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Editorial to the thematic issue: Bioeconomic strategies and systems as tools for achieving sustainable agriculture and rural development

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INTRODUCTION

The idea of the bioeconomy is a relatively new economic concept closely connected with the practical implementation of Sustainable Development principles. The concept originated as a novel interdisciplinary approach based on an innovative way of using biological resources through biotechnology. It is no coincidence that the first steps towards the bioeconomy in Europe can be linked to the support and development of biotechnology (Warchold et al. 2025; Patermann and Aguilar 2018).

We can today identify different approaches to defining the bioeconomy, including resource-based, biotechnology-based, and ecologically-based perspectives. The high number of definitions reflects the broad scope and use of the bioeconomy, from alternative biological energy sources to an emphasis on new technologies and an ecological lifestyle (Lewidov 2013; Staffas et al. 2013; Enviwiki 2025).

Like many new concepts, adherents of bioeconomy models have major ambitions: reducing CO_2 emissions, eradicating hunger, increasing competition, and solving the energy crisis (Carus and Dammer 2018; Srivastav et al. 2025; Vivas et al. 2025). This new economic paradigm has now been institutionalized in the political strategies and policy documents in many countries around the world. The first ones in EU and US were issued in 2012 (European Commission 2012; The White House Office of Science and Technology Policy 2012). In Brazil, a country with one of the most developed bioeconomies, this sector has been supported since the late 1990s (Cudlínová et al. 2020).

In its relatively short history, the practice and perception of bioeconomy have undergone quite turbulent developments, from complete confidence in finding an alternative energy source in biological carbon (Aguilar and Twardowski 2023) to a skeptical assessment of the risks associated with its global application. Major risks, such as a land loss and degradation, linked to the pressure to increase food prices and biodiversity reduction are mentioned as obstacles that need to be overcome (McCormick and Kautto 2013; de Assis et al. 2017).

We can see also significant changes resulting from the use of different generations of resources, from the first generation based on alternative uses of food or technological crops to the fourth generation primarily focused on advanced, genetically engineered organisms, especially microalgae and cyanobacteria (McCormick and Kautto 2013; Priefer et al. 2017).

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Similar to evolutions in the generation of bioeconomy resources, views of the roles of bioeconomy are changing. Today, there is a visible shift towards circularity and an increasing emphasis on the importance of waste and its role as resource (Socaciu 2014; Priefer et al. 2017; D'Amato and Korhonen 2021; Muscat et al. 2021; Nifatova et al. 2024).

The bioeconomy is a much broader topic than agriculture and sustainable agricultural systems, but the connection between the bioeconomy and agriculture is absolutely fundamental. Biological resources/biomass globally are predominantly sourced from agriculture and forestry (von Braun 2018; Nowak et al. 2021; Wang et al. 2022; Khanna et al. 2024). One of the main aims of the bioeconomy is the issue of food security, which necessitates finding a solution to the global problem of feeding a still-increasing population. The bioeconomy plays an important role in these discussions, especially in countries in the Global South (Kleinschmit et al. 2025; Trujillo-Cayado et al. 2025).

CHARACTERISTICS OF ARTICLES

The articles in this special issue provide strong theoretical introductions that deal especially with the development and scientific interpretation of the bioeconomy, and the popularization of political support, visions, and discussions. The articles are based on an analysis of literature focused on the bioeconomy in various contexts: bioenergy, waste and Life Cycle Assessment (European Union), food industry (Romania), governmental policies of agricultural bioeconomy (China), and agricultural waste (Indonesia). The articles successfully capture the latest situation in bioeconomy research, not only from the perspective of agriculture, but also from a general theoretical perspective on the bioeconomy concept and its development. They capture current and future trends in the interconnection between the bioeconomy and the circular economy and their impact on overall economic development. The term circular bioeconomy appears frequently in the articles, reflecting the theoretical and practical interconnection of the two concepts.

