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The importance of adequate policies and governance mechanisms to build a Sustainable Bioeconomy Strategy

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Resumo

O avanço da bioeconomia conduziu a uma nova era, em que os produtos e serviços de origem fóssil são substituídos por materiais sustentáveis, renováveis e de base biológica, desenvolvidos com recurso a abordagens focadas na circularidade. Esta mudança não só protege os recursos naturais e os ecossistemas, mas pode igualmente manter e impulsionar o equilíbrio económico e social, através do desenvolvimento de novos modelos de negócio, produtos e serviços. Contudo, devido à natureza multifacetada da bioeconomia, a criação de políticas públicas e mecanismos de governação adequados é uma tarefa complexa. O estabelecimento de políticas eficazes exige um quadro que potencie as sinergias entre os sectores da agricultura, da energia, do ambiente e social. Dada a sua complexidade, uma implementação bem sucedida exige colaboração interministerial, coerência política e coordenação entre várias partes interessadas a nível local, regional, nacional, da UE e mesmo internacional. A integração de conhecimentos científicos do meio académico e de projectos de investigação que envolvam diversos atores da indústria, dos sectores público e privado e, dos decisores políticos, é crucial para a definição de políticas públicas eficazes. Tendo em conta as mudanças globais em curso, é imperativo reavaliar os conhecimentos, as políticas e os mecanismos de governação existentes. Este trabalho tem como objetivo fornecer uma avaliação das políticas europeias e nacionais ligadas à bioeconomia, salientando simultaneamente as lacunas críticas que devem ser colmatadas para a sua implementação sustentável. Estas lacunas incluem a conceção de mecanismos para regular a gestão dos solos e da água nas diferentes cadeias de valor, a resolução da concorrência na utilização da biomassa entre sectores e a formulação de políticas para a gestão da água e do solo, a fim de melhorar a sua qualidade, propriedades e disponibilidade e outras questões essenciais, tais como a literacia e a criação, consolidação e transferência de conhecimento.

Palavras-Chave: Bioeconomia, Politícas Públicas, Desenvolvimento Sustentável

Abstract

The advancement of the bioeconomy has conducted to a new era, whereby fossil-based products and services are replaced by sustainable, renewable, and circular biobased materials and approaches. This shift not only safeguards natural resources and ecosystems. It can maintain or even further boost economic and societal equilibrium, through the development of new business models, products and services. However, due to the multifaceted nature of the bioeconomy, creating suitable public policies and governance mechanisms is a complex task. Establishing effective policies requires a framework that leverages synergies across agriculture, energy, environment, and social sectors. Given its intricacy, successful implementation demands inter-ministerial collaboration, policy coherence, and coordination among various stakeholders at local, regional, national, EU, and even, international levels. Integrating scientific insights from academia and research projects involving diverse stakeholders from industry, public and private sectors, and policymakers is crucial for shaping balanced and effective public policies. In light of ongoing global changes, reassessing existing knowledge, policies, and governance mechanisms is imperative. This work aims to provide an overview of existing European and national policies supporting the bioeconomy, while underscoring critical gaps that must be addressed for its sustainable

implementation. These gaps include designing mechanisms to regulate soil and water management in the different value chains, resolving competition in the use of biomass between sectors, formulating policies for water and soil management in order to improve their quality, properties and availability, and other key issues such as literacy and the creation, consolidation and transfer of knowledge.

Key-words: Bioeconomy, Public Policies, Sustainable Development (no máximo 5 palavras).

Introduction

Bioeconomy has gained considerable importance as a mean to foster a balanced development with respect to environmental, social and economic aspects. Bioeconomy is an economic sector that encompasses several sectors, including agriculture and forestry, fishery and aquaculture and other industries, namely paper, textile, food, textiles, pharmaceuticals, chemicals, energy, etc (Figure 1). The Bioeconomy sector uses knowledge of biological resources, biological processes and biological principles together with key enabling and converging technologies, such as bio- and nano-technologies, digitalisation and information technology, to develop environmental, sustainable, economic and social balanced products and services (Gould 2023; Stephenson 2022).

