

Aligning Stakeholder Governance with Industry 5.0: Enablers and Barriers in Rural Bioeconomy Transformation

TAMARA BESEDNJAK VALIČ, ERIKA DŽAJIĆ URŠIČ & JANJA LOZAR¹

Abstract Integrating bioeconomy principles into the emerging Industry 5.0 agenda is presented as a way to reconcile competitiveness with sustainability, resilience, and human-centric development. This chapter examines how stakeholder governance in rural regions enables or constrains such transformations, with a particular focus on the roles of governance enablers and barriers in the relevance of territorial/local self-government. Conceptually, it links debates on stakeholder governance, the bioeconomy, and Industry 5.0, arguing that rural bioeconomy pathways are shaped by the interplay of institutions, networks, and cognitive frames, rather than technology or markets alone. This article examines how stakeholder governance arrangements enable or constrain rural bioeconomy transformation across three case regions (Slovenia, Montenegro, and Baden-Württemberg). Using Industry 5.0 as a normative frame and SOFIA as an analytical coding approach, it identifies key institutional, network, and cognitive enablers and barriers, and derives governance-relevant implications for territorial development.

Keywords: • bioeconomy • Industry 5.0 • stakeholder governance • rural development • circular economy • multi-level governance

CORRESPONDENCE ADDRESS: Tamara Besednjak Valič, Ph.D., Senior Scientific Associate, Rudolfovo - Science and Technology Centre, Podbreznik 15, 8000 Novo mesto, Slovenia; Head of Centre for social and technological transformations and circularity, Podbreznik 15, 8000 Novo mesto, Slovenia; Associate Professor, Faculty of Information Studies, Ljubljanska cesta 31a, 8000 Novo mesto, Slovenia; School of Advanced Social Studies, Gregorčičeva ulica 19, 5000 Nova Gorica, Slovenia, e-mail: tamara.valic@rudolfovo.eu. Erika Džajić Uršič, Ph.D., Senior Scientific Associate, Rudolfovo - Science and Technology Centre, Podbreznik 15, 8000 Novo mesto, Slovenia; Associate Professor, Faculty of Information Studies, Ljubljanska cesta 31a, 8000 Novo mesto, Slovenia; School of Advanced Social Studies, Gregorčičeva ulica 19, 5000 Nova Gorica, Slovenia, e-mail: erika.ursic@rudolfovo.eu. Janja Lozar, Research Assistant, School of Advanced Social Studies, Gregorčičeva ulica 19, 5000 Nova Gorica, Slovenia, e-mail: janja.lozar@fuds.si; Faculty of Information Studies, Ljubljanska cesta 31a, 8000 Novo mesto, Slovenia, e-mail: janja.lozar@fis.unm.si.

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1 Introduction

The governance of sustainability transitions relies on complex interactions among stakeholders, particularly in the context of rural bioeconomy development. This chapter discusses the crucial role of stakeholder governance in facilitating or constraining the goals of Industry 5.0, emphasizing that successful integration primarily requires effective governance arrangements. The argument posits that aligning rural bioeconomy strategies with the Industry 5.0 paradigm hinges less on mere technological advancements and more on fostering collaboration, alleviating structural inequities, and integrating human-centric values into governing processes.

Industry 5.0 represents a paradigm shift toward a more human-centric, sustainable approach in industrial environments. It emphasizes the collaboration of human intelligence and machine capabilities, aiming to create a balance between economic growth, societal well-being, and environmental stewardship. Furthermore, it is increasingly recognized more as a conceptual framework rather than solely a technological paradigm (Noori et al. 2020). Besides, it emphasizes human engagement alongside advanced technologies, striving for increased productivity while also pursuing social equity and environmental sustainability. From a governance perspective, Industry 5.0 functions less as an innovation policy and more as a normative benchmark against which institutional arrangements, stakeholder participation, and coordination capacities can be evaluated.

However, the fragmentation in current literature limits the connections drawn between governance structures and the achievement of Industry 5.0 goals (de Graaf, 2016; Potočan et al., 2021). Europe's strategy on Industry 5.0 is framed within broader initiatives, such as the European Green Deal and the New Industrial Strategy, which aim to promote sustainable practices across various sectors (Abozaid, 2024; Gudz et al., 2021). The European Green Deal is particularly significant as it strives to transform the EU's economy, addressing climate change by enhancing the EU's energy efficiency and environmental sustainability ambitions (Abozaid, 2024). Moreover, the New Industrial Strategy emphasizes bolstering Europe's industrial ecosystem to ensure its global competitiveness while transitioning towards a climate-neutral economy (Gudz et al., 2021). Key initiatives under this strategy include the European Raw Materials Alliance, which underlines the crucial role of raw materials in ensuring sustainable industrial growth and fostering circular economies (Belov, 2020).

Stakeholder governance within the Industry 5.0 framework is critical for driving initiatives that are socially responsible, economically viable, and environmentally sustainable. The EU aims to foster a collaborative environment conducive to innovation by empowering various stakeholders, including businesses, governmental entities, and civil society (Bingham et al., 2005; Roman et al., 2020). Notably, incorporating diverse

perspectives into decision-making processes promotes transparency, builds public trust, and fosters inclusivity, all of which are critical for achieving long-term multilateral goals (Roman et al., 2020). To fully realize the potential of Industry 5.0, coherent policy frameworks are required that align stakeholders' motivations and expectations (Gudz et al., 2021).

From a sociopolitical standpoint, the participation of diverse stakeholders is critical for fostering the values of transparency, trust, and inclusivity that are required for Industry 5.0 to be implemented successfully. Historical examples demonstrate that governance frameworks, such as co-management systems, can facilitate collaborative engagement, leading to improved outcomes across multiple sectors (Vignieri, 2020). Political dynamics and established interests, on the other hand, may act as impediments to effective governance, stymying progress toward comprehensive industry reform. The challenge lies in transitioning from a theoretical understanding of stakeholder interactions to a practical assessment of their impact on policy implementation and social equity (Kolugala et al., 2022)

Stakeholder governance provides a framework for collaborative decision-making, which is crucial for addressing the complex challenges associated with sustainability transitions. Schultz et al. argue that stakeholder governance goes beyond simple stakeholder relationships, advocating for a systemic approach to catalyze collaborative efforts among diverse entities—an essential component for transitioning to a circular economy aligned with Industry 5.0 goals. Furthermore, Borchardt et al. emphasize that the transformation anticipated by Industry 5.0 goes beyond technological innovation, encompassing holistic business model re-evaluations that necessitate inclusive stakeholder engagement and governance structures that promote social resilience and human-centric development (Borchardt et al., 2022).

