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COMMITTEE ON AGRICULTURE

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Bioeconomy for sustainable food and agriculture

Executive Summary

This document responds to the guidance from the 43rd Session of the FAO Conference stressing the importance of the bioeconomy for sustainable agrifood systems and subsequently, highlighting the need to discuss this topic within FAO Governing Bodies and Technical Committees.¹ It summarises the status of global bioeconomy development, including the role of crops, livestock, forestry, fisheries, and aquaculture in the bioeconomy, outlines key challenges to be addressed, identifies opportunities to enhance contributions of agrifood systems to the bioeconomy, and provides a brief update on FAO's work on bioeconomy.

In 2021, the 42nd Session of the FAO Conference elevated *Bioeconomy for Sustainable Food and Agriculture*, to the status of a Programme Priority Area within the FAO Strategic Framework 2022-31. This PPA supports four key work areas: policy advisory services, capacity development and country support, partnerships, and knowledge sharing and advocacy. FAO has identified several gaps and opportunities for policymakers, including the need for policy coherence, enhanced data collection and analysis, and the involvement of local communities and marginalised groups in co-designing inclusive strategies.

Capacity development gaps must be addressed, and investments should be leveraged to scale up innovative ideas. Knowledge exchange platforms, cross-sectoral partnerships, and South-South cooperation are vital for breaking down silos and enhancing collective impact. Empowering stakeholders through science, education, and community engagement, with investments in research and educational programmes to strengthen knowledge and skills are also important to address challenges on the demand side. FAO's role as a leading global convening body on the bioeconomy for sustainable food and agriculture through the inclusive consideration of diverse and regionally balanced perspectives in FAO's normative, policy and scientific work on the bioeconomy is to be further strengthened. To this end, it is proposed that FAO establish a multistakeholder global bioeconomy partnership to serve as a catalyst for the development of policies, strategies and plans,

¹ Retrieved from [C 2023/REP \(para. 29 a.\)](#), which reads: "stressed the importance of bioeconomy for sustainable agrifood systems and highlighted the need to discuss this topic within Governing Bodies and Technical Committees of FAO, bearing in mind the ongoing collaboration between COAG and COFO on the linkages between agriculture and forestry and the COFO-COAG joint work roadmap," and "recognized the importance of the inclusive consideration of diverse and regionally balanced perspectives in FAO's normative, policy and scientific work, by means of progressive integration, including through voluntary financial instruments."

building capacities, knowledge systems and incentives at global, regional, national, and subnational levels.

Suggested action by the Committee

The Committee is invited to:

- a) *acknowledge* FAO's work on bioeconomy for sustainable food and agriculture in the context of the Programme Priority Area;
- b) *encourage* Members to formulate and implement national, regional, and global bioeconomy policies, strategies and action plans fully incorporating sustainable crops and livestock production, forestry, fisheries and aquaculture and the associated value chains, with a view to promote cross-sectoral collaboration and inclusive engagement of stakeholders, including small-scale producers and marginalized groups;
- c) *recognize* FAO's leadership in advancing work to support the development of a sustainable bioeconomy and *encourage* FAO to build upon its comparative advantages working across agricultural sectors to improve data, promote policy coherence and scale up technical support and capacity development for Members to advance sustainable bioeconomy practices across agrifood systems, upon request, and to mobilize resources;
- d) *recommend* FAO, in close collaboration with relevant UN entities and stakeholders, to initiate a multistakeholder global bioeconomy partnership to serve as a catalyst for the development of policies, strategies and plans, building capacities, knowledge systems and incentives at global, regional, national, and subnational levels.

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I. Introduction

1. Over the past 50 years, material use has surged, with a further 60 percent increase expected by 2060, necessitating a shift towards sustainable resource utilization. Absolute extraction of biomass has nearly doubled.²
2. The anticipated rise in biomass demand for food, energy, housing, and other materials, underscores the need for a sustainable bioeconomy. A well-developed sustainable bioeconomy provides an approach for managing the trade-offs in biomass³ use, enhancing synergies across different sectors, to reach environmental, social, and economic sustainability objectives, while addressing challenges of food insecurity and malnutrition, climate change, biodiversity loss, and environmental degradation, thereby aligning with the 2030 Agenda for Sustainable Development.⁴
3. The bioeconomy utilizes biological resources to replace fossil fuel-based resources with biobased goods, processes, and services across all economic sectors. It is an economy driven by science and technology, harnessing biotechnological knowledge, representing not only a technological and economic shift but also a social transformation. It requires the inclusion of local communities, Indigenous Peoples, women, and youth to ensure equitable benefits and address environmental and climate challenges, thus realizing the transformative potential of the bioeconomy.
4. FAO's work on the bioeconomy officially began with the issuance of the *Communiqué of the 7th Berlin Agriculture Ministers' Summit* held under the Global Forum for Food and Agriculture (GFFA) on 17 January 2015, who advocated that “FAO continues and intensifies its work on the primacy of food security in bioeconomy and provides information and pertinent policy advice for the benefit of its Members,” and acknowledged that FAO, in collaboration with other partners, would provide the appropriate platform for “*tangible action and international cooperation [that] are necessary to seize the opportunities provided by sustainable bioeconomy for agriculture and rural development while securing the primacy of food security and nutrition*”.⁵
5. In June 2021, the 42nd Session of the FAO Conference decided to elevate *Bioeconomy for sustainable food and agriculture* to the status of a Programme Priority Area (PPA) within the FAO Strategic Framework 2022-31, under *better environment* (BE2). This makes FAO the first and, so far, the only United Nations Agency to have elevated bioeconomy to the level of a strategic priority. While the PPA BE2 primarily focuses on the Sustainable Development Goal (SDG) 12 *Ensure sustainable consumption and production patterns*, and particularly Targets 12.2, 12.4 and 12.5 related to sustainable resources management, reducing pollution, and minimizing waste generation, the bioeconomy concept is an integrated approach for agrifood systems transformation as it provides a range of benefits across all other SDGs,⁶ and towards *better production, better nutrition, a better environment, and a better life*.
6. The 42nd Session of the FAO Conference adopted the following definition for bioeconomy: “*Bioeconomy is the production, utilization, conservation, and regeneration of biological resources, including related knowledge, science, technology, and innovation, to provide sustainable solutions (information, products, processes and services) within and across all economic sectors and enable a transformation to a sustainable economy.*”⁷ It furthermore specified that the term was “*to be used without the addition of ‘circular’*”.