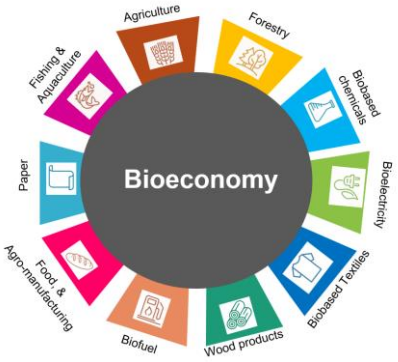

Figure 1 – Sectors of relevance for Bioeconomy

Due to the potential enabled within bioeconomy for the proper management and development of land and biological resources within ecological limits, for the assurance of development of sustainable solutions throughout the entire value chain, and for social and economic stability, there has been significant attention devoted to both innovation and research, as well as to public policy development (Avillez 2021, Bengtsson 2010; Energy Transitions Commission and the European Forest Institute 2021, Eversberg 2022, Vargas-Carpintero 2020, Gardossi 2023).

Within this research there are many challenges associated for a successful implementation of Bioeconomy national and international targets. This includes the need to develop and integrate monitoring, regulation, financial, regulatory and other instruments, considering environmental and socio-economic relevant aspects.

In order to fully exploit the potential of Bioeconomy, specific strategies have been developed both within the European Union and at national levels. Within these strategies, specific goals, targets have been identified and proposed, which aim at the development of alternatives for the replacement of fossil-based products and associated services by sustainable, renewable, circular bio-based materials and services, that ensure the conservation of natural resources and ecosystems, while providing both economic and societal equilibrium. Bioeconomy strategies and activities derived from them are aligned and support the achievement of the UN Sustainability Development Goals and the Green Deal Strategy, which has the following objectives: i) assurance of food and nutrition security; ii) management of natural resources and ecosystem services; iii) reduction of the use of non-renewable resources; iv) replacement of fossil-based resources by renewable, non-fossil based resources (wind, solar, bioenergy, etc); v) improvement of European competitiveness and creation of sustainable business and additional jobs (European Commission 2019; United Nations 2024). By harnessing the potential of biological resources in a sustainable manner, the bioeconomy offers pathways to address pressing global challenges while fostering long-term economical and social prosperity for current and future generations.

1. European Bioeconomy Strategy: Evolution and Objectives

The European Bioeconomy Strategy, introduced in 2012 and revised in 2018, focuses on enhancing R&D activities to promote the efficient use of renewable resources. With five core objectives, including food security, climate change mitigation, and economic competitiveness, it aligns with the European Green Deal and the UN Sustainable

Development Goals. Key targets involve ecosystem preservation, sustainable resource management, and biomass valorization. Innovative processes, products, and business models are identified as essential for driving bioeconomy growth and enhancing circularity (European Commission 2022; Directorate-General for Research and Innovation, European Commission (2012), Directorate-General for Research and Innovation, European Commission 2018). Some of the key pillars outlined within the European Bioeconomy Strategy are: i) the assignment of dedicated land and aquatic areas for the preservation and restoration of ecosystems; ii) the implementation of sustainable management practices and use of nature-based solutions for conservation and restoration of key land and aquatic resources; iii) the improvement of sustainable management and application of circular economy approaches to agriculture, forestry, sea and other water based activities. The application of these approaches shall have benefits in terms of biodiversity conservation and restoration, should ensure food security and compliance with environmental targets, energy transition targets and other important objectives set by the 18 United Nations SDGs and the European Green Deal.

2. Portuguese Bioeconomy Sustainability Strategy: Integration and Objectives

Integrated into Portugal's 2030 Strategic Agenda, the Portuguese Bioeconomy Sustainability Strategy aims to reinforce innovation, biodiversity protection, and carbon neutrality. Aligned with the European Biodiversity Strategy, it emphasizes the conservation, restoration and valorisation of natural resources, through a sustainable resource management, and rural development, the development of sustainable and competitive value chains and the promotion of social fairness and territorial cohesion.

Through knowledge building and knowledge transfer, policy adaptation, and funding initiatives, Portugal seeks to achieve a sustainable and competitive economic development trajectory. The Action Plan designated as Horizon 2025, and entitled Sustainable Bioeconomy Action Plan (BAPS) was designed to expedite Portugal's transition to a sustainable and circular bioeconomic model in alignment with the Portuguese and European Bioeconomy Strategies. The aim of this plan is to harness the potential arising from different primary sectors (agriculture and forestry, aquaculture and fishery) and the strategical location of Portugal, with an extensive maritime territory. By emphasizing the processing and valorization of organic raw materials, arising from the different key Portuguese primary sectors, it is aimed to establish new value chains and revenue schemes that engage these traditional sectors. In parallel it is expected to promote sustainable production and strategic utilization of locally-sourced biological resources, foster research and innovation, generate and transfer knowledge and raise public awareness on the importance of this transition.

