



BIOECONOMY STRATEGIES: VISIONS AND PROSPECTS

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ABSTRACT

Bioeconomy, as an evolving concept, gained serious interest in the past two decades. It is considered a key driver in resolving a number of global challenges and is integrated into a broader framework with circularity, green transition and sustainable development. At this point, many international, national and regional strategic documents are linked to bioeconomy and directed to its strategic objectives. The aim of the paper is to present comparative analysis of bioeconomy strategies at global and national levels in order to observe the main concepts, vision and priorities and highlighted future agenda, prospects and recommendations for better integration and coordination. The analysis of the published strategic documents shows that there are no global framework and internationally accepted definition of bioeconomy. There are diverse understandings and differences in key priorities and goals between Europe, Asia, and South and North America. The bioeconomy remains a political concept, with a significant number of countries engaged in implementing its guiding principles. Until 2030, the ambitions in bioeconomy strategies and policies will be tested. In this regard, significant support is needed in the form of specific measures and financial instruments to realize investments in this field.

Key words: sustainability, green transition, biotechnology, innovation

INTRODUCTION

Bioeconomy, as an evolving concept, gained serious interest in the past two decades. It is considered a key driver in resolving a number of global challenges and is integrated into a broader framework with circularity, green transition and sustainable development. While the first definitions of the term can be traced to the middle of the XX century and were noticeable in the research of Georgescu-Roegen (1), the political debate started with introduction of the concept by Enriquez and Martinez at a genomics seminar in 1997 (2). The OECD in 2009 first published political agenda that stimulated strategy development across the globe (3). At this point, number of international, national and regional strategic documents are linked to bioeconomy and directed to its strategic objectives and priorities.

The aim of the paper is to present comparative analysis of bioeconomy strategies at global and national levels in order to observe the main

concepts, vision and priorities and highlighted future agenda, prospects and recommendations for better integration and coordination.

The paper is structured as follows: first, the materials and methods are presented. Second, the key international strategies that shaped the bioeconomy agenda are analysed. The third part outlines the national strategies in different continents and compares their features and goals. The fourth part discusses prospects and highlights the main conclusions and recommendations.

MATERIALS AND METHODS

The survey applies historical and comparative methods of analysis. The bioeconomy strategies are observed in a review of literature, government papers, official documents and reports. The methodology is based on Meyer framework (4) and includes strategy selection, analysis of their objectives and assessment of the links and relations between different strategic documents. It should be pointed out that the comparison between strategies is made by observing their main features and priorities. The systematic analysis outlines the main

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drivers, barriers and prospects for bioeconomy development.

The survey is focused on fully dedicated to bioeconomy strategies that have already been published. The analysis covers all continents. However, it should be noted that the survey does not include the Australian and New Zealand because, in this part of the world, no published strategy is dedicated to bioeconomy. The reports of the European Commission and the data from Knowledge Centre for Bioeconomy is used for the study.

RESULTS AND DISCUSSION

The concept of bioeconomy evolved and shifted from the perspective of replacing fossil fuels and decreasing nonrenewable resource dependency to a broader framework and implementation of sustainability principles and social inclusion. Different organizations and unions published strategies and/or official documents dedicated to bioeconomy. They form the features of the concept in different continents and regions (**Table1**).

Table 1. Key aspects of international bioeconomy strategies

Region Institution/Country	Definition of bioeconomy	Key objectives	Vision
OECD, 2009 The Bioeconomy to 2030: Designing a Policy Agenda	„application of biotechnology to primary production, health and industry“	- Prepare the foundation for the long-term development of the bioeconomy - Reduce barriers to biotechnology innovation - Promote the integration of biotechnology research across commercial applications - Create dialogue among governments, citizens and firms	Biotechnology-centered
European Union, 2018 A sustainable bioeconomy for Europe, Strengthening the connection between economy, society and the environment : updated bioeconomy strategy	„covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles“	-Ensure food and nutrition security -Manage natural resources sustainably -Reduce dependence on non-renewable, unsustainable resources -Limit and adapt to climate change -Strengthen European competitiveness and create jobs	Transformation-centered
USA, 2018 National Bioeconomy Blueprint	“ the use of research and innovation in the biological sciences to create economic activity and public benefit“	-Strengthening R&D Advancing From Lab to the Market -Reducing Regulatory -Barriers -Developing a Bioeconomy Workforce -Fostering Partnerships	Biotechnology and innovation-centered
Economic Commission for Latin America and the Caribbean (ECLAC), 2018 Towards a sustainable bioeconomy in Latin America and the Caribbean	"production, utilization and conservation of biological resources, to provide information, products, processes and services in all economic sectors aiming toward a sustainable economy"	-Promote sustainable development -Promote climate action -Promote social inclusion -Promote innovation processes	Bio resources-centered

