



Doi: 10.46793/MAK2026.361C

NATIONAL BIOECONOMY ROADMAP AS A DRIVER OF GREEN AGRIBUSINESS TRANSFORMATION

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Abstract: The Bioeconomy Roadmap of the Republic of Serbia defines a strategic framework for advancing the green transformation of agribusiness through sustainable resource use, circularity, and innovation. This paper aims to present the relevance of the Roadmap for agriculture and biomass-based value chains. The document was developed through a multi-actor co-creation process involving public institutions, research organization, industry, and civil society, utilizing analytical reviews and participatory consultations. The main results include the identification of key barriers to bioeconomy implementation, including institutional and policy gaps (limited readiness of institutions, insufficient policy support and the need for policy adjustments), knowledge and technological limitations (low awareness of bioeconomy, technological and digital constraints), and financial constraints, as well as five priority action areas: institutional strengthening, international cooperation, sustainable management of biological resources, support for circular bio-based production, and development of innovative biotechnologies. The road map provides a governance and implementation model that can enhance resource efficiency, strengthen bio-based value chains and improve resilience of the agribusiness sector. The conclusions emphasize the need for integrated policies, targeted investments, and knowledge transfer to accelerate Serbia's transition toward a competitive, low-carbon agricultural system aligned with EU objectives.

Keywords: Bioeconomy, Circularity, Agribusiness, Biomass, Innovation

INTRODUCTION

Background and Problem Definition

Three converging pressures are reshaping agribusiness in Europe: (i) climate-change impacts on production stability and risk (heat, drought, extreme events), (ii) persistent resource inefficiency across agri-food systems (nutrient losses, residues treated as waste rather than feedstock), and (iii) continued dependence on fossil-based inputs and predominantly linear value chains (produce - process - consume - discard) (Guo et al., 2022; Beillouin et al., 2020; Lakatos and Csabai, 2025; Billen et al., 2021; Paris et al., 2022). These pressures expose structural vulnerabilities in primary production and biomass-based industries, while also increasing the policy demand for measurable decarbonisation and resource circularity across value chains (Siankwilimba et al., 2025; Lyu et al., 2024; European Commission, 2020).

Within this context, the bioeconomy is understood as the sustainable production and conversion of renewable biological resources and secondary biomass streams into food, feed, bio-based products and bioenergy, integrating circularity and low-carbon innovation across value chains (European Commission, 2018; Bugge et al., 2016). The EU's Bioeconomy Strategy positions the bioeconomy as a strategic pathway for modernising primary production systems, stimulating bio-based industrial transformation, and improving environmental performance, explicitly embedding circularity as a systemic design principle rather than an “end-of-pipe” solution (European Commission, 2025; Jander et al., 2025).

However, translating these strategic ambitions into agribusiness transformation requires operational governance tools that connect policy priorities with investment logic, stakeholder coordination, and implementable actions at sectoral and territorial levels (Kardung et al., 2021; European Commission, 2025). This is particularly critical in countries where bioeconomy policy is still emerging, institutional responsibilities remain fragmented, and cross-sectoral coordination is weak, limiting the capacity to mobilise private and public investments (Bracco et al., 2018; Ronzon and M'Barek, 2018). These conditions tend to stall uptake of bio-based innovations even when biomass potential is high (European Commission, 2025).

Policy and Scientific Relevance

At EU level, the green transformation of agribusiness is anchored in an integrated policy architecture. The European Green Deal sets the overarching framework for a transition to a climate-neutral and resource-efficient economy (European Commission, 2019). The New Circular Economy Action Plan operationalises circularity as a competitiveness agenda, prioritising systemic changes in value chains, markets, and product-policy frameworks (European Commission, 2020b). The EU Bioeconomy Strategy complements this framework by positioning the bioeconomy as a cross-sectoral transformation pathway that integrates agriculture, forestry and biomass-based industries with circularity, innovation and climate objectives, emphasising the sustainable mobilisation of biological resources, value-chain integration and measurable contributions to decarbonisation and resilience (European Commission, 2025). The Farm to Fork Strategy positions the food system, hence agriculture and biomass chains, as a core lever of sustainability, explicitly linking production practices, value-chain performance, and environmental outcomes (European Commission, 2020a).

