

# **A review on strategies, policies and mechanisms supporting Bioeconomy and Sustainable Development**

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## **Abstract.**

Bioeconomy development has established a new paradigm by which fossil-based products and associated services are replaced by sustainable, renewable, circular biobased materials, which will ensure the preservation of natural resources and ecosystems, while ensuring both an economical and a societal balance. A successful implementation of Bioeconomy requires the availability of appropriate public policies and governance mechanisms. Given the multisectorial nature of Bioeconomy, the adequacy of public policies and governance mechanisms will require a framework exploiting synergetic and complementary aspects from agriculture, energy, environment and social areas. Due to its inherent complexity, a successful implementation of Bioeconomy strategies shall consider interministerial cooperation, policy coherence, coordination between local, regional, national, EU, international stakeholders and integration of scientific knowledge provided by Academia and Research driven projects, involving multiple stakeholders from industry, private and public sectors, policy makers, etc. This work reviews the current status of European and National policies supporting Bioeconomy and reflects on some of the gaps that need to be addressed to ensure a successful implementation of the Bioeconomy sector.

**Keywords:** Bioeconomy, Public Policies, Sustainability Development Goals, European Green Deal

## **1 Introduction**

### **1.1 Bioeconomy: definition and relevance in the current global situation**

Bioeconomy includes all sectors and services that make use of biological resources for the production and processing of products and services. Bioeconomy can be defined as the economical sector that covers agriculture, forestry, fishery, aquaculture and other industries, namely food, textile, pharma, chemistry, etc for which the knowledge of biological resources, biological processes and biological principles is used together with key enabling and converging technologies, such as bio-, nano-technologies, digitalization and information technology. The Bioeconomy sector covers therefore, all areas that rely on biological processes and resources, namely micro-organisms, plants,

animals, as well as organic waste and agroindustrial derived biomass<sup>[1-2]</sup>. Due to the importance of Bioeconomy for proper management of land and biological resources within ecologic boundaries, the assurance of sustainability across the whole value chain, as well as the assurance of a social and economic stability and balance, the European Union has established an EU Bioeconomy Strategy<sup>[3]</sup>. This is aimed at identifying, defining and evaluating appropriate goals, that will ultimately lead to the development of measures, instruments and adequate policies, assuring appropriate trade-offs and maximizing synergies between, economical, social and environmental aspects of the utilization of land, sea and biomass. In essence, Bioeconomy is based on the development of a paradigm by which fossil-based products and associated services shall be replaced by sustainable, renewable, circular biobased materials, which will ensure the preservation of natural resources and ecosystems, while assuring both an economical and a societal balance.

The 2030 United Nations Sustainable Development Agenda <sup>[4]</sup> and the European Green Deal<sup>[5]</sup> are aligned and set the ambition for the definition of specific targets which shall ensure a climate neutral, resource efficient, competitive and sustainable development, with models and principles enabling prosperity, equality, social balance, health and wellbeing. The approaches, policies, instruments and governance models to be followed shall be developed while tackling global challenges such as climate change, social, demographic and migration and socio-economic challenges.

The main objectives of the Green Deal Strategy <sup>[5]</sup> include the assurance of food and nutrition security, the management of natural resources and ecosystem services, the reduction of non-renewable resources and replacement of these by renewable, non-fossil based resources (wind, solar, bioenergy, etc) and the improvement of European competitiveness, through creation of sustainable business and additional jobs. The current socio-economical European instability set by multiple political and health related issues, which come on top of several other global challenges, has set an even higher relevance to both the United Nations Sustainable Development Goals and the European Green Deal Development Goals. An holistic approach combining an adequate use of knowledge, networks and requirements from academia, industry, government, and civil society, will enable a proper and fast achievement of the EGDDGs and UN-SDGs targets.