Source: Own survey based on (4) and (5)

OECD was the first international organization to publish official documents related to bioeconomy and paved the way for developing strategies in the USA and Europe. "The Bioeconomy to 2030: Designing a Policy Agenda" (3) is a document focused on biotechnology and its application in agriculture, industry and health. The agenda pointed out main definitions and presented two timelines-2015 and 2030, as a starting point for concept development. The report discusses different scenarios that address the "feed vs. fuel" debate and sustainable supply and use of biomass. The strategy outlined the need for policy adjustments, sectorial and cross-sectorial integration and coordination. The main funding of the document is related to the internalization of bioeconomy, setting the way to cooperation, dialogue, and decreasing institutional barriers to address the global challenges that society is facing. The OECD considers biotechnology a key driver for boosting bioeconomy development and focuses on the economic aspect of the concept. Innovation and cooperation are the main features for successfully applying the principles. Although there is no official strategic document after the Agenda 2030, OECD published reports related to bioeconomy. In 2018 there is a comprehensive document, "Meeting Policy Challenges for a Sustainable Bioeconomy" (6), which continues the organisation's vision closely linked to biotechnology. The main messages there were related to biomass production and biorefineries. It pointed out the need for global agreement and cooperation directed to applying innovations and policy documents with a clear focus, linkages to each other and no overlapping and miscommunication. The understanding of OECD mainly concentrates on the biotechnology application and does not shift significantly. The main contribution of the paper is related to the acknowledgement of the global importance of bioeconomy and the need for local actions.

In the USA "National Bioeconomy Blueprint" (7) was presented in 2012, and it is divided into two parts. The first describes the importance and background of bioeconomy development in the USA, while the other part introduces the strategic goals and principles. Biotechnology is at the centre of this strategy. However, the main driver for its application is considered research and development that will lead to economic,

social and health benefits for society. Compared to the OECD agenda, the USA Blueprint has a strategic plan highlighting different actions and activities which the federal government and agencies should implement. Although it is considered a key strategy that shapes the global agenda, it still has a national focus and outlook for the rest of the world (8).

In addition to National Bioeconomy Blueprint, in 2022 Schmidt Futures initiative published the strategic document *The U.S. Bioeconomy: Charting a Course for a Resilient and Competitive Future* (9). The report outlines the opportunities to integrate artificial intelligence and biology to stimulate biotechnology-based innovations and solutions in different areas that could transform the US economy and link the concept with sustainability and climate change. The development of the US bioeconomy shows a clear focus on R&D, and the new strategic documents highlight the extended understanding of the possibilities for implementing the bioeconomy principles. International cooperation and the path to a sustainable and circular future are the main goals of the updated document. Despite the new moments since the first published strategy, the USA's vision for bioeconomy development remains focused on biotechnology as a key driver.

Along with OECD, Europe plays a key role in the bioeconomy's development. The first bioeconomy strategy of the EU was established in 2012 (10). The 2012 strategy aims to "pave the way to a more innovative, resource-efficient and competitive society that combines food security with the sustainable use of renewable resources for industrial purposes while ensuring environmental protection" (10). In 2017 the review of the Bioeconomy Strategy outlined that although there are positive trends, the perspectives and prospects of the concept should include important principles related to all the element of sustainability and circularity. In the 2012 Bioeconomy strategy, there is no clear interdisciplinary and cross-sectorial focus. Therefore, in 2018 the EU developed a new strategy. It included five major objectives and was combined with the Action plan. There is a strong link between EU Bioeconomy strategy, Sustainable Development Goals and the European Green Deal (11).