² UNEP. 2024. *Global Resources Outlook (2024): Bend the trend – Pathways to a liveable planet as resource use spikes*. Nairobi, International Resource Panel. <https://www.unep.org/resources/Global-Resource-Outlook-2024>

³ Organic material (both living and dead), e.g. trees, crops, grasses, tree litter, algae, animals, manure and waste of biological origin excluding material embedded in geological formations and materials transformed to fossilized material and excluding peat [ISO/TS 14067:2013, 3.1.8.1]

⁴ FAO. 2022. *The State of World's Forests 2022* <https://openknowledge.fao.org/items/0c46e9fb-5fec-4738-9db5-65b474f0b9b7>

⁵ Cited in: FAO. n.d. *Overview | Sustainable and circular bioeconomy for food systems transformation*. In: FAO. [Cited 26 April 2024]. <https://www.fao.org/in-action/sustainable-and-circular-bioeconomy/overview/en/>

⁶ Calicioglu, Ö.; Bogdanski, A. *Linking the bioeconomy to the 2030 sustainable development agenda: Can SDG indicators be used to monitor progress towards a sustainable bioeconomy?* *New Biotechnol.* 2021, 61, 40–49.

⁷ C 2021/LIM/4: <https://openknowledge.fao.org/server/api/core/bitstreams/00470b61-650a-4ef8-b027-dd408fcf95e9/content>

7. This document responds to the guidance from the 43rd Session of the FAO Conference highlighting the need for FAO Governing Bodies and Technical Committees to discuss the topic of bioeconomy.⁸ It summarizes the status of global bioeconomy policy and practice development, including the role of crops, livestock, forestry, fisheries, and aquaculture systems in the bioeconomy, outlines key challenges to be addressed, identifies opportunities to enhance contributions of agrifood systems to the bioeconomy, and provides a brief update on FAO's work on bioeconomy.

II. Global Bioeconomy for Sustainable Food and Agriculture: towards common objectives

8. By enhancing resource efficiency, mitigating climate change, conserving biodiversity, combatting land degradation, stimulating economic growth, driving innovation, minimizing waste, and building resilience, the bioeconomy can foster more efficient, resilient, equitable and sustainable agrifood systems.⁹

9. The bioeconomy is gaining increased recognition. Currently, 23 countries and three regions are implementing specific bioeconomy strategies. Additionally, approximately 35 countries have strategies related to bioscience and biotechnology of relevance to the agrifood sector. This coverage is expanding rapidly, and FAO is tracking the development of these strategies.¹⁰

10. Dedicated national bioeconomy approaches take on different forms depending on the context. Fifteen common sustainability objectives were identified across these strategies, touching upon environmental, social, and economic dimensions of sustainability underpinned by a good governance dimension. These objectives include “*safeguarding food security, substituting fossil-fuel based products with sustainable bioproducts, incentivizing the sustainable and efficient use of biological resources while protecting biodiversity, water, and soil and mitigating and adapting to the effects of climate change, creating jobs and revitalising urban and rural economies, establishing fair and equitable value chains*”, and others.¹¹

11. While there is not one universally agreed-upon definition of what constitutes a bioeconomy and its progression is always context-specific, agrifood systems are commonly at the centre of all bioeconomy strategies. This aligns countries and regions to common objectives of enhancing food security, reducing greenhouse gas (GHG) emissions, minimizing waste and promoting circularity,¹² driving competitiveness, and fostering inclusion through innovation. With bioeconomy strategies, countries not only aim to make agrifood systems more sustainable across all dimensions, but also to leverage their potential for advancing the whole economy, creating and connecting new industries,

⁸ C 2023/REP: <https://openknowledge.fao.org/server/api/core/bitstreams/f1f7c772-8139-4931-ac88-12dc5f927220/content> Which reads: “stressed the importance of bioeconomy for sustainable agrifood systems and highlighted the need to discuss this topic within governing bodies and technical committees of the FAO, bearing in mind the ongoing collaboration between COAG and COFO on the linkages between agriculture and forestry and the COFO-COAG joint work roadmap”, and “recognised the importance of the inclusive consideration of diverse and regionally balanced perspectives in FAO’s normative, policy, and scientific work, by means of progressive integration, including through voluntary financial instruments”.

⁹ von Braun, J., Afsana, K., Fresco, L.O. & Hassan, M. 2021. *Science for Transformation of Food Systems: Opportunities for the UN Food Systems Summit*. https://sc-fss2021.org/wp-content/uploads/2021/09/ScGroup_Reader_UNFSS2021.pdf

¹⁰ FAO. 2024. *Dashboard on bioeconomy strategies and related actions for sustainable development*. [online]. Rome, FAO. [Cited 31 December 2023]. <https://www.fao.org/in-action/sustainable-and-circular-bioeconomy/dashboard/en/>. Updated with up-to-date FAO internal database (unpublished).

¹¹ Gomez San Juan, M. & Bogdanski, A. 2021. *How to mainstream sustainability and circularity into the bioeconomy. A compendium of bioeconomy good practices and policies*. Rome, FAO. <https://openknowledge.fao.org/handle/20.500.14283/cb5798en>

¹² Circularity aspects refer mostly to the end of life of products, i.e. waste management procedures that follow non-conventional disposal routes, including biodegradation, aerobic or anaerobic composting, anaerobic digestion, and other waste management options. It can also be applied to other stages of the value chain, meaning to retain the value of biological resources in the economic cycle as long as possible before these resources reach the end-of-life stage. Source: Gomez San Juan, M., Bogdanski, A. & Dubois, O. 2019. *Towards sustainable bioeconomy - Lessons learned from case studies*. Rome, FAO. <https://openknowledge.fao.org/handle/20.500.14283/ca4352en>

generating decent employment opportunities, and increasing social well-being.^{13,14} However, to ensure that bioeconomy development is sustainable, social, economic, and environmental objectives, as well as good governance principles should be considered equally, when analysing its benefits and trade-offs.¹⁵

12. A common element found in most of the strategies is the capacity of the bioeconomy to generate additional value within agrifood systems, leveraging existing resources more effectively and tapping into previously untapped resources, such as waste, residues, and by-products. Circularity and cascading use of biomass¹⁶ are essential elements, which involve recycling and maximizing the availability and utilisation of biological resources throughout their lifecycle.