## **2 Bioeconomy: Strategy, Policy Instruments and Future Approaches**

### **2.1 Bioeconomy: European and Portuguese Context**

The importance of Bioeconomy does not limit itself to the enhancement of more sustainable, circular and environmentally friendly business models within different industry areas. The introduction of biological concepts, processes and know-how into the economy can work as a catalyst to regional and rural development through the growth of new business models. These have an obvious benefit in what concerns economic growth and reduction of territorial disparities. Examples are the use of agroindustrial

wastes as sources of energy and nutrient/biobased components, which might on one hand support the energetic transition and decarbonization and on the other hand exploit the potential of secondary products and further valorization on areas such as the organic fertilizer and the pharmaceutical industry. In addition, processes leading to reuse and reutilization of organic waste and wastewater, retrieved through the application of appropriate technologies, can, while combined with the use of biotechnology and digitalization, enable a step change in areas such as crop and animal productivity. Additional benefits of the development of Bioeconomy related with well-being, nutrition and health improvement, can arise from the application of a more sustainable and efficient use of natural resources and services and decarbonization across the entire value chain. This has been the driving force for the development of European and National Bioeconomy Strategic Programs.

The first European Bioeconomy Strategy dates from 2012 <sup>[6]</sup> and was mainly focused on the enhancement of R&D activities targeting the development of practices leading to more efficient use of renewable resources. The first revision of this strategy occurred in 2018 <sup>[7]</sup> and kept the five original objectives defined within the initial strategy, which included: the assurance of food and nutrition security, the sustainable management of natural resources, the dependency decrease of fossil-based, non-renewable resources, the mitigation and adaptation towards climate change and the strengthening of European competitiveness through development of more competitive business and the creation of additional jobs. These objectives, are in line with the targets of the European Green Deal and the United Nations Sustainability Development Goals.

An important target defined within the European Bioeconomy Strategy deals with the assignment of dedicated land and aquatic areas for the preservation and restoration of ecosystems, the implementation of sustainable management practices and the use of nature-based solutions within terrestrial and aquatic ecosystems. This approach is expected to lead to benefits in what concerns climate change mitigation and adaptation, biomass management enhancement and improvement of ecosystem/ecosystem services preservation and resilience. Another key focus of the European Bioeconomy strategy includes appropriate management of agriculture, forestry, land, sea, water resources and biomass. These should ensure primarily food security and secondly compliance with environmental targets, energy transition and other important objectives set by the 18 United Nations SDGs and the European Green Deal. Development of innovative processes, products and new business models, driving an improved use of biomass resources, biomass waste and wastewater valorization, enhanced circularity and energy/resource efficiency, constitute another important pillar from the European Bioeconomy Strategy.

The Portuguese Bioeconomy Sustainability Strategy for 2030 is integrated into the 2030 Strategic Agenda for Portugal <sup>[8,9]</sup>, which was recently developed and is mainly based on three important pillars: economy, society and territorial development. This strategy implementation, aims to i) reinforce the use of innovation, technology and digitalization; ii) ensure a demographic equilibrium, territorial cohesion and social fairness; iii) enable the climate transition and ensure the sustainable use of resources and iv) assure a sustainable and competitive economic development for Portugal. The 2030 Bioeconomy Portuguese Strategy <sup>[9]</sup> action pillars are aligned with the European

Biodiversity Strategy and focus mainly on i) protection and reinforcement of biodiversity; ii) valorization of natural resources and reduction of dependency from non-renewable resources; iii) sustainable management of natural resources; iv) achievement of carbon neutrality; v) valorization of innovative processes, innovation and digitalization as enablers to boost bioeconomy and vi) promotion of rural development.

The achievement of the objectives outlined by the 2030 Portuguese Bioeconomy Strategy <sup>[9]</sup> shall be enabled by different initiatives, which are linked to knowledge build-up, knowledge transfer, policy and regulation assessment and adaptation, funding initiatives to support R&D and Business development and Market driven initiatives.

Fundamental knowledge build-up shall be supported by research and development initiatives and projects involving multiple actors of the society, namely public and private sectors, research institutes, universities, etc. This shall boost and lead to a faster implementation of ideas into concrete products and services, accelerate knowledge transfer and speed up the development of startups within the areas of Bioeconomy.