Scientifically, this policy landscape intensifies the need for research that connects circular bioeconomy concepts to sector-specific transformation pathways in agribusiness and evaluates governance instruments that can convert broad goals into sequenced actions with accountable actors and monitoring logic. In other words, the research gap is less about whether bioeconomy and circularity matter, and more about how transition instruments are designed and deployed under real institutional, financial and coordination constraints (Hausknost et al., 2017).

For non-EU candidate countries such as Serbia, the relevance of the green transition and bioeconomy is amplified by the EU accession dynamic, as alignment with the EU acquis and Green Agenda priorities entails substantial legal and institutional obligations,

particularly under Chapter 27. A recent report highlights persistent structural weaknesses, including fragmented governance, limited administrative capacity, delayed implementation of secondary legislation, and chronic underinvestment across key domains such as waste management, water protection, climate policy, and industrial emissions control (Coalition 27, 2025). The report underscores that Serbia's primary challenge is no longer the absence of legislation, but the inability to operationalise and enforce existing rules through effective institutions, financing mechanisms, data systems, and stakeholder engagement. These governance gaps directly constrain the uptake of circular, low-carbon practices in agribusiness and biomass-based sectors, despite the country's high biological resource potential. In this context, an operational Bioeconomy Roadmap emerges as an instrument for translating environmental compliance requirements into coordinated, investment-ready actions that support structural transformation rather than just declarative alignment.

National Context of Serbia

Serbia has substantial biological-resource potential relevant for a circular bioeconomy (agriculture and forestry residues, biomass streams, and associated processing sectors), yet value addition and cascading use remain underdeveloped. The Bioeconomy Roadmap of the Republic of Serbia explicitly recognises this gap. Bioeconomy practice is at an early stage, primarily driven by sectoral initiatives rather than by a unified coordination mechanism, and it needs better data, stronger science-industry links, and more structured planning for resource streams and investments (Čule et al., 2025). This is occurring in a policy environment where energy and climate planning is being strengthened, signalling increased attention to renewables and transition investments, including areas connected to biomass and resource efficiency (Government Republic of Serbia, 2024). At the same time, broader circular-economy transition efforts supported by international partners illustrate both momentum and the continuing need for coherent governance and stakeholder coordination (Ministry of Environmental Protection of the Republic of Serbia, 2020).

Against this backdrop, the Roadmap for the Bioeconomy in the Republic of Serbia (developed within the Horizon Europe CEE2ACT project) is positioned as the first integrative, policy-support document that consolidates national priorities, identifies implementation barriers, and proposes a governance and action structure through a multi-actor co-creation process (Čule et al., 2025).

Objectives of the Paper

Building on the Roadmap for the Bioeconomy in the Republic of Serbia and its development process, this paper analyses the Roadmap as a driver of green agribusiness transformation in Serbia. Research has specific objectives to examine the Roadmap as a governance instrument, to assess its function as an operational bridge between policy, research and practice and to synthesise key barriers, priority actions and implications for agribusiness. It focuses on how the Roadmap's actions can improve resource efficiency, strengthen biomass-based value chains, and enhance the sector's resilience and competitiveness.

Although Serbia does not yet have a dedicated national bioeconomy strategy, bioeconomy principles are embedded across several strategic documents, most notably through their

integration into the upcoming Circular Economy Development Programme, where bioeconomy is recognised as a tool for linking sustainable production, processing, and consumption. In this context, the Roadmap represents the first systematic attempt to operationalise these principles by defining a shared vision, strategic goals, and priority actions for bioeconomy development. The paper therefore contributes to the literature by assessing how a bioeconomy roadmap can function as an intermediate governance instrument in accession countries, bridging strategic policy commitments and implementation capacity in the agribusiness sector.