13. FAO has identified several major gaps and opportunities in the global bioeconomy landscape of relevance to FAO's work. One of the primary gaps lies in the lack of coherence between bioeconomy policies and national development strategies, including agrifood systems pathways. Policymakers should recognise the inherent interconnectedness of these domains and work towards strengthening the alignment between them. This will not only enhance the overall effectiveness of bioeconomy initiatives but also ensure that they are firmly rooted in the broader sustainability goals of the countries.

14. Another gap is the limited availability and analysis of bioeconomy-related data. Robust data on biomass availability, trade-off assessments and potential bioeconomy applications that support sustainability principles and criteria are crucial for informed decision-making and the development of targeted strategies. By enhancing the collection and analysis of these data, policymakers can gain a deeper understanding of the bioeconomy potential and tailor their policies accordingly.

15. Importantly, the path to a thriving bioeconomy must involve the active participation of local communities, Indigenous Peoples, women, youth, and other vulnerable and marginalized groups of society. Co-designing inclusive bioeconomy strategies, policies, and programmes with these stakeholders can foster a bottom-up approach to technologies and practices selection and implementation, and ensure their integration in bioeconomy value chains and associated markets, so that these communities receive sufficient benefits for their vital role in providing renewable materials and in maintaining healthy ecosystem services. This collaborative process not only ensures that the solutions are tailored to local needs but also promotes a sense of ownership and buy-in from these communities themselves.

16. The bioeconomy holds immense potential, but its realization is hindered by gaps in capacity development. While knowledge on best local innovations exists, there is a lack of initiatives actively deploying these solutions. By leveraging investments and enhancing coordination among bioeconomy projects, innovative ideas can be scaled up. This would allow proven technologies and practices to reach communities in need. Establishing platforms for knowledge exchange, cross-sectoral partnerships, and South-South cooperation where applicable, can amplify the collective impact of bioeconomy efforts.

¹³ Gomez San Juan, M. & Bogdanski, A. 2021. *How to mainstream sustainability and circularity into the bioeconomy. A compendium of bioeconomy good practices and policies*. Rome, FAO. <https://openknowledge.fao.org/handle/20.500.14283/cb5798en>

¹⁴ Meyer, R. 2017. *Bioeconomy Strategies: Contexts, Visions, Guiding Implementation Principles and Resulting Debates*. *Sustainability*, 9(6), 1031. <https://www.mdpi.com/2071-1050/9/6/1031>

¹⁵ FAO. 2021. *Aspirational Principles and Criteria for a Sustainable Bioeconomy*. Rome, FAO. <https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1606806/>

¹⁶ Cascading use involves the reuse of residues and the recycling of materials across the value chain. In a cascading approach, the biomass is processed into a bioproduct that is used at least once more (single-stage use) or several more times (multi-stage use) before disposal. To operationalise this concept, it is important to have good governance mechanisms to decide which value should be used to decide on the sequence through which the biomass should be used, i.e. GHG emissions, most efficient use of biomass, economic value addition, local needs, etc.; and who should decide on the value that should prevail. Sources: Gomez San Juan, M., Bogdanski, A. & Dubois, O. 2019. *Towards sustainable bioeconomy - Lessons learned from case studies*. Rome, FAO. <https://openknowledge.fao.org/handle/20.500.14283/ca4352en>; and Dubois, O. & Gomez San Juan, M. 2016. *How sustainability is addressed in official bioeconomy strategies at international, national and regional levels. An overview*. Rome, FAO. <https://openknowledge.fao.org/handle/20.500.14283/ca4352en>

17. To overcome the challenges of limited consumer uptake, the key is to empower diverse stakeholders through targeted efforts in science, education, and community engagement. Investments in strengthening scientific research and educational programmes related to the bioeconomy can help build a robust knowledge base and equip the next generation with the necessary skills and expertise to drive innovation in this field. Countries should ensure that bioeconomy-related capacity-development initiatives specifically target and empower youth, women, and Indigenous Peoples. These groups often face disproportionate barriers in accessing and participating in, and benefitting from the bioeconomy. By empowering them, countries can unlock their vast potential as agents of change and make bioeconomy value chains and value webs more accessible and inclusive for all members of the community.

18. The current global bioeconomy landscape is characterized by a lack of coherence in actions among various public and private sector stakeholders, at the global, but also at national level. The diversity of bioeconomy approaches, which reflect regional, national, and subnational circumstances and capabilities, could prove advantageous in fostering integration at both regional and global levels. Therefore, there is a need to establish dedicated global, national, and local partnerships focused on the bioeconomy. These partnerships should bring together a diverse range of stakeholders across sectors, including governments, the private sector, research institutions, and civil society organizations, to improve cooperation and knowledge-sharing. By fostering these multi-level partnerships, the bioeconomy can gain greater societal acceptance and support. Collaborative efforts can help address concerns, raise awareness, and demonstrate the tangible benefits of the bioeconomy to local communities, ultimately driving wider adoption and implementation.

19. FAO's role as a leading global convening body on the bioeconomy for sustainable food and agriculture through the inclusive consideration of diverse and regionally balanced perspectives in FAO's normative, policy and scientific work on the bioeconomy is to be further strengthened. To this end, it is proposed that FAO establish a multistakeholder global bioeconomy partnership to serve as a catalyst for the development of policies, strategies and plans, building capacities, knowledge systems and incentives at global, regional, national, and subnational levels. FAO, working in partnership with relevant UN entities, international financial institutions (IFIs) and other relevant stakeholders, can leverage its longstanding technical expertise and convening power to foster stronger partnerships and invigorate global cooperation on bioeconomy.

