore, not only a halt to deforestation but also the promotion of ecosystem restoration, reforestation, or pro-forestation (i.e., the expansion of natural vegetation even beyond the mere covering of recent losses) may need to be on the agenda for a sustainable bioeconomy."

Target 2 of the Kunming-Montreal Global Biodiversity Framework (CBD, 2022) aims to ensure that by 2030 at least 30% of degraded areas are effectively restored to enhance biodiversity and ecosystem functions and services, as well as ecological integrity and connectivity. Target 6 reinforces the need to minimise the impacts of invasive alien species. The United Nations has also declared the period of 2021 to 2030 as the UN Decade of Ecosystem Restoration.

5

Bioeconomy as Enabler of Sustainable Development

The bioeconomy offers numerous opportunities for sustainable development – by providing pathways to address inequalities, creating jobs in rural areas, empowering vulnerable communities, driving economic growth and promoting resource efficiency. It can also contribute to carbon sequestration and align with global goals such as the UN's Sustainable Development Goals (SDGs) and the Paris Agreement. However, sustainable outcomes are not guaranteed. Creating win-win outcomes in both environmental and socio-economic dimensions requires efforts in knowledge acquisition, policymaking and the development of institutional frameworks, both nationally and through international collaboration. Moreover, to enable product flow and viable costs of bioeconomy products, a lack of infrastructure and logistical barriers must also be addressed, especially if business owners are from far regions or indigenous peoples and local communities.

5.1 Economic Development through Innovation

Despite differences in local context, most bioeconomy strategies of G20 members revolve around the importance of research, development and innovation (R&D&I) (Aguilar et al., 2019; Viaggi, 2020; Wei et al., 2022).

R&D&I activities play a crucial role in driving long-term economic growth. As a result, the bioeconomy and sustainable development are closely intertwined (von Braun, 2014). Innovation enables an economy to increase its output using the same or fewer resources, and technology has the potential to significantly improve people's living standards (Grossman & Helpman, 1994; Rosenberg, 2006).

The success of R&D&I activities tends to be improved by the overall impact of positive economies of scale and scope, as well as the localised overflow of new economic knowledge among entities in a concentrated geographical area, either within a particular industry (specialisation) or between different industries (diversification)[12] (Audretsch & Belitski, 2022; Bilbao-Osorio & Rodríguez-Pose, 2004). For the bioeconomy, local knowledge is even more relevant, due to the local specificities of biological resources and the need to manage those resources locally (El-Chichakli et al., 2016).

One example is the creation of a bioeconomy cluster of different stakeholders in the Almeria region of Spain, including local farmers, plant breeding companies, entrepreneurs and the University of Almeria. It provides support to these entities through applied R&D&I and ensures that knowledge is shared with private companies. This has allowed the region to become one of Europe's most productive agricultural areas since the 1980s, with the agricultural sector accounting for 45% of local jobs, and helps the region to develop the necessary conditions for implementing a bioeconomy model (Table 1) (Egea et al., 2018).

Similar clusters of agricultural production and innovation can also be found in Argentina and Brazil (Sasson & Malpica, 2018). As indicated in Table 1, several conditions need to be met for a bioeconomy cluster to thrive and enable the transfer of knowledge, as no individual can fulfil all of the requirements alone. In other words, the successful implementation of a bioeconomy model requires concerted efforts from producers, governments, academia and investors.

[12] In economic jargon, knowledge and R&D spillovers can be seen as positive externalities (Audretsch & Belitski, 2022).

Table 1 – Existing Conditions for Implementing a Bioeconomy Model in Almeria

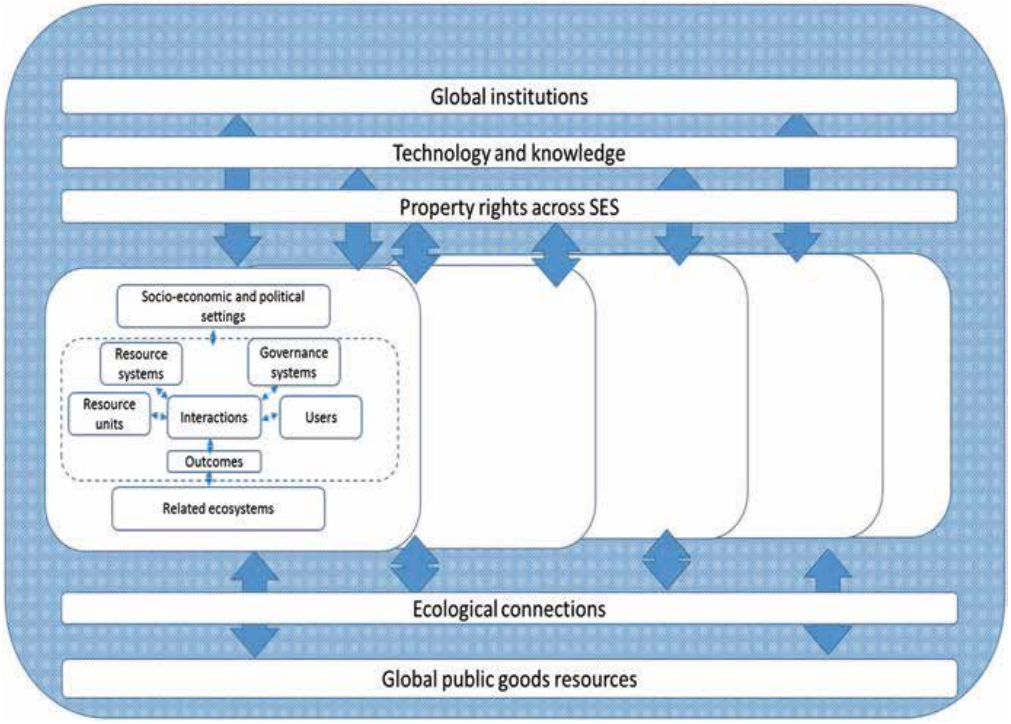
High and continuous production rate of biomass within 120 km
Willingness of producers and entrepreneurs to invest in new business models
Strong cooperative organisations, which can act as providers of raw material, investors and end-users
Bioeconomy is included as a priority in the regional development policy of the Autonomous Community of Andalucía
Strong production system that gives confidence to investors, funding bodies and financial entities
Excellence in the scientific know-how and business expertise available
Industrial parks and infrastructure in the private sector
Solid base on knowledge and adequate support of R&D&I institutions and companies
Good infrastructure, logistics, communication and transport

Source: Egea et al. (2018)

5.2 Inclusive Growth in the Bioeconomy

The decisions to conserve, invest in and use natural resources are influenced by complex societal interactions, encompassing both local and global, social and ecological systems, as illustrated in Figure 1.

Figure 1 – Socioecological Technological Value-enhancing Web System View of the Bioeconomy



Source: Viaggi (2020)

There is no guarantee that the bioeconomy will be equally beneficial to all groups in society; and it may even reinforce or deepen existing gender and social inequalities. For example, income and benefit distribution in the bioeconomy could lead to competition between food supply and biomass energy production, which could subsequently trigger food insecurity. It could also lead to a loss of resources and livelihoods for smallholder groups.

Inclusive growth of the bioeconomy requires an understanding of existing inequalities – such as gender, class, ethnicity, age and religion – and to transform and correct these to sustainable structures and processes. Actively involving all relevant stakeholders, including indigenous peoples and local communities, businesses, academia and governmental institutions, in co-creation and decision-making processes regarding the bioeconomy can help ensure that all interests and needs are considered, leading to more equitable outcomes.

Additionally, creating a consumer market for socio-biodiversity products can be challenging. Consumer preferences and habits, influenced by cultural norms and societal trends, are often resistant to change. Consumers may have concerns about the authenticity, quality and legitimacy of socio-biodiversity products, particularly if there are no recognised certification schemes or labelling systems in place. Many consumers may also not be familiar with the concept or the importance of supporting products that promote biodiversity conservation and sustainable livelihoods.

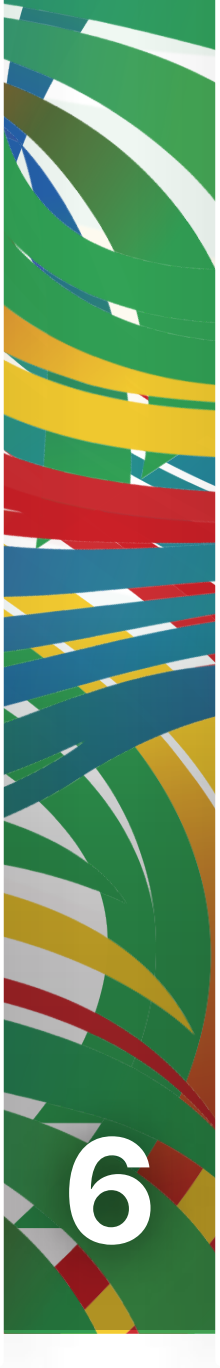
5.3 Health and Well-Being

The bioeconomy has the potential to greatly contribute to health and well-being in numerous ways. One of the most direct contributions of the bioeconomy to health is through the provision of more nutritious, varied and sustainably produced food. This includes novel food sources, like algae or plant-based proteins.

Additionally, the bioeconomy supports research and development for novel drugs, therapies and vaccines, many of which use biological processes or materials. Biotechnology also allows for personalised medicine, improving healthcare effectiveness.

As the bioeconomy promotes the use of renewable resources and aims to reduce waste, it helps protect the environment, which also benefits the health of society. For example, using biofuels instead of fossil fuels can lower air pollution, reducing respiratory health issues.

Furthermore, research has shown that spending time in nature can have a profound impact on physical and mental health, such as reducing stress levels, lowering blood pressure, and reducing symptoms of anxiety and depression (Darcy et al., 2022; Sandifer et al., 2015). This in turn reduces healthcare costs.



G20 National and Regional Bioeconomy Strategies

6.1 Scope and Definition

While the scope and definition of the bioeconomy may differ between the G20 members, broad societal goals, such as sustainable consumption, climate mitigation, and job creation, are consistently emphasised. In industrialised countries, bioeconomy policies have been designed to support and facilitate the transition from traditional fossil-based systems to more sustainable, bio-based alternatives. In these strategies, the focus has been on high-value products and the optimisation of value chains.

In countries and regions with large productive landscapes, such as Brazil and the African Union, a new economic paradigm is emerging that seeks to emphasise the biotic and climatic balance of the planet without harming the socio-economic development and the well-being of the populations that live in these biomes.[13]

An increasing number of countries and regions have integrated bioeconomy policies into industrial strategy and green growth plans, including measures such as funding for research and development, tax incentives or subsidies for bio-based industries, supportive regulatory frameworks and standards that promote the use of bio-based products.

Given the breadth of experience across the G20, the G20 Initiative on Bioeconomy (GIB) may want to consider exploring how G20 members have integrated bioeconomy elements into industrial strategy and green growth plans. The following sections provide examples as part of the stocktake.

6.2 Policy Enablers

The role of policy in the bioeconomy is to provide a supportive and enabling environment that encourages investment, research, innovation and the widespread adoption of sustainable practices and technologies. Policies can be applied throughout the bioeconomy value chain, from production, processing, commercialisation and consumption of biological resources to renewable biological materials and bio-based products.

Agricultural and land use policies: At the primary production stage, agricultural and land use policies play a crucial role in shaping the bioeconomy. For example, land zoning and planning policies allocate suitable areas for different agricultural activities or bio-based industries, which helps guide investment and resource allocation. Clear land ownership rules and transparent land registration systems can reduce conflicts and uncertainties. Furthermore, subsidy and incentive programmes can help encourage sustainable production practices, land conservation, biodiversity preservation and the development of a circular economy. By aligning these policies with bioeconomic objectives, governments can create an enabling environment for the bioeconomy to thrive.

[13] See the Nairobi Declaration on Climate Change (2023): https://au.int/sites/default/files/decisions/43124-Nairobi_Declaration_06092023.pdf

UK as a Case Study

The UK Environmental Land Management (ELM) scheme is an agricultural subsidy programme aimed at incentivising sustainable land management practices and promoting environmental conservation. The ELM scheme supports farmers and landowners in implementing environmentally conscious practices, such as improving soil health, managing water resources, promoting biodiversity, reducing greenhouse gas emissions and enhancing the overall environmental sustainability of their land. The scheme aims to align agricultural practices with broader environmental goals in the United Kingdom.

In the processing stage, common examples of policy enablers across the G20 members include bioenergy policies and tax incentives or subsidies for bio-based products.

Bioenergy policies: Most G20 members have bioenergy strategies that promote the production and use of biomass as energy and transportation fuels. These often include feed-in tariffs, tax incentives and grants for bioenergy production, as well as targets for increasing the production, distribution and consumption of biofuels.

Environmental regulations: Environmental regulations are crucial for the bioeconomy to prevent the overexploitation of natural resources and to minimise pollution and environmental damage. For example, most G20 members have regulations that address land zoning, soil management, deforestation, pesticide and fertiliser use. Additionally, regulations may restrict activities in protected areas and require environmental impact assessments and permits. Many regions have also established water rights systems and permitting processes to control water use and ensure that water resources are distributed fairly and efficiently among users.

Subsidies and tax incentives: Governments may offer several types of subsidies and tax incentives for bio-based products. For example, they may provide investment tax credits to encourage private companies to invest in bio-based materials. These credits reduce the amount of tax a company owes based on the amount of investment made. Governments may also have consumer incentive programmes to reduce the price of bio-based products, so they are more affordable and competitive compared to traditional alternatives.

Finally, in the commercialisation stage, policymakers may use strategies such as Green Public Procurement (GPP) policies, carbon pricing mechanisms or trade policies.

Germany as a Case Study

Germany has introduced a Bioeconomy Bonus programme, which provides financial incentives to consumers who choose bio-based materials for construction projects. The programme aims to encourage the use of sustainable building materials and reduce environmental impact.

Green Public Procurement Policies (GPP): GPP policies refer to government initiatives and guidelines aimed at promoting environmentally friendly practices in public procurement processes. These policies encourage public authorities to consider the environmental impact of their procurement decisions and prioritise the purchase of goods and services with lower environmental footprints.

France as a Case Study

France has implemented several measures to promote bio-based products. One of them is the inclusion of criteria favouring bio-based products in public procurement contracts.

For example, France is actively promoting the use of renewable materials in construction projects through policy measures, certification systems, carbon reduction targets and research initiatives. By focusing on using bio-based materials such as bamboo, hemp and mycelium (mushroom-based materials), it can replace traditional building materials.

South Korea as a Case Study

South Korea has set specific targets for GPP implementation. For example, by 2022, the government aimed to increase the procurement of eco-friendly products by 30% compared to 2017 levels. The country has also introduced various measures to support GPP implementation, including training programmes, information systems and verification processes.

Carbon pricing mechanisms: The majority of the G20 members have carbon pricing mechanisms. These take the form of either a carbon tax or a cap-and-trade system, some countries use both. Carbon pricing mechanisms create financial incentives that accelerate the transition to a low-carbon economy. They provide support for the growth and sustainability of the bioeconomy by promoting bio-based alternatives and encouraging resource efficiency and circularity.

Canada as a Case Study

The federal government in Canada implemented the Pan-Canadian Framework on Clean Growth and Climate Change in 2016, which includes a national carbon pricing system known as the Greenhouse Gas Pollution Pricing Act (GGPPA).

Under the GGPPA, provinces and territories are required to either implement a carbon tax or a cap-and-trade system.

Trade policies: Trade policies can facilitate to the development of a bioeconomy. By eliminating tariffs and other barriers to the trade of environmental goods, policies allow for the global distribution of these goods and increase access to advanced biotechnologies. Subsidies can also be used to incentivise the shift away from carbon and toward renewable fuels.

In November 2020, 50 members of the World Trade Organisation announced their intentions to intensify work on trade and environmental sustainability through the Trade and Environmental Sustainability Structured Discussions (TESSD), which complements the work of the Committee on Trade and Environment and other WTO bodies. The TESSD is co-chaired by Canada and Costa Rica with participation from G20 members, including Australia, Canada, China, EU, Japan, Mexico, Russia, Saudi Arabia, South Korea, Turkey, UK and the US.

The TESSD has four working groups: 1) trade of environmental goods and services; 2) trade-related climate measures; 3) circular economy; and 4) subsidies. Through these working groups, the WTO is exploring opportunities to support environmental and climate goals and promote more sustainable production and consumption.

6.3 Cross-cutting Themes

6.3.1 Research, Development and Innovation

The bioeconomy is called a 'knowledge economy' because it heavily relies on scientific knowledge, research and innovation to drive its growth and development. As such, all G20 members have policies that support research, development and innovation in the bioeconomy. R&D has focused on understanding biological systems, developing new technologies, designing efficient processes and exploring new sources of materials and energy. Related programmes aim to optimise resource utilisation, improve product quality, enhance environmental sustainability and create new economic opportunities.

Most of the G20 members allocate funds and offer grants to researchers and companies involved in bioeconomy R&D. Furthermore, most countries and regions have programmes that support interdisciplinary collaborations between scientists, engineers, policymakers and entrepreneurs. Technology clusters, also known as innovation clusters or technology parks, have played a significant role in the bioeconomy of many countries. Collective knowledge and expertise contribute to the advancement of this field and the development of innovative solutions that address societal challenges, such as climate change, resource depletion and a growing global population.