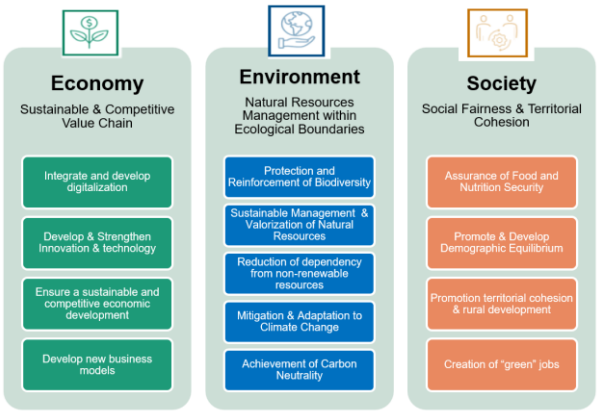

Figure 2 – Pillars of intervention and objectives of Bioeconomy Portuguese and European Strategies

3. Enablers for the implementation of the Portuguese Bioeconomy Strategy

In order to achieve the objectives of Portugal's 2030 strategy for the Bioeconomy, it is essential to apply a co-creative and transdisciplinary approach engaging multiple stakeholders with expertise in multiple vectors, namely competence development and knowledge transfer; policy instruments and governance models adaptation and assessment, funding and intersectoral R&D programs and business development and marketing. This means that Academia, Industry, public administration, policy decision makers and civil society requirements, knowledge and expertise shall be combined and considered.

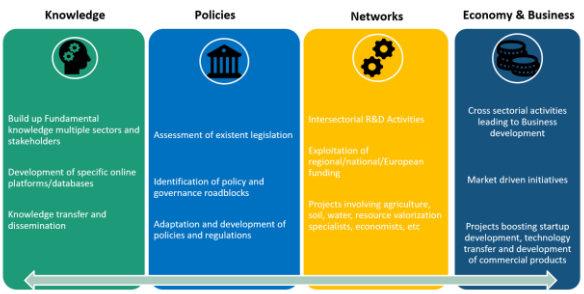

Figure 3 – Key enablers for Bioeconomy Portuguese and European Strategies

Building fundamental knowledge across various sectors and stakeholders is imperative for fostering collaboration, innovation, and sustainable development, serving as a cornerstone for the advancement of Bioeconomy. However, this is merely one aspect to consider. Equally essential are tools that facilitate access to information, foster collaboration, and drive innovation across relevant domains and actors within the Bioeconomy sphere. The development of specific tools, particularly open-access online platforms and databases, assumes a critical role in this regard. These platforms serve as centralized hubs and repositories of knowledge, pertinent data, and best practices. Users can seamlessly integrate information, access and share knowledge, and ultimately analyze data, resources, and expertise without being constrained by geographical boundaries or specific Bioeconomy sectors. Ensuring the robustness of available data requires implementing adequate governance frameworks and tools to safeguard privacy, security, and integrity. By promoting knowledge sharing, collaboration, and innovation, these platforms catalyze progress and enable individuals and organizations to make informed decisions and tackle complex challenges more effectively. Knowledge transfer and dissemination are indispensable processes for ensuring that valuable insights, discoveries, and best practices reach their intended audiences and have a significant impact. Communication and dissemination strategies should reach out to diverse stakeholders, including policymakers, practitioners, researchers, Bioeconomy-related companies, and the general public. An array of channels and methods, including publications, conferences, workshops, training programs, multimedia materials, and digital platforms, can be employed for knowledge transfer and dissemination. Tailoring these strategies to the preferences and needs of different audiences is paramount for maximizing their reach and effectiveness. Ultimately, effective knowledge transfer and dissemination contribute to informed decision-making, capacity building, and positive societal outcomes across various sectors and contexts. By leveraging a variety of channels and approaches, stakeholders can amplify the impact of their knowledge and expertise, thereby driving innovation and progress in the Bioeconomy sector.