The first step for a proper implementation of an adequate Bioeconomy strategy is the assessment of residues and subproducts resulting from both primary and secondary sectors. This includes the materials arising from primary sectors, such as agriculture and animal production, forestry, fishery and aquaculture and the associated secondary transformation sectors (e.g. olive oil industry, wine industry, dairy industry etc). Once this knowledge is obtained it will be essential to make it available to the general public, via for example the development of specific online platforms/databases.

An essential aspect for the implementation of the Bioeconomy strategy is the evaluation of current legislation, policies and the adjustment of these to enable and facilitate the growth of Bioeconomy. This work shall be done with the support of experts from multisectorial areas, policymakers, agriculture, soil, water, resource valorization specialists, economists, etc. These working groups shall map any existent legislation, policy and governance roadblocks to the development of Bioeconomy, and identify necessary adjustments and changes to these legislation instruments that will ultimately enable the valorisation of byproducts and waste from both primary and secondary industries.

The adaptation of current policies and for example, the change of classification of some primary and secondary industry residues into subproducts, will minimize the barriers for the entry and use (in its total or in specific parts) of this type of subproducts into the Bioeconomy market.

Another important pillar of the strategy is focused on the development of intersectorial R&D activities, which will be the basis for the development of alternative business models and resource valorization within the entire value chain. An outcome of these initiatives shall be the development and implementation of bioeconomy-based technologies ranging from TRL4 to TRL9. The engagement of multisectorial partners in these R&D activities will facilitate startup development, technology transfer and development of commercial products, creating in this way an additional economic value.

Another crucial aspect will be to develop communication and dissemination strategies targeting the acceptance and the increase of public confidence towards biobased products integrating subproducts on their content. Besides this, there will be the need

to establish the tools (e.g. legal, regulatory, governance, etc) enabling an improvement of the competitiveness and valorization of biobased products.

## **2.2 Public Policy Adjustment and Development for Bioeconomy– The Portuguese Approach**

The adjustment and development of public policies capable of addressing the targets outlined by European and National Bioeconomy Strategies requires an holistic approach, integrating the inputs from different sectors, namely research, technology development, economic infrastructures, regional, national, european actors and civil society. This is particularly important if one considers the different areas of relevance for the Bioeconomy sector, which include but are not limited to energy, agro-food, agroecology and health. In this sense, in order to create adequate platforms to boost Bioeconomy, most european countries are developing holistic national Bioeconomy strategies rather than strategies related to specific policy areas. Furthermore, and even more essential: Bioeconomy-related policies shall be built upon three dimensions - Environment, which addresses mainly the management of land and biological resources within ecological boundaries; Economy, which shall consider the development of sustainable value chains and overall consumption; and Society, that relates with social fairness. The development of adequate consortiums and the strategic alignment of different relevant actors, financially supported by several national and european funding schemes will ultimately result on the achievement of essential knowledge (e.g. technical, business, etc) which will be of essence to support the development of technically based and adequate public policies.

The appropriate implementation of the Bioeconomy Strategy will require the development of different types of policies, which include direct regulations, economic instruments and voluntary systems <sup>[10]</sup>. Implementation of specific regulations for waste management, separation, classification, the change of category of given subproducts from primary and secondary industries from waste to secondary by-products, the implementation of restricted areas (ecological zoning) to protect and improve specific habitats and restore important ecosystems and their services, restrictions on the use of chemical fertilizers, regulations to reinforce proper management of manure, wastewater and agro-industry effluents are examples of direct regulations. Direct regulations are designed in order to create obligatory standards and rules that need to be followed by key players. Fulfilment of these regulations is subject to control and non-compliance leads to the implementation of a set of “punishment” measures.

Economic instruments are a type of policy instrument that typically supports key stakeholders to follow the standards and rules defined within direct regulations. Examples of economic instruments are financial incentives supporting the creation of associate and collaborative groups, rural development incentives for the development of more sustainable farming, development and implementation of systems/technologies/practices leading to decarbonization, waste fees, etc. Economic instruments can include specific loans, grants, subsidies, feed-in tariffs, tax incentives, premiums and general R&D funds (national, European).