III. Crops, livestock, forestry, and aquatic food systems in the bioeconomy

20. By strengthening the connection among agricultural sectors, and between these sectors and the broader economy, bioeconomy can serve as a catalyst for more equitable economic development and social progress. It can create additional income streams and employment opportunities by leveraging new resources and providing new markets that increase the resilience of agrifood systems.¹⁷

Crop production

21. Crops and crop residues can serve as the primary feedstock for various biobased industries and applications. Crops provide raw materials for bioenergy production, including biofuels like bioethanol and biodiesel, reducing reliance on fossil fuels. Crops contribute to the production of biobased materials, such as bioplastics, textiles, and construction materials, offering sustainable alternatives to fossil-based products. Crop residues and by-products are utilized in biorefineries to produce biochemicals, biomaterials, and other value-added products.

22. However, crop production may face several challenges with regards to land use trade-offs, especially regarding the competition between biomass end-use sectors. Therefore, a holistic

¹⁷ Wesseler, J. & von Braun, J. 2017. Measuring the Bioeconomy: Economics and Policies. *Annual Review of Resource Economics*. Volume 9. <https://www.annualreviews.org/content/journals/10.1146/annurev-resource-100516-053701>

consideration of synergies among biomass production, new technologies for producing and processing biomass, and new links within and between value chains, is needed.¹⁸

23. Biotechnological innovations in genetics and breeding have led to tremendous gains in productivity, adaptation to biotic and abiotic stresses, such as climate change impacts, and enhanced nutritional value. Biotechnology can reduce agrochemical reliance, promote soil health, and benefit small-holder farmers. Genetic engineering can offer pest-resistant crops and biofortified crops that improve nutrition and promote better health outcomes, especially in rural areas in low- and middle-income countries, where diets are significantly reliant on self-produced or locally procured staple crops.¹⁹ Bioeconomy can support the cultivation of a diversified range of crop species, including underutilised and neglected crops, agroforestry practices, or new varieties with high nutritional value and resilience to local environmental conditions.

24. The use of biobased fertilizers and soil amendments, including biochar, supports the reduction of agrochemicals use in agriculture and related emissions, and improves soil health, leading to better crop productivity and enhanced ecosystem services. Countries and regions are increasing their ecosystem restoration commitments, and bioeconomy can help develop value chains necessary to sustain restoration activities in the long term. Bioeconomy can reduce soil and water pollution. Examples include microbial and phyto-remediation, as well as integrated agrosilvofisheries to restore peatlands.²⁰

Livestock production

25. Bioeconomy can bring many opportunities to the livestock sector, such as improving waste management, applying circularity and upcycling principles, and improving the sustainability of feed production including from sustainable management and restoration of pastoral and agrosilvopastoral systems. Studies have shown that the implementation of a zero feed-food competition scenario would result in a transformation of the food production system where livestock can be fed mostly on residues, by-products and marginal lands, and croplands are used to produce crops for direct human consumption. Additionally, alternative feed sources and feed supplements like algae and insect protein reduce reliance on traditional crops, while biotechnology enhances the nutritional quality of feed.²¹

26. Livestock waste, like manure, has the potential to be converted into valuable resources, like bioenergy and fertilizers, using anaerobic digestion, composting, and various bioconversion methods, decreasing emissions, but also creating new sources of income. Additionally, the production of biobased materials from animal by-products includes, for instance, collagen for biomedical applications and biobased polymers from animal fats.

27. Advancements in microbiome science and innovation provide invaluable insights in the intricate relationships among humans, animals, and their surrounding ecosystems, in line with the One Health approach.^{22,23} The application of prebiotics, probiotics, symbiotics, and postbiotics has demonstrated advantages in enhancing plant, animal, and human health.

¹⁸ von Braun, J. 2014. *Bioeconomy and sustainable development – dimensions*. Rural 21.

https://www.rural21.com/fileadmin/downloads/2014/en-03/rural2014_03-S06-09.pdf

¹⁹ FAO. 2023. *The State of Food Security and Nutrition in the World*. Annex 5 p. 217 “Technology and innovation”.

<https://openknowledge.fao.org/server/api/core/bitstreams/620611b1-fd72-4b98-aead-9216f4af5ddd/content>

²⁰ Gomez San Juan, M., Harnett, S. & Albinelli, I. 2022. *Sustainable and circular bioeconomy in the biodiversity agenda: Opportunities to conserve and restore biodiversity in agrifood systems through bioeconomy practices*. Rome, FAO.

<https://openknowledge.fao.org/server/api/core/bitstreams/5c24cce4-5cff-410d-bdf0-6061f3ad3887/content>

²¹ Mottet, A., de Haan, C., Falcucci, A., Tempio, G., Opio, C. & Gerber, P., 2017. *Livestock: On our plates or eating at our table? A new analysis of the feed/food debate*. *Global Food Security*, 14

<https://www.sciencedirect.com/science/article/pii/S2211912416300013?via%3Dihub>

²² FAO. 2024. *Four new reports highlight importance of the microbiome for food safety, soils and nutrition*. [online]. Rome, FAO. [Cited 24 April 2024]. <https://www.fao.org/newsroom/detail/four-new-reports-highlight-importance-of-the-microbiome-for-food-safety--soils-and-nutrition/en>

²³ FAO. 2024. *One Health*. [online]. Rome, FAO. [Cited 24 April 2024]. <https://www.fao.org/one-health/overview/one-health-overview/en>

28. Biotechnology innovations, including antibiotics alternatives, vaccine production, and gene technologies (such as breeding programmes) can lead to improved animal health and productivity, while reducing the environmental impacts of livestock farming.