Aligning bioeconomic strategies with such governance frameworks in rural areas can help to mitigate potential conflicts caused by competing interests in resource utilization (Ratner et al., 2013). Inclusive governance processes in the promotion of bioeconomy can reduce socio-environmental tensions, implying that stakeholder engagement is critical for achieving equitable outcomes. Bezama et al. argue that the effectiveness of bioeconomy initiatives is inextricably linked to regional stakeholder roles, making stakeholder governance critical for long-term rural development (Bezama et al., 2019).

Despite its potential benefits, stakeholder governance faces challenges. The literature highlights gaps in the practical application of collaborative governance principles. According to Ansell and Gash (2008), the success of collaborative governance engagements can be influenced by various contextual factors, including stakeholder trust and the ability to foster a consensus-oriented decision-making environment. This

complexity implies that simply establishing governance frameworks is insufficient; cultivating cooperative relationships among stakeholders is equally critical.

Furthermore, the concept of fairness is critical in negotiations with multiple stakeholders. Hennig- Hennig-Schmidt et al. (2024) emphasize the importance of fairness in shaping cooperative behaviors in resource management and policy implementation. However, it is unclear how these principles can be applied universally across diverse settings, particularly in rural contexts marked by significant economic and social disparities.

To effectively bridge the gap between rural bioeconomy strategies and Industry 5.0 paradigms, governance arrangements must prioritise long-term collaborative frameworks. This includes integrating local knowledge and stakeholder expertise, as well as ensuring that governance designs are adaptable to changing socioeconomic conditions (De Besi & McCormick, 2015). Tapaninaho and Heikkinen argue that sustainability-oriented business models should be tailored with specific attention to stakeholder dynamics, emphasizing the importance of incorporating fairness and equity into economic structures (Tapaninaho & Heikkinen, 2022).

Madzik et al., (2025) suggest that participatory mechanisms can empower local stakeholders and promote resilience and sustainability in rural bioeconomic practices. The human-centric focus of Industry 5.0 emphasizes the importance of incorporating diverse stakeholder perspectives for inclusive technological transitions that benefit rural communities (Potočan et al., 2021).

Moreover, developing strategies that recognize the complexity of stakeholder dynamics is imperative. Understanding how governance mechanisms influence corporate behavior and industry standards can help bridge existing gaps in the literature, ultimately steering operational strategies toward more sustainable practices (Albareda et al., 2008; Jamali et al., 2008). Addressing regulatory complexities associated with corporate social responsibility, in particular, presents an opportunity to align industry practices with the fundamental principles of Industry 5.0 (Han, 2019).

Effective stakeholder governance not only promotes compliance with established norms but also enhances the capacity of industrial sectors to adapt to emerging challenges (D. Zhang & He, 2022). This adaptability is critical in the context of sustainability, where stakeholder engagement and collaboration can spark innovation and generate mutual benefits.

Europe's overarching strategy for Industry 5.0 aims to integrate technological innovation with a human-centric approach, supported by effective stakeholder governance. This strategic direction aligns with the EU's vision of sustainability and competitiveness, stressing the importance of coordinated governance systems. As the EU continues to

refine its strategies and engage diverse stakeholders, it stands to cultivate an industrial environment that thrives on innovation while prioritizing societal and environmental responsibilities.

Empirically, the chapter examines three European case regions—Slovenia, Montenegro, and Baden-Württemberg—representing different institutional contexts, governance capacities, and stages of bioeconomy development. Using the SOFIA (Social Fields Approach) analytical framework, the study combines a structured review of grey literature with expert discussions to identify key governance enablers and barriers across three analytical categories: institutions, networks, and cognitive frames. This analytical design enables a systematic examination of how stakeholder dynamics and regulatory frameworks shape the interaction between multi-level governance structures and Industry 5.0 normative objectives in rural bioeconomy development.

Against this background, Industry 5.0 is employed in this chapter not as a technological roadmap but as a normative governance framework that allows us to evaluate how multi-level stakeholder arrangements enable or constrain human-centric, sustainable, and resilient rural bioeconomy transitions. The chapter addresses the following research question: *What key enablers and barriers in multi-level stakeholder governance shape the implementation of the rural bioeconomy within the framework of Industry 5.0 normative guidelines?*

Answering this question, the chapter contributes to current debates on the governance of sustainability transitions by explicitly linking stakeholder governance theory, rural bioeconomy development, and the Industry 5.0 paradigm. We will try to demonstrate that aligning rural bioeconomy strategies with Industry 5.0 is less a matter of technological innovation than of designing governance arrangements capable of sustaining cooperation, reducing structural inequalities, and embedding human-centric values in territorial development processes.

2 Literature overview

Stakeholder Governance and its potentials for understanding transitions in the bioeconomy

At the heart of contemporary debates on sustainable transformation lies the question of how diverse interests can be aligned towards shared societal goals. Stakeholder governance provides one line of responses, bringing into focus the interplay between industry, policymakers, researchers, and citizens, emphasising collaborative responsibility in shaping economic and technological pathways. By framing governance as a dynamic negotiation among actors (Westin & Montgomerie, 2024) with different expectations, resources, and values (O'Connor & Shahwan, 2025). This approach offers a foundation for understanding how emerging models, such as the bioeconomy and

Industry 5.0, can be steered towards outcomes that serve both environmental integrity and social well-being.