Italy as a Case Study

The Italian National Technological Clusters are strategic initiatives defined by the Ministry for Education, University and Research (MIUR) for innovative sectors of national significance. The clusters are associations that bring together public and private entities, such as academic institutions, research organisations, enterprises and organisations representing the civil society, with a focus on research and innovation.

The Italian Bioeconomy Strategy refers to three clusters, particularly important in driving the implementation of the strategy: Agro-food CL.AN., Green Chemistry SPRING and Blue Growth BIG.

6.3.2 Sustainable Use of Biodiversity

Most of the bioeconomy policies and strategies of the G20 members consider the sustainable use of resources, recognising the important role that biodiversity plays in the provision of ecosystem services and in supporting the overall health and resilience of ecosystems.

As part of this stocktake, policies and strategies relating to the sustainable use of biodiversity were reviewed. Particular attention was paid to policies that incentivise sustainable resource management, protection of vulnerable ecosystems and the equitable sharing of benefits derived from biological resources.

Payment for Ecosystem Services

For example, the overwhelming majority of G20 members have market mechanisms, or Payment for Ecosystem Services (PES) programmes, that account for the economic value of ecosystem services. PES programmes are a type of nature market that enables landowners, who conserve or restore nature, to receive funds from trade in ecosystems services (see section 7 for a further discussion on nature markets).

Via PES programmes, the government or private sector beneficiaries of an ecosystem service provide incentives to landowners or stewards in return for managing their land or resources in a sustainable way. By offering financial incentives, PES programmes contribute to local economic development and reduce pressures from activities that may harm ecosystems, such as unsustainable logging or poaching. They help conserve biodiversity by aligning economic incentives with environmental goals, ultimately contributing to the long-term conservation and sustainable use of natural resources.

Mexico as a Case Study

Mexico has implemented the National Payments for Ecosystem Services Programme which provides financial incentives to landowners for conserving forests, protecting watersheds, and promoting sustainable land use practices.

The programme operates through a variety of mechanisms, including direct payments for specific ecosystem services, collective contracts with community-based organisations, and trust funds for conservation projects. The Mexican government provides the financial resources for the programme through dedicated funding sources, such as taxes on water use and revenues from environmental fees.

Access and Benefit Sharing

Most of the G20 members recognise the value of indigenous and local knowledge for the bioeconomy, and the importance of access and benefit sharing. Sixteen of the G20 members are signatories to the Nagoya Protocol and have enacted laws that establish a legal framework for accessing genetic resources and sharing benefits.

Additionally, many G20 countries have established (or are in the process of establishing) national information systems for genetic heritage and associated traditional knowledge (see Annex 6.2.2 for further examples).

India as a Case Study

The People's Biodiversity Registers (PBRs) in India help document and protect traditional knowledge associated with bioresources. The PBRs serve as repositories of local biodiversity-related information and ensure that local communities' rights regarding traditional knowledge are acknowledged and preserved.

Brazil as a Case Study

Brazil has more than 30 years of experience in implementing access and benefit-sharing policies. An early example is Law n˚2, 186-16 from 2001, which was criticised for being bureaucratic and discouraging research and development. A more recent example is Law nº 13, 123 from 2015, which is focused more on regulating results. This accumulated experience has allowed Brazil to jump from 3,000 applications for access (R&D) in 15 years to more than 70,000 applications and 17,000 products, which are registered on the SisGen electronic platform (National Management System of Genetic Heritage and Associated Traditional Knowledge). The SisGen is the official website through which users comply with the law, registering access and economic exploitation results, and providing efficiency and transparency.

Bioeconomy and National Climate Strategies

For countries with stand-alone bioeconomy strategies, the link with national climate policy is often subtle. Most of the G20 strategies incorporate circular economy principles, emphasising the efficient use, reuse, and recycling of biological resources, which in turn reduces greenhouse gas emissions. Others have energy-related objectives, such as increasing biofuel production and reducing reliance on fossil fuels. These strategies also have implicit links to national climate policy.

Additionally, food security and sustainable agriculture are common objectives of bioeconomy strategies across the G20. Many countries have ongoing initiatives focused on sustainable farming practices and climate-resilient crops, improving soil health and nutrient recycling in agriculture, which are interlinked with national climate adaptation plans (see Annex 6.2.2 for additional case studies).

Russia as a Case Study

Many countries have a unique resource in the form of abandoned agricultural land, which can be planted with crops specifically adapted to absorbing greenhouse gases and cultivated using carbon farming methods to multiply the sequestration potential.

The Ministry of Science and Higher Education of Russia, together with HSE University, are involved in a pilot project to create carbon test sites in several Russian provinces. An HSE-operated carbon project — the Pokrovsky agricultural carbon test site — will soon be launched in the Moscow, Kaluga and Kirov regions.
(https://www.hse.ru/en/news/823486920.html)

Biodiversity Conservation and Restoration

While conservation and restoration are rarely included as bioeconomic activities, many G20 strategies recognise the importance of conserving and restoring ecosystems to ensure a sustainable bioeconomy. This can be seen in the numerous Payment for Ecosystem Services programmes or agroforestry initiatives implemented in G20 countries.

Additionally, many G20 members recognise the job creation potential of conservation and restoration activities.

African Union as a Case Study

The African Forest Landscape Restoration Initiative, also known as AFR100, is an initiative supported by the African Union. AFR100 was launched in 2015 with the goal of restoring 100 million hectares (roughly 247 million acres) of degraded land across the African continent by 2030.

The initiative aims to address a range of challenges, including deforestation, climate change, loss of biodiversity and land degradation while also promoting sustainable development and improving livelihoods for communities dependent on forest resources.

Through a voluntary partnership, countries and organisations commit to targets and action plans aligned with the African Union's Agenda 2063 and the Bonn Challenge, a global effort to restore 350 million hectares of degraded land worldwide by 2030.

Indonesia as a Case Study

Indonesia has undertaken several notable mangrove restoration programmes that aim to create employment opportunities for fishermen and coastal communities. One example is the Green Coast programme. Launched by the Ministry of Marine Affairs and Fisheries, the programme aims to protect and restore mangrove ecosystems while providing employment opportunities. It engages communities in activities like mangrove planting, monitoring and ecotourism development. Additionally, the programme encourages sustainable small-scale fishing practices, ensuring a balance between conservation and livelihoods.

Saudi Arabia as a Case Study

Saudi Arabia has also been actively engaged in restoration, reforestation and agroforestry projects that aim to create employment opportunities for local communities. For example, the Saudi Green Initiative announced in 2021 aims to plant 10 billion trees across the country by 2030. This ambitious project aims to restore landscapes, increase green cover, and create job opportunities for Saudi citizens in nurseries, planting and landscaping activities.

Another example is the Al-Ahsa Oasis revitalization project. Al-Ahsa, a UNESCO World Heritage site, is home to one of the largest oasis systems in the world. The project aims to preserve and restore this historic oasis by engaging local communities in reforestation and agroforestry practices. It provides opportunities for locals to be involved in planting traditional date palm trees and maintaining the green infrastructure of the oasis.

6.3.3 Bioeconomy as an Enabler of Sustainable Development

Economic Growth through Innovation

All of the G20 bioeconomy strategies aim to create jobs and economic growth. Most include various initiatives targeted at skills development, training and value chain development. For those countries that track bioeconomy indicators, the key areas monitored include data related to employment levels, new job opportunities, and the overall impact of the bioeconomy on the labour market.

Argentina as a Case Study

Argentina's bioeconomy programme called "Programa de Desarrollo de la Bioeconomía Argentina" (Programme for the Development of the Argentine Bioeconomy) focuses on fostering the development and integration of the bioeconomy sector within the country. It includes various initiatives aimed at skills development, training and value chain development. This entails creating employment opportunities at multiple stages of the value chain, including for farmers and producers, processors, distributors and service providers.

Additionally, Argentina has a Bioeconomy Programme for small and medium sized enterprises (SMEs) (Programa de Bioeconomía para PYMES).

This programme aims to provide specific support and resources to SMEs in the bioeconomy sector, including financial assistance, technical training and access to markets and networks.

Brazil as a Case Study

EMBRAPII, or the Brazilian Company of Research and Industrial Innovation, is a major Brazilian organization that collaborates with companies, research centres and educational institutions to support innovation projects within the industrial sector, helping to develop the country's economy through the enhancement of technology and innovation. With support from the Brazilian Development Bank (BNDES), EMBRAPII has provided BRL3.24 billion of funding to corporate research and development projects.

Inclusive Growth in the Bioeconomy

Most G20 bioeconomy strategies recognise the potential for inclusive growth through rural economic development. Bioeconomy policies to support rural development typically focus on promoting sustainable farming practices, developing and enhancing skills and strengthening market links.

Turkey as a Case Study

The Turkish Growth and Innovation Fund (TGIF) was established in May 2016 by the Small and Medium Enterprises Development Organisation of Turkey (KOSGEB), the Industrial Development Bank of Turkey (TSKB), and the European Innovation Fund (EIF). It provides equity capital to traditional sectors, as well as innovative and technology-oriented businesses.

For example, one beneficiary of TGIF capital is an agricultural fintech company called Tarfin. Through the Tarfin mobile app, Turkish farmers find the closest partner stores that offer the necessary inputs (e.g. fertiliser, seeds etc.), compare prices and instantly apply for financing. Working with 15,000 farmers across Turkey, Tarfin has so far completed over 26,000 transactions.

Health and Wellbeing

Few bioeconomy strategies emphasise health and wellbeing as an explicit aim, although traditional medicine is an integral part of the healthcare system in several countries such as China, India and Brazil.

Other countries are increasingly recognising the role of nature for health and wellbeing, and countries such as Japan, the UK, Australia and Canada have public health policies that promote spending time in nature.

China as a Case Study

Traditional Chinese Medicine (TCM) is deeply rooted in Chinese culture and has been used for thousands of years to promote health and treat various illnesses. The Chinese government recognises the economic and cultural value of TCM and has included it in its national bioeconomy plans. TCM is considered an important part of China's healthcare system and is integrated into various policy initiatives and strategies, including research, development, and commercialisation of TCM products.

The TCM market size reached USD$18.8 billion in 2021 and is expected to register a revenue compound annual growth rate (CAGR) of 11.9% by 2030, as estimated by Emergen Research.

Japan as a Case Study

Shinrin-yoku, which is the practice of forest bathing, has gained popularity in Japan and is regarded as a beneficial practice for reducing stress and improving overall well-being. In response to its growing recognition, the Japanese government has introduced policies and initiatives to support Shinrin-yoku. For example, the Japan Forest Therapy Association was established to promote research, training and certification programmes for forest therapy guides. Additionally, there have been efforts to designate certain areas as official forest therapy bases to encourage the practice of Shinrin-yoku.

7

Financing the Bioeconomy

7.1 Financing Today's Bioeconomies

Financing the bioeconomy is distinctly different from financing biodiversity, but the two are interrelated. Most economic estimates refer to the biodiversity financing needed to protect and preserve natural ecosystems, enhance biodiversity and support ecological resilience. However, there are less estimates of the capital requirements needed to fund a global bioeconomy.

The bioeconomy encompasses a wide range of industries with different capital requirements based on the scope of financing needed, for example for research and development, infrastructure investment, production facilities and market development. Additionally, the capital needs can vary from small-scale, bio-based start-ups to large, multinational corporations.

According to a study by the Paulson Institute, The Nature Conservancy and the Cornell Atkinson Centre for Sustainability (2020), the financial resources necessary to transform production systems and protect biodiversity are estimated at US$598 billion and US$824 billion annually. This includes the cost of shifting the agriculture (US$315-420 billion), rangelands (US$81 billion), forestry (US$19-32 billion) and fisheries (US$23-47 billion) sectors to more sustainable practices.

At the same time, the food, land and ocean use systems offer significant business opportunities in a nature-positive scenario.[14] In its 2020 report, 'The Future of Nature and Business', the World Economic Forum estimates that US$3.6 trillion of additional annual revenue or cost savings could be achieved through transforming production systems (WEF and AlphaBeta, 2020). Over half of the opportunity is found in Latin America, Africa, India and low-income countries in the Asia-Pacific. Ecotourism is among the largest opportunities, potentially creating an additional annual revenue of US$290 billion by 2030 (WEF and AlphaBeta, 2020). This opportunity is especially substantial for developing countries that possess intact biodiversity-rich habitats such as Congo, Kenya and Vietnam.

In the same report, the World Economic Forum estimates that the total capital investment required to capture the opportunities presented by the food, land and ocean use systems is US$440 billion per year (WEF and AlphaBeta, 2020).

Brazil as a Case Study

In the 2010/2011 crop season, Brazil launched the Low-Carbon Agriculture Programme, providing low-interest loans to farmers who implement sustainable agricultural practices, such as crop-livestock integration systems and nitrogen-fixing techniques (FGVces, 2019; OECD, 2023; World Bank Group, 2020).

[14] Nature positive means enhancing the resilience of the planet and societies to halt and reverse nature loss (WEF, 2021).

7.2 Financing Mechanisms

Financing a bioeconomy aligned with global goals such as the UN Sustainable Development Goals (SDGs) and the Paris Agreement will require reforms to international financial and economic architecture in order to mobilise the capital needed. This architecture refers to the governance arrangements that safeguard the stability and function of the global monetary and financial systems.

Existing reform efforts have focused on the climate dimensions of monetary policy and financial regulation. This has ranged from broadening the mandates of central banks and banking regulators to strengthening the role of multilateral development banks. However, most recently, the G7 has launched an 'Alliance on Nature Positive Economies', focused initially on advancing disclosures of nature-related risks.

One part of the solution is to pivot toward explicitly valuing nature in economic activities, rather than under-valuing or ignoring it entirely. This can include markets for natural resources, such as agriculture, fisheries and forestry, as well as markets for natural assets, such as land rights and freshwater rights. There are also public purpose 'credit' markets for carbon, biodiversity and derivative markets that seek to conserve and invest in nature or mitigate nature-related risks. Across these markets, a range of instruments and mechanisms exist (Table 1) (see Annex 7.1 for further details).

Catalysing the necessary finance for a sustainable bioeconomy will require a combination of policy incentives, regulation and new governance frameworks at the local, regional and international levels. For example, the mandate of central banks and supervisors can be broadened to require private financial flows to align with relevant government and international policy commitments on nature and climate. Similarly, green fiscal budgeting and sustainability-linked sovereign finance are two examples of efforts to align public finance flows with commitments under the Kunming-Montreal Global Biodiversity Framework.

Additionally, financing the bioeconomy will require addressing challenges such as (i) the need for substantial investments in projects or companies without a credit history or guaranteed revenue; (ii) the lack of guarantees or project assets; (iii) land tenure issues; and (iv) the lack of access to the financial system, which is typical for smallholder agricultural systems and socio-biodiversity value chains.

Taking note of the finance track and the nature-based solutions component of the G20 Sustainable Finance Working Group, the G20 Initiative on Bioeconomy (GIB) may want to examine existing reform efforts that have a bioeconomy dimension. This could include policy alignment with central banks and supervisors, changes to trade and investment rules (particularly for commodity markets), financing schemes and investment models focused on the bioeconomy, and aligning public finance (including capital from multilateral development banks) with international commitments.

Under the Kunming-Montreal Global Biodiversity Framework, Target 19 aims to mobilise US$200 billion per year for biodiversity from all sources, including US$30 billion through international finance. Advancing towards this target would undoubtedly benefit from corresponding policy alignment with central banks and supervisors, adjustments to trade and investment rules (especially for commodity markets), and the development of financing schemes and investment models focused on the bioeconomy.

Table 2 - The Many Forms of Nature Markets - A Taxonomy

Type	Description	Category	Traded element	Segments
Asset markets	Markets in which the right to use ecosystem assets with long-lived value are traded	Real assets	Rights to use an entire ecosystem asset and resulting services	Agricultural land, timberland, water rights, biodiversity intellectual property, additional ecosystem assets
Intrinsic markets	Markets in which provisioning, regulating or cultural services are traded	Products	Use of provisioning services	Hard and soft commodities, legal and illegal wild species, genetic materials, water rights leases
		Conservation	Conservation of nature for direct economic benefit or altruistic value	Payments for ecosystem services, overseas development aid, philanthropic grants, sustainability-linked debt
		Access	Access to or use of cultural services	Wildlife tourism
Credit markets	Markets in which credits that reflect efforts to enhance or conserve ecosystem assets or services are traded	Nature-specific credits	Credits that reflect the value of ecosystem services	Mitigation banks, water quality credits, voluntary biodiversity credits
		Nature-related carbon credits	Credits that reflect the value of carbon sequestration or storage	Nature-related voluntary carbon credits, AFOLU (Agriculture, Forestry and Other Land Use) sector compliance carbon allowances
Derivative markets	Markets for financial products which directly reflect ecosystem values or ecosystem risks	Financial products	Financial products directly tied to ecosystem assets or services	Commodity derivatives, nature-related insurance, wildlife non-fungible tokens (NFTs), biodiversity loss insurance, securitisation of ecosystem assets, water futures

Source: Taskforce on Nature Markets and Vivid Economics (2022)

8

International Cooperation to Foster a Global Bioeconomy

To date, much of the focus on the bioeconomy has been at the national and regional levels. However, with the globalisation of bioresources and expanding trade in bio-based products, distinct international dimensions arise that warrant cooperation. These include addressing transboundary impacts and risks, such as climate change; research, development, and innovation; monitoring and reporting; sustainability indicators; trade and economic issues; and knowledge exchange.