Voluntary approaches typically enable the development of good codes of practice and positive change of behaviour. Examples include voluntary certification schemes, labelling (e.g. organic farming), development of platforms for infosharing and communication, capacity building and knowledge build-up initiatives are also part of these voluntary instruments.

Considering the Portuguese context only, there are a couple of policy instruments that will support Bioeconomy development <sup>[9]</sup>. These include i) the Strategic Plan for the Common Agriculture Policy (PEPAC 2021-2027) <sup>[11]</sup>; ii) the Portuguese Agenda for Agriculture Innovation<sup>[12]</sup>; iii) the National Strategy for Farm and Agroindustrial effluents (ENEAPAI) 2030<sup>[13]</sup>; iv) the National Strategy for the promotion of Cereal production<sup>[14]</sup>; v) the National Plan for the promotion of Biorefineries<sup>[15]</sup>; vi) the National Plan for Carbon Neutrality 2050 (RNC2050)<sup>[16]</sup>; vii) the National Plan for Energy and Climate 2021-2030 (PNEC2030)<sup>[16]</sup>; viii) the European Strategy for Reduction of Methane emissions<sup>[18]</sup> and ix) the Fertilizer Regulations (Regulamento (CE) n.º 2019/1009 de 25 de Junho de 2019)<sup>[19]</sup>.

Important measures outlined within the policy instruments referred above address different important pillars: Food, Energy, Valorization of Subproducts, Water and Soil Management, Emissions, Knowledge Buildup and Dissemination, R&D and Economical growth.

Some of the most relevant actions focusing on the Food topic include:

- the establishment of a specific target for the 20% increase of Mediterranean diet being followed
- the promotion of innovation initiatives leading to a more sustainable, efficient and economically balanced agriculture, such as the implementation of precision agriculture and digitalisation, use of biotechnology as a tool to improve species (e.g. adaptation to increase resilience towards climate change), etc
- the improvement of soil quality and overall crop yield by the application of organic matter as soil fertilizer

Areas of action to be highlighted within the Energy and Carbon footprint reduction pillar include:

- fostering the increase of energetic efficiency and use of renewable energies within the agriculture sector
- reduction of greenhouse gas emissions by 85% in comparison with 2005, and the capture of 13 million tons of carbon within the agriculture and forestry sectors
- an overall liquid reduction of emissions in the agriculture sector ranging from 21 to 49%
- valorisation in biorefineries of residual agro-industry, forestry and agriculture biomass with low or now value for other sectors (e.g. animal food, other), aiming at the generation of a sustainable business model for residues not used for other applications. This includes use of rice straw, residues from corn crops, pruning biomass from olive orchards, vineyards and fruit orchards, olive oil pomace, wine pomace, manure and other biomass from agro-industries.

- increasing annual renewable energy consumption by 47% till 2030
- expanding practices such as conservation agriculture and precision agriculture, reduction of emissions associated with farming and fertilizer usage
- applying agriculture management practices promoting carbon capture, such as biodiverse pasture and regenerative agriculture.

Some examples of measures to be implemented in the areas of Sustainability development include:

- to reach an increase of more than 50% for certified sustainable production land area with respect to the total agriculture area
- to reduce emissions and increase carbon capture within the agriculture sector
- to use additives within animal feed aiming at the reduction of methane emissions
- to reduce the use of nitrogen based fertilizers and replace mineral based by organic based fertilizers
- to develop management systems for manure aiming at a decrease of the emissions

Approaches for appropriate management of wastewater and other wastes arising from the primary and secondary industry sectors include:

- establishment of valorization schemes for agropecuary and agro-industrial wastes, with special emphasis on the recovery of these and valorization, aiming at the development of a closed cycle for nutrients and water, following the principles of circular economy
- development of suitable management schemes, clear definition of appropriate systems for recovery, treatment, reuse and valorization of agro-industry effluents.

Measures to boost Research and Development, Knowledge Build-up and transfer in the areas of Bioeconomy include:

- increase of the investment in R&D by 60% and general reinforcement from R&D on the areas of relevance for Bioeconomy
- promotion of initiatives to boost training and overall communication to the civil society on topics related with sustainable agroindustry practices, bioeconomy, resource valorization, decarbonization and other relevant topics.