Cross-sectoral activities, projects and initiatives involving multiple stakeholders, from academia, industry, civil society, public admin and policy decision makers, can catalyze business development. Interdisciplinary research together with appropriate market-driven initiatives and innovation projects can drive startup growth, facilitate technology transfer, and nurture the development of new business models, commercial products and services. By aligning business strategies with market demands, Bioeconomy startups shall thrive, while technology transfer shall accelerate the commercialization of bio-based solutions. Altogether, such initiatives shall stimulate economic growth, create employment opportunities, and contribute to the sustainable environmental, socio-economic advancement of the bioeconomy sector. Effective communication strategies are vital for increasing public acceptance and confidence in biobased products.

Regulatory tools, including legal frameworks and governance mechanisms, are necessary to improve competitiveness and valorization of biobased products. By establishing a supportive regulatory environment, with adequate policy instruments, regulations and incentives, policymakers can stimulate innovation and market uptake of bioeconomy solutions and public acceptance.

Assessing existing legislation impacting the Bioeconomy is vital to gauge its alignment with sector objectives and evolving challenges. This entails examining a range of policy instruments and laws spanning agriculture, environment, trade, and intellectual property to pinpoint areas where regulations may hinder or facilitate Bioeconomy growth. Identifying obstacles like outdated regulations or conflicting mandates, alongside understanding specific Bioeconomy needs, informs policymakers of necessary reforms. Addressing these governance roadblocks demands a transdisciplinary approach involving diverse stakeholders, considering economic, environmental, and societal factors. Adapting and developing policies is key to fostering an environment that promotes innovation, investment, and sustainability within the Bioeconomy. Ensuring coherence, transparency, and responsiveness in policy frameworks empowers governments to unleash the full potential of biobased industries, driving economic progress, environmental stewardship, and societal well-being.

In the following section, we will review the Portuguese instruments that shall have impact on the development of a sustainable bioeconomy strategy.

4. Policy Instruments with impact on the Portuguese Bioeconomy Strategy

In the context of Portugal, several policy instruments are intimately linked to the development of Bioeconomy. These include the Strategic Plan for the Common Agriculture Policy - PEPAC 2021-2027 (PEPAC 2021), the Portuguese Agenda for Agriculture Innovation (Conselho de Ministros 2020), the National Strategy for the promotion of Cereal production (Conselho de Ministros 2018), the Fertilizer Regulations (European Parliament, Council of the

European Union 2019), the National Plan for Carbon Neutrality 2050 -RNC2050 (Conselho de Ministros(2019), the National Plan for the promotion of Biorefineries (Conselho de Ministros 2017), the National Plan for Energy and Climate 2021-2030 - PNEC2030 (Conselho de Ministros 2020) and the National Strategy for Farm and Agro-industrial effluents - ENEAPAI 2030 (Conselho de Ministros 2022).

These instruments are linked with several sectors of relevance for the Bioeconomy sector, such as food, energy, valorization of subproducts, Water and Soil Management, emissions, knowledge buildup and dissemination, R&D, and economic growth. They delineate important measures aimed at fostering sustainability, innovation, and socio-economic prosperity within Portugal's Bioeconomy sector , establishing specific goals and targets to be achieved within coming years.

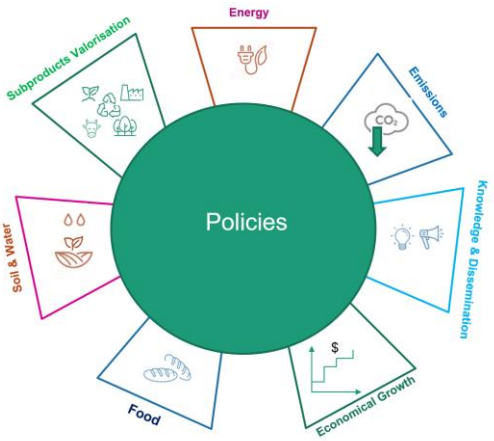

Figure 4 – Key Areas of Public Policy intervention linked with the Bioeconomy sector

The instruments above pave the path to the achievement of specific goals outlined within both Portuguese Bioeconomy strategy linked specifically with the food sector, the energy and emissions sector and subproducts valorisation sector. Due to its relevance towards food security, ecosystems and ecosystem related services, soil and water are also specific areas of intervention, for which public policy development is essential. Economical growth, knowledge and dissemination, as well as social aspects are also embedded within relevant policies and mechanisms.