Forests, forestry, and forest-based value chains in the bioeconomy

29. As one of the most biologically rich terrestrial systems, forests provide a range of ecosystem services that support local communities, agriculture, food security and nutrition, and various economic sectors. Sustainable forest production, conservation, and restoration – often referred to as Sustainable Forest Management (SFM) – contributes to biodiversity protection, climate adaptation and mitigation²⁴ (including through carbon storage in forest biomass, soil and wood products, and material substitution²⁵); addressing land degradation and desertification; and sustaining and improving livelihoods, food security and nutrition, cultural values, and human health (including through agroforestry, other integrated production systems and forest management strategies).²⁶

30. Forest-based value chains are essential elements of the bioeconomy.²⁷ They provide sustainable and environmentally beneficial products (feedstock) that can substitute non-renewable products and energy.²⁸ They support food and agricultural, construction, pharmaceutical, and bioenergy sectors by supplying wood, food, feed, fibre, bioenergy, non-wood forest products, biochemicals, bioplastics, and manufactured cellulosic textiles.²⁹ The development of legal and sustainable forest-related value chains has the potential to underpin carbon-neutral economies while generating decent employment and livelihoods for millions of people.^{30,31,32}

31. Enhancing the contribution of forestry to bioeconomy would require: (i) the increased sustainable supply of forest-based biomass, goods and services through a combination of strategies, including increasing the area of, and productivity of, naturally regenerated and planted forests, as well as utilizing agroforestry and restoration approaches; (ii) the improved value-adding, manufacturing efficiency and bioenergy flows and promotion of the cascading use of forest products, including non-wood forest products; (iii) a change of consumption patterns; and (iv) a transition to more circular and sustainable bioeconomies that create socio-economic opportunities for rural development and for local communities depending on forest resources.

²⁴ Verkerk, P.J., Hassegawa, M., Van Brusselen, J., Cramm, M., Chen, X., Maximo, Y. I., Koç, M. *et al.* 2022. *The role of forest products in the global bioeconomy – Enabling substitution by wood-based products and contributing to the Sustainable Development Goals*. Rome, FAO. <https://doi.org/10.4060/cb7274en>

²⁵ UFRO (International Union of Forest Research Organizations). 2024. *Unlocking the Bioeconomy and Non-Timber Forest Products*. [online]. Viena. [Cited 22 April 2024]. <https://www.iufro.org/science/task-forces/bioeconomy-and-non-timber-forest-products/>

²⁶ FAO and UFRO (International Union of Forest Research Organizations). 2022. *Inspire for the future: The Role of Forests in Ensuring Sustainable Production and Consumption*. <https://www.fao.org/3/cc2259en/cc2259en.pdf>

²⁷ FAO. 2023. *Bioeconomy for sustainable food and agriculture*. Rome, FAO. <https://www.fao.org/3/cc6905en/cc6905en.pdf>

²⁸ FAO. 2021. *Advisory Committee on Sustainable Forest-based Industries. Strategic Framework 2020–2030*. Rome, FAO. <https://www.fao.org/3/cb4294en/cb4294en.pdf>

²⁹ FAO. 2022. *The State of the World's Forests 2022. Forest pathways for green recovery and building inclusive, resilient and sustainable economies*. Rome, FAO. <https://doi.org/10.4060/cb9360en>

³⁰ Lippe, R.S., Schweinle, J., Cui, S., Gurbuzer, Y., Katajamäki, W., Villarreal-Fuentes, M. & Walter, S. 2022. *Contribution of the forest sector to total employment in national economies - Estimating the number of people employed in the forest sector*. Rome and Geneva, FAO and ILO. <https://doi.org/10.4060/cc2438en>

³¹ FAO & UNECE. 2019. *Green jobs' trends and their implications for the forest sector in achieving the objectives of the Rovaniemi Action Plan for the Forest Sector in a Green Economy*. <https://unece.org/fileadmin/DAM/timber/meetings/2019/20190327/Draft-GREEN-JOBS-IN-FOREST-SECTOR-policy-brief.pdf>

³² Li, Y., Mei, B., Linhares-Juvenal, T., Formenton Cardoso, N. & Tshering, C. 2022. *Forest sector contribution to national economies 2015 – The direct, indirect and induced effects on value added, employment and labour income*. Forestry Working Paper No. 33. Rome, FAO. <https://doi.org/10.4060/cc2387en>

Fisheries and aquaculture

32. Aquatic foods hold the potential for a major contribution to global food security and nutrition, while providing livelihood benefits to people around the world.^{33,34} In 2022, global fisheries and aquaculture production surged to 223.2 million tonnes, with 185.4 million tonnes of aquatic animals and 37.8 million tonnes of algae. By 2032, aquatic animal production alone is forecasted to increase by 10 percent in ten years, including through sustainable aquaculture production, providing a larger proportion of nutritious food requirements, especially in low-income countries.³⁵

33. The “blue bioeconomy” is a significant part of the broader bioeconomy, encompassing the sustainable use of freshwater and marine resources. From reducing pollution to valorizing waste, aquatic food systems are integral components of bioeconomy strategies, integrated into sustainable development pathways, especially in Small Island Developing States (SIDS).³⁶

34. Some prominent examples of the “blue bioeconomy” include innovative technologies for efficient aquatic products production, seaweed-based value chains creation, circular aquaculture, optimized resource utilisation, such as linking biorefineries with ports, improving value addition and stimulating inclusive blue growth. Women represent almost half of the post-harvest workforce, contributing significantly to processing and the broader aquatic value chain development.³⁷

35. Countries are prioritizing innovative and technological advancements in fisheries and aquaculture by deploying advanced aquaculture technologies like water recirculation plants, and by promoting collaboration among sectors to accelerate sustainable operating models. They are enhancing aquatic species’ resilience through genomics-based breeding programmes and integrating monitoring and control systems using information and communication technologies (ICT) and Big Data Analytics to combat illegal fishing. Additionally, efforts focus on integrating marine energy technologies with aquaculture, pursuing ecosystem-based management of fisheries, and investing in innovative practices, such as smart hatchery systems. Sustainable aquaculture is being encouraged through programmes emphasizing industrial symbiosis and the cascading use of by-products and effluents, including the expansion of multitrophic aquaculture for marine sustainability and resource recovery.³⁸

IV. Update on FAO’s work on Bioeconomy for Sustainable Food and Agriculture

36. FAO’s bioeconomy activities are closely aligned with the goals of the Organization’s strategies and relevant action plans on Climate Change 2022–2031,³⁹ Mainstreaming Biodiversity across Agricultural Sectors,⁴⁰ and Science and Innovation.⁴¹

37. Integrating the three dimensions of sustainability is the most crucial global challenge for bioeconomy to ensure that it not only supports immediate economic gains, but also contributes to the enduring health of the planet and people. FAO’s *Aspirational Principles and Criteria for a*

³³ UN Nutrition. 2021. *The role of aquatic foods in sustainable healthy diets*. Rome, FAO. https://www.unnnutrition.org/wp-content/uploads/FINAL-UN-Nutrition-Aquatic-foods-Paper_EN_.pdf

³⁴ In Bangladesh, Cambodia, Ghana, Indonesia, Sierra Leone, Mozambique, and various Small Island Developing States (SIDS), aquatic foods already contribute 50 percent or more of total animal protein intake.