There are a broad range of international institutions working on various aspects of the bioeconomy, which risks duplication or fragmentation of initiatives in the absence of cooperation. Under the Stockholm Environment Institute's initiative on Governing Bioeconomy Pathways, authors Stefan Boessner, Francis Johnson and Zoha Shawoo mapped the international institutions, fora and processes that could strengthen cooperation on the global bioeconomy (Boessner et al., 2021).

Table 3 - International Institutions Relevant for the Governance of Bioeconomy Pathways

Market and Economic	Knowledge	Informational	Commitment and Agenda
WTO	Biofuture Platform	Roundtable on Sustainable Biomaterials (RSB)	Commitment and Agenda Convention on Biological Diversity (CBD)
OECD	Global Bioeconomy Council	The Global Bioenergy Partnership (GBEP)	Convention to Combat Desertification (UNCCD)
UNCTAD	Food and Agriculture Organisation	International Organisation for Standardisation (ISO)	United Nations Framework Convention on Climate Change (UNFCCC)
G20, G7	UNIDO, UNDP, UNEP		
	World Intellectual Property Organisation (WIPO)		
	International Bioeconomy Forum (IBF)		

Source: Modified from Boessner et al., 2021

Different levels of cooperation have strengths and weaknesses that should be considered. For example, international organisations such as the G20 could play a more concrete role in shaping a sustainable, global bioeconomy due to their convening and coalition-building power to tackle issues and level the playing field for bio-based products. Regional initiatives, on the other hand, have the potential to bridge the gap between the local and the international level.

They can build on commonalities and shared interests between countries within a region. Based on such common interests, regional initiatives can test and share experiences, best practices and lessons learnt when deploying new biotechnologies or new bioeconomy policies before expanding them globally.

For example, three regional institutions with bioeconomy strategies and initiatives include the European Union (EU), the East African Community (EAC), and the Organisation of American States (OAS). The member countries of these regional institutions benefit from sharing experiences of the bioeconomy within the region.

Some national and regional bioeconomies warrant cooperation at a global level because of the exceptional levels of biodiversity that have global significance in the context of the climate crisis and nature loss. For example, the rainforests of the Amazon Basin and Congo Basin are globally important carbon sinks that have been the focus of international cooperation on conservation finance, combatting nature crime in value chains and scientific research.

Additionally, international cooperation is important for research, development and innovation because it allows for the exchange of knowledge, resources and expertise between different countries and regions. This emphasis on learning and knowledge sharing is an overarching theme across all perspectives on the bioeconomy.

Furthermore, one of the High-Level Principles on Bioeconomy, as suggested by the Brazilian Presidency of the G20, is a commitment to pursue international collaboration and partnerships for technology transfer, capacity building and joint research initiatives (see Annex 1 for the proposed High-Level Principles on Bioeconomy).

9

Emerging Themes

Several themes have emerged from the stocktaking exercise which align with the proposed High-Level Principles on Bioeconomy in Annex 1. As such, they could form the basis of a G20 Initiative on Bioeconomy (GIB) programme of work to support learning, and, where appropriate, common approaches and cooperation. Building on this foundation, the GIB could deliver a broad stocktaking with a thematic focus and policy insights, set in a systematic analytic framework as follows:

1. Bioeconomy integration into economic, industrial and green growth plans: Exploring how G20 members have integrated bioeconomy elements into national, regional and sector plans would enable learnings as to how the bioeconomy fits into wider development planning and policies.

2. Livelihoods and equity outcomes and opportunities: Deepening shared understanding of the livelihoods and equity dimensions and opportunities of bioeconomy development experiences and associated policy options, particularly for the most vulnerable populations such as small-scale farmers, indigenous peoples and local communities and others, would help ensure the long-term sustainability and resilience of bioeconomy strategies.

3. Bioeconomy-enabling finance: Understanding how developments in sustainable finance could broadly or specifically support bioeconomy developments, would enable learnings as to how to fund growth, drawing from and informing the work of the G20 Sustainable Finance Working Group.

4. Facilitating biotrade: Better understanding of the evolving importance of 'biotrade' arising from the development of a global bioeconomy would facilitate consideration of enabling policies, regulations and incentives.

5. Bioeconomy measurement: Sharing experience on the methodologies, indicators and data sources for measuring the bioeconomy would enable a greater understanding of the dynamics of the bioeconomy, its potential and also its usefulness in different contexts.

In advancing a focused exploration of these key aspects of the G20 member experiences on bioeconomy, the GIB would be well placed to develop an enabling analytic framework to support learning and develop a common understanding. This could include a variety of knowledge-sharing mechanisms, such as stocktake reports on bioeconomy themes, structured policy dialogues among G20 members and related networks, workshops and study tours, as well as practitioner networks across the bioeconomy value chain. G20 members would be encouraged to establish cross-ministerial focal points for knowledge sharing.

Furthermore, the bioeconomy is inherently dynamic and interconnected, constantly evolving due to advancements in technology and scientific research. Given the dynamism of ongoing developments in the bioeconomy, and practical constraints that limit coverage during the Brazilian G20 Presidency, the GIB could usefully highlight other key themes that might be valuable to consider in the future, whether through the G20 or other international cooperation platforms and initiatives.

This horizon scan would form the basis for continued work by the GIB in subsequent years and would establish a foundation for international partners to carry forward work on the bioeconomy.

The GIB would on this basis deliver a set of High-Level Principles on the Bioeconomy, along with indicative substantive areas suited for continued international cooperation, as a contribution to the final G20 Heads of State Communiqué at the end of the Brazilian presidency.

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Annexes

Annex 1

Proposed High-Level Principles on Bioeconomy

Bioeconomy strategies must be designed with an integrated approach that harmonizes economic, social, and environmental dimensions, acknowledging the interdependence of these factors.

Bioeconomy actors must commit to the conservation and sustainable use of biodiversity by adopting practices that minimize negative impacts on ecosystems, protect endangered species, and promote sustainable resource use.

Policies promoting the bioeconomy should prioritize social equity by ensuring fair access to resources and equitable sharing of their benefits, promoting job creation, and safeguarding the rights of vulnerable populations.

The development and deployment of bioeconomy technologies should adhere to ethical standards, ensuring that potential risks are scientifically assessed, and benefits are equitably distributed.

Decision-making processes related to the bioeconomy should be inclusive, involving diverse stakeholders such as indigenous peoples, local communities, small-scale farmers, family farmers, local governments, academia, and industry.

International collaboration and partnerships for technology transfer, capacity building, and joint research initiatives should be pursued by G20 countries.

Transparent reporting mechanisms should be established to track the progress of bioeconomy initiatives, ensuring accountability in achieving sustainability and inclusivity goals.

Annex 2

2.1 Definitions of bioeconomy

'Bioeconomies' are most often defined as markets using biotechnologies to meet growing energy needs sustainably.

As such, the core benefit of bioeconomies, using biotechnologies, including bio-based products and bioenergy, is seen in the opportunity to extract value from natural biological processes and expedite the transition away from fossil-fuel economies (Mittra & Zoukas, 2020).

In an analysis of 6,976 peer-reviewed papers from 1996 to 2022 Wei et al. (2022) identified four research areas of the bioeconomy: biotechnology, bioindustry, policy and strategy and sustainable development. The latter is often called the "modern bioeconomy" when it refers to the relationship between the bioeconomy and the circular economy. The countries which primarily published the academic papers were the USA, the UK, Australia, Spain, France, Norway, Germany and the Netherlands (Wei et al., 2022).

Since it emerged as a concept, the definition of the bioeconomy has broadened (Wei et al., 2022):

- Initially, it focused on the management of natural resources, particularly fisheries.
- From 1998 to 2002, it expanded to include research on sustainable rates of exploitation, marine environmental protection, population dynamics, and renewable energy from 2003 to 2012.
- From 2013 to 2017, researchers included a focus on the transformation of biomass into bio-based products, biotechnology, and new agricultural systems.
- Since 2018, publications have increasingly explored the relationship between the bioeconomy and sustainable development.

Wei et al. (2022) define the bioeconomy as "the use of abundant biological resources to meet the economic and social demand for biological products through advanced practical biotechnology in a circular way, so as to alleviate the increasing pressure on population, food, energy, environment, and so on". The authors propose to establish the bioeconomy based on several visions which include:

- a whole vision, where the bioeconomy transition is holistic, transforming into a new international system, rather than a part of a larger system;
- a biotechnology vision, where biotech innovation includes the convergence of different disciplines, such as big data and artificial intelligence;
- a bioindustry vision, where demand is better understood;
- a policy vision, where bioeconomy policies and strategies across different countries are consistent; and
- a sustainability vision, among others, where the relationship between the bioeconomy and the achievement of the UN Sustainable Development Goals (SDGs) is strengthened (Wei et al., 2022).

Some countries, such as Finland, Sweden and Germany, were early adopters of bioeconomy strategies and began formulating policies and frameworks to promote the bioeconomy in the early 2000s. Another milestone occurred in 2012, when the European Commission published its first bioeconomy strategy. This gave impetus to a broad movement of thinking and gave rise to the development of national bioeconomy strategies. Now, over 60 countries and regions have bioeconomy or bioscience-related strategies. Bioeconomy approaches are not mutually exclusive, and differences are rooted in diverse priorities and strategies, contexts, and drivers.

For example, in Brazil, several visions of the bioeconomy have emerged. In addition to Uma Concertação pela Amazônia (Amazon Concertation), the Brazilian Coalition on Climate, Forests and Agriculture proposed a bioeconomy approach in September 2021. The Coalition suggests a bioeconomy that would add value to productive supply chains and ecosystem services derived from native vegetation, whether exclusively or in combination with planted forests, agricultural or pastoral systems, ranging from small-scale extractive or family-based to larger-scale agroforestry systems.

The Coalition's proposed bioeconomy explores the interface between agriculture, livestock and forests, aiming to scale up sustainable and biodiverse production systems that promote landscape restoration, soil regeneration, biodiversity conservation, ecosystem service valuation, and agricultural efficiency.

Despite the growing research on bioeconomy in life sciences since the 1990s, the implications for the social field are not yet well understood.

Currently existing literature in social sciences raises bioethical concerns about the commodification of nature and the inherent and ascribed value of biological objects and processes (Mittra & Zoukas, 2020). In particular, publications discuss how previously non-economic entities like natural resources can be monetised from a bioeconomy perspective. Other essential considerations are to identify the inherent and ascribed value of the bioeconomy and its role as an asset-based proposition (Mittra & Zoukas, 2020).

This Global Stocktake builds on previous research undertaken in recent years. The OECD publication, 'Meeting policy challenges for a sustainable bioeconomy' published in 2018, identified some of the priority issues to be addressed from a policy perspective. Further work in the policy area progressed in 2021 during the Italian Presidency of the G20 in partnership with the OECD, culminating in the paper, 'Bioeconomy national strategies in the G20 and OECD countries: Sharing experiences and comparing existing policies'. More recently, a technical document was prepared for the Indian Presidency of the G20 in 2023, 'Knowledge Exchange on Circular Bioeconomy' (MoEFCC & TERI, 2023), which highlights the synergies between the bioeconomy and the circular economy and provides recommendations on policy options for countries to promote the sustainable use of bio-resources in line with the 3Rs (reduce, reuse, recycle).

Furthermore, this stocktake aims to complement the discussions taking place in other international processes, such as the G7 Alliance on Nature Positive Economies.

2.2 Certification Standards for Bioenergy and Sustainable Use of Biomass

Several certification schemes focus on the utilisation of renewable biological resources as substitutes for fossil-based products. The Roundtable on Sustainable Biomaterials (RSB), for example, is a global sustainability standard and certification system for bioenergy, biomaterials, and bio-based products. It sets criteria for environmentally, socially and economically responsible production and processing. The table below provides the most commonly used certification standards.

Table 4 – Selected standards and certification schemes and their components or coverage

Acronym	Scheme, programme or standard	Commodity/process, relation to others	Type of mecanism	Environmental						Socio-economic		
				GHG emissions	Biodiversity	Carbon stock	Soil	Air	Water	Land use management	Land rights	Food security
ISCC	International Sustainability and Carbon Certification	All feedstocks, all supply chains	Certification	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bonsucro	Bonsucro EU	Sugar cane and derived products	Certification	✓	✓	✓	✓	✓	✓	✓	✓	
RTRS	Roundtable on Responsible Soy EU	Soy-based products	Certification	✓	✓	✓	✓	✓	✓	✓	✓	
RSB	Roundtable on Sustainable Biometerials EU	Biomass for biofuels and biomaterials	Certification	✓	✓	✓	✓	✓	✓	✓	✓	✓
SAN	Sustainable Agriculture	Various agricultural crops and commodities linked to Rain Forest Alliance	Technical Network		✓	✓	✓	✓	✓	✓		
RSPO RED	Roundtable on Sustainable Palm Oil RED	Palm oil products	Certification	✓	✓	✓	✓	✓	✓	✓	✓	✓
PEFC	Programme for Endorsement of forest certification	Forest management	Certification		✓	✓	✓	✓	✓	✓	✓	
FSC	Forest Stewardship Council	Forest management	Certification		✓	✓	✓	✓	✓	✓	✓	
SBP	Sustainable Biomass Programme	Woody biomass [e.g., wood pallets, wood chips, linked to PEFC and FSC	Certification	✓	✓	✓	✓	✓	✓	✓	✓	
WOCAT	World Overview of Conservation Approaches and Technologies	Global network on sustainable land management	Best Practice Network			✓	✓	✓	✓	✓		
ISO 13065: 2015	Bioenergy	Biomass and bioenergy, including conversion processes	Standard	✓	✓	✓	✓	✓	✓	✓	✓	✓
ISO 14055: 2017	Land Degradation and Desertification	Land-use management including restoration of degraded land	Standard	✓				✓	✓	✓	✓	

✓ indicates that the issue is adressed in the standard or scheme

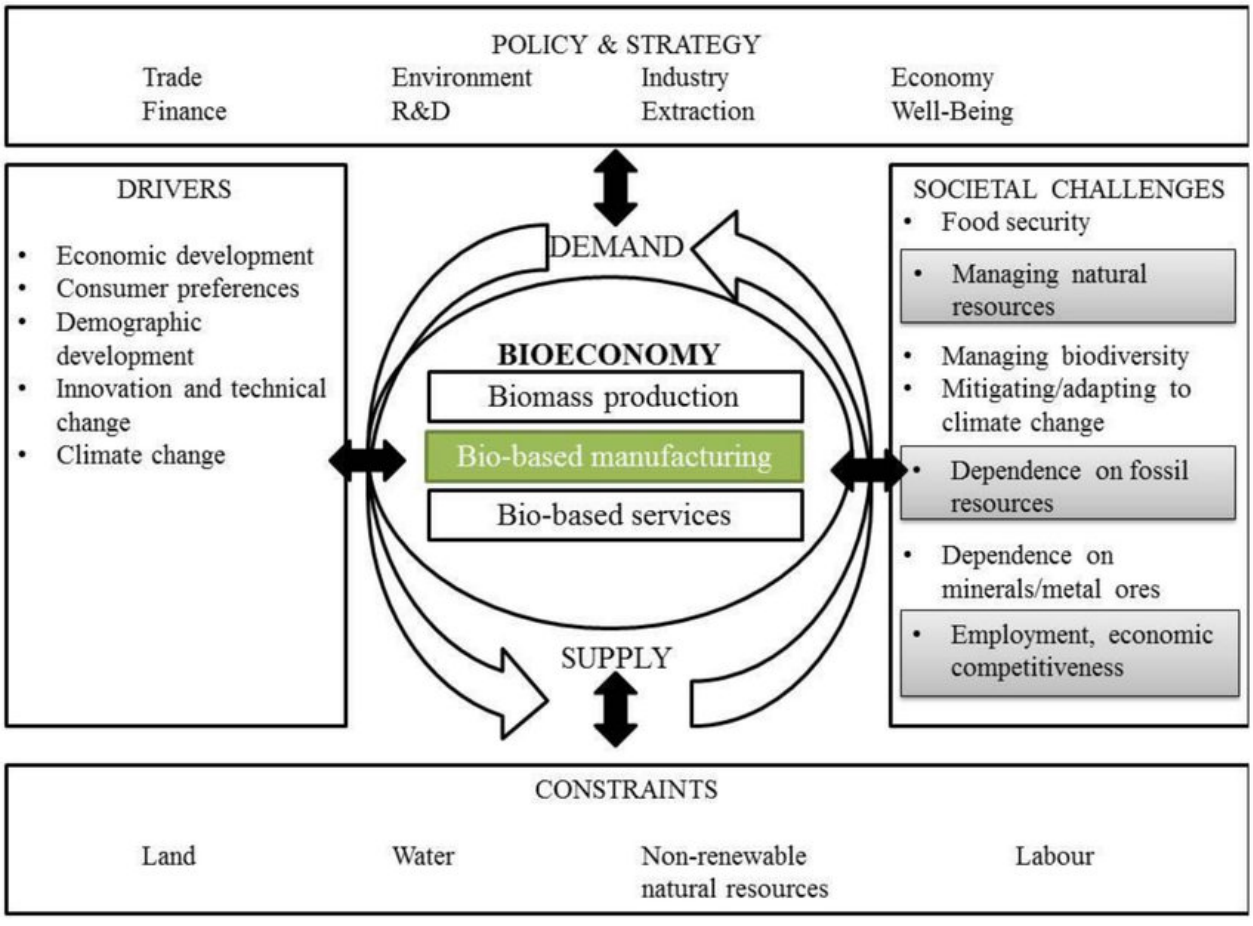
Source: Hurlbert (2019)

2.3 The Bioeconomy Transition Framework

The concept of bioeconomy transition, while not well understood, has generally referred to a reduction in fossil resource use through substitution with biogenic resources. One framework to measure the progress of transition is the "Bioeconomy Transition Framework".