For the food sector and related areas, such as agriculture and forestry, key measures to be implemented were outlined within the Portuguese agenda for agriculture innovation (Conselho de Ministros 2020), the national strategy for the promotion of cereal production (Conselho de Ministros 2018) and other relevant instruments (PEPAC 2021). Some measures include the promotion and increase by 60% of innovation in agriculture for sustainability, efficiency, and economic growth, including the development and use of precision agriculture and digitalization. In several of the instruments, biotechnology appears as an important tool to develop species with higher resilience to climate change and other global challenges. As crop yields are intimately linked with soil quality, health and productivity, several of the measures are linked with the implementation of sustainable management practices, and bio- nature-based practices, namely biofertilizers (replacement of nitrogen based fertilizers by organic matter), mulching and use of other natural-based resources, aiming at an enhancement of soil properties and water retention. This will be promoted/enhanced through the implementation of new limits for a couple of contaminants, such as cadmium, and other substances present in mineral fertilizers, that was established on the European Fertilizer Regulations (European Parliament, Council of the European Union 2019).

Focusing on sustainability and productivity, but also carbon neutrality, the instruments outlined different other measures such as, the adoption of agriculture management practices for carbon capture (e.g. biodiverse pasture and regenerative and conservation agriculture). There are other targets which are deeply linked with socio-economic and health aspects, such as the establishment of a target for a 20% increase in adherence to the Mediterranean diet, targeting the adoption of more healthy diets and the incorporation of at least 80% of young farmers in regions of the interior, which is focusing on territorial cohesion and strengthening of the development of rural areas, both outlined as targets within the Portuguese Agenda for Agriculture Innovation (PEPAC 2021).

The National Plan for the promotion of Biorefineries (Conselho de Ministros 2017), the National Plan for Carbon Neutrality 2050 - RNC2050 (Conselho de Ministros 2019), the National Plan for Energy and Climate 2021-2030 - PNEC2030 (Conselho de Ministros 2020), and other relevant instruments linked with emissions, energy transition and carbon footprint reduction, establish important targets for Bioeconomy related sectors. The first important objective establishes the ambition to reach carbon neutrality by 2050 in Portugal, through the reduction in 85% of greenhouse gas emissions, with respect to 2005 and by the capture of 13 million tons of carbon in agriculture and forestry. The objectives outlined for an improvement of energy y efficiency and renewable energy adoption in agriculture, with a clear target for an increase of renewable energy

consumption in agriculture by 47% till 2030, shall also contribute to the ambition to reach carbon neutrality by 2050. Other guidelines linked with emission reductions are the development of manure management systems and valorization of these residues to decrease emissions and enable their application as fertilizer, the use of additives in animal feed to decrease methane emissions and the implementation of conservation and precision agriculture to reduce emissions and fertilizer usage.

Aiming at subproducts valorization several measures have been outlined across different instruments. These include the valorization of residual biomass in biorefineries for sustainable business models, the valorization of agricultural and agro-industrial wastes (biomass and wastewater), focusing on nutrient and water cycle closure, in line with circular economy principles, and the development of clear management schemes for the recovery, treatment, reuse, and valorization of agro-industrial effluents.

Other areas with great potential for subproduct valorization are linked with sea and marine resources. Blue biotechnology exhibits substantial growth potential in the foreseeable future and shall contribute considerably to the development of bioeconomy. Blue biotechnology approaches have the potential to harness genetic resources and leveraging compounds sourced from marine organisms for various industrial applications including pharmaceuticals, medical solutions, cosmetics, etc. From a social perspective this is of extreme importance, as this transition will require highly skilled workers in this field and will lead to the development of employment opportunities. Due to inherent potential of sea and marine bioproducts, one can expect significant downstream prospects across diverse fields, namely scientific research, pharmaceutical and cosmetic development, packaging, and food production (European Commission 2020).

The importance of research and development, knowledge build-up, and knowledge transfer, appear clearly in many of the Bioeconomy relevant instruments. Measures such as increasing R&D investment by 60% and reinforcing R&D efforts in Bioeconomy-related areas are some of the key targets mentioned within the different strategic instruments. Promotion of initiatives for training and public awareness on sustainable agro-industrial practices, bioeconomy, resource valorization, and decarbonization are also identified as essential tools to boost further the development of Bioeconomy.

5. Conflicts and Gaps to be addressed by Policy Instruments impacting Bioeconomy

From the overview provided on previous chapters concerning the different sectors covered by Bioeconomy and the multisectoral and disciplinary nature of the associated policy instruments, it is clear that the transformation towards a bioeconomy will face several challenges.