Following the definitions, stakeholder governance is, in general, understood as the set of formal and informal mechanisms (among those contracts, norms, and organizational designs and networks) that organizations use to manage relationships with multiple stakeholders, resolve collective action problems in joint value creation, and sustain cooperation by ensuring perceived fairness among stakeholders beyond shareholders alone. The theories that encompass the term itself are not new, as the foundational work was published in the 1980s, with *Strategic Management: A Stakeholder Approach* by R. Edward Freeman. The work introduced the concept of organisations managing relationships with all groups affected by their activities. Attention shifted from shareholder primacy to broader accountability (Freeman, 1984). Jumping forward, as his work was left aside, until some 15-10 years ago, for more economic theories (Bridoux and Stoelhorst 2022) a stakeholder turn occurred. The stakeholder perspective has been adopted by numerous authors in recent years (e.g. Barney, 2018; Klein et al., 2012; Zollo et al., 2018). It was in 2022, Flore Bridoux and J.W. Stoelhorst advanced stakeholder governance as a distinct theoretical framework. They emphasised how governance resolves collective action problems in joint value creation via fair formal and informal contracts that sustain stakeholder cooperation (Bridoux & Stoelhorst, 2022). In their recent work, they identify three complementary theoretical strands that collectively support the development of a renewed theory of strategic governance. The first rests on the argument that value creation and value capture can only be properly explained when the mutual dependence of stakeholders is placed at the centre of analysis. Stakeholders are engaged in a dual process: they collaborate in generating value, yet simultaneously strive for its distribution (Brandenburger & Stuart Jr., 1996). The second strand highlights that human behaviour is shaped not only by self-interest but also by social preferences and moral sentiments. This is crucial, as interdependent stakeholders create value largely by addressing collective action dilemmas (Bridoux & Stoelhorst, 2022), where the tension between individual benefits and collective interests is ever-present. The third strand involves viewing the firm as a nexus of both formal and informal contracts. This perspective has long been a foundational aspect of stakeholder theory (Jones, 1995). In this context, the contractual view presents the firm as a network of freely associating individuals who come together to create value collectively (Freeman & Phillips, 2002). Recent studies have investigated the role of stakeholder involvement in creating and sustaining value. These studies emphasise the intricacy of stakeholder contributions and their broader implications for different organisational structures. One key insight is that some stakeholders, situated outside the firm, beyond the traditional boundaries that strategy scholars usually define, often invest in firm-specific assets, which are vital for generating value (Bridoux & Stoelhorst, 2022). For example, Odziemkowska & Dorobantu (2021) explore the nature of contractual relationships between corporations and local communities. Another consideration is raised by Bacq & Aguilera (2022), who

highlight that the recipients of responsible innovation may include individuals who, in fact, have made minimal, if any, contributions to its development.

Stakeholder governance provides a valuable analytical lens for understanding transitions to the bioeconomy, as it highlights the interdependence of actors whose collaboration is essential for reshaping production and consumption systems centered on renewable biological resources. The concept of the bioeconomy has emerged as a transformative framework with the potential to address pressing global challenges, including climate change, resource scarcity, and economic sustainability. As societies grapple with the detrimental environmental impact of fossil fuel dependence and the urgent need to transition (Staffas et al., 2013) toward renewable resources, the bioeconomy offers a compelling vision for a more sustainable future (Mertens et al., 2019). However, as the researchers seem to agree upon the benefits and challenges posed by the new economic concept, in the literature, we can detect differences in naming the phenomenon. Wreford et al. (2019) list numerous such naming: “bioeconomy”, “bio-based economy”, and even “bio-based society” and “knowledge-based bioeconomy” (see also Mukhtarov et al., 2017; Scarlat et al., 2015). Overall, regardless of differences in naming, it seems researchers share the meaning as bioeconomy being a strategy to generate wealth while addressing environmental challenges through reducing and reintegrating waste streams, deriving new value from waste, and unlocking economic opportunities through advancements in science, design, and the development of production systems and resilient industries (see also Martinez de Arano et al., 2018). However, it was not always like this, as in the past, researchers associated the term with scientific and research activities centered on biotechnology (Wreford et al. 2019).

Following the definition European Commission, (2018a, p.1), “*The bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services. To be successful, the European bioeconomy needs to have sustainability and circularity at its heart. This will drive the renewal of our industries, the modernisation of our primary production systems, the protection of the environment, and will enhance biodiversity*”.

Understanding bioeconomy from the standpoint of stakeholder governance, we recognise the complementarity of knowledge, capabilities, and motivations dispersed across industry, research institutions, and public authorities. This approach can help us understand how coordinated action can accelerate the development of sustainable value chains (Uršič et al., 2024). Viewed through this lens, stakeholder governance not only

provides explanatory power for why certain bioeconomic initiatives gain traction but also points to pathways for fostering innovation ecosystems that support resilience, societal acceptance, and the broader goals associated with Industry 5.0. Building on these foundations, the transition towards a bioeconomy aligned with the principles of Industry 5.0 can be understood as a distinctly stakeholder-driven undertaking. Both fields rely on a complex web of relationships that connect research institutions, firms, regulators, and citizens, each contributing knowledge, resources, and expectations that influence the direction of innovation.

Because the shift towards renewable, circular production systems presents a series of collective action challenges (Fric et al., 2025), the governance dynamics and individual competences outlined above become particularly important (Fric et al., 2023). Trust, reciprocity, and shared purpose are essential for mobilising the cooperation needed to redesign value chains (Gangaliuc, 2022), also around biological resources, while embedding the human-centric ethos that Industry 5.0 promotes. The following sections of this chapter examine how these interactions influence the development of bio-based markets and impact the EU's broader sustainability objectives.

However, applying stakeholder governance to bioeconomy transitions also exposes significant shortcomings that must be acknowledged. While the rhetoric of collaboration and co-creation is widely invoked, the governance of bio-based innovation often remains shaped by power asymmetries, expertise disparities, and resource imbalances. Large industrial actors and scientific institutions typically exert disproportionate influence over strategic priorities, technological choices, and the framing of sustainability benefits, leaving smaller stakeholders—particularly local communities and civil society—limited scope to shape outcomes meaningfully. Moreover, the notion that broad stakeholder engagement automatically leads to socially desirable or environmentally robust transitions risks obscuring deeper structural tensions, such as competing land-use demands, economic lock-ins, and the political interests embedded within EU policy mechanisms. A critical reading, therefore, suggests that while stakeholder governance offers important conceptual tools, its practical application requires far more scrutiny if it is to support a genuinely just and sustainable bioeconomy rather than reinforce existing hierarchies under the guise of inclusivity. In this chapter, Industry 5.0 is employed as a normative framework for evaluating whether rural bioeconomy governance arrangements promote human-centricity, sustainability, resilience, and democratic legitimacy. The focus is therefore on how governance structures embed citizens and stakeholders in decision-making, rather than on market-formation enabling conditions.