In this Framework, bioeconomy sustainability objectives are formulated as "societal challenges", and where the bioeconomy is expected to have a positive impact on these objectives, the authors have derived indicators for the challenges in the grey boxes below.

Figure 2. Bioeconomy Transition Framework (green represents the bioeconomy sector examined and grey the societal challenges, for which indicators are developed in this study)



Source: Jander, W. et al. (2020)

2.4 Metrics and Indicators

Metrics and indicators to measure bioeconomies often differ (see Table 5 below) and depend on the used economic sector classification. The bioeconomy can be subdivided into three broad sectors: biomass production (primary sector), bio-based manufacturing (secondary sector) and related services, such as trade (tertiary sector). While the primary sectors agriculture and forestry are always included in international monitoring systems, the chemical sector, for example, is at least partly considered in most of them (see Table 5 below).

Table 5 – Overview of bioeconomy sectors and indicators suggested in this study compared with current literature

Literature	Bioeconomy Sectors Covered	Economic Indicators	Environmental Indicators	Innovation Indicators
This study	Bio-based manufacturing sectors with substitution potential (case here: bio-based surfactants. More sectors in [19].	Number of employees, gross value added, turnover, foreign sales, investment	Energy consumption, land footprint, fossil-resource saving	Publications, patents
Biber-Freudenberger et al. 2018 [17]	Primary and high-tech bioeconomy sectors	Value added, employment, exports	Selected indicators linked to SDGs	Patent applications
Capasso and Klitkou 2020 [20]	Sectors with a bio-based share	Value added, employment, productivity	-	-
D'Adamo et al. 2020 [4]	Sectors with a bio-based share	Employment, turnover, value added	-	-
Efken et al. 2016 [11]	Sectors with bio-based inputs	Employment, gross value added	-	-
Egenolf and Bringezu 2019 [18]	Not specified	-	Agricultural land, forest, water, material, climate footprints	-
Frietsch et al. 2016 [21]	Sectors with bio-based related patents	-	-	patents
Fuentes-Saguar et al. 2017 [22]	Selected bioeconomy sectors	Output and employment multipliers	-	-
Iost et al. 2019 [23]	Sectors with bio-based inputs	Employment, gross value added, turnover	-	-
Jander and Grundmann 2019 [24]	Bio-based substitute products	Substitution share, fossil-resource saving	-	-
Loizou et al. 2019 [13]	Sectors with a bio-based share	Output, employment, income multipliers	-	-
Ronzon and M'Barek 2018 [3]	Sectors with a bio-based share	Number of persons employed, turnover, value added, labor productivity, location quotient	-	-
Wen et al. 2019 [14]	Selection of mainly bio-based sectors + bioenergy	Value added	-	-
Wydra 2020 [25]	Sectors with a bio-based share	-	-	R&D expenditures, patents

Source: Jander, W. et al. (2020)

Economic indicators: These metrics assess the economic aspects of the bioeconomy, such as job creation, value-added contributions, and the size of the bio-based industries. They help evaluate the economic viability and growth of the bioeconomy sector.

Environmental indicators: These metrics focus on the environmental sustainability of the bioeconomy, including both terrestrial and marine resources. They include measurements of greenhouse gas emissions, resource efficiency, land use, water consumption and waste generation. These indicators also provide an assessment of the environmental impact and effectiveness of bio-based processes and products.

Innovation indicators: These metrics track the level of innovation, technological development, and research activities within the bioeconomy. They can include the number of patents, research funding, collaboration networks and advancements in bio-based technologies. Monitoring these indicators helps evaluate the progress and level of innovation in a sector.

Monitoring progress in the bioeconomy requires tracking a combination of indicators, including beyond economic, environmental, innovation also social and sustainability indicators. By adopting a holistic approach, policymakers, researchers and stakeholders can assess the overall performance and sustainability of the bioeconomy sector.

Social indicators: These metrics gauge the social aspects of the bioeconomy, such as social inclusion, gender equality and rural development. They can include measurements of job quality, access to benefits of the bioeconomy and social equity. These indicators provide a measure of the bioeconomy’s contribution to social well-being and inclusivity.

Sustainable development indicators: These metrics align with the United Nations' Sustainable Development Goals (SDGs) and assess the bioeconomy's contribution towards achieving them. Indicators may include targets related to food security, energy access, climate action, responsible production and consumption, and biodiversity conservation.

Monitoring of the bioeconomy allows countries to assess their resource utilisation, conservation efforts and potential impacts on nature. It helps actors identify unsustainable practices, implement corrective measures and make informed decisions to safeguard the health and resilience of ecosystems.

Annex 3

3.1 Agriculture Technologies

Remote monitoring of fisheries and aquaculture: Technology has facilitated remote monitoring and management of fish stocks in both wild fisheries and aquaculture. Sensors and remote sensing tools allow fishery managers to monitor ocean conditions, track fish migration patterns, and control water quality parameters in aquaculture operations. This data-driven approach helps in sustainable fishery management and optimises aquaculture production.

Big data and advanced analytics: The availability of big data and advanced analytics has revolutionised decision-making in traditional industries. By integrating and analysing vast amounts of data, farmers, foresters and fishers can make informed decisions to optimise operations, predict market demand and manage risks effectively.

Automation: Robotics and automation have brought about significant changes in agriculture. Autonomous tractors, harvesting machines and drones can perform tasks more efficiently and accurately than manual labour. This helps in increasing productivity, reducing labour costs, and addressing labour shortages in rural areas.

Traceability and quality control: Technology enables the implementation of robust traceability systems in food production. From farm to fork, digital solutions like blockchain can provide transparency and traceability, ensuring food safety and quality control. Consumers can track the origin and journey of products, while producers can identify and rectify any issues quickly.

Additionally, sensor technologies, data analytics, and cold chain management plays a crucial role in maintaining the quality and freshness of perishable products. Advances in refrigeration technologies and insulation materials contribute to improved efficiency in maintaining proper temperature and humidity throughout the supply chain, minimising post-harvest losses of food products.

Regenerative agriculture technologies: Regenerative agriculture is a holistic approach to farming that focuses on rebuilding and enhancing soil health, ecosystem resilience and biodiversity. It aims to regenerate natural resources while improving agricultural productivity and farm profitability.

Regenerative agriculture practices include minimising soil disturbance using methods such as cover crops and crop rotation, integrating livestock into cropping systems, practising agroforestry and utilising organic amendments. These practices enhance soil organic matter, water retention, nutrient cycling, and carbon sequestration, promoting long-term sustainability and resilience.

While regenerative agriculture focuses on ecosystem restoration and resilience, precision agriculture aims to minimise environmental impacts by reducing the use of inputs.

But both, precision and regenerative agriculture, prioritise sustainable production and environmental stewardship. The integration of these approaches can lead to more sustainable farming systems that support ecosystem services, biodiversity and climate resilience.

They can work together to achieve sustainable and productive farming systems. For example, regenerative agriculture practices can support the long-term sustainability of precision agriculture by improving soil health and resilience. Healthy soils enhance water infiltration, nutrient availability, and root development, leading to more accurate and effective use of precision techniques.

Precision agriculture technologies and data-driven insights can be applied to regenerative agriculture systems to optimise resource management and improve efficiency. For example, precision technology can be used to fine-tune irrigation schedules, target nutrient applications, and monitor crop health.

Bayer's Carbon Project – Case Study

Bayer is a multinational company that offers a range of agricultural solutions. It supports precision agriculture methods like precision planting and variable rate application (VRA) of inputs. Bayer also promotes regenerative agriculture practices like cover cropping and soil health management to improve the sustainability of its services.

In Brazil, Bayer's PRO Carbono initiative allies with farmers and scientific and technological partners to turn sustainability into a business by intensifying good practices that enhance carbon sequestration in the soil and increase productivity.

Key interventions for crop protection include seeds and biotechnologies, precision planting, seed treatment applications, enhanced formulations, biologicals, product stewardship (such as protection strips, drift reduction), active ingredients with enhanced environmental profile, and digital agriculture. This is coupled with no-till farming, crop-livestock-forestry integration, cover crops and other regenerative agriculture practices.

Traditional Knowledge and Technology Development:

Examples of technologies and innovations that effectively incorporate traditional knowledge of indigenous peoples range from agriculture and resource management to medicine and environmental protection.

For agricultural technologies, the most common examples include:

- Drip irrigation systems that draw on traditional water management practices; and
- Indigenous crop varieties being used in breeding programs to create more resilient genetically modified crops.

Additionally, some socio-biodiversity products offer innovations that incorporate traditional knowledge. These are products that are derived from the natural resources available in a particular region and are produced in a way that is deeply intertwined with the cultural and social practices of local communities, often indigenous or traditional populations. These products are not only significant for their economic value but also for their role in conserving biodiversity and sustaining the livelihoods and culture of the people who produce them.

For example, the company Tobasa BioIndustrial develops technologies and processes for forest extraction and the industrialisation of the babassu coconut. Innovations range from collecting and breaking the coconut to the technological processing of its products. These include coconut oil, protein feed, energetic biomasses, amylaceous flour, starch alcohol and activated carbon. Furthermore, its supply chain is fully covered by the indigenous people and local communities that reside in the forest area of Tocantins within the Legal Amazon.[15]

Ensuring Inclusivity and Equity:
In a paper from 2022, Bastos Lima provides several recommendations to ensure inclusivity and equity in agricultural commodity value chains. First, alternating between feedstock production and food production helps to ensure food security and reduce vulnerability to existing livelihoods. Second, agricultural cooperatives can empower smallholders in the negotiating phase of contract farming terms. Finally, the livelihoods of smallholders are strengthened as they gradually ascend in the bio-based value chain (e.g., seed oil extraction).

Bastos Lima goes on to provide an example from Brazil, in which the government established Petrobras Biofuels, a public company, to lead on smallholder contracting. The company improved technical assistance and fostered the creation of smallholder cooperatives to enhance organisational capacity. Additionally, the government started promoting mixed food-and-feedstock cultivation while limiting the latter to prevent exacerbated exposure to market price volatility and food security risks. Finally, the government implemented a policy requiring that smallholder contracts are always approved by a representative collective organisation (e.g. agricultural cooperatives or local workers' union) to balance the negotiation power and safeguard vulnerable smallholders.

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[15] https://www.tobasa.com.br/

3.2 Bio-refineries

Technologies used in bio-refineries have greatly enhanced the efficiency of extracting, processing, and utilising biological resources.

Advanced Extraction Technologies
Among notable examples of bio-refinery companies that employ advanced extraction techniques are:

Avantium, a Netherlands-based company, has developed a proprietary technology called Dawn Technology that combines supercritical fluid extraction (SFE) and enzymatic hydrolysis. This process allows the production of high-quality, plant-based sugars and lignin from non-food biomass for various applications such as biofuels and biochemicals.

Greenshift Corporation, based in the United States, focuses on developing advanced extraction technologies for various industries, including bio-refineries. Its extraction processes, such as ultrasound-assisted extraction (UAE), are used to improve the efficiency and yield of biofuel production from feedstocks like algae and corn.

Novozymes, a Danish biotech company, is known for its expertise in enzymatic hydrolysis. It develops and provides enzymes specifically designed to break down complex biomass structures into simple sugars, enabling bio-refineries to produce ethanol, bioplastics and other valuable products from renewable feedstocks.

Renmatix, an American company, specialises in the production of cellulosic sugars through a process called Plantrose®. This proprietary technology employs supercritical water to break down biomass, enabling the extraction of valuable sugars that can be used in the production of bio-based chemicals, materials and fuels.

Woodspin brings together Suzano, the world's largest hardwood pulp producer, and Finnish materials technology pioneer Spinnova to create a wood-based fibre. It is the exclusive producer and distributor of climate-positive, wood-based fibres to fashion houses, brand holders and their supply chain partners.

Process Automation Technologies

Among notable examples of bio-refinery companies that utilise process automation technologies are:

GranBio, a Brazilian company, operates a biorefinery that uses process automation to optimise the production of second-generation ethanol from sugarcane bagasse. It employs sensors to monitor and control key parameters; data analytics to optimise process efficiency; and machine learning algorithms to predict and prevent potential operational issues.

Pacific Ethanol, a U.S.-based company, owns and operates bio-refineries that produce ethanol and associated co-products. It utilises sensors throughout their production processes to monitor variables like temperature, pressure and flow rates. This data is assessed by using data analytics and machine learning algorithms, enabling the company to optimise production efficiency and quality.

RWE Generation, a German energy company, has a biorefinery in the UK that converts biomass into power, heat and biomethane. It applies process automation technologies, such as sensors, to monitor and control various aspects of their operations; data analytics to optimise energy generation and resource allocation; and machine learning algorithms to improve process efficiency.

Clariant, a Swiss specialty chemicals company, operates a biorefinery in Germany that converts agricultural residues and other biomass into advanced biofuels and biochemicals. It utilises sensors to monitor process parameters, and machine learning algorithms to analyse data and optimise production efficiency and yield.

Fermentation and Anaerobic Digestion Technologies

Among notable examples of bio-refinery companies that utilise fermentation and anaerobic digestion technologies are:

GranBio's biorefinery, located in Brazil, is known for its advanced cellulosic ethanol production. It uses a combination of fermentation and enzymatic hydrolysis to convert agricultural waste, such as sugarcane bagasse and straw, into ethanol. In August 2023, the company announced plans to build a demonstration plant capable of producing three million litres of sustainable aviation fuel annually, using wood chips and sugarcane waste as raw material.

Enerkem, a Canadian company operating a bio-refinery, uses anaerobic digestion and gasification technologies. It converts municipal solid waste into biofuels and chemicals like methanol and ethanol.

LanzaTech's biorefinery, located in China, takes waste gases from steel mills and converts them into valuable chemicals and fuel through a process called fermentation. This innovative approach helps reduce carbon emissions and turns waste into resources.

US company Green Plains operates several bio-refineries that utilise fermentation to produce ethanol and other valuable co-products from corn feedstock. It also explores new technologies to enhance the overall efficiency of its operations.

Genetic Engineering and Synthetic Biology Technologies
Among notable examples of bio-refinery companies that utilise genetic engineering and synthetic biology technologies are:

Ginkgo Bioworks, a synthetic biology company based in the U.S., utilises biocatalysis in its biorefinery projects. It focuses on engineering microorganisms to produce specialty chemicals, fragrances and food ingredients.

Bioweg, a German company, uses fermentation, material science and molecular simulation to create biodegradable and sustainable, bio-based ingredients. Together with Ginkgo Bioworks, Bioweg announced a collaboration to optimise the production of bacterial cellulose and to produce novel variants of cellulose with improved performance.

Arzeda is a synthetic biology company that applies biocatalysis to its biorefinery projects. It uses computational protein design and enzyme engineering to optimise chemical processes for the production of specialty chemicals and materials.

Biocatalysis Technologies
Among notable biorefinery projects applying biocatalysis technologies are:

Avantium developed a biorefinery project called "Dawn Technology". It uses biocatalysis to convert non-food plant material into chemicals and plastics.

LanzaTech aims to convert carbon emissions into sustainable fuels and chemicals. It uses biocatalysis in its biorefinery projects to convert industrial waste gases, such as carbon monoxide and carbon dioxide, into valuable products.

Amyris is a biotechnology company that employs biocatalysis in its biorefinery projects. It develops yeast-based fermentation processes to produce renewable chemicals, fuels, and ingredients for various industries.

Algal Technologies

Among notable biorefinery companies applying biocatalysis technologies are:

Sapphire Energy, based in the United States, has developed a biorefinery that uses algae to produce renewable crude oil. It cultivates algae in open ponds and converts it into crude oil, which can be further refined into fuels like gasoline, diesel and jet fuel.

Algenol, also based in the United States, focuses on producing ethanol from algae. Its bio-refineries cultivate algae in photobioreactors, where the algae converts carbon dioxide into ethanol through photosynthesis. This method allows for more efficient carbon capture and produces a renewable fuel source.

Algix, located in the United States and Mexico, specialises in utilising algae to produce bioplastics. Its bio-refineries extract proteins from algae and convert these into biopolymer pellets. These pellets can be used in a variety of plastic applications, providing a sustainable alternative to traditional petroleum-based plastics.