MATERIAL AND METHODS

The study employs a qualitative, policy-oriented research design that draws on structured document analysis, comparative policy alignment, and participatory governance assessment. The primary source of analysis is the Bioeconomy Roadmap of the Republic of Serbia (Čule et al., 2025), complemented by relevant EU bioeconomy and circular economy policy frameworks, national strategic documents in agriculture, energy, forestry, and waste management, and selected outputs of the CEE2ACT project.

The analytical approach followed a multi-step framework comprising: (i) mapping bioeconomy-relevant sectors and biomass-based value chains, (ii) identification and clustering of key implementation barriers, (iii) analysis of priority action areas defined in the Roadmap, and (iv) assessment of their relevance for green agribusiness transformation. The research also draws on the multi-actor co-creation process underpinning the Roadmap, involving public administration, research institutions, industry and SMEs, and civil society, with the National Bioeconomy Hub serving as a coordination platform.

RESULTS AND DISCUSSION

Bioeconomy Roadmap as a Governance Instrument

The Bioeconomy Roadmap of the Republic of Serbia is designed as an operational governance instrument rather than a purely strategic document. It articulates a long-term vision, translates it into five strategic goals, and links these goals to a structured action framework that specifies stakeholder roles, implementation phases, financing options, and monitoring mechanisms. This structure establishes a direct link between policy objectives and implementation capacity, explicitly addressing coordination across ministries, public enterprises, local authorities, research institutions, SMEs, and civil society. The Roadmap anticipates staged delivery through short- and medium-term actions, diversified funding sources, and systematic monitoring, thereby embedding implementation logic into its design.

This governance orientation is reflected in the Roadmap's emphasis on clearly assigned responsibilities, phased implementation horizons (1-3 years and 3-5 years), mixed financing models (national budgets, EU funds, private-sector engagement and PPPs), and a defined monitoring and risk-mitigation framework, including indicators, reporting procedures, digital tools, knowledge transfer and capacity-building measures. These elements collectively distinguish the Roadmap from declarative strategy documents by operationalising coordination, sequencing, and accountability.

In contrast to existing sector-specific strategies in Serbia, such as those addressing agriculture, forestry, energy, or waste management in isolation, the Roadmap provides added value by integrating agriculture, forestry, bio-based industries, and bioenergy within a single cross-sectoral framework. This integration enables the Roadmap to function as a horizontal coordination tool that aligns sectoral policies with green transition objectives and EU bioeconomy and circular economy agendas, while offering a shared reference point for agribusiness transformation across value chains.

From a comparative perspective, analysis of the CEE2ACT national roadmaps shows that three governance features are standard across countries: (i) bottom-up coordination through national bioeconomy hubs, (ii) action-oriented planning with indicative timelines, and (iii) initial development of monitoring and indicator frameworks (CEE2ACT Project, 2025). However, countries differ significantly in institutional maturity, policy anchoring, and proximity to a formal national bioeconomy strategy.

Within this comparative context, Serbia's Bioeconomy Roadmap places stronger emphasis on operational governance and implementation logic than many other CEE roadmaps. While roadmaps in countries such as Bulgaria and Romania predominantly outline thematic priorities and sectoral opportunities, the Serbian Roadmap more explicitly links strategic objectives to defined action areas, responsible actors, and coordination mechanisms, reflecting a response to persistent national governance fragmentation. Unlike several CEE counterparts, where bioeconomy policy remains embedded within sector-specific strategies, the Serbian Roadmap adopts a genuinely cross-sectoral governance approach, positioning agriculture, forestry, biomass residues, and bioenergy within a unified framework. This positioning highlights its role as a policy-bridging instrument tailored to contexts with high biomass potential but limited implementation capacity, where enforceable and sequenced actions are more critical than vision alignment alone.

Identified Barriers to Bioeconomy Implementation in Serbia

The Roadmap identifies a set of interrelated barriers that constrain the effective implementation of bioeconomy principles and the transformation of agribusiness and biomass-based value chains. These barriers are grouped into three categories: institutional and policy barriers, knowledge and technological barriers, and financial and market barriers.