The Bioeconomy Strategy provides a framework covering different sectors and

policies, allowing to build synergies and ensuring sustainability (12). The EU strategy is directed to transformation, coordination, and integration with broader concepts and is related to EU ambitions to be climate neutral and to develop a zero-carbon economy. The main focus is on biological resources, green transition and a circular, just and sustainable society.

The main strategic framework in South America was established as a guideline for national and regional bioeconomy strategies. It was prepared in a workshop and part of the Global Bioeconomy Summit 2018. (13) The agenda focuses on using natural resources with a strong focus on climate change, sustainability and social benefits. The document highlighted drivers, limitations and opportunities for bioeconomy in Latin America and the Caribbean. Compared to the EU strategy that considers SDG as the main starting point, this strategy outlines biodiversity and biomass as the main focus. Along with that international cooperation and integration are also seen as a priority.

The comparison between the leading international strategies shows different visions for bioeconomy as a concept. The OECD and the USA concentrate their priorities towards the biotechnology application and consider R&D as a main path for bioeconomy development. The EU and the Latin America and Caribbean strategies are strongly related to sustainability and address challenges such as biomass production, climate change and biodiversity. However, in the EU, there is a clear Action plan and new framework with Farm to Fork, Biodiversity strategy, Forest Strategy, Climate Law, Zero pollution action plan and Renewable Energy. Europe sets ambitious goals in order to achieve Green Deal objectives. The concept in the EU is much broader and includes more sectors and links with other important global challenges (14).

The international strategies in different continents lead to the development of national and regional strategies (**Figure 1**). According to data, Europe is the continent with the most number of published strategies dedicated to bioeconomy.