Taken together, the literature on stakeholder governance and the bioeconomy suggests that the realization of Industry 5.0 principles depends less on technological availability and more on the quality of governance arrangements. Human-centricity, sustainability, and resilience—core elements of Industry 5.0—emerge as outcomes of how institutions

coordinate, how networks stabilise cooperation, and how actors cognitively frame bio-based transitions. This insight directly informs the analytical focus of the empirical analysis.

3 Industry 5.0 and its focus on Human-Centred futures – the potentials for bioeconomy

Industry 5.0 has been introduced by the European Commission as a complementary paradigm to Industry 4.0, explicitly reorienting industrial development towards human-centered, sustainable, and resilient futures (Breque et al., 2021; European Commission, 2018b). Rather than treating technological upgrading and automation as ends in themselves, Industry 5.0 frames industry as a provider of societal value, operating within universal boundaries and supporting high-quality work and social cohesion. In parallel, the renewed EU bioeconomy strategy conceptualizes the bioeconomy as a systemic transition towards the sustainable use of biological resources across sectors, emphasizing the linkages between the economy, society, and environment, as well as the importance of citizen and consumer engagement for legitimacy and the uptake of bio-based solutions (European Commission, 2018b). When these two agendas are read together, Industry 5.0 provides a normative and institutional framework for a human-centred bioeconomy, in which governance structures are co-shapers of production systems, regulatory expectations, and the cultural meanings attached to “bio-based” lifestyles. In the following sub-sections, we elaborate on six interrelated dimensions of this human-centred Industry 5.0 vision and its implications for the bioeconomy:

3.1 Human-centric innovation (Industry 5.0 puts humans at the center of innovation)

A key departure of Industry 5.0 from earlier industrial paradigms is its emphasis on humans – not technologies – occupying the central position in innovation processes. The European Commission explicitly frames Industry 5.0 as placing “the wellbeing of the worker at the centre of the production process”, moving from shareholder-driven optimisation to broader stakeholder value (Berardo, 2023; Breque et al., 2021; Directorate-General for Research and Innovation, 2024). Academic work on Industry 5.0 similarly underscores a re-humanisation of industry, where human creativity, judgement, and ethical responsibility are complemented – rather than displaced – by advanced digital technologies and collaborative robots (Coelho et al., 2023).

In the context of the bioeconomy, this human-centric perspective implies that innovation in bio-based products and processes cannot be understood solely as a technological substitution of fossil-based inputs. Instead, it foregrounds users’ values, everyday practices, and identities as structural components of innovation trajectories (Gaffey et al., 2021).

A human-centric Industry 5.0 approach thus requires participatory design methodologies, user-centred experimentation (e.g., living labs) and forms of social innovation that integrate local knowledge and cultural meanings into bio-based value chains, particularly in rural regions where bioeconomic transformations directly affect livelihoods and landscapes.

3.2 Sustainability and circularity (Industry 5.0 demands: regenerative processes, bio-based circularity, sustainable material cycles)

Industry 5.0 explicitly links industrial competitiveness to sustainability and circularity, arguing that future prosperity depends on production systems that respect planetary boundaries and contribute to climate neutrality, biodiversity protection, and resource efficiency (Breque et al., 2021; ESIR, 2022).

The updated EU bioeconomy strategy aligns with this view by promoting a sustainable and circular bioeconomy, in which biomass production, processing, consumption, and end-of-life management are organised as regenerative cycles rather than linear chains (European Commission, 2018b).

Theoretically, the integration of Industry 5.0 and bioeconomy debates reinforces a shift from “weak” to “strong” sustainability: the goal is not merely to increase the share of bio-based materials, but to restructure socio-technical systems so that material and energy flows are reduced, circulated, and socially embedded. Recent work on the circular economy has highlighted tensions between efficiency-oriented, technocratic interpretations of circularity and more systemic, justice-oriented approaches that foreground the power, culture, and symbolic dimensions of change (Korhonen et al., 2018; Uršič et al., 2024).

Industry 5.0 strengthens the latter by insisting that circularity must generate co-benefits for workers, communities – for example, by supporting quality jobs in bio-based sectors, ensuring safe and healthy working environments in biomass processing, and addressing distributional effects along supply chains. Sustainability and circularity are increasingly mediated through labels, standards, narratives, and digital information tools. Bio-based products compete not only on price and performance, but also on their ability to credibly demonstrate lower environmental footprints and contributions to local circular ecosystems. Life-cycle assessment (LCA), eco-design, and extended producer responsibility schemes become critical infrastructural elements in the human-centred bioeconomy, translating complex environmental impacts into signals that can inform consumer choices without offloading responsibility solely onto individuals (Sevigné-Itoiz et al., 2021; Sinkko et al., 2023).

3.3 Systemic resilience (Industry 5.0 calls for resilient, decentralized, and adaptable ecosystems, with strong regional networks)

Resilience is the third foundational pillar of Industry 5.0. The concept is used in EU policy documents to describe industrial ecosystems that can withstand shocks, adapt to crises, and reconfigure in ways that preserve social welfare and ecological integrity (Breque et al., 2021; ESIR, 2022). Rather than relying exclusively on highly optimized, just-in-time global supply chains, Industry 5.0 encourages diversified, decentralized, and regionally grounded production systems, supported by robust networks of SMEs, cooperatives, and social enterprises (Pilvere et al., 2015).

In bioeconomy contexts, resilience is particularly salient given exposure to climate impacts, price volatility for biomass and energy, and geopolitical disruptions. A human-centred Industry 5.0 perspective suggests that resilience is not only infrastructural and ecological but also social and institutional. Rural communities engaged in forestry, agriculture, and bio-based processing need capacities to experiment, learn, and reorganise in response to disturbances. This implies, for example, fostering diverse portfolios of bio-based activities (e.g., combining food, fibre, bio-based materials and ecosystem services), investing in local skills and entrepreneurial ecosystems, and ensuring that value from bio-based chains is retained regionally rather than being extracted by distant corporate actors (Alves et al., 2023; Lange et al., 2021).