Institutional and policy barriers emerge as the most critical constraints. The Roadmap highlights limited institutional readiness for coordinated bioeconomy governance, weak integration of bioeconomy objectives into sectoral policies, and insufficient inter-ministerial coordination across agriculture, forestry, energy, environment, and innovation portfolios. The absence of a dedicated operational framework and clearly assigned responsibilities further undermines policy coherence, despite the existence of multiple relevant strategic documents at the national level.

Knowledge and technological barriers are linked to low awareness and limited understanding of bioeconomy concepts among public authorities, producers, and SMEs. The Roadmap points to insufficient knowledge dissemination, weak science-industry linkages, and limited uptake of digital tools and advanced bio-based technologies in

agriculture and biomass processing. These gaps reduce the capacity for innovation and constrain the scaling-up of circular and bio-based solutions.

Financial and market barriers include restricted access to targeted financing instruments, underdeveloped incentives for bio-based investments, and high perceived risks associated with innovative bioeconomy projects. Fragmented and short-term funding mechanisms, often poorly aligned with bioeconomy priorities, discourage private-sector engagement and slow market development, particularly for SMEs.

When placed in a comparative CEE context, the barriers identified in Serbia largely mirror those reported in Bulgaria, Romania, Slovakia, and Hungary, where fragmented governance, limited coordination, insufficient awareness, and constrained financing are recurrent challenges (CEE2ACT Project, 2025). However, Serbia is characterised by more pronounced gaps between strategic intent and operational capacity, reflecting accession-related pressures and delayed translation of policy commitments into concrete instruments.

EU-level bioeconomy assessments reinforce this interpretation, showing that although many CEE countries possess substantial biomass potential, the absence of integrated governance structures, stable financing, and effective knowledge-transfer mechanisms remains a systemic obstacle (European Commission, 2018; 2025). In this context, the Serbian Bioeconomy Roadmap responds directly to these constraints by explicitly identifying barriers and linking them to priority action areas, thereby enabling a shift from declarative alignment toward implementable and measurable pathways for agribusiness transformation.

Priority Action Areas and Relevance for Agribusiness

The vision of the Bioeconomy Roadmap of the Republic of Serbia is centred on efficient, rational, and responsible resource use grounded in circular bioeconomy principles. It emphasises waste prevention, valorisation of residues and by-products, investment incentives, and the creation of added value with minimal environmental impact (Čule et al., 2025). Agribusiness is positioned as a core pillar of this transition, reflecting its dual role as a primary biomass provider and a key beneficiary of bioeconomy development.

The first priority action area, institutional capacity-building and policy support, focuses on establishing a coherent strategic, legislative, and institutional framework supported by incentive mechanisms and targeted capacity-building. By strengthening human and organisational capacities and improving cross-sectoral coordination, this action area addresses fragmented governance and creates more predictable conditions for bio-based investments. For farmers and agri-SMEs, this translates into clearer regulatory settings, reduced administrative uncertainty, and improved access to harmonised support schemes.

The second action area, international and regional cooperation, supports Serbia's integration into European bioeconomy networks, research initiatives, and markets. For agribusiness and biomass processors, this facilitates technology transfer, market access, and compliance with EU sustainability standards, while also enabling knowledge exchange and joint value-chain development in rural and cross-border regions.

The third action area, sustainable management of biological resources, is directly linked to agribusiness performance and resilience. It promotes improved land, forest, and biomass management practices that enhance productivity while safeguarding ecosystems. For farmers and rural communities, this supports diversification, sustainable intensification, and increased retention of local value, particularly through the use of agricultural and forestry residues.

The fourth action area, support for circular bio-based production and value chains, represents the most direct lever for agribusiness transformation. By prioritising cascading biomass use and waste-to-resource models, it creates new income streams for farmers, strengthens agri-SMEs involved in processing and logistics, and stimulates rural employment by anchoring value addition closer to biomass sources.

The fifth action area, development of innovative biotechnologies and circular solutions, focuses on research, demonstration, and market uptake. A key emphasis is placed on public-private partnerships, which facilitate cooperation between research institutions, public authorities, and industry. For agribusiness, this includes biotechnologies for sustainable inputs, bio-based materials, and precision and digital applications that improve resource efficiency. Pilot projects, living labs, and stronger research-industry linkages are particularly relevant for innovation-oriented agri-SMEs and start-ups.