Heliae Development, based in the United States, has developed a biorefinery platform that uses algae for multiple applications. It focuses on cultivating algae strains rich in unique compounds like proteins, lipids and omega-3 fatty acids. These valuable components can be extracted and used in various industries such as food, nutraceuticals and personal care products.

G20 countries listed in order of their biorefining capacity:

United States: The United States has a substantial biorefining capacity, with various facilities spread across the country. As of now, the total capacity is approximately 16 million tonnes per year.

Brazil: Brazil is a global leader in biofuels production, particularly ethanol derived from sugarcane. It currently has a biorefining capacity of around 14.5 million tonnes per year.

Germany: Germany has been investing significantly in bioenergy and bio-refineries. Its current biorefining capacity is estimated to be around nine million tonnes per year.

Canada: Canada has been actively developing its biorefinery sector, especially for wood biomass and biofuels. Its current capacity is around six million tonnes per year.

Australia: Australia has been focusing on bio-refineries for the production of biofuels and biochemicals. Its capacity is estimated to be around five million tonnes per year.

France: France is making progress in biorefining, with a focus on producing biofuels and biomaterials. It currently has a biorefining capacity of around four million tonnes per year.

China: China has been actively investing in bio-refineries, particularly for biofuels and biochemicals. Its capacity is estimated to be around three million tonnes per year.

India: India has been increasing its biorefinery capacity, particularly for biofuels and bioplastics. Its current capacity is around two and a half million tonnes per year.

3.3 Bio-based Materials

Two bio-based materials that are growing in applications are lignin and nanocellulose.

Lignin is the most abundant aromatic molecule in nature, representing about 30% of non-fossil carbon in the biosphere. Lignin can be produced as a co-product from kraft pulping (non-food competing feedstock) processes and has a high scalability potential. Lignin is mainly used as residue after combustion to generate clean energy. However, based on new research, it is identified as a potential substitute for petroleum and for applications in various industries: automotive, aviation, raw materials for concrete and bio-oils.

Nanocellulose, on the other hand, is considered a 'supermaterial' because it is strong, light and impermeable. The automotive and aeronautics industries have already seen benefits from the development of this material.

Cellulose nanofibers are known for various characteristics including reduced capacity to absorb water, making them ideal for applications such as food packaging, biomedicine, gas containment and even cosmetics.

Along these lines, Klabin, a Brazilian company, invested in the Israeli startup Melodea to develop new barrier solutions. Among these are nanocellulose crystals, which are transparent and highly resistant and can be used for conducting electricity. One application for this product is foldable mobile phone screens.

Some of the sectors that are most quickly adopting bio-based materials include:

A

Packaging: The packaging industry is increasingly turning to bio-based materials as a sustainable alternative to traditional petroleum-based plastics. Bio-based packaging materials, such as bioplastics derived from renewable sources like corn, forest species, or sugarcane, are gaining popularity due to their reduced environmental impact.

Many regions and countries have regulations requiring the use of bio-based or biodegradable materials in packaging and plastics. For instance, the European Union has implemented the Single-use Plastics Directive, which mandates the use of bio-based alternatives for single-use plastic items like cutlery, plates and cotton buds.

B

Textiles and fashion: The fashion industry is exploring bio-based materials for sustainable textile production. Fabrics made from materials like bamboo, forest species, hemp and even agricultural waste, such as pineapple fibres or orange peels, are being used as eco-friendly alternatives to conventional textiles. In the textile industry, growth in viscose (or rayon), derived from soluble cellulose, is another notable phenomenon and already accounts for approximately 6% of the global textile market.

C

Automotive: The automotive industry is incorporating bio-based materials in the manufacturing of interior components, such as car seats and panels. Bio-based plastics are being used to reduce the reliance on petroleum-based materials and minimise environmental impact.

D

Construction: The construction sector is embracing bio-based materials as a means to mitigate the industry's carbon footprint. Examples include using engineered wood products, such as cross-laminated timber, as a sustainable alternative to traditional building materials like concrete or steel.

In some areas, regulations promote the use of bio-based materials in construction to reduce environmental impact. For example, France implemented legislation in 2020 requiring public buildings to incorporate a minimum percentage of bio-sourced or recycled materials.

E

Personal care and cosmetics: Bio-based ingredients are gaining traction in the personal care and cosmetics industry. Natural and organic ingredients derived from plants, such as essential oils, botanical extracts and biodegradable formulations, are being utilised to meet the growing demand for environmentally friendly cosmetic products.

Furthermore, technology helps improve the quality and functionality of bio-based materials, making them more competitive than traditional alternatives. Through research and development, scientists can enhance properties like strength, durability and flexibility, broadening the range of applications for bio-based materials.

The benefits of this shift to bio-based materials are manifold. Firstly, they are renewable and derived from natural resources, reducing the reliance on fossil fuels and non-renewable resources. This helps mitigate environmental damage and reduce carbon emissions, leading to a more sustainable and environmentally friendly manufacturing process.

Secondly, bio-based materials are often biodegradable or compostable, meaning they can break down naturally, reducing waste accumulation and pollution. This is especially important in sectors like packaging and agriculture, where single-use materials are prevalent.

For example, mycelium, the root structure of mushrooms, has emerged as a promising bio-based material option. It can be grown into complex shapes and forms, making it suitable for packaging, construction materials and even fashion. Mycelium-based materials are natural, biodegradable, and can be produced with low energy and resource inputs.

Moreover, diversifying raw material sources by using bio-based materials fosters economic resilience. It reduces vulnerability to price fluctuations in traditional resource markets and creates new opportunities for farmers and rural communities by providing crop diversification options.

3.4 Biotechnology, Bioinformatics and Computational Biology

Examples for research in biotechnology, bioinformatics and computational biology are listed below.

The Brazilian Biorenewables National Laboratory (LNBR) is one of four national laboratories within the Brazilian Centre for Research in Energy and Materials (CNPEM)[16] that is “dedicated to the development of microorganisms and enzymes to establish new industrial production models that can generate wealth and jobs, while reducing the impacts on the environment”. The LNBR utilises synthetic, structural and computational biology to engineer and customise platforms for the production of biofuels, biochemicals and biomaterials.[17]

Genomics of the Brazilian Biodiversity (GBB) is a bioinformatics project launched in 2022 by the Vale Institute of Technology – Sustainable Development (ITV-DS), in partnership with the Chico Mendes Institute for Biodiversity Conservation (ICMBio). The project aims to develop a genomic map of Brazilian fauna and flora species, including exotic species, of those that are threatened with extinction, or those with the potential to generate income for farmers involved in the bioeconomy.[18]

Another bioinformatics example is the Human Variome Project (HVP), a global initiative aimed at collecting, curating and sharing information on genetic variations that can influence human health. It focuses on creating public databases called “variant databases” to consolidate and interpret genetic variation data from around the world. The project's ultimate goal is to improve the diagnosis, treatment and prevention of genetic disorders. G20 members involved include Australia, Canada, China, France, Germany, India, Japan, the United Kingdom and the United States.

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[16] CNPEM is a non-profit private institution funded by the Brazilian Ministry of Science, Technology and Innovations (MCTI).

[17] https://lnbr.cnpem.br/

[18] https://www.itv.org/imprensa/dna-sequenciamento-genomico-e-biodiversidade/

3.5 Technological Horizons for the Bioeconomy

The technological horizons for the bioeconomy are varied and diverse. Technological advances have been made in food systems transformation through precision agriculture, aquaponics and cultivated proteins. In energy systems, second-, third- and fourth-generation biofuels are on the horizon. Additionally, technological advances have been made in bio-based hydrogen production, which has the potential to transform not only energy but also transport and industrial systems.

Biomimicry involves studying and understanding the principles, patterns, processes and strategies found in living organisms and ecosystems and applying them to create innovative and sustainable solutions. Biomimicry spans various disciplines, including engineering, architecture, materials science, robotics and sustainable design. By observing and understanding these natural systems, scientists, engineers and designers can uncover valuable insights and translate them into technological innovations.

The technological horizon for the bioeconomy will involve collaborative networks that bring together various stakeholders, including researchers, industry partners, policymakers and local communities. For example, the Cocoa Innovation Center (CIC) in Bahia, Brazil is using Artificial Intelligence (AI) to develop quality control and traceability systems for cocoa. The initiative emerged from a collaborative network, including public universities, the private sector, civil society and local producers.

Annex 4

4.1 Biodiversity's Role in the Bioeconomy

Biodiversity plays a crucial role in the bioeconomy at various levels, including ecosystems, habitats, species and genetic diversity.

Ecosystems rely on biodiversity to function properly. A diverse range of species within an ecosystem contributes to its resilience, stability and productivity. Different species have unique roles such as pollination, nutrient cycling and pest control, which are critical for maintaining a healthy ecosystem. These ecosystem services are vital for supporting various economic activities, such as agriculture, forestry and ecotourism.

Biodiversity is vital for maintaining the integrity and stability of specific habitats. Diverse habitats can support a larger number of species with specialised needs, creating complex food webs and ecological interactions. The loss of habitat biodiversity can lead to the decline or extinction of specific species that depend on them for shelter, food and reproduction. The preservation and restoration of diverse habitats are important to maintain a sustainable bioeconomy, by promoting sustainable resource extraction and offering opportunities for research and development.

Each individual species contributes to the overall biodiversity. The diversity of species is often an indicator of an ecosystem's health and functioning. In the bioeconomy, species diversity is essential for activities like aquaculture, agriculture and horticulture, as it allows for the cultivation of a wide range of crops and livestock. Additionally, diverse species provide alternative sources of pharmaceuticals, biofuels and bioproducts.

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[19] https://istoedinheiro.com.br/tecnologia-ajuda-selecao-de-cacau-de-qualidade/

Genetic diversity within species is crucial for their adaptation and resilience to environmental changes. It allows populations to respond to challenges such as diseases, climate change and habitat degradation. In the bioeconomy, genetic diversity is paramount for breeding programmes, improving crop yields, developing disease-resistant varieties, and maintaining a healthy supply of livestock. It also provides opportunities for biotechnological advancements and potential discoveries of new beneficial traits.

Biodiversity contributes significantly to the resilience and sustainability of the global economy in several ways:

Economic diversification: Biodiversity provides the foundation for various economic sectors like agriculture, forestry, fisheries and tourism. A diverse range of species and ecosystems enables countries to diversify their economic activities, reducing dependence on a single sector. This helps mitigate risks associated with market fluctuations and ensures a more resilient and balanced economy.

Ecosystem services: Biodiversity supports numerous ecosystem services that are fundamental to human well-being and economic activities. These services include pollination, nutrient cycling, water purification, climate regulation and soil fertility. By maintaining healthy ecosystems, biodiversity helps sustain agricultural productivity, water availability and other essential services that underpin economic activities worldwide.

Climate change adaptation: Biodiversity plays a vital role in climate change adaptation and resilience. Diverse ecosystems and species are more capable of adapting to changing environmental conditions. Forests and other natural habitats help regulate local and regional climates, reduce the risk of extreme weather events and provide carbon storage. Protecting and restoring biodiversity-rich areas contribute to climate change mitigation and enhance the resilience of communities and economies.

Genetic resources and biotechnology: Biodiversity provides a vast array of genetic resources that can be used in various industries, such as pharmaceuticals, agriculture and biotechnology. Genetic diversity within species offers opportunities for developing climate-resilient crops, disease-resistant livestock and innovative bioproducts. These advancements contribute to sustainable economic growth and technological innovation.

Cultural and aesthetic value: Biodiversity is not solely important for economic reasons. It also holds immense cultural and aesthetic value. Preserving diverse ecosystems, habitats and species contributes to the maintenance of cultural heritage and provides recreational and tourism opportunities. Cultural and nature-based tourism can generate revenue and promote sustainable economic development while preserving biodiversity and cultural traditions.

Overall, biodiversity is crucial for the resilience and sustainability of the global economy by diversifying economic activities, providing essential ecosystem services, aiding climate change adaptation, fostering technological innovation and preserving cultural value. Recognising and protecting biodiversity is essential for ensuring a thriving global economy today and for future generations.

Preserving and promoting biodiversity not only enhances the resilience of ecosystems but also provides a foundation for sustainable economic development, innovation and a myriad of industries that rely on biological resources.

4.2 Nature's Contributions to People

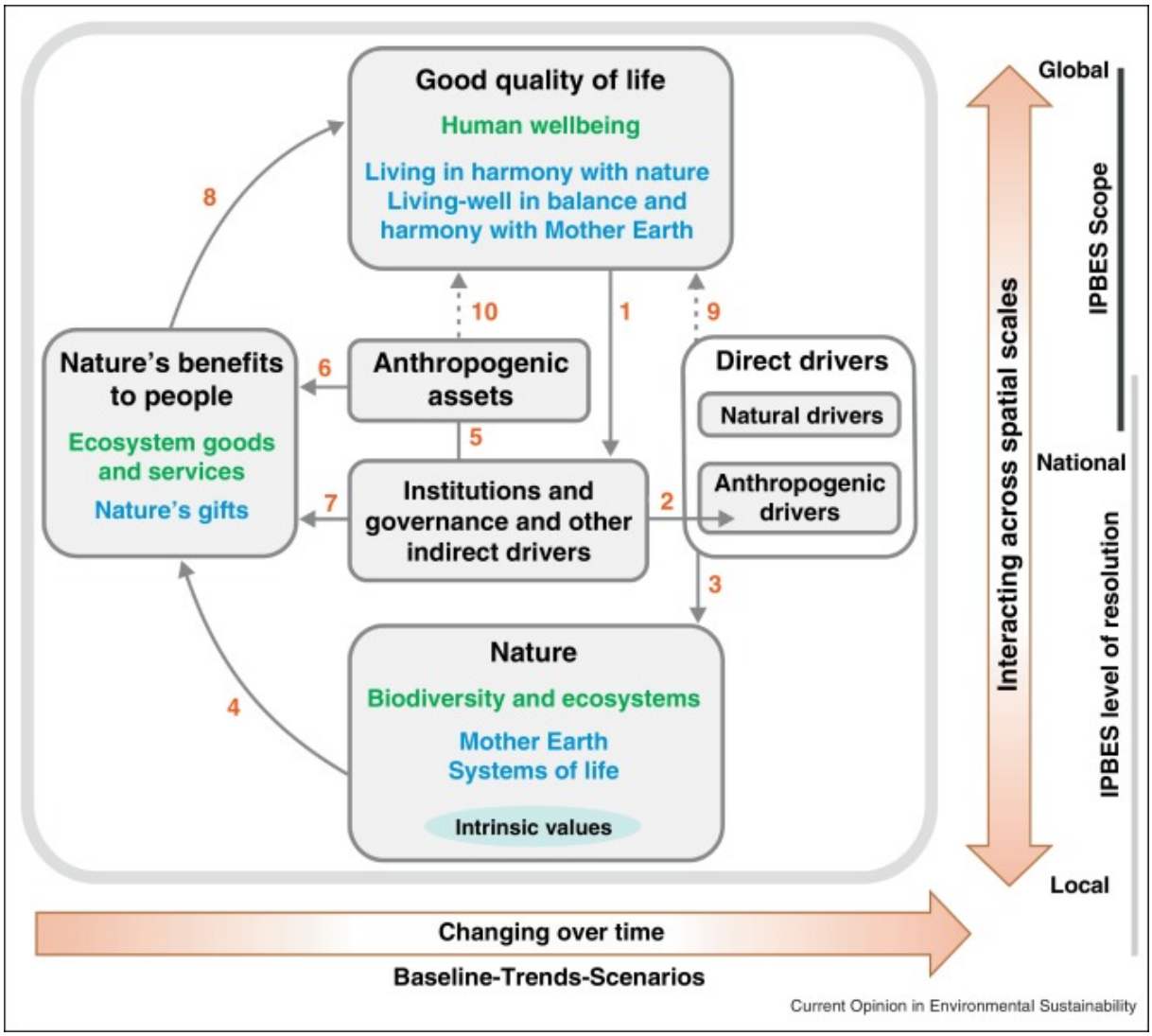
Nature's contributions to people (NCP),[20] represented within the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) framework (see Figure 3), is a more comprehensive concept than ecosystem services as it integrates diverse worldviews regarding the society-nature relationship (Díaz et al., 2018). As the term bioeconomy itself indicates the nature-society relationship, the IPBES framework and the NCP concept can be a thoughtful way of emphasizing this inter-linkage of nature and society within the bioeconomy (Bastos Lima & Palme, 2022).

IPBES framework recognises the central role of culture in shaping the nature-people relationship: It places side-by-side concepts such as Mother Earth, nature's gift and ecosystem services, thereby elevating and integrating a wider range of perspectives and stakeholders from social sciences to local practitioners, including indigenous peoples and local communities. As such, discussions need to consider different ideas of the bioeconomy, as it is seen from different perspectives, worldviews and parts of the world. Also, the framework notes that according to nature's contributions to people nature and society are co-produced, which is key for the bioeconomy, combining nature, technology and knowledge to a new form of economy (Díaz et al., 2015).