³⁵ FAO. 2024. *The State of World Fisheries and Aquaculture 2024. Blue Transformation in Action*. Rome, FAO. <https://openknowledge.fao.org/server/api/core/bitstreams/a4151f1e-3130-4504-a7d7-4b066de59030/content>

³⁶ FAO. 2022. *The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation*. Rome, FAO. “Nutritional and environmental benefits of aquatic food consumption”, p.87 <https://openknowledge.fao.org/handle/20.500.14283/cc0461en>

³⁷ FAO. 2022. *The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation*. Rome, FAO. <https://openknowledge.fao.org/handle/20.500.14283/cc0461en>

³⁸ Kangning, Y. and S. Yubang (2022). An overview of disruptive technologies for aquaculture. *Aquaculture and Fisheries*, Volume 7, Issue 2, Pages 111-120, <https://www.sciencedirect.com/science/article/pii/S2468550X21000617?via%3Dihub>

³⁹ FAO. 2022. *FAO Strategy on Climate Change 2022–2031*. Rome.

<https://openknowledge.fao.org/server/api/core/bitstreams/f6270800-ee7-498f-9887-6d937c4f575a/content>

⁴⁰ FAO. 2020. *FAO Strategy on Mainstreaming Biodiversity across Agricultural Sectors*. Rome.

<https://openknowledge.fao.org/handle/20.500.14283/ca7722en>

⁴¹ FAO. 2022. *FAO Science and Innovation Strategy*. Rome.

<https://openknowledge.fao.org/server/api/core/bitstreams/e9d1ee6c-c0f1-4312-9a1a-c09ba0a4fbdc/content>

Sustainable Bioeconomy represent the first global effort to provide a framework for monitoring the sustainability of the bioeconomy and to assist in managing trade-offs.⁴² These Aspirational Principles and Criteria cover the three dimensions of sustainability (social, economic, and environmental) while also promoting good governance. Translating them into effective bioeconomy policies and practices that balance potential trade-offs requires a context-specific approach.⁴³ The Aspirational Principles and Criteria can be used in monitoring and evaluation frameworks to measure the sustainability of the bioeconomy or to monitor and evaluate a country's progress as it transitions towards a sustainable bioeconomy.

38. FAO continues to support Members to engage on bioeconomy through relevant Multilateral Environmental Agreements (MEAs) and international processes.^{44,45}

39. As of April 2024, supported both by the FAO regular budget and by donor contributions, FAO is engaged in around 150 bioeconomy-related projects associated with the PPA BE2. The funding in support of PPA BE2 is estimated at almost USD 59 million for the current biennium (2024-25), comprised of USD 19.6 million in assessed and USD 39 million in forecast voluntary contributions.⁴⁶ FAO supports four key areas of work: policy advisory; capacity building and country support; partnerships; and knowledge creation and advocacy.⁴⁷

40. FAO provides **policy advisory services** to assist policymakers in establishing and implementing national and regional bioeconomy strategies, action plans, and programmes in line with the *Aspirational Principles and Criteria for Sustainable Bioeconomy*, in support of multiple SDGs and goals of MEAs. In addition, FAO provides technical assistance to Parties to the Rotterdam Convention on implementing policies related to the use of hazardous pesticides, biological alternatives, and integrated pest management.⁴⁸

41. FAO provides **capacity development and country support** with bioeconomy projects that leverage local capacities and biological resources. For example, FAO supports countries with the valorization of underutilised residues, by-products and co-products from crops, forestry, fisheries and aquaculture through bioinnovations that minimize emissions and foster circular systems, transforming waste into valuable resources. In different countries including Barbados, Cabo Verde, Ghana, Kenya, Malawi and Mozambique, FAO supports projects to convert aquatic food processing by-products into products, such as fish silage for feed or fertilizer use, fish powder for food purposes, or leather from fish skin as an alternative to conventional leather in the fashion industry, while providing additional sources of income. In Pakistan, FAO is implementing a project that valorizes non-edible biomass from banana production into a sustainable, alternative textile fibre, saving it from open burning or

⁴² FAO. 2021. *Aspirational Principles and Criteria for a Sustainable Bioeconomy*. Rome, FAO. <https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1606806/>

⁴³ Gomez San Juan, M. & Bogdanski, A. 2021. *How to mainstream sustainability and circularity into the bioeconomy. A compendium of bioeconomy good practices and policies*. Rome, FAO. <https://www.fao.org/documents/card/en/c/cb5798en>

⁴⁴ Gomez San Juan, M., Harnett, S. & Albinelli, I. 2022. *Sustainable and circular bioeconomy in the climate agenda: Opportunities to transform agrifood systems*. Rome, FAO. https://www.fao.org/3/cc2668en/cc2668en.pdf?trk=public_post_comment-text

⁴⁵ Gomez San Juan, M., Harnett, S. & Albinelli, I. 2022. *Sustainable and circular bioeconomy in the biodiversity agenda: Opportunities to conserve and restore biodiversity in agrifood systems through bioeconomy practices*. Rome, FAO. <https://www.fao.org/3/cc3417en/cc3417en.pdf>

⁴⁶ CL 174/3: Adjustments to the Programme of Work and Budget 2024-25 <https://openknowledge.fao.org/server/api/core/bitstreams/6fa19efa-f0cb-4d7b-88e3-aa018b63a451/content> - Annex 3: 2024-25 Budget by budgetary chapter <https://www.fao.org/3/nn723en/nn723en.pdf>

⁴⁷ PC 137/INF/8: <https://openknowledge.fao.org/server/api/core/bitstreams/e875c3e2-fc73-455f-a1ac-6efa5340f9e6/content>

⁴⁸ FAO. 2022. Sustainable Bioeconomy and FAO. Rome, FAO. <https://openknowledge.fao.org/items/740411e9-8f5d-4cd7-9785-72ab848515fc>

disposal in landfills.⁴⁹ In Azerbaijan,⁵⁰ India,⁵¹ Rwanda,⁵² and Zambia,⁵³ FAO promotes the sustainable production of bioenergy from crop and biomass residues.