The essay on *'Deconstruction of China's agricultural bioeconomy policies in the context of sustainable systems transition – Based on policy texts analysis,'* focuses on the political dimension and importance of government support for the bioeconomy, emphasizing its role in agriculture and the economy as a whole. The article includes analyses of important documents and strategies related to the bioeconomy in the EU, US, and China, as well as the inclusion of the bioeconomy in documents that are not specifically dedicated to the bioeconomy, e.g., the Green Deal in the EU and the US, but which include strategies common to bioeconomy approaches. It presents various concepts of bioeconomy definitions, ranging from biotechnological and resource-driven to ecological forms of interpretation. After a general theoretical introduction, the article focuses primarily on agricultural bioeconomy policy in China from demand, supply, and environmental perspectives. It is essentially a national analysis of the role and importance of bioeconomy in regional and national policy documents that influence agriculture in China.

The contribution on *'Closed-circle bioeconomy: applied aspects agricultural implementation'* is a theoretically-focused article dealing with the bioeconomic situation in the EU. It is based on a literature analysis of specific policies and sectoral developments, particularly in agriculture, bioenergy, and waste processing. The analysis monitors the evolving dynamics of global interest in the bioeconomy field through the lens of publication activity, clarifies sector-specific developments within this new economic field, compares different countries through documents focused on bioeconomy, and finally describes the funding landscape within the field of bioeconomy. In connection with waste management, the authors emphasize life cycle assessment. The article comments on the bioeconomic strategies of various EU countries and analyzes factors shaping bioeconomy development and the role of innovation.

The article on '*Revealing key links between components in the circular economy'* combines a theoretical section devoted to the circular bioeconomy and the practical application of the circular bioeconomy in Romania, which the authors identify as representative of developing countries. The primary focus of the essay is the potential of pragmatic bioeconomy strategies to improve food systems in Europe. Among the recommendations made by the authors are the need for wider adoption of so-called 'green practices' by the agricultural community as well as the implementation of dynamic systems, including the widespread employment of green human capital (GHC). This article is unique in its analysis of the role of green human capital at both theoretical and practical levels in relation to the food sector and agriculture. It includes a literature review and analysis of various interconnected theories, including Natural Resource Based Theory (NRBV) and Dynamic Capability Theory (DCT), in research-

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ing the fields of green logistics (GL) and green human capital (GHC) in emerging economies. The theoretical research is supplemented by a sociological survey in small and medium enterprises SMEs. The responses of survey respondents, experts in the food business, serve as verification and feedback on the results obtained in the literature review.

The last article '*Modelling the circular bioeconomy in the palm oil industry: Emerging approaches to address cattle feed shortages in Indonesia',* concerns Indonesia and the palm oil industry. This study aims to contribute to finding alternative resource of cattle feeding using the waste residuum from palm industry. The authors employ system dynamics analysis to address cattle feed shortages using a circular bioeconomy (CBE) model. The method of semi-structured interviews is used to explore additional insights to construct the CBE model. The focus is on development of a model based on the recovery and reuse (as feed in cattle production) of waste and other byproducts generated by the palm oil industry. This industry is a major producer of biomass, which carries negative environmental and economic consequences. Implementing bioeconomy systems in which oil palm industry byproducts are able to be consumed by livestock thus has major implications for sustainable development of both the agricultural and food sectors.

CONCLUSION

From the articles described above it is evident that the bioeconomy is a new sector that is attractive to the fast developing economies such as Indonesia and China by offering them a comparative advantage and new ways of processing traditional raw materials. However, the EU also represents an important platform for the application of this new economic sector.

All authors emphasize agriculture as one of the most important areas from the perspective of bioeconomy. Less attention is paid to risks such as soil and water degradation, deforestation, reduced biodiversity, and pressure on food prices. It is clear that the authors are relying on the fact that combining circularity with the bioeconomy can solve most of these serious problems.

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