Moreover, the IPBES framework describes both the global, generalising perspective and the context-specific perspective, even if they are often blended. Although it is possible to agree on a broad definition of nature-people interactions from a global perspective, it may not be possible to apply a unique scheme to a local context-specific perspective due to differences in worldviews and incommensurability (Díaz et al., 2018). Along the same line, as biodiversity is tied to a territory, one must consider the specific characteristics, technologies and knowledge from local communities, organisations and governments to be able to use and profit from it in a sustainable way considering all people involved. While the G20 will discuss the bioeconomy from a global and generalising perspective, they must consider context-specific characteristics to promote the sustainable use of biodiversity.

[20] NCP entails all contributions, both positive and negative, of living nature to people's quality of life (Díaz et al., 2018).

Figure 3 – The IPBES Conceptual Framework



Source: Díaz et al. (2015)

The UN Food and Agriculture Organisation has already noted that the global agri-food system is undermining biodiversity, which is the basis of genetic resources and ecosystem-regulating contributions from nature (FAO, 2019).

The integration of biodiversity in bioeconomy strategies can go beyond developing new products and services to a more balanced and holistic view of the relationship between society and nature. Bastos Lima and Palme (2022) define a restorative bioeconomy in line with the concept of nature's contributions to people. The authors suggest four critical frontiers:

1. expanding natural habitats and their biodiversity beyond conservation;
2. developing a knowledge- and technology-intensive bioeconomy underpinned by traditional knowledge and incorporating the concept of socio-biodiversity;
3. enhancing social participation and inclusiveness of bioeconomy governance, so that programmes address critical issues such as poverty, food insecurity and gender inequalities; and
4. developing a bioeconomy beyond the commodification of nature, where respect for socio-biodiversity, social inclusion and food sovereignty are objectives in their own right.

4.3 Bidirectional Nature-Society Interaction

Replacing non-renewable resources with renewable ones requires a large amount of biomass, which in itself demands the proper functioning of ecosystems and climate systems. However, extensive cultivation of biomass, without adequate management, can alter ecosystems. Furthermore, innovation and development of biotechnology benefit from the diversity found in living organisms, such as species and genetic material. This highlights the interdependencies and impacts between nature and society in the context of the bioeconomy.

4.4 Traditional Knowledge

Traditional knowledge plays a significant role in contributing to a more sustainable bioeconomy in several ways:

Conservation and management: Traditional knowledge often incorporates sustainable practices for the conservation and management of natural resources. Indigenous peoples and local communities have developed knowledge systems over generations that emphasise the sustainable use of biological resources. This knowledge includes traditional farming techniques, sustainable harvesting practices and ecosystem management approaches. Incorporating such traditional knowledge into bioeconomic activities helps ensure the long-term sustainability of resource utilisation.

Biodiversity preservation: Traditional knowledge systems have a deep understanding of the local environment, including intricate knowledge about plant and animal species, their habitats and the interconnections between them. This knowledge can guide sustainable practices for the preservation of biodiversity, ensuring the maintenance of healthy ecosystems and genetic diversity. By integrating traditional knowledge into conservation strategies, it becomes possible to protect valuable species and habitats while supporting the bioeconomy.

Traditional agricultural practices: Traditional agricultural practices often prioritise biodiversity conservation and sustainability. Practices such as agroforestry, crop rotation and the use of traditional seed varieties contribute to maintaining soil health, reducing chemical inputs and enhancing resilience against pests and diseases. By recognising and incorporating traditional agricultural knowledge, the bioeconomy can benefit from sustainable farming practices that support food security, farmer livelihoods and environmental conservation.

Medicinal and herbal practices: Traditional knowledge about the use of plants and natural remedies for healthcare is invaluable for the development of sustainable pharmaceuticals and herbal products. Indigenous communities possess extensive knowledge of medicinal plants and their applications. Incorporating this traditional knowledge into drug discovery and development processes can help identify potential leads for pharmaceuticals and foster a more sustainable approach to healthcare.

Cultural heritage and governance: Traditional knowledge systems are closely tied to cultural heritage and indigenous governance structures. Recognising and respecting traditional knowledge contributes to the empowerment of indigenous communities and local stakeholders. This recognition fosters inclusive decision-making processes, promotes biodiversity conservation, and ensures that the benefits of the bioeconomy are shared equitably among communities.

Indonesia as a Case Study

Forum Kerjasama Budaya dan Tradisi (FKBT) is a platform established by the Indonesian government to facilitate the documentation, sharing and preservation of traditional knowledge systems. It brings together indigenous communities, researchers, policymakers and NGOs to exchange knowledge and promote the sustainable use of traditional practices.

4.5 Biodiversity Conservation and Restoration

The success of the bioeconomy will depend on effectively promoting technology, science and knowledge. These aspects can also be innovated by adopting a new approach to intercultural knowledge equity (Bastos Lima & Palme, 2022). Investments in innovation, thus, need to also support and provide technical assistance. They need to ensure the feasibility of local businesses and expand the capabilities of indigenous peoples and local communities to produce their own products and services, by respecting their self-determination, rights, local lifestyles and values, and by promoting good quality of life and well-being under their own terms.

In line with Target 21 of the Global Biodiversity Framework, which is seeking to ensure the best available data, information and knowledge are accessible to decision-makers, practitioners and the public to guide effective equitable governance.

Furthermore, as more broadly noted, the bioeconomy has the potential to innovate on bioproducts and processes linked to a circular economy. “There are various examples of novel goods that can be developed from native biodiversity and potentially produced at scale, such as organic pesticides for biological control, active principles for medicaments, or bio-based solvents to replace petroleum-based ones.... That includes, for instance, many so-called secondary metabolites, which form the basis of much of the pharmaceutical and cosmetics industries” (Bastos Lima & Palme, 2022).

4.6 Innovation in Conservation

Several innovations in conservation utilise nature's contributions to people, leveraging ecosystem services to address environmental challenges. Among these are:

Nature-based Solutions (NbS): NbS encompass a range of approaches that use natural ecosystems or processes to address societal and environmental challenges. Examples include restoring coastal wetlands for storm protection, creating urban green spaces to mitigate heat island effects, or implementing agroforestry practices to enhance soil fertility and crop resilience.

Payments for ecosystem services (PES): PES mechanisms involve compensating landowners or communities for conserving or restoring natural resources and ecosystems that provide valuable services. For instance, farmers may receive payments for implementing practices that improve water quality or store carbon in soil.

Indigenous and community-led conservation: Recognising the traditional ecological knowledge and practices of indigenous peoples and local communities, this approach promotes their active involvement in conservation efforts. By respecting indigenous rights and empowering communities, this approach ensures sustainable resource management and protects biodiversity.

Biodiversity offsets: Biodiversity offset programmes aim to compensate for biodiversity losses from development projects by creating or restoring equivalent habitats elsewhere. These programmes ensure that net biodiversity remains constant or increases despite development activities.

Sustainable agriculture and agroecology: Agriculture and forestry are managed sustainably, in particular through the sustainable use of biodiversity. This includes a substantial increase in biodiversity-friendly practices, such as sustainable intensification, agroecological and other innovative approaches. Such practices contribute to the resilience and long-term efficiency and productivity of production systems, and to food security, conserving and restoring biodiversity and maintaining nature's contributions to people, including ecosystem functions and services.

These innovations recognise the value of ecosystem services and their critical role in supporting human well-being. By integrating nature's contributions to people, these approaches offer effective strategies for conservation and sustainable development while recognising the interdependence of humans and nature.

Argentina as a Case Study

The Green Corridor project, implemented by Fundación Vida Silvestre (the Argentina branch of WWF) in the Misiones Province, aims to restore the Atlantic Forest, one of the most threatened tropical forests in the world, by creating biological corridors between protected areas, reintroducing endemic species and promoting sustainable forest management. This project employs local communities in various aspects of reforestation activities, including nursery management, tree planting and forest management.

4.7 Bioeconomy and the Kunming-Montreal Global Biodiversity Framework (GBF)

The Kunming-Montreal Global Biodiversity Framework (GBF), which was adopted during COP15 in December 2022, includes targets and goals that were set under the Convention on Biological Diversity (CBD) to tackle the loss of biodiversity and encourage its conservation and sustainable use. The GBF sets out 23 targets for urgent action until 2030 and establishes four long-term goals for 2050. These targets and goals are in line with the recommendations presented in this stocktaking report.

Table 6: Overview of Goals and Targets of Global Biodiversity Framework

Goal A	Goal B	Goal C	Goal D
Increase the area of natural ecosystems by 2050; halt extinction, reduce extinction rate	Use and manage biodiversity sustainability; enhance nature's contribution to people	Share fairly and equitably benefits from generic resources and traditional knowledge with IPLC	Secure adequate means of implementation and make them accessible to all parties

Reducing threats to biodiversity	Sustainable use and benefit sharing	Implementation and mainstreaming
1) Ensure all land and sea areas are under biodiversity-inclusive spatial planning or effective management	9) Ensure sustainable management and use of wild species, including customary sustainable use, by IPLC	14) Integrate biodiversity into policies, regulations, etc. and align financial flows with goals and targets of the Global Biodiversity Framework
2) Ensure +30% of degraded freshwater, marine and terrestrial ecosystems are under restoration by 2030	10) Manage areas covering agriculture, aquaculture, fisheries and forestry sustainably	15) Ensure companies and financial institutions monitor, assess and disclose nature risks, dependencies and impacts
3) Ensure +30% of land areas and inland water and of sea areas are conserved by 2030	11) Enhance nature's contributions to people through NbS and ecosystem-based approaches	16) Encourage sustainable consumption choices, including 50% reduction in food waste by 2030
4) Halt threatened species' extinction and maintain and restore genetic diversity of species	12) Increase green and blue spaces (area and quality) in urban and densely populated areas	17) Implement biosafety measures and measures for handling biotech and the distribution of its benefits
5) Ensure sustainable, legal and safe harvesting: trade and use of wild species	13) Ensure fair and equitable benefit sharing from use of genetic resources, digital sequence information (DSI) and traditional knowledge	18) Eliminate, phase-out, reform nature harmful subsidies by at least US$500 billion per year by 2030
6) Eliminate, minimise, or mitigate impact of introduction of invasive, alien species		19) Mobilise finance by at least US$200 billion by 2030, including funds from developed and developing countries
7) Reduce nutrient loss, pesticides, and hazardous chemicals risk by +50% and eliminate plastic pollution		20) Strengthen capacity-building, development, access and transfer of technology through collaboration
8) Minimise impact of climate change and ocean acidification on biodiversity through NbS or ecosystem-based adaptation (EbA)		21) Ensure decision makers' access to best available data, information and knowledge
		22) Ensure equitable participation in decision-making related to biodiversity by IPLC women and youth
		23) Ensure gender equality in the implementation of the framework

Source: CBD (2022)

Annex 5

5.1 Moving up the Commodity Value Chain to Foster Sustainable Green Growth

Moving up the commodity chain has, under certain conditions, the potential to foster green growth and minimise environmental impact. By moving up the commodity chain, countries or industries can focus on producing higher-value products or engaging in more sustainable practices.

One way this can be achieved is through the adoption of cleaner and more efficient production technologies and practices. For example, investing in renewable energy sources or implementing eco-friendly manufacturing processes can reduce carbon emissions and other environmental pollutants.

Additionally, moving up the commodity chain often involves adding value to raw materials, which can lead to more sustainable practices. This may include promoting recycling and circular economy principles, where materials are reused instead of being discarded as waste.

However, it's important to note that moving up the commodity chain alone may not guarantee green growth. It requires a comprehensive approach that considers the entire supply chain, including responsible sourcing of raw materials, reducing waste throughout the production process and ensuring sustainable consumption patterns.

Ultimately, fostering green growth requires a combination of factors, including strong policy frameworks, technological advancements, consumer awareness and industry collaboration.

5.2 Rural Development

The bioeconomy has the potential to invigorate rural development in several ways. First and foremost, the bioeconomy encompasses the sustainable use of renewable biological resources, such as agriculture, forestry and fisheries. By leveraging these resources, rural areas can stimulate economic growth and create new job opportunities, which are often crucial for rural communities.

The bioeconomy can invigorate rural development through the cultivation of bioenergy crops. The production of biofuels and biomass for energy generation can provide a source of income for farmers and businesses in rural areas. This not only helps diversify rural economies but also reduces reliance on fossil fuels, contributing to a cleaner and more sustainable energy sector.

Additionally, the bioeconomy encourages the development of value-added products and innovations derived from biological resources. This includes the production of bioplastics, biocomposites and bio-based chemicals, among others. By fostering innovation and entrepreneurship in rural areas, the bioeconomy can attract investments, create local industries and promote rural development.

Furthermore, the bioeconomy promotes sustainable agriculture practices and the diversification of farming systems. This can lead to increased productivity, improved soil health and reduced environmental impact. In turn, it enhances the resilience of rural communities, supports the conservation of natural resources and contributes to long-term rural development.

Overall, the bioeconomy offers opportunities for rural areas to leverage their biological resources, stimulate economic growth and create sustainable livelihoods. By capitalising on these opportunities, rural communities can achieve a more prosperous and resilient future.

Italy as a Case Study

Italy has established several regional development initiatives to promote the growth of the bioeconomy. For instance, in the southern regions of Calabria and Sicily, initiatives have been implemented to support the production of renewable energy from biomass, creating new jobs in these areas.

5.3 Social Development Goals

Social development goals can be achieved through the bioeconomy in several ways. Firstly, the bioeconomy heavily relies on research and innovation, which often lead to advancements in healthcare. For example, biotechnology and bioengineering can yield novel medical treatments and therapies, leading to improved health outcomes. Additionally, the bioeconomy can support the production of bio-based pharmaceuticals, vaccines and diagnostic tools that are more affordable and accessible, especially in resource-constrained areas.

Moreover, the bioeconomy can contribute to education by fostering innovation and creating employment opportunities. As the bioeconomy expands, it generates a demand for professionals skilled in various fields, such as biotechnology, agriculture and environmental science. This demand for a skilled workforce can drive investments in education and training programmes, ensuring that individuals have the necessary knowledge and skills to participate in this growing industry. Improved education and skills development can enhance overall human capital, leading to higher living standards and socioeconomic development.

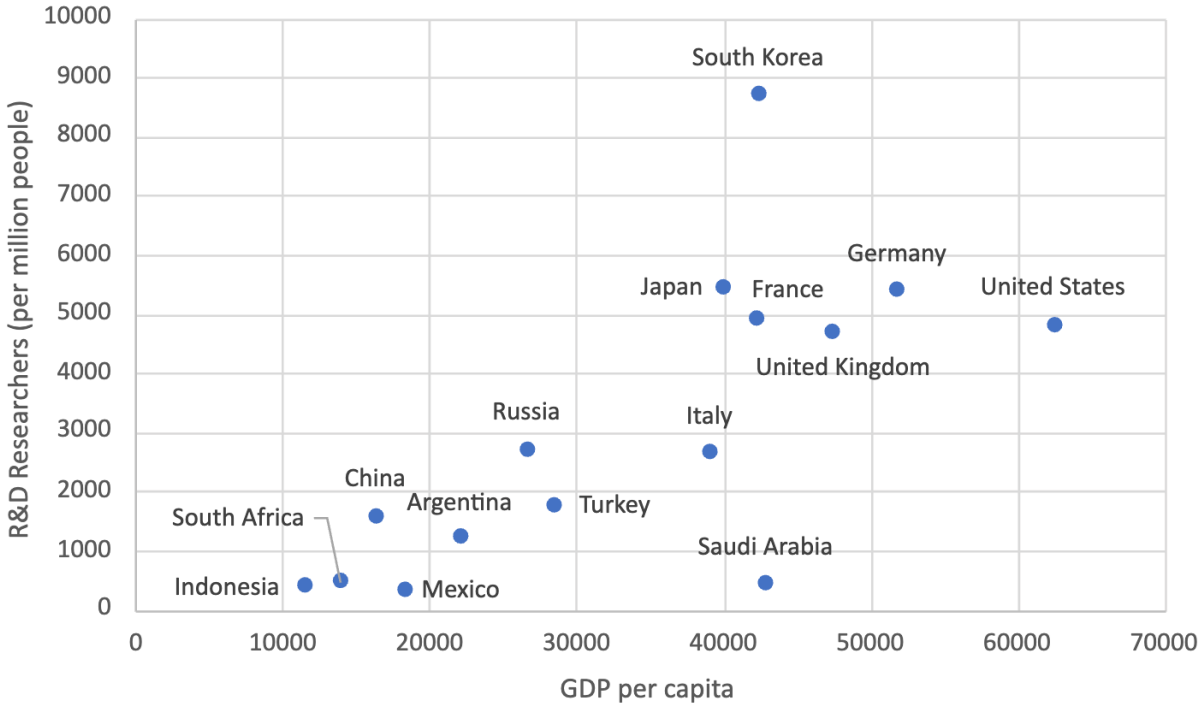
Furthermore, by promoting the use of renewable resources and reducing dependence on fossil fuels, the bioeconomy can help mitigate climate change and improve air and water quality. These environmental benefits, in turn, have positive impacts on public health and well-being.

In summary, the bioeconomy contributes to social development goals by advancing healthcare through research and innovation, creating employment and educational opportunities and promoting sustainable practices that improve public health and environmental conditions.