This includes the conflict for the use of territory and overall resources, namely biomass, for the production of food versus the production of energy and other conflicts such as the ecological effects on the expected increase of land use and exploitation of natural resources targeting an increase of bioeconomy related activities such as energy production (e.g. bioenergy and renewable energy), food production and other bioeconomic products and services.. Solving or diluting these conflicts comes through the development of policy instruments and regulations, capable of addressing issues of overexploitation of natural resources as well as displacement, environment degradation and risk to biodiversity. A good result can be achieved at local and regional levels through the support of local communities, farmers and land owners and the simultaneous development of instruments such as the payment for ecosystems services in rural areas. This approach focuses on the development of actions to improve ecosystems and their capability of providing services. The initiative aims to develop more sustainable approaches for land management targeting the improvement of e.g. soil health, water and energy management, crop yield and simultaneously, to monitor the benefits of these practices on ecosystems and their services. The instrument is based on the application of incentives to promote management practices, with positive effects on the provision of ecosystem services, ecosystems and biodiversity, productivity and socio-economic profitability.

Another important aspect relates with the need of further develop instruments for monitoring and regulating the quality and the availability of key resources, such as water and soil. This is essential as both, soil and water are on the basis of many bioeconomic sectors. As previously stated, bioeconomy targets are fundamentally linked with the need to increase food availability, a challenge required to meet the escalating food demands associated with a rising global population, while mitigating the strain on finite natural resources. This predicament underscores an imperative for urgent, strategic initiatives and policies to devise sustainable land and water management solutions. In Portugal, a robust legislative framework for water governance, rooted in the

Water Framework Directive (Directive 60/2000), exists, alongside various planning mechanisms delineating objectives, measures, and monitoring protocols for water resource utilization. Nevertheless, the pressing issue of water scarcity, exacerbated by increasing demand and declining supply, and climate change, necessitates comprehensive reassessment of water related policies and governance instruments. This reassessment should encompass the prioritization of existing water allocation, synergies with other sectors like agriculture, industry and tourism, establishment of effective governance structures, and promotion of efficiency-enhancing mechanisms. Furthermore, it is imperative to further valorize wastewaters from Agro-industries, directing their use to other applications, e.g. irrigation..

For soils and soil management in particular, notable deficiencies persist in terms of data availability, monitoring systems, defined objectives, adequate policies and training provisions for users and managers, among other aspects. Soil is an essential element for the provision of food, for the maintenance of ecosystems and their associated services and therefore, of key importance for the implementation of the bioeconomy strategy. So far the European Union has identified this resource as fundamental, having created the European Soil Mission strategy, which will offer overarching directives and has drafted the Soil Directive, which is currently being reviewed. However, there is still a lot to do in a national context: the adaptation of the European guidelines to national contexts and realities and the development of soil districts and clear objectives to improve soil health at regional levels is imperative.

Addressing these and other additional challenges and implementing solutions aiming at a sustainable bioeconomy development, requires a focused approach to mitigate tensions, prevent conflicts, and encourage collaborative processes of co-creation. These efforts should encompass establishing realistic goals and employing suitable methods across different levels and sectors. Nonetheless, effectively executing these strategies necessitates an innovative approach marked by research and development, vigorous transdisciplinary dialogue, knowledge exchange an transfer and smooth integration of essential environmental and socio-economic aspects on policy instruments.

Conclusions and Final Remarks

Developing a sustainable bioeconomy poses a significant challenge due to its multifaceted nature and the inherent conflicts among sectors competing for shared resources such as territory, biomass, water, and energy. Therefore, governance structures and public policies are key pillars for the advancement of the bioeconomy. Given the interconnectedness of the bioeconomy with numerous sectors, effective public policies and governance mechanisms will necessitate a framework that exploits synergies and complementary elements across various domains, spanning agriculture, energy, environment, and social areas. The successful execution of bioeconomy strategies will demand the promotion of interministerial collaboration, policy alignment, and coordination across different tiers of governance (local, regional, national, EU, international).

The European and Portuguese Bioeconomy Strategies represent concerted efforts towards sustainable development through resource efficiency and innovation. By aligning with global sustainability agendas and fostering collaboration across sectors, shall address societal challenges while promoting economic growth. Initiatives such as knowledge building, policy adaptation, and intersectorial collaboration are critical for realizing the full potential of the bioeconomy. Through effective communication and regulatory frameworks, stakeholders shall be able to unlock opportunities for a thriving bioeconomy that balances environmental, economic, and social objectives.

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Notes:

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