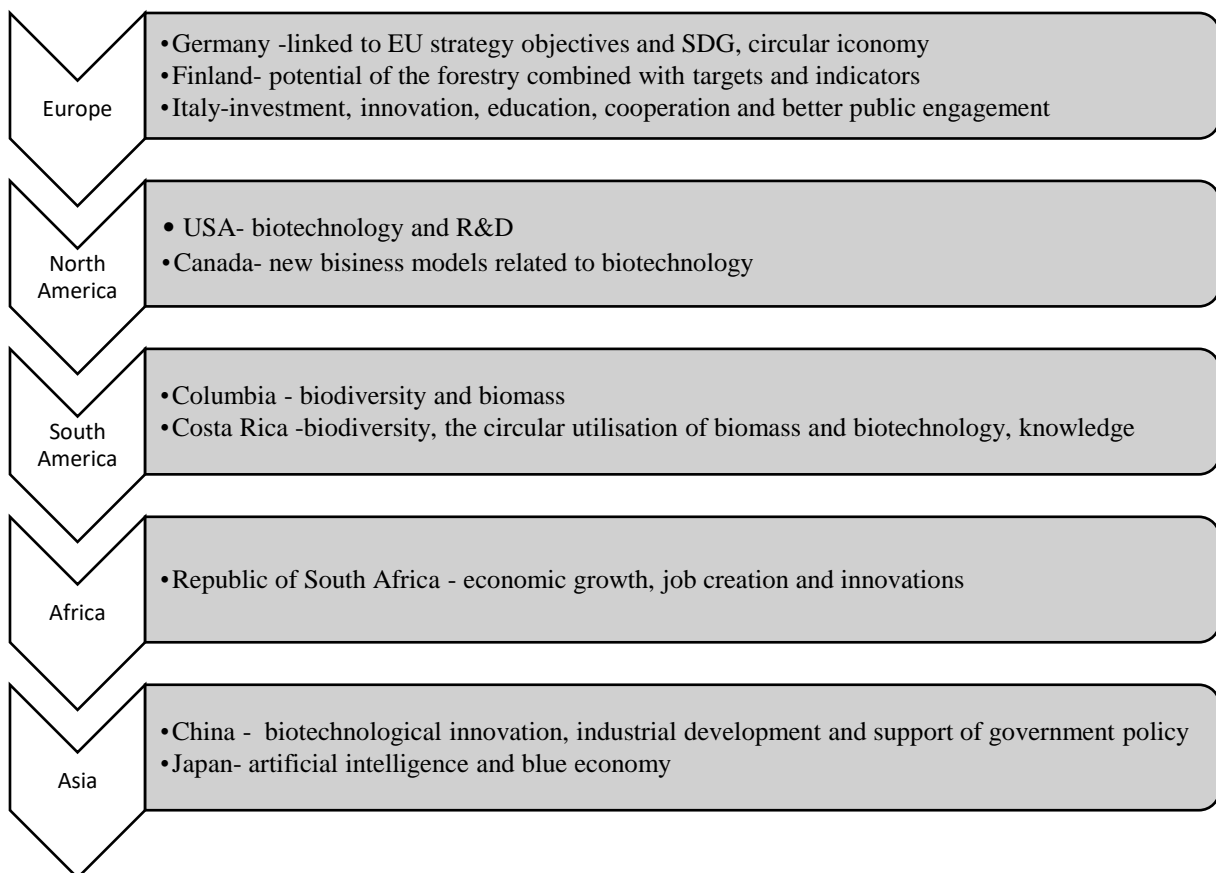


Figure 1. Selected national strategies for bioeconomy and key features
Source: Own survey

In 2011, Germany became one of the first countries to publish "National Research Strategy Bioeconomy 2030: Our Route towards a Biobased Economy". Based on the strategic agenda, the document is directed to accelerate the transformation of industry and society (15). In 2013 Germany established National Policy Strategy for the Bioeconomy directed towards a bio-based and sustainable economy (16). The first documents were concentrated more toward bio-based economy and industry and not so much to bioeconomy.

In January 2020, the German federal government published the updated National Strategy for the bioeconomy. The strategy defines the main goals and guidelines in the field of the bioeconomy and presents the measures for their implementation. The strategic documents highlight biological knowledge, new technologies and raw materials as opportunities for a "future-oriented, sustainable and climate-neutral economy" (17). The objectives are connected to the EU Bioeconomy strategies and are in parallel with the ambitious goals set by the Green Deal.

The first version of the Italian Bioeconomy Strategy was published in 2017 and updated in 2019. The main strategic goal is to achieve a 15% increase in the contribution of the Italian bioeconomy by 2030. The strategy connects this goal with six objectives directed to investment, innovation, education, cooperation and better public engagement (18). The strategy introduced specific indicators to assess the development of bioeconomy contributions. The Italian strategy includes not only a vision but also strategic goals and the ways to achieve them, making the document one of the most comprehensive.

In 2022, Finland published bioeconomy strategy. The main vision of the strategy is to increase the added value of the bioeconomy. The strategic goal will be achieved by creating economic growth and jobs based on sustainable solutions. In this regard, the Finnish strategy aims to ensure the growth of the added value of the bioeconomy from 3% to 4%, and this indicator to be 50 billion EUR in 2035. (19). The strategy describes the measures taken according to priorities and the monitoring features. Like Italy, the Finnish Strategy links targets to results, taking into account new visions in the concept and is focused on

Finland's potential for biomass production from forestry.

In 2022 the EU published a progress report on implementing the Bioeconomy Strategy (20). According to the latest EU data from April 2022, there are ten EU Member States with bioeconomy strategies and seven EU Member States developing their strategies. Bulgaria is one of the countries that still need a specific document related to bioeconomy (21).

The selected bioeconomy strategies are well-designed and follow the path set by 2018 EU strategy. They include indicators and target mainly to the timeframe 2030-2035.

Several leading countries have published their bioeconomy strategy along with the EU Member-states. In the survey, some key strategic documents in all continents are observed, emphasizing bioeconomy-oriented strategies.

The first strategic document in Canada was the Canadian Blueprint: Beyond Moose and Mountains, published in 2008 and related to the bio-based economy (22). Canada's first National Bioeconomy Strategy was published in 2019 and presented the opinion of more than 400 industry representatives nationwide (23). The strategy presents its own definition of bioeconomy, and the main focus is on biotechnology with a strong connection with business and innovation.