3.4 Multi-stakeholder collaboration (Industry 5.0 emphasizes ecosystem collaboration)

Industry 5.0 is closely aligned with mission-oriented and ecosystem-based approaches to innovation policy, which argue that complex societal challenges, such as climate change and sustainability transitions, require coordinated action across public, private, and civic actors rather than isolated firm-level optimization (Directorate-General for Research and Innovation, 2024; Mazzucato, 2018). Policy documents emphasize “ecosystem collaboration” as a defining characteristic of Industry 5.0, positioning governments, regions, businesses, research organizations, and citizens as co-producers of direction, knowledge, and resources. Applied to the bioeconomy, this shift in attention focuses on regional bio-based ecosystems, where public administrations, universities, farmers, forest owners, processors, retailers, NGOs, jointly negotiate trajectories (X. Zhang et al., 2022). Governance arrangements may take the form of bioeconomy clusters, regional innovation platforms, multi-actor partnerships, or living labs. Such arrangements are particularly relevant for rural and peripheral regions, where institutional thickness, social capital, and trust networks influence whether bio-based strategies reinforce existing inequalities or open up inclusive development paths. Citizens are not passive “final users” in these ecosystems, but rather stakeholders with a voice and agency (Bălan et al., 2025). They can participate in agenda-setting (e.g., through consultations on regional bioeconomy

strategies), co-creation (e.g., community-supported agriculture, cooperative renewable energy, and bio-refinery initiatives), and monitoring (e.g., citizen science on biodiversity impacts of biomass production). This resonates strongly with Industry 5.0's insistence on democratic legitimacy and shared ownership of industrial transformations.

3.5 Digital transformation in agriculture (digitalisation challenges and opportunities)

Digitalisation is a key enabler – but also a potential source of new asymmetries – in the transition towards a human-centred bioeconomy. Research on digital agriculture and “Agriculture 4.0” has documented how sensors, remote sensing, AI-based decision support, and farm management platforms can increase efficiency, reduce inputs, and enable fine-grained environmental monitoring, while simultaneously raising concerns about data ownership, power relations, and farmers’ autonomy (Klerkx et al., 2019). OECD work on the digital transformation of agriculture similarly emphasises both the opportunities for better, evidence-based agri-environmental policies and the need for governance frameworks that protect privacy, ensure interoperability, and prevent lock-in to proprietary platforms (OECD, 2019). From an Industry 5.0 perspective, digital technologies in the bioeconomy should be deployed in ways that enhance human capabilities and relational qualities rather than merely intensifying surveillance and control. In practice, this means:

- Utilizing digital traceability and product passports with transparent information on the origin, environmental, and social impacts of bio-based products enables informed choices and strengthens trust in bio-based claims (Rasheed Aboumorra & Ladu, 2024).
- Supporting farmers and forest owners with open, user-friendly tools that respect data sovereignty and are co-designed with end-users, so that digitalisation reduces administrative burdens and enhances decision-making instead of introducing new dependencies (Wang et al., 2025).
- Leveraging digital platforms to connect producers in regional markets (e.g., online marketplaces for local bio-based products, community-supported schemes), thereby shortening value chains and reinforcing regional resilience (Blanc et al., 2019; McAllister, 2025; Talwar & Holden, 2022).

Critically, Industry 5.0 reframes digitalisation not as an autonomous technological wave but as a value-laden socio-technical process that must be governed to align with human wellbeing, sustainability, and justice – a crucial consideration in bioeconomy sectors where power asymmetries between global tech providers, agri-food corporations, and small producers are pronounced (Pilvere et al., 2015).

3.6 Policy/system reform (Industry 5.0 requires adaptive governance and supportive regulatory environments)

Industry 5.0 presupposes adaptive governance and regulatory environments capable of steering industrial and bioeconomic transitions towards societal missions rather than reacting to them *ex post*. This perspective aligns with mission-oriented innovation policy, which suggests that states should not only correct market failures but also actively shape and create markets in ways that address grand challenges (Mazzucato, 2018). For the bioeconomy, this translates into multi-level policy architectures that:

- Provide clear, long-term signals on climate, biodiversity, and circularity objectives (e.g., climate neutrality targets, biodiversity strategies, circular economy action plans), thereby reducing uncertainty for investors in the bio-based sector.
- Align agricultural, forestry, energy, regional development, and innovation policies to avoid contradictory incentives (e.g., between biomass for energy, food security, and biodiversity).
- Introduce regulatory frameworks and standards that define what constitutes “sustainable bio-based”, prevent greenwashing, and ensure that environmental and social externalities are internalized.
- Strengthen participatory and deliberative mechanisms in policy design and evaluation, so that workers, farmers, consumers, and local communities can influence the direction and pace of bioeconomic transformations (Koukios et al., 2018; Munshi & Mani, 2025; Nilsson et al., 2021).

Industry 5.0 governance also requires institutional learning and reflexivity. Instruments such as experimentation spaces, regulatory sandboxes, and *ex-ante* impact assessments can help policymakers test and adapt regulations in real-world settings, particularly where digitalisation and bio-based innovation interact in novel ways (Eriksson et al., 2025). The emerging Industry 5.0 Community of Practice at the EU level exemplifies efforts to develop such reflexive governance capacities by facilitating mutual learning among diverse stakeholders and showcasing concrete practices that operationalize human-centric, sustainable, and resilient industries in various regional contexts (European Commission, 2024).

These six dimensions conceptualise Industry 5.0 as a normative and institutional framework within which the bioeconomy can be developed not merely as a technological or sectoral project, but as a human-centred societal transformation. They emphasize that citizens are structurally embedded actors in this transformation – through their preferences, practices, political voice, and participation in collaborative governance – and thus provide a theoretical lens for analyzing concrete regional bioeconomy trajectories in Europe (Bálan et al., 2025; Pilvere et al., 2015).