Compared with other CEE roadmaps, Serbia's Roadmap prioritises governance coordination, sustainable resource management, and circular value chains (CEE2ACT Project, 2025). However, it places stronger emphasis on operationalisation and implementation mechanisms, reflecting national accession-related constraints and enforcement gaps. This focus on agribusiness actors and rural development needs reinforces the Roadmap's role as an implementation-oriented policy framework rather than a purely strategic vision.

Implications for Green Agribusiness Transformation

The Bioeconomy Roadmap sends a clear strategic signal to shift Serbian agribusiness from primary production toward higher-value, bio-based value chains. By promoting cascading biomass use, bio-based products, and integration with forestry, energy, and bio-processing sectors, it enables farmers, agri-SMEs, and processors to capture greater value along the chain (Čule et al., 2025).

A central implication is improved resource efficiency, particularly through systematic utilisation of residues and by-products. Circular approaches reduce losses, close nutrient loops, and support sustainable input use, thereby lowering environmental pressures while improving cost efficiency and regulatory compliance, issues of particular importance for small and medium agribusinesses (Swastika, 2024; Behera, 2025).

The governance and support framework also strengthens agribusiness resilience and competitiveness by encouraging innovation, income diversification, and adoption of bio-based and digital solutions. Evidence from other CEE countries shows that coordinated bioeconomy policies can support rural development, agri-SMEs, and long-term adaptability to climate and market risks (CEE2ACT Project, 2025).

Finally, the Roadmap facilitates alignment with EU sustainability, climate, and circular bioeconomy objectives (European Commission, 2019, 2020a,b, 2025). By translating EU-level ambitions into nationally tailored, operational actions, it supports gradual convergence while addressing domestic structural constraints. In this sense, the Roadmap serves as both a strategic and a practical transition tool to advance green agribusiness transformation in Serbia.

CONCLUSION

The Bioeconomy Roadmap of the Republic of Serbia represents a practical policy-support tool that moves beyond strategic declarations by providing a structured framework for coordinating policies, actors, and investments relevant to the green transformation of agribusiness. By explicitly linking bioeconomy objectives with agriculture, forestry, biomass processing, and rural development, the Roadmap acts as a catalyst for agribusiness transformation, encouraging the shift from primary production toward value-added, circular bio-based value chains. At the same time, it lays a foundation for the future development of a comprehensive national bioeconomy strategy, offering tested governance logic, priority action areas, and implementation pathways.

The analysis highlights several key success factors for effective implementation. An integrated policy approach is essential to overcome sectoral fragmentation and ensure coherence across agriculture, energy, environment, innovation, and rural development policies. Targeted investments, supported by predictable financing instruments and incentives, are required to enable farmers, agri-SMEs, and biomass processors to adopt bio-based innovations and circular practices. Equally important is systematic knowledge transfer, including capacity-building, stakeholder engagement, and stronger links between research, industry, and public administration, which together enable the translation of policy goals into operational outcomes.

Without timely and coordinated implementation, the Roadmap risks remaining a declarative document, sustaining existing gaps between policy ambition and on-the-ground transformation in agribusiness and rural areas. Looking ahead, priority next steps include the gradual institutionalisation of the Roadmap through monitoring milestones, financing mechanisms, and stakeholder governance structures, as well as its evolution toward a formal national bioeconomy strategy aligned with EU transition objectives. Beyond its national relevance, the Serbian Bioeconomy Roadmap offers broader applicability to other Western Balkan and CEE countries facing similar challenges, providing a transferable model for bridging policy ambition and implementation capacity in support of greener, more resilient, and more competitive agribusiness systems.

ACKNOWLEDGMENT

This paper presents results developed within the CEE2ACT project (2022-2025), which has received funding from the European Union's Horizon Europe research and innovation program under Grant Agreement No. 101060280. The authors also acknowledge the valuable contributions of members of the National Bioeconomy Hub, whose active participation, expertise, and feedback were essential for the co-creation and validation of the National Bioeconomy Roadmap.

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