In 2019, Japan also published its bioeconomy strategy with a time horizon of 2030. It closely links the bioeconomy with environmental, economic, social and health goals and describes the circular bioeconomy as a key driver for sustainable and healthy living system (24). Recognising the limited potential for biomass production, Japan's strategy concentrates on applying artificial intelligence and biogenetic resources. It points out the need for government, academia and science cooperation towards new innovative solutions. Japan's strategy acknowledged innovation and biotechnology. However, it does not include clear linkages with sustainable development goals.

China released Bioeconomy development plan in 2021. According to the strategic document, the bioeconomy in the country will be developed in four main areas: biomedicine, bioagriculture, biomanufacturing and biosecurity. The plan proposes three ways to

improve the development of the bioeconomy: biotechnological innovation, industrial development and support of government policy. (25). China's plan sets up ambitious goals, large scale and impressive investments, emphasising biotechnology and industrial development. However, the commitment to sustainable development goals is indirect and not clear.

In South America, Colombia and Costa Rica have bioeconomy strategies. The vision of the Colombia Strategy, published in 2020, is to ensure the effective and sustainable management of biomass, biodiversity and ecosystem services to generate products and processes with high added value through science, technology and innovation (26).

It should be noted that for Colombia, biodiversity maintenance plays a crucial role because 10% of the world's species are found there (27).

Costa Rica's Bioeconomy strategy was introduced in 2020 as a part of cooperation with Economic Commission for Latin America and the Caribbean. The main vision is to "Build a Costa Rica with high-value-added sustainable production in all regions and emerging biocities, based on the fair and equitable use of biodiversity, the circular utilisation of biomass and the country's biotechnological progress as an element of the knowledge society." (28). The strategic documents include three key objectives linked to sustainable development, productive transformation, innovation and cross-sectorial convergence.

Leading in Africa is South Africa's Bioeconomy Strategy, published in 2013. The vision for South Africa's bioeconomy is concentrated to the higher contribution of bioeconomy, in terms of gross domestic product, through the creation and growth of new industries that develop biological services, products and innovations (29). The Strategy focuses mainly on economic development. However, this is one of the first strategies, and the specifics of the continent and welfare in the country influence the strategy priorities and objectives.

Based on the overview of the different bioeconomy strategies, there is a difference in key priorities and objectives between Europe, Asia, South and North America. European bioeconomy strategies at the national level are closely linked to sustainable development goals

and directed to transition toward circular and green models of production and consumption. In North America, on the other hand, there is an emphasis on innovation and biotechnology. In Asia, China presents an ambitious plan with a broad scope, while Japan concentrates on the blue economy and new technological solutions related to robotics, representing its comparative advantage. The potential for bioeconomy development in South America is high, but only two countries have published bioeconomy strategies. Due to the specifics of natural resources in this part of the world, strategies are oriented towards biomass production and biodiversity. In Africa, the objectives are primarily aimed at achieving higher economic and social goals due to the lower standard of living. In addition, not only the European but also the strategies in the other continents take into account the need for dialogue, coordination and unification of efforts to achieve the priorities of the bioeconomy.

CONCLUSIONS AND RECOMMENDATIONS

Based on the analysis, some conclusions and recommendations can be drawn:

- (1) There are many bioeconomy strategies across the globe. The concept evolves and shifts to more sustainable and green principles. However, there is no internationally accepted definition of bioeconomy, and diverse understanding is connected to the main principles, objectives, application. The lack of global framework could make the application of the concept challenging.
- (2) The ambitious goals set by the biotech-focused US vision and the transformation EU strategies could face a number of challenges in achieving results. The global economy is still too dependent on fossil fuels, and the 2030 horizon is too close to realizing its full potential, especially for new applications and value chains.
- (3) The biotechnology vision and biomass production could lead to conflict related to food, feed and energy security. There is no clear consensus and global solutions in this field.
- (4) Most strategies aim for better policy coordination and multi-sectorial linkages. Despite the efforts, the implementation of cross-sectoral policies still needs to be improved, and policy integration remains an issue.
- (5) The bioeconomy still is a political concept, with a significant number of countries engaged in implementing their priorities and goals. Until

2030, the ambitions in bioeconomy strategies and policies will be tested. In this regard, significant support is needed in the form of specific measures and financial instruments to realize investments in this area.

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