4 Research

The empirical analysis follows the SOFIA conceptual approach (Rončević et al., 2022), combining a structured review of grey literature with expert discussions in three case regions (Slovenia, Montenegro, and Baden-Württemberg). First, we analyzed EU, national, and regional strategies, policy reports, and project documents related to the bioeconomy, rural development, and Industry 5.0 to identify key governance arrangements, actor arrays, and implementation gaps.

These insights were then triangulated with qualitative data from expert focus groups and semi-structured discussions with public authorities, research organizations, civil society actors, and rural producers, as well as insights from governance and territorial development (Fric et al., 2023). The research design and subsequent coding were structured around three main analytical categories – (a) institutions, (b) networks, and (c) cognitive frames – and fourteen coding themes. The categories and themes are summarized in Table 1, which supports an implementation- and governance-oriented analysis of rural bioeconomy transformation. Industry 5.0 is applied here as a normative evaluative lens, rather than as a framework for market formation, enabling conditions. Empirical material was coded using the SOFIA approach and organised through three analytical categories (institutions, networks, cognitive frames), which structure both the results and the cross-case comparison. Industry 5.0 principles are used as evaluative criteria to interpret empirical findings across the three analytical categories. Institutional arrangements, network structures, and cognitive frames are evaluated in terms of their contributions to or obstructions of human-centricity, sustainability, resilience, and inclusive governance.

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Table 1: Codebook divided by categories and themes

Theme	Theme description
Category: Institutions	
Institutional engagement & strategic orientation	References to national/regional strategies, institutional mandates, or organisational roles in rural bioeconomy or innovation
Bottom-up vs Top-down governance dynamics	Tensions, complementarities, or failures in cooperation between central authorities and local stakeholders.
Funding availability, accessibility and limitations	Issues concerning availability of funds, administrative burdens, match funding, sustainability after funding, scale-up problems
Legislation, regulation and policy coherence	Misalignment of regulations, inconsistent legal interpretation, regulatory barriers to circular practices
Digitalisation and e-government barriers	Digital literacy, availability of digital public services, administrative digital tools
Governance capacities and administrative barriers	Bureaucratic inefficiencies, inconsistent local procedures, lack of coordination, weak advisory services
Category: Networks	
Local initiatives, community energy and embedded knowledge	Locally anchored practices, informal organisations, grassroots entrepreneurship, rural knowledge
Market integration and scale-up challenges	Difficulties transitioning from pilot projects to market, lack of cooperatives, inadequate economies of scale
Stakeholder collaboration & networks	Evidence of cooperation between universities, research institutions, civil society, farmers, businesses, clusters
Power asymmetries and unequal Participation	Unequal influence across actors, institutional dominance, marginalised groups
Innovation ecosystems and technological potential	Availability and use of technologies, digital tools, AI, new value-chain methods, robotisation
Category: Cognitive frames	
Civil society roles, capacities and limitations	Contributions of NGOs, their advocacy role, community connections, political tensions, and structural barriers
Social and generational factors	Demographic change, youth migration, attitudes of older versus younger farmers, cultural norms
Success stories and enabling factors	Concrete examples of successful bio-based initiatives and what enabled them
Long-term sustainability and future directions	Measures needed for durable bioeconomy transitions

Source: own work, 2025.

5 Results

Findings are presented in line with the analytical framework outlined in Table 1, which is structured around three overarching categories and their associated coding themes. The section emphasises cross-case patterns as well as region-specific distinctions across Slovenia, Montenegro, and Baden-Württemberg. Responses were coded based on the identified themes. The results are as follows:

5.1 Institutions

Institutional Engagement and Strategic Orientation

Across Slovenia, Montenegro, and Baden-Württemberg, institutions exhibit different levels of strategic maturity in rural bioeconomy development. Slovenian research organisations demonstrate a long-term commitment, having produced concrete innovations, such as bio-based packaging from tomato residues. Baden-Württemberg benefits from coherent regional planning supported by federal instruments. Montenegro, by contrast, appears to employ high-quality strategies that often fail to translate into effective implementation. This gap between aspiration and delivery reveals a structural weakness where political ambition and administrative capacity remain unaligned.

Bottom-Up vs Top-Down Governance Dynamics

Local initiatives in all regions demonstrate motivation and contextual expertise, yet central authorities often fail to recognise or support this potential. In Montenegro, bottom-up activity is widespread but undervalued. Slovenia's bottom-up processes are visible, but structurally limited by the absence of a regional structural organisation. Meanwhile, Baden-Württemberg benefits from more structured interactions; however, challenges emerge when initiatives extend beyond regional boundaries. The evidence for all regions in question suggests that top-down strategies remain overly bureaucratic and insufficiently adaptive to local realities.

Funding Availability, Accessibility, and Limitations

While focus group participants acknowledge that funding channels exist, these channels often remain inaccessible to rural actors due to the complexity of administrative processes. EU programmes are perceived as too bureaucratic and impose significant reporting burdens, leaving smaller organisations with limited human resources. Early-phase project funding is attainable; however, financing for scale-up is scarce, and private investors often show reluctance to enter uncertain markets. Slovenian and German actors are exploring alternative financial models, reflecting growing recognition that reliance on competitive EU calls is insufficient.

Legislation, Regulation and Policy Coherence

Regulatory frameworks often lag behind the principles of circularity. This was observed in cases such as waste classification rules, where certain rules, particularly those applicable to Slovenia, hinder the transformation of waste streams into secondary raw materials. Such a situation discourages circular practices. In Montenegro, strategies and laws exist, but they are inconsistently interpreted and poorly coordinated across institutions. Exhibited legal and policy incoherence creates uncertainty and limits the scope for experimentation required in the bioeconomy.

Digitalisation and E-Government Barriers

Digitalisation is viewed as essential but remains unevenly developed. Montenegro, in particular, faces challenges with limited digital services, weak institutional coordination, and low citizen digital literacy. These barriers hinder access to funding, administrative processes, and the adoption of innovative solutions. Systematic investment in digital education and interoperable public services is necessary in the context of Montenegro.