42. FAO supports countries in identifying bioeconomy practices, such as biobased plant nutrient management alternatives (biofertilizers, biostimulants, and biological control). For example, in Kenya and Uruguay, FAO works on reducing the use and prevalence of harmful agrochemicals by supporting farmers in accessing finance for the adoption of alternatives. FAO also works on bio-inputs in Latin America and the Caribbean and investment options to upscale them.⁵⁴

43. FAO supports Members with technical expertise to enhance sustainability and increase the productivity of wood and non-wood forest products' value chains from natural and planted forests as a contribution to a sustainable bioeconomy. In Pakistan, FAO supports capacity-building efforts aimed at the conservation and sustainable use of medicinal plants and non-timber forest products in the Astore Valley and Deosai National Park Buffer Zone of Gilgit-Baltistan. In Jordan, FAO is bolstering the resilience of rural women by valorizing forest products, addressing challenges in a country with limited forest cover.

44. FAO engages in **partnerships** to facilitate dialogue and knowledge exchange to maximize synergies and manage trade-offs when implementing bioeconomy innovations in agrifood systems. In addition to facilitating the work of the International Sustainable Bioeconomy Working Group (ISBWG),⁵⁵ FAO is a partner and provides secretariat services to the Global Bioenergy Partnership (GBEP), which has a dedicated working group on *Bioenergy in the context of the broader bioeconomy*;⁵⁶ the Livestock Environmental Assessment and Performance (LEAP) Partnership, with a Task Advisory Group on *Circular Bioeconomy Approaches*;⁵⁷ and the Advisory Committee on Sustainable Forest-based Industries (ACSFI), which identified bioeconomy as one of its strategic priorities aiming at “*identifying and disseminating good practices as well as related capacity building to support the development of innovative forest product value chains in the forest bioeconomy*”.^{58,59} FAO also engages in international bioeconomy fora, such as the International Advisory Council on Global Bioeconomy (IACGB)⁶⁰, the International Bioeconomy Forum (IBF)⁶¹ and the World

⁴⁹ FAO. 2024. *New FAO-led bioeconomy project in Pakistan scoops multimillion dollar grant*. [online]. Rome, FAO. [Cited 23 April 2024]. <https://www.fao.org/in-action/sustainable-and-circular-bioeconomy/resources/news/details/en/c/1643196/>

⁵⁰ FAO. 2023. *Hazelnut sector in Azerbaijan – Options for green energy interventions along the value chain*. Environment and Natural Resources Management Working Paper, No. 98. Baku. <https://doi.org/10.4060/cc8599en>

⁵¹ FAO. 2022. *Establishing residue supply chains to reduce open burning. The case of rice straw and renewable energy in Punjab, India*. Environment and Natural Resources Management Working Paper No. 95. Rome. <https://doi.org/10.4060/cb9570en>

⁵² FAO. 2023. *Sustainable bioenergy potential from crop, livestock and woody residues in Rwanda: An integrated bioenergy and food security approach*. Environment and Natural Resources Management Working Paper, No. 97. Rome <https://doi.org/10.4060/cc7094en>

⁵³ FAO and the Ministry of Energy of Zambia. 2020. *Sustainable bioenergy potential in Zambia – An integrated bioenergy and food security assessment*. Environment and Natural Resources Management Working Papers No. 84. Rome. <https://doi.org/10.4060/cb1528en>

⁵⁴ Bullor, L., Braude, H., Monzón, J., Cotes Prado, A. M., Casavola, V., Carbajal Morón, N. y Risopoulos, J. 2023. *Bioinsumos: Oportunidades de inversión en América Latina - Direcciones de inversión No. 9*. Roma, FAO. <https://doi.org/10.4060/cc9060es>

⁵⁵ FAO. 2024. *ISBWG (International Sustainable Bioeconomy Working Group)*. [online]. Rome, FAO. [Cited 24 April 2024]. <https://www.fao.org/in-action/sustainable-and-circular-bioeconomy/international-sustainable-bioeconomy-working-group/en/>

⁵⁶ GBEP (Global Bioenergy Partnership). 2024. *Bioenergy in the context of the broader bioeconomy*. [online]. Rome, FAO. [Cited 24 April 2024]. <https://www.globalbioenergy.org/programmeofwork/task-force-on-sustainability/bioeconomy/en/>

⁵⁷ LEAP (Livestock Environmental Assessment and Performance). 2024. *Technical Advisory Group on Circular Bioeconomy Approaches*. [online]. Rome, FAO. [Cited 24 April 2024]. <https://www.fao.org/in-action/sustainable-and-circular-bioeconomy/technical-advisory-group-on-circular-bioeconomy-approaches/en/>

⁵⁸ FAO. 2021. *Advisory Committee on Sustainable Forest-based Industries. Strategic Framework 2020–2030*. Rome, FAO. <https://www.fao.org/3/cb4294en/cb4294en.pdf>

⁵⁹ FAO. 2021. *Building a forest-based bioeconomy to halt climate change and achieve multiple: Sustainable Development Goals (SDGs)*. <https://www.fao.org/3/cb7013en/cb7013en.pdf>

⁶⁰ IACGB (International Advisory Council on Global Bioeconomy). 2024. *Mission and Vision*. [online]. Berlin. [Cited 23 April 2024]. <https://www.iacgb.net/mission>

⁶¹ IBF (International Bioeconomy Forum). 2024. [online]. [Cited 23 April 2024]. <https://euraxess.ec.europa.eu/worldwide/africa/news/participation-euraxess-africa-5th-international-bioeconomy-forum-ibf>

Bioeconomy Forum (WBF)⁶². As regards resource partnerships on bioeconomy that support engagement at national, regional and global levels, FAO has ongoing partnerships with the governments of Canada, Ireland and the Kingdom of the Netherlands.