5.4 Economic Development through Research, Development and Innovation

Although Research, Development and Innovation (R&D&I) play a crucial role for the bioeconomy and in driving long-term economic growth. As a result, the bioeconomy and sustainable development agendas are closely intertwined (von Braun, 2014).[21, 22] Indeed, innovation enables an economy to increase its output using the same or fewer resources, and technology has the potential to significantly improve people's living standards (Grossman & Helpman, 1994; Rosenberg, 2006). Still, there appears to be a correlation between R&D activities and gross domestic product (GDP) per capita, with economically wealthier countries having less biological diversity (Figure 4)

Figure 4 – R&D researchers per million people vs. GDP per capita in G20 countries in 2021



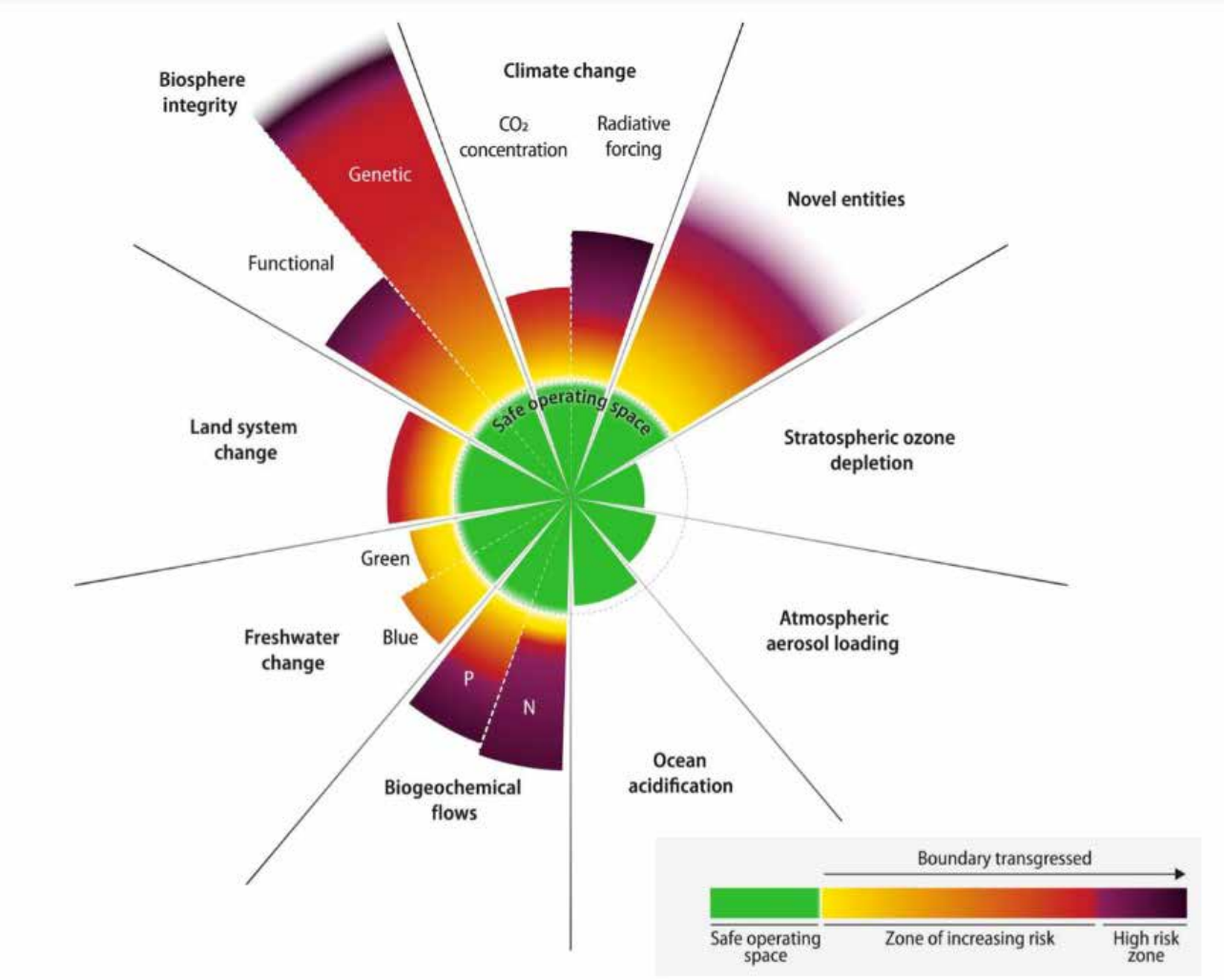
Source: Ritchie et al. (2023)

However, in the context of a bioeconomy, it is necessary to ensure that any economic growth takes the biosphere into account and stays within planetary limits. While economic production should stay within a safe operating range, it has already been exceeded in six instances (Figure 5).

[21] Other connections between the bioeconomy and sustainable development are possible, such as the bioeconomy's contributions to the Sustainable Development Goals (SDGs), for instance, by helping to ensure sustainable food production (SDG2) and affordable and clean energy (SDG7) (Chavarria, et al., 2020).

[22] The South African Department of Science and Technology, for instance, explicitly that the goal of the bioeconomy is "to generate sustainable economic, social and environmental development" (Hlangwani et al., 2023).

Figure 5 – Current Status of Control Variables for all Nine Planetary Boundaries



Source: Richardson et al. (2023)

Additionally, changing income and benefit distribution in the bioeconomy could lead to competition between food supply and biomass energy production, which could subsequently trigger food insecurity. This could also lead to a loss of resources and livelihoods for groups of smallholders. There is no guarantee that the bioeconomy will be equally beneficial to all groups in society, and it may even reinforce or deepen existing gender and social inequalities.

5.5 The Circular Bioeconomy

In order to ensure that the bioeconomy is closely connected to the circular economy and achieves a higher level of efficiency in biomass usage, particularly in agricultural activities, countries have been promoting the concept of bio-refineries and biomass-based value chains or webs,[25] especially in agricultural regions and economies (Scheiterle et al., 2018). For instance, while ethanol production from sugarcane in Brazil has been extensive since at least the 1970s,[24] relying solely on sugar (and maize) crops will not produce enough ethanol to meet climate and energy goals (von Braun, 2014). Consequently, there has been a growing focus on the cascading use of sugarcane biomass and by-products, such as the use of sugarcane residues, filter cakes and vinasse to produce bioplastics, lubricants, pharmaceuticals and other bioeconomy products (Scheiterle et al., 2018).

Agricultural residues, as well as waste in general, are easily available and contain highly organic content. Thus, they are suitable for use as feedstock, which reduces the reliance on petroleum and minimises the negative environmental effects caused by waste accumulation (Mohan, et al. 2018). In the past, incineration was the dominant method to convert municipal solid waste into energy. However, with the emergence of the bioeconomy, waste bio-refineries are increasingly recognised for their ability to produce basic chemicals, biopolymers and bioplastics, as well as specialty and fine chemicals. If these technologies are adopted on a wider scale, countries can lessen their dependence on imported resources, particularly fossil fuels (Tsui & Wong, 2019).

Where waste cannot be used as an input, bioeconomy solutions can help alleviate the problem. For example, Chile has successfully employed bioleaching (biometallurgy) in copper mining, utilising extremophilic microbes to extract metals in a more cost-effective and less harmful manner, while also reducing waste from ore-tailings (Sasson & Malpica, 2018). Similarly, in South Africa, agricultural waste has been used to manufacture biocontrol compounds that help prevent fruit spoilage as well as to undertake biological treatment of nutrient-rich wastewater. This approach enhances soil fertility, reduces the need for fertilisers, and lowers production costs (Hlangwani, et al. 2023).

To effectively implement bioeconomy models, a comprehensive approach to all economic activities is necessary, rather than relying solely on traditional, linear value chains that move from inputs to outputs and waste disposal (Aguilar et al., 2019).

Such a systemic approach highlights the importance that stakeholder engagement has in promoting better and more efficient use of biological resources. This is because knowledge is dispersed and R&D&I endeavours depend on the specific feedstock available locally, which means that the bioeconomy benefits from the interactions between various entities, such as indigenous communities, businesses, universities and governments (Egea et al., 2018; El-Chichakli et al., 2016).

In summary, there are multiple ways in which the bioeconomy can enable sustainable development. In this section, emphasis was given to the role that R&D&I activities can have in boosting economic growth while making greater and more balanced use of biological resources. This pathway from R&D investment to technological innovation and growth is one that could be followed by policymakers in all G20 countries and elsewhere (Bilbao-Osorio & Rodríguez-Pose, 2004).

To this point, the concept of bioeconomy seems to reinforce the localised character of knowledge generation, given the context-dependent nature of biomass types and their possible uses. Simultaneously, it is calling for the active promotion of cooperation efforts involving academic institutions, businesses, local communities and governmental institutions to further the scientific and applied know-how in developing new bioeconomy products and technologies (Alviar, et al., 2021; Scheiterle et al., 2018).

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[23] Interlinkages between different value chains that rely on the same type of biomass (Virchow, et al. 2016).

[24] Brazil's National Alcohol Programme ("Próalcool") was enacted in 1975 (Decree No. 76,593/1975).

Annex 6

6.1 Policy Enablers

6.1.1 Trade Policies

Trade can facilitate a bioeconomy by eliminating tariffs and other barriers to trade in environmental goods, allowing for the global distribution of these goods and increasing access to advanced technologies. Through subsidies, trade can also incentivise the shift away from carbon and toward renewable fuels.

In November 2020, 50 members of the World Trade Organisation (WTO) announced their intentions to intensify work on trade and environmental sustainability through the Trade and Environmental Sustainability Structured Discussions (TESSD), which complements the work of the Committee on Trade and Environment and other WTO bodies. The TESSD is co-chaired by Canada and Costa Rica with participation from G20 members, including Australia, Canada, China, the EU, Japan, Mexico, Russia, Saudi Arabia, South Korea, Turkey, the UK and the US.

The TESSD has four working groups: 1) trade in environmental goods and services; 2) trade-related climate measures; 3) circular economy; and 4) subsidies. The WTO is also working to speed up the spread of new technologies needed for climate adaptation and has released a report which finds that increased trade is the best method to make deep cuts in global greenhouse gas emissions without reducing living standards.

Policymakers across the G20 members apply a combination of push and pull policies to influence various aspects of the bioeconomy. A push policy aims to stimulate economic activity by directly increasing demand or encouraging production. Some common examples across the G20 members include bioenergy policies, green public procurement policies, carbon market mechanisms and tax incentives or subsidies for bio-based products.

6.1.2 Bioenergy Policies

Most G20 members have bioenergy strategies that promote the production and use of biomass in energy and transportation fuels. These often include feed-in tariffs, tax incentives, grants for bioenergy production and targets for increasing the production, distribution and consumption of biofuels.

6.1.3 Public Procurement

Public procurement is an important demand-side policy in supporting the bioeconomy, as it can drive demand for sustainable and bio-based products. Governments have significant purchasing power and can use public procurement policies to prioritise bio-based products, set sustainability criteria and give preference to bioeconomy solutions. For example, governments can prioritise bio-based materials in construction projects, biofuels for public transportation and bioplastics for packaging used in public institutions. By doing so, they create a stable market for bio-based products, driving investment and growth in the bioeconomy sector.

6.1.4 Labels and Raising Awareness

Ecolabels provide consumers with information about the environmental impacts of a product throughout its life cycle. They can help promote sustainable consumption by guiding consumers towards more eco-friendly choices, including bio-based products.

Ecolabels on bio-based products encourage producers to adopt sustainable practices and reduce their environmental footprint. Ecolabel standards can incentivise the use of renewable resources, reduced energy consumption, waste reduction and lower emissions, all of which are essential for a thriving bioeconomy.

By combining public procurement efforts and eco-labelling initiatives, governments can create a positive feedback loop. They can drive demand for bio-based products through procurement policies, leading to increased production and innovation in the bioeconomy. This heightened supply of bio-based products can then be supported by eco-labelling schemes that inform consumers and reinforce sustainable choices. Overall, this approach can foster the growth of the bioeconomy and contribute to a more sustainable future.

Korea as a Case Study

Korea's Act on Encouragement of Purchase of Green Products in 2005 defines the products and services applicable for green public procurement as:

i) Certified or meeting the underlying criteria set by the Korea Eco-label;
ii) Certified or meeting the criteria of the quality certificate for recycled products (Good Recycled Mark); and
iii) Complying with other environmental criteria set by the Ministry of Environment following consultation with the heads of the relevant ministries.

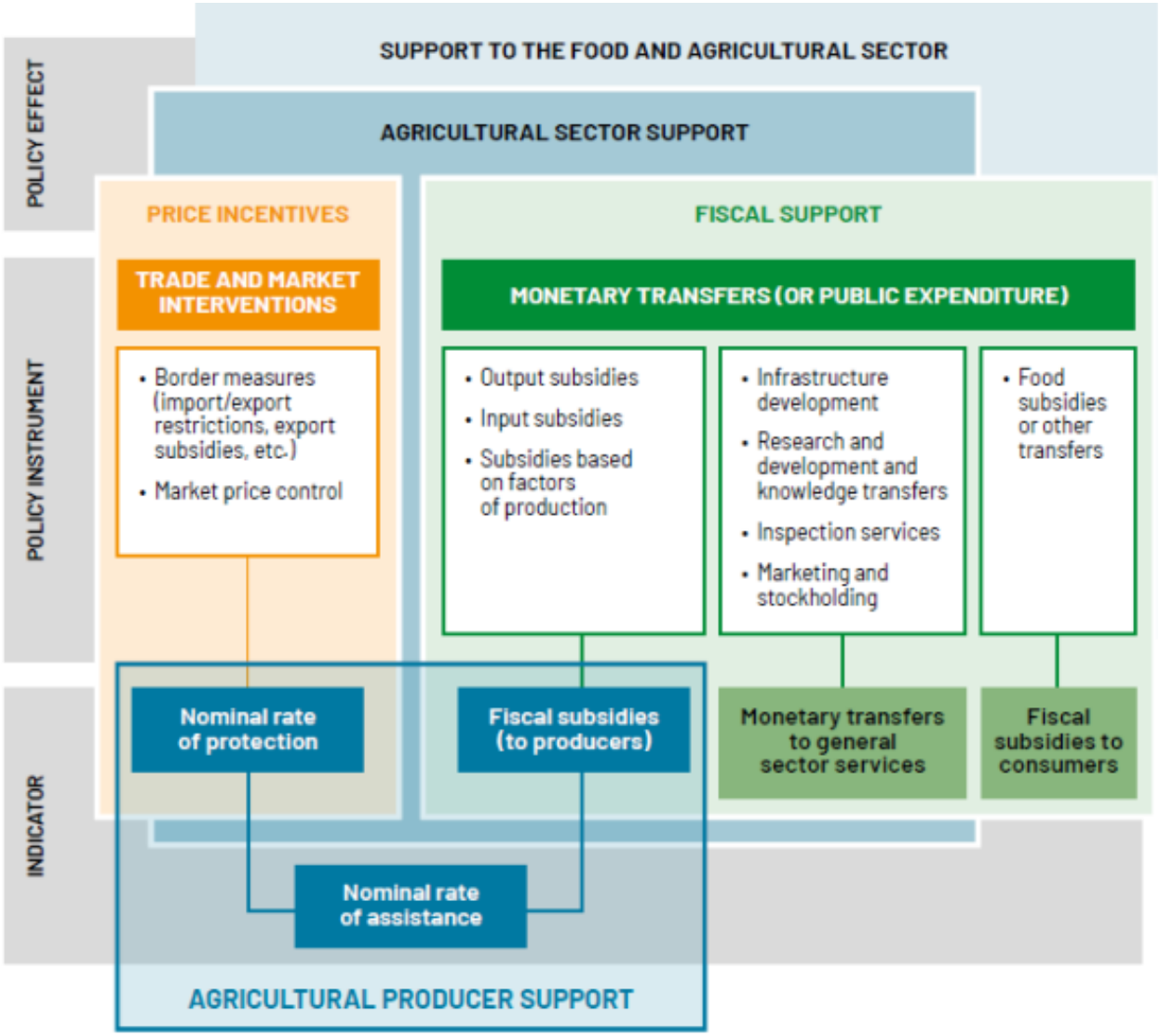
6.1.5 Agricultural and Land Use Policies

The main policy instruments that support agriculture are price incentives and fiscal subsidies. Price interventions increase or depress domestic prices and, as a result, generate incentives (or disincentives) for farmers. They consist mainly of border measures (such as import tariffs or quotas, export bans or subsidies), and/or market price regulations (e.g. domestic price fixation policies).

Fiscal subsidies, on the other hand, are linked to production or unconstrained use of variable inputs. Those targeting farmers include subsidies based on factors of production, such as planting certain crops or maintaining a herd of livestock, subsidies for the use of inputs and subsidies based on output level.

Some examples of policy measures that support a sustainable bioeconomy include providing credit to farmers to shift to sustainable agricultural practices, managing water scarcity, and shifting away from harmful forms of agricultural producer support which distort economic signals.