Governance Capacities and Administrative Barriers

Administrative inefficiency consistently emerges as a significant obstacle in all the countries in question. Montenegro faces acute challenges: inconsistent procedures, weak advisory services, and a lack of basic producer data at the municipal level. Even in Slovenia and Baden-Württemberg, complex administrative requirements limit the participation of stakeholders across value chains in the bioeconomy. These barriers disproportionately affect small producers, reinforcing existing inequalities and hindering the uptake of innovation.

These institutional barriers directly undermine the human-centric and resilience-oriented objectives of Industry 5.0. From the perspective of the research question, these findings suggest that institutional enablers and barriers at multiple governance levels significantly influence whether rural bioeconomy strategies can transition from formal alignment with Industry 5.0 principles to their practical implementation.

5.2 Networks

Local Initiatives, Community Energy, and Embedded Knowledge

Grassroots initiatives showcase the potential of community-driven innovation, particularly emphasised in Montenegro. It is in Montenegro that examples from women-led wool valorisation groups and local composting projects illustrate practical and

socially embedded solutions. Such initiatives, however, receive limited recognition from central authorities, reflecting a persistent undervaluation of local knowledge and bottom-up leadership.

Market Integration and Scale-Up Challenges

Transitioning from pilot activities to market-ready solutions remains difficult across regions. Many rural actors lack the financial and organisational capacity to scale up, and cooperative structures are often underdeveloped. Perceptions that bio-based products are inherently more costly discourage broader market adoption. These structural limitations hinder the evolution of pilot projects into enduring economic activities.

Stakeholder Collaboration and Networks

Cooperation among research institutions, civil society, farmers, and businesses forms the backbone of many successful initiatives. This holds true for all three countries. Examples include Slovenian research–industry partnerships and Montenegro’s NGO-led rural engagement. Networks, however, are often dependent on project funding and tend to dissolve once the financial cycle ends. Sustained collaboration requires more institutionalised structures that go beyond temporary project formats.

Power Asymmetries and Unequal Participation

Larger institutions and well-resourced actors remain better positioned to shape bioeconomy agendas, while smaller producers and local communities struggle to access funding or influence policy. Potential political tensions between NGOs and state actors can further complicate the process of inclusive governance. These asymmetries risk undermining efforts toward socially equitable bioeconomy transitions.

Innovation Ecosystems and Technological Potential

Technological tools, such as digital material stream analytics, wastewater reuse technologies, and early-stage agricultural automation, offer promising opportunities for improvement. Slovenia and Baden-Württemberg appear better positioned to adopt these innovations, while Montenegro struggles with digital literacy and limited infrastructure. Technology alone cannot compensate for institutional weaknesses, but it remains an important enabler when embedded within supportive governance systems.

The project-based nature of networks limits the development of resilient and inclusive Industry 5.0-aligned ecosystems. This demonstrates that, within a multi-level stakeholder governance context, network stability and institutionalization function as key enablers for

Industry 5.0 goals, while project dependence constitutes a structural barrier to resilience and long-term transformation.

5.3 Cognitive frames

Civil Society Roles, Capacities and Limitations

Civil society organisations play a central role in supporting rural actors, particularly in Montenegro, where NGOs enjoy higher levels of trust among citizens than state institutions. They contribute to capacity-building, advocacy, and direct mentorship. Yet political scepticism, limited financial stability, and constrained access to policymaking processes restrict their broader systemic influence. In Germany, resource limitations prevent many NGOs from participating meaningfully in strategic debates.

Social and Generational Factors

Demographic change and generational divides shape rural innovation trajectories. Older rural residents often lack digital competencies, while younger people may lack motivation to remain in agriculture or rural areas. Participants argue that broader cultural change is essential to avoid deepening social and economic decline. Within this context, initiatives such as campaigns to valorise rural entrepreneurship were outlined.

Success Stories and Enabling Factors

Examples such as Slovenia's tomato-stem packaging and Montenegro's composting initiatives demonstrate that progress is possible when local demand, cross-sector collaboration, and appropriate funding align. Clusters and regional cooperation can enhance the likelihood of success, but such cases remain exceptions rather than systemic patterns.

Long-Term Sustainability and Future Directions

Long-term progress was noted to require stable financial frameworks, market development, legislative reform, and stronger local governance capacities. Participants emphasise that project-based interventions are insufficient. Without systemic changes in addressing markets, governance, and cultural barriers, the bioeconomy risks remaining fragmented and failing to deliver transformative outcomes. These cognitive frames shape how stakeholders perceive legitimacy, risk, and opportunity, thereby mediating the effectiveness of governance arrangements and influencing whether Industry 5.0 principles are internalised or remain abstract policy narratives.

The results suggest that rural circular bioeconomy development does not fail at a single point but at the intersection of institutions, networks, and cognitive frames: where institutions can implement strategies (not merely produce them), where networks remain stable beyond project cycles, and where collaboration and trust dominate the prevailing mindset, tangible innovations and steps toward market uptake emerge. Conversely, in contexts marked by a persistent strategy–implementation gap, weak digital and administrative capacity, and uneven power distribution among actors, innovation tends to stall at the pilot level. Local initiatives remain largely supported through informal arrangements, and the system remains fragmented. In comparative terms, Baden-Württemberg exhibits more coherent institutional support and vertical coordination. Slovenia demonstrates relatively strong research-to-innovation examples but faces constraints in coordination and scaling. Montenegro exhibits high bottom-up energy, yet it encounters the strongest barriers in implementation capacity, digitalization, and the formal integration of civil society into decision-making processes.

6 Discussion

This discussion directly addresses the research question of how multi-level stakeholder governance enablers and barriers shape the implementation of rural bioeconomy in relation to Industry 5.0 normative guidelines. The findings confirm that the implementation of the rural bioeconomy in line with Industry 5.0 is primarily a multi-level stakeholder governance problem rather than a technological one. In stakeholder governance, value creation depends on governance arrangements that mitigate collective action problems and sustain cooperation among interdependent actors through perceived fairness, voice, and credible commitments (Freeman, 1984; Bridoux & Stoelhorst, 2022). Industry 5.0 adds a normative benchmark: transitions should be human-centric, sustainable, resilient, and democratically legitimate (Breque et al., 2021). Our cases demonstrate that the gap between ambition and delivery arises when these normative expectations intersect with the realities of fragmented institutions, unstable coordination, and contested legitimacy—classic failure modes of multi-level governance in territorially embedded transitions.