### **2.3 Future approaches to support and boost Bioeconomy**

The United Nations Sustainability Development Goals, the European Green Deal, the Farm to Fork Strategies and the European Strategy for Biodiversity set and define the basis for the creation of an adequate Bioeconomy Strategy. There are two important resources that play a very crucial role and are essential for the achievement of the targets outlined by the strategies above: these are the soil and the water. Climate change and other global challenges developed scenarios that have placed the availability and health of these two crucial resources at risk. Water scarcity is exacerbated by climate change – this is particularly critical in countries of the Mediterranean area, which have been subject to a significant increase in temperatures and drought events. Risks

associated with soil quality are also an important challenge worldwide and in particular in the Mediterranean basin. In Portugal only, it is known that 25% of the soil has elevated risk of degradation and very low levels of organic matter <sup>[20,21]</sup>.

Portuguese governance instruments, mechanisms and processes regulating water management are mainly defined within the Portuguese Directive for Water (Diretiva 60/2000) and other mechanisms for water monitoring, such as qualitative and quantitative evaluation of the waters, which include both water mass and quality evaluation. However, as a consequence of climate change and further reduction of water availability, it is more and more critical to reevaluate, adapt and optimize current legislation and consider a multisectorial approach involving different sectors, agriculture, tourism, industry, etc. Current issues such as water scarcity, pollution and competition of water resources across different sectors, constitute a new challenge for which proper action is required.

As for the soil, there is a need to define, at an European and National scale, the adequate procedures to monitor quality and define adequate measures, policies and instruments to ensure an improvement of soil quality and overall soil restoration.

An essential path towards the improvement of soil quality shall arise from the work done at an European and National level (Missão Solo). Within these platforms, it is aimed to develop systems for monitoring soil health, collection of soil data within Portugal and creation of a network of farms and living-labs devoted to the study of soil and relevant for the Portuguese production systems (e.g. montado, olive orchards, vineyards, pasture, etc). These initiatives shall be the basis for the creation of adequate national policies for the soil.

There is therefore the need to adapt current governance mechanisms, involving different government areas (agriculture, environment), public and private sectors, central, regional and local administration and scientists. The latter will be ultimately the ones providing technical knowledge, capable of defining solid and adequate measures for improvement of quality and management of these two essential resources – water and soil – which are, as stated before, critical for the development of the Bioeconomy Sector.

### **3 Concluding remarks**

The Bioeconomy sector constitutes a business with an unique potential, providing means to link multiple sectors, such as the primary and secondary production and other industrial processes focusing on energy, valorization and sustainable development. The growth of the Bioeconomy sectors constitutes an important platform to boost sustainable development, economic stability and social development, being therefore critical for the improvement of circularity, achievement of carbon neutrality and development of new opportunities for jobs and market diversification.

Critical platforms for Bioeconomy development include governance and public policies. Given the links of bioeconomy to many different sectors, the adequacy of public policies and governance mechanisms will require a framework exploiting synergetic and complementary aspects from different areas, ranging from agriculture, energy,



environment and social aspects. Due to its inherent complexity, a successful implementation of Bioeconomy strategies will require the fostering of interministerial cooperation, policy coherence and coordination at different levels (local, regional, national, EU, international).

In the current context of global change, it is unavoidable to revisit current knowledge, policies and governance mechanisms. Filling the current gaps and ensuring a sustainable development, will require the acquisition of knowledge, the development of R&D projects focusing on the areas of relevance for Bioeconomy, the involvement of international stakeholders, multisectorial and multidisciplinary approaches. Last but not least, the Bioeconomy sector will only succeed with the acceptance of general society. This will require efficient communication schemes, public society involvement and overall initiatives to engage the society on the development of Bioeconomy sectors [22].

There are however still some gaps that need to be addressed: development of proper mechanisms to regulate the management of land and water across different value chains, solutions to regulate competition between the use of biomass in different sectors and the development of adequate policies for water management and soil quality evaluation/management ensuring the improvement of the quality, health and availability of these two important resources.

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