Figure 6: Schematic overview of agricultural policy support instruments and indicators



Source: FAO, UNDP, and UNEP. (2021)

6.2 Cross Cutting Themes

6.2.1 Research, Development and Innovation

The bioeconomy is called a 'knowledge economy' because it heavily relies on scientific knowledge, research and innovation to drive its growth and development. As such, all G20 members have policies that support research, development and innovation in the bioeconomy. R&D has focused on understanding biological systems, developing new technologies, designing efficient processes, and exploring new sources of materials and energy. These programmes aim to optimize resource utilisation, improve product quality, enhance environmental sustainability and create new economic opportunities.

Most of the G20 members allocate funds and offer grants to researchers and companies involved in bioeconomy R&D. Furthermore, most countries and regions have programmes that support interdisciplinary collaborations between scientists, engineers, policymakers and entrepreneurs. Technology clusters, also known as innovation clusters or technology parks, have played a significant role in the bioeconomy of many countries. This collective knowledge and expertise contribute to the advancement of this field and the development of innovative solutions that address societal challenges, such as climate change, resource depletion and a growing global population.

Technology Clusters
Technology clusters help advance bioeconomies and can be grouped into different types. The most common type is the research and innovation cluster, which brings together research institutions, universities and companies focused on biosciences, biotechnology and related fields. Their primary aim is to promote research and innovation, fostering collaborations that lead to advancements in areas such as genomics, personalised medicine, agricultural biotechnology and bio-based materials. Another common type employed is industrial clusters, which focus on the commercialisation and production of bio-based products and technologies. They bring together companies, suppliers, and manufacturers involved in different stages of the bioeconomy value chain. These clusters have often shared infrastructure, specialised facilities and logistic networks to support the production and distribution of bio-based products.

Regional and rural development clusters focus on enhancing the economic potential of rural areas by promoting bioeconomy activities. They aim to develop sustainable agricultural practices, bioenergy production, bio-refineries and other bio-based industries that utilise local resources. Such clusters often have strong connections with the agricultural sector and actively involve farmers, local communities, and regional authorities.

One case study is the Bazancourt-Pomacle cluster (BPC) in the Marne department, Grand Est region, France. It is emblematic of a biocluster concept because it emphasises sustainability through intense innovations in the use of bio-resources, and through the optimal use of standards among the firms. Additionally, the BPC is a territorial cluster, meaning that it utilises natural resources from the surrounding region and does not import them from distant regions or other countries. The BPC not only has a local and regional influence, but it also transfers expertise of the bioeconomy to different French universities. At the EU level, the example of the BPC helps to design bioeconomy-related policies. At the global level, the knowledge developed at the BPC is applied in the production of new, bio-based products (e.g. in Canada and Thailand), thus shaping the global bioeconomy market.

6.2.2 Sustainable Use of Biodiversity

Payments for Ecosystem Services

Most of the bioeconomy strategies of the G20 have considered the sustainable use of resources, recognising the important role that biodiversity plays in the provision of ecosystem services and in supporting the overall health and resilience of ecosystems. Additionally, most of the G20 members have market mechanisms, or Payments for Ecosystem Services (PES) programmes, that account for the economic value of ecosystem services.

By offering financial incentives, PES programmes contribute to local economic development, reducing pressures from activities that may harm ecosystems, such as unsustainable logging or poaching. They help conserve biodiversity by aligning economic incentives with environmental goals, ultimately contributing to the long-term conservation and sustainable use of natural resources.

Access and Benefit Sharing

The Traditional Knowledge Database in Indonesia is a digital platform intended to preserve and document traditional knowledge possessed by indigenous and local communities across the nation. Developed by the Indonesian Institute of Sciences (LIPI), the database aids in implementing the Nagoya Protocol, which Indonesia ratified in 2014, emphasising the fair and equitable sharing of benefits arising from the utilisation of genetic resources.

In Brazil, a prototype of a community-based genetic database, called the Amazon Biobank,[25] has been developed. It utilises blockchain technology to create a transparent and verifiable record of transactions involving genomic data. Additionally, smart contracts are implemented to establish an internal monetary system for all participants involved in collecting, inserting, processing, storing and validating genomic data. By combining these emerging technologies, the Amazon Biobank ensures fair benefit-sharing among all participants who contribute data, knowledge and computational resources. It also offers traceability and auditability, facilitating the association between biotechnological research and DNA data.

Moreover, Brazil has successfully established a benefit-sharing fund, through which bioeconomy initiatives can be funded. The National Fund for Benefit Sharing (FNRB) was established by law (Law No. 13,123/2015) and is linked to the Ministry of the Environment. Its purpose is to support actions, activities and projects aimed at valorising genetic heritage (genetic resources) and associated traditional knowledge, as well as promoting their sustainable use through the National Programme for Benefit Sharing (PNRB), created by the same law.

The Fund has a financial nature and is governed by a management committee, which is composed of eight representatives from the federal government and eight representatives appointed by entities or organisations representing the beneficiaries of the fund's resources: indigenous peoples, traditional communities, traditional farmers and an academic representative. In this regard, the management of the FNRB's resources is carried out with direct participation from the beneficiaries of the Fund's resources, who have the right to vote.

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[25] https://github.com/amazon-biobank/biobank-FIG

The FNRB is tasked with implementing the National Programme for Benefit Sharing (PNRB), which aims to promote, among others:

- **A** Conservation of biodiversity
- **B** Recovery, creation and maintenance of ex-situ collections
- **C** Prospecting and capacity-building of human resources associated with the use and conservation of biodiversity
- **D** Protection, promotion of the use and valorisation of associated traditional knowledge.
- **E** Implementation and development of activities related to the sustainable use of biodiversity, its conservation and benefit sharing
- **F** Promotion of research and technological development
- **G** Support for the efforts of indigenous peoples, traditional communities and traditional farmers in the sustainable management and conservation of biodiversity
- **H** Development of an efficient and sustainable system of ex-situ and in-situ conservation, as well as the development and transfer of appropriate technologies for that purpose, to enhance the sustainable use of genetic heritage
- **I** Development and maintenance of various cultivation systems that promote the sustainable use of genetic heritage
- **J** Preparation and implementation of sustainable development plans for traditional peoples or communities

Bioeconomy and National Climate Strategies

Many countries have ongoing initiatives focused on sustainable farming practices, climate-resilient crops, improving soil health and nutrient recycling in agriculture, which are interlinked with national climate strategies. The ABC Plan is a Brazilian agricultural policy for climate adaptation and low-carbon emissions, designed to promote sustainable and efficient food production while addressing global climate change. It was first implemented in 2010 and will continue until 2030 with the new version, ABC+ 2020-2030, which will establish new and reinvigorated sustainable strategies adapted for all Brazilian biomes. The plan is monitored and validated by various committees and aims to contribute to the UN 2030 Agenda for Sustainable Development, specifically the Sustainable Development Goals (SDGs) 2 Zero Hunger and 13 Climate Action.

6.2.3 Bioeconomy as an Enabler of Sustainable Development

Job Creation and Skills Development

The bio-ecology vision of the bioeconomy has emerged as a new paradigm for sustainable development. However, the societal challenges that the bioeconomy is expected to tackle will depend on the specific development context of each country. All G20 bioeconomy strategies aim to create jobs and economic growth. Most include various initiatives that target skills development, training and value chain development. For those countries that track bioeconomy indicators, the key areas monitored include data related to employment levels, new job opportunities and the overall impact of the bioeconomy on the labour market.

Rural Development

Additionally, most G20 bioeconomy strategies have recognised the potential for local economic development, particularly in rural areas. Bioeconomy policies supporting rural development typically focus on promoting sustainable farming practices, developing and enhancing skills and strengthening market links.

Brazil as a Case Study

Brazil implemented the Social Fuel Programme (Programa Combustível Social) to incorporate smallholder farmers and family agriculture in the biofuel production chain. This programme encourages the cultivation of crops for biodiesel production, providing income opportunities to rural communities and promoting social inclusion.

Additionally, the National Biodiesel Production and Use Programme (PNPB) involves family farmers by mandating a minimum percentage of biodiesel produced by smallholders in Brazil's overall biodiesel production. It also requires that smallholder contracts are approved by a representative collective organisation to make negotiations more balanced and safeguard against smallholder vulnerability. This programme prioritises inclusiveness and rural development, ensuring access to benefits for local communities.

Japan as a Case Study

Local production for local consumption: Japan strongly emphasises local production and consumption, which helps support rural development. Efforts are being made to promote the consumption of locally grown agricultural products and support the establishment of local supply chains. This not only strengthens local economies but also preserves traditional farming practices.

Turkey as a Case Study

Turkey's Ministry of Agriculture and Forestry offers a range of support programmes targeting rural development. These programmes focus on activities such as agricultural development, rural entrepreneurship, agricultural investments and diversification of rural income sources. They provide financial incentives, grants, training and technical assistance to rural communities and farmers.

In addition, the Rural Development Coordination Network (KORKAR) is a network established by the Ministry of Agriculture and Forestry to coordinate rural development efforts across different ministries and agencies. It aims to enhance cooperation, share knowledge and facilitate effective implementation of rural development policies and programmes.

Annex 7

7.1 Financial Instruments and Mechanisms

The nature-positive financial landscape has been evolving through the development of a range of instruments and mechanisms,[26] including:

Biodiversity-relevant government subsidies: These are environmentally motivated subsidies that target, for example, forest management, environmentally friendly agriculture and pesticide-free cultivation (OECD, 2021).

Use-of-proceeds bonds: The proceeds of these bonds, including green and blue bonds, finance pre-selected projects or activities. In 2022, 36 sovereign green bonds featured the use of proceeds for agricultural projects related to certified organic agriculture, soil restoration, low-impact agriculture and sustainable fisheries (AIIB, 2023; CBI, 2022). In September 2023, the Brazilian federal government launched a framework containing guidelines for the issuance of sovereign sustainability bonds to finance environmental positive contributions, like sustainable agricultural practices, the implementation of biofertiliser production units and the restoration of degraded pastures (Brazil, 2023).

Sustainability-linked bonds and loans: These financial instruments tie predefined sustainability targets to key performance indicators (KPIs), which can include commitments to nature and biodiversity (AIIB, 2023).

Outcome bonds (or outcome-based bonds): These bonds include (1) pay-for-conservation outcomes (e.g., Wildlife Conservation Bond), (2) revenue-based outcome bonds (e.g., Emissions Reduction-linked Bond), (3) catastrophe bonds (e.g., CAT-Mex).

[26] https://github.com/amazon-biobank/biobank-FIG

Loan guarantees: The loans can reduce the risk to the private sector of investing in nature by covering the risk of a business's non-performance (World Bank Group, 2020). According to the European Investment Bank (EIB, 2017), bioeconomy project proponents in the EU require public loans and guarantees to trigger a catalytic effect and help attract private investors.

Biodiversity offsets and credits: Project developers have the option of purchasing biodiversity credits or investing in their own biodiversity offset projects if they want to offset the unavoidable impacts of their business. Nature-related credit markets are valued at over US$5 billion per year, with at least 37 countries requiring, by law, biodiversity offsets as a prerequisite for certain developments. Australia, for example, has biodiversity offset schemes in place at the national and sub-national levels, and is also developing a new legislative framework to support a national voluntary biodiversity market (AIIB, 2023; NatureFinance, 2022; NatureFinance, Carbone4, & GEF, 2023; OECD, 2021; World Bank Group, 2020).

Development aid: Multilateral institutions have typically helped de-risk private, biodiversity-related investments through concessional loans and provided grants to foster capacity development (OECD, 2023).

Private philanthropy: Biodiversity-related initiatives from private philanthropies help to fill funding gaps in developing countries (OECD, 2023).

Blended finance: The financing method uses catalytic capital from public or philanthropic sources to increase private sector investment, reduce investment risks for private investors and expedite the implementation and expansion of projects. It allows for the exploration of new business models and/or the expansion of successful ones. Launched by The Nature Conservancy, Tropical Forest Alliance and the UNEP, the Innovative Finance for the Amazon, Cerrado and Chaco (IFACC) initiative seeks to direct investments to farmers in South America to transition to more sustainable business models, combining farm loan products, farmland investment funds, corporate debt instruments and capital market offerings (AIIB, 2023; The Climate Champions Team, Center for Global Commons, & Systemiq, 2023; World Bank Group, 2020).

Investment risk management: It involves actions taken by financial institutions to incorporate biodiversity into risk assessment and investment processes, aiming to direct financial flows away from projects with negative impacts on biodiversity and ecosystems to projects that mitigate negative impacts, or pursue positive environmental impacts as a co-benefit. Tools for assessing biodiversity impacts and dependencies in companies and projects include the Taskforce on Nature-related Financial Disclosures (TNFD) recommendations the Natural Capital Finance Alliance's Exploring Natural Capital Opportunities, Risks and Exposure (ENCORE) (Global Canopy, 2021; The Climate Champions Team et al., 2023; World Bank Group, 2020).

Annex 8

Intergovernmental organisations

The Group of Seven (G7) and the Group of Twenty One (G20) are high-level political and economic fora that are comprised of the world's largest economies' finance ministries. The G20 accounts for around 80% of gross world product (GWP), 75% of international trade, two-thirds of the global population, and 60% of the world's land area. Both the G7 and the G20 have member states with national bioeconomy strategies.

The World Trade Organisation (WTO) is an intergovernmental organisation that directly governs trade and economic issues. Since its establishment in 1994, the WTO has always had a twin objective of advancing trade and achieving sustainable development. In the preamble of the Marrakesh Agreement, the first paragraph states that "trade and economic endeavour should be conducted with a view to ... allowing for the optimal use of the world's resources in accordance with the objective of sustainable development, seeking both to protect and preserve the environment and to enhance the means for doing so ...".

On 17 June 2022, the WTO Agreement on Fisheries Subsidies was adopted, prohibiting harmful fisheries subsidies. It is the first WTO agreement to focus on the environment. In addition, Article 7 of the Agreement provides for the creation of the WTO Fisheries Funding Mechanism for targeted technical assistance and capacity building to help developing and least-developed country members implement the Agreement.

The Organisation for Economic Co-operation and Development (OECD) is a forum that was founded in 1961 to stimulate economic progress and world trade. The OECD developed a comprehensive bioeconomy strategy in 2009 titled 'The Bioeconomy to 2030: Designing a Policy Agenda'. In 2018, under the Directorate for Science, Technology and Innovation, a new policy paper was published, titled 'Meeting Policy Challenges for a Sustainable Bioeconomy', which sets out a policy framework that countries can use to "identify their relative strengths and weaknesses, fill policy gaps and understand the bigger picture for the international bioeconomy".The United Nations Conference on Trade and Development (UNCTAD) is an international organisation within the United Nations that promotes the interests of developing countries in global trade. BioTrade is an UNCTAD initiative launched in 1996 as a "blueprint for sustainable development action into the twenty-first century". The BioTrade initiative currently supports countries in achieving their commitments under the Convention on Biological Diversity (CBD) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The BioTrade Principles and Criteria were developed as a framework for governments, businesses and civil society to ensure the sustainable use of biodiversity.

Knowledge sharing initiatives

The Biofuture Initiative evolved from the Biofuture Platform, a 23-country effort established in 2016 under the leadership of Brazil. The initiative aims to "accelerate development, scale-up, and deployment of sustainable bio-based alternatives to fossil-based fuels, chemicals and materials." Key partners include the IEA Bioenergy Technology Collaboration Program (TCP), the International Renewable Energy Agency (IRENA) and the Global Bioenergy Partnership (GBEP).

Regional initiatives

Organisation of American States (OAS): The OAS has been actively involved in promoting initiatives related to the bioeconomy in the Americas. The OAS recognises the potential of the bioeconomy to foster sustainable development, create jobs and address environmental challenges. The OAS promotes projects that leverage the sustainable use of biological resources, such as agriculture, forestry, aquaculture and other bio-based industries.

One of the notable initiatives by the OAS is the Inter-American Program for the Development of Bioeconomy (IAPB). This program aims to support OAS member states in developing their bioeconomy sectors, enhancing regional cooperation and promoting knowledge sharing. The IAPB encourages the adoption of sustainable practices, facilitates capacity building and helps countries develop policies and strategies for the bioeconomy.

Mercosur: Mercosur, the South American trade bloc, has been actively involved in initiatives related to the bioeconomy. Mercosur recognises the potential of the bioeconomy to promote sustainable development, job creation and reduce the dependence on non-renewable resources. One of the key initiatives is the Mercosur Bioeconomy Programme, which aims to foster the development and integration of sustainable practices in various sectors such as agriculture, forestry, fisheries and biotechnology.

The Mercosur Bioeconomy Programme focuses on promoting research, innovation and technological advances in bioeconomy-related areas. It encourages investments in bio-based industries, promotes the sustainable use of natural resources and seeks to enhance international cooperation in the field. The programme also aims to support the development of legislative frameworks and policies that encourage the growth of the bioeconomy sector within Mercosur member countries.

Through its initiatives, Mercosur aims to harness the potential of the region's rich biodiversity and natural resources while promoting sustainable practices that contribute to economic growth and environmental conservation.

The Global Bioeconomy

Preliminary Stocktake of G20 Strategies and Practices: a contribution to the Brazilian G20 Presidency's Global Initiative on Bioeconomy

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