45. FAO engages in **knowledge creation and advocacy** activities through developing practice-oriented tools to support the devising of bioeconomy policies, the implementation of good practices, and the monitoring and evaluating of bioeconomy performance and impact, and through the organization of workshops, training sessions, and capacity-building programmes about the concept of bioeconomy and how it can be integrated into various sectors of the economy. FAO has created and contributed to numerous knowledge products that address various dimensions of bioeconomy, including innovative forest-based products,⁶³ soil microbiome,⁶⁴ unlocking the potential of algae,⁶⁵ bioeconomy in urban food agenda,⁶⁶ exploring the applicability of sustainability indicators for bioenergy to other sectors,⁶⁷ non-wood forest products in Asia,⁶⁸ wood residues in the transition to sustainable bioenergy,⁶⁹ among others.

V. The way forward

46. FAO Members can unlock the potential of a bioeconomy to contribute substantively to achieving the SDGs and the 2030 Agenda for Sustainable Development. FAO has relevant technical expertise, knowledge products, operational capacities, networks, and access to finance to support Members in their efforts to enhance and scale up the role of crops, livestock, forestry, fisheries and aquaculture and the associated value chains in agrifood systems transformation and the bioeconomy.

47. However, unlocking the full potential of the bioeconomy will require considerably greater policy emphasis on using data, knowledge, science, technology, innovation, scaled-up capacity development and investments to adapt the sustainable management of biological resources and related value chains, while addressing the need for equitable sharing of the benefits and social costs of bioeconomy initiatives.

48. During the current biennium (2024–2025), in the framework of the PPA BE2 on *Bioeconomy for sustainable food and agriculture*, FAO is building on the following elements that have stood out as success factors during the first biennium of implementation (2022–2023):

- a) Strengthening integration of bioeconomy policies into national policies and improving general policy coherence. This includes enhancing the collection of bioeconomy-related data, focusing on biological resources and biomass availability and potential applications that support sustainability principles and criteria. Co-designing bioeconomy strategies, policies and programmes with local communities can support adopting a bottom-up approach to technology selection, and mainstreaming bioeconomy in other sectoral policies, including food systems transformation pathways.

⁶² WBF (World BioEconomy Forum). 2024. *The Four-Pillar Structure*. [online] [Cited 22 April 2024]. <https://wcbef.com/>

⁶³ Verkerk, P.J., Hasegawa, M., Van Brusselen, J., Cramm, M., Chen, X., Maximo, Y. I., Koç, M. *et al.* 2022. *The role of forest products in the global bioeconomy – Enabling substitution by wood-based products and contributing to the Sustainable Development Goals*. Rome, FAO. <https://doi.org/10.4060/cb7274en>

⁶⁴ Kendzior, J., Warren Raffa, D. & Bogdanski, A. 2022. *The soil microbiome: a game changer for food and agriculture – Executive summary for policymakers and researchers*. Rome, FAO. <https://www.fao.org/documents/card/en/c/cc0717en>

⁶⁵ Cai, J., Lovatelli, A., Aguilar-Manjarrez, J., Cornish, L., Dabbadie, L., Desrochers, A., Diffey, S. *et al.* 2021. *Seaweeds and microalgae: an overview for unlocking their potential in global aquaculture development*. FAO Fisheries and Aquaculture Circular No. 1229. Rome, FAO. <https://doi.org/10.4060/cb5670e>

⁶⁶ FAO. 2019. *FAO framework for the Urban Food Agenda*. Rome. <https://www.fao.org/3/ca3151en/ca3151en.pdf>

⁶⁷ Köppen, S., Fehrenbach, H. & Silvana, Bürck. 2022. *Linking bioenergy and the bioeconomy: The GBEP Sustainable Bioenergy Indicators and Sustainable Bioeconomy Indicators - Similarities, Differences and Perspectives for Convergence*. <https://www.fao.org/3/cc7557en/cc7557en.pdf>

⁶⁸ FAO and Non-Timber Forest Products-Exchange Programme. 2020. *Naturally Beautiful – Cosmetic and beauty products from forests*. Bangkok. <https://openknowledge.fao.org/items/4b06c809-a74e-440c-9a1d-b9580ecce9e4>

⁶⁹ Thiffault, E., Gianvenuti, A., Zuzhang, X. and Walter, S. 2023. *The role of wood residues in the transition to sustainable bioenergy – Analysis of good practices and recommendations for the deployment of wood residues for energy*. Rome, FAO. <https://www.fao.org/documents/card/en/c/cc3826en>

- b) Improving the knowledge base, reporting and consolidation of lessons learned. This includes empowering youth, women and Indigenous Peoples and other groups, as this can contribute to overcoming issues related to consumer acceptance and bioeconomy uptake by making bioeconomy value chains more accessible and common.
- c) Empowering FAO Decentralized Offices to scale up bioeconomy solutions on the ground through continuous knowledge exchange, capacity development, and advisory services, providing technical, policy, monitoring criteria and investment support. This entails increasing the number of projects working on the ground to deploy the bioeconomy, such as scaling up innovative ideas “from the lab to the market” by leveraging investments and enhancing coordination and synergy among bioeconomy projects, increasing technology transfer and South–South and Triangular Cooperation.
- d) Increasing public–private partnerships and synergies, as well as collaboration across FAO’s divisions and offices, with impactful partnerships, relevant programmes and projects, including those submitted to vertical funds, PPAs, and the value-added impact areas (VAIAs).
- e) Consolidating FAO’s role as a leading global convening body on the bioeconomy for sustainable food and agriculture through the inclusive consideration of diverse and regionally balanced perspectives in FAO’s normative, policy and scientific work on the bioeconomy. Global, national, and local partnerships dedicated to the bioeconomy are needed to improve cooperation among countries and among these three levels.