Institutional barriers in the cases can be explained as coordination failures across levels and sectors. Multi-level governance requires the alignment of policy objectives, rules, and instruments across ministries, agencies, regions, and municipalities—especially when policy issues encompass climate change, biodiversity, agriculture, waste/circularity, innovation, and regional development (European Commission, 2018b; Lange et al., 2021). Where alignment is weak, actors face contradictory signals and inconsistent regulatory interpretation. In governance theory terms, this increases transaction costs (time, compliance, uncertainty), which disproportionately burdens small rural actors and undermines inclusive stakeholder participation—directly conflicting with Industry 5.0’s human-centricity. From an Industry 5.0 perspective, such institutional

failures undermine human-centricity and democratic legitimacy by systematically excluding less-resourced rural stakeholders from meaningful participation.

A second institutional barrier concerns implementation capacity. Mission-oriented strategies can create compelling narratives, but without administrative capacity and enabling instruments, they remain “strategy without delivery” (Mazzucato, 2018). The cases illustrate this mechanism clearly: even where strategies are comparatively mature, administrative burdens, regulatory lag, and insufficient scale-up instruments prevent pilots from becoming durable territorial pathways. Montenegro exemplifies this mechanism in a more pronounced form: strategic ambition is evident, yet execution is constrained by limited administrative capabilities and weak institutional interoperability. Theoretically, this is not a “Montenegro problem”; it is the predictable outcome when institutional design over-emphasises planning and under-invests in delivery capacity at the subnational level.

From a stakeholder governance perspective, the most relevant institutional enablers are those that reduce transaction costs and make participation feasible for less-resourced stakeholders, including coherent regulatory interpretation, simplified procedures, advisory capacity, interoperable e-government, and funding designs that reward long-term collaboration and scale-up rather than merely compliant reporting. This reframes “administrative simplification” as a fairness mechanism, reducing structural exclusion and enhancing the perceived legitimacy of the transition.

The analysis of networks suggests that many promising rural bioeconomy initiatives are effectively “projectified”. Cooperation between research institutions, civil society organisations, farmers, and businesses often depends on time-limited project funding, and networks tend to weaken once funding cycles come to an end. Even in Baden-Württemberg, where regional planning and cluster structures are comparatively strong, respondents highlight difficulties in maintaining collaboration beyond specific initiatives or administrative boundaries. In Montenegro, vibrant grassroots activity – including women-led wool initiatives and composting projects – remains weakly connected to formal innovation systems and lacks stable institutional support. This stands in tension with Industry 5.0’s emphasis on ecosystem collaboration and mission-oriented, multi-actor partnerships (Breque et al., 2021; Directorate-General for Research and Innovation, 2024) and with stakeholder governance approaches that conceive firms and territories as nexuses of formal and informal contracts linking diverse stakeholders (Jones, 1995; Freeman & Phillips, 2002). The results, therefore, add empirical weight to concerns that, without institutionalised and durable network structures, stakeholder rhetoric may obscure rather than resolve underlying coordination problems. The network findings are best interpreted through theories of network governance and stakeholder coordination. Stakeholder governance assumes that cooperation can be sustained when actors perceive a fair distribution of value and can rely on stable relationships (Bridoux & Stoelhorst,

2022). In practice, many rural bioeconomy initiatives are “projectified”: cooperation is assembled around time-limited funding and dissolves when projects end. This produces weak credible commitment and limited accumulation of relational capital—so learning, trust, and coordination costs reset every cycle. In Industry 5.0 terms, this undermines resilience: ecosystems cannot become robust if they are structurally temporary.

This is why intermediaries matter, both theoretically and practically. Durable intermediaries (cluster organisations, cooperatives, regional coordinators, boundary spanners) function as governance infrastructure: they lower coordination costs, stabilise cooperation beyond programme cycles, and help resolve conflicts across administrative boundaries. Without them, “stakeholder governance” becomes rhetorical—an invitation to collaborate without institutional conditions that make collaboration sustainable. This so-called project-based logic stands in clear tension with Industry 5.0’s emphasis on resilience, which presupposes continuity, learning, and durable stakeholder relationships rather than episodic cooperation (Bhiri, 2025; Lampel, 2011).

Power asymmetries reinforce these network failures. When better-resourced actors dominate agenda-setting and access to funding, stakeholder governance fails its own premise of fairness: those who must implement change locally become peripheral. This also reduces effectiveness because territorially misaligned solutions emerge when implementers lack a voice. A direct theoretical implication is that inclusive partnerships are not only normative but also efficiency-enhancing, as they improve problem-fit and implementation feasibility.

Cognitive frames further mediate these institutional and network dynamics. Across regions, civil society organisations are recognised as crucial intermediaries, particularly in Montenegro, where NGOs enjoy relatively high levels of trust and play a central role in capacity-building and mentoring. Yet they operate under conditions of financial precarity, political scepticism, and limited access to formal decision-making arenas – an empirical illustration of theoretical arguments about stakeholders outside the firm who nevertheless invest in firm- or system-specific assets that are vital for value creation (Brandenburger & Stuart, 1996; Bridoux & Stoelhorst, 2022). Demographic change and generational divides amplify these tensions: older rural residents often lack digital competencies, while younger people are reluctant to remain in agriculture or rural areas, reflecting wider cultural narratives that undervalue rural entrepreneurship and bio-based innovation (Klerkx et al., 2019; Gangaliuc, 2022). These findings underscore that human-centered Industry 5.0 futures cannot be built solely on technological upgrading; they require shifts in societal attitudes, recognition of local knowledge, and explicit efforts to mitigate social fragmentation.

The three categories – institutions, networks, and cognitive frames – thus jointly reveal a tension between the normative promises of stakeholder governance and Industry 5.0 and

the realities of rural bioeconomy development. Theoretically, stakeholder governance assumes that value creation and value capture can be aligned through mechanisms that ensure perceived fairness and sustain cooperation (Bridoux & Stoelhorst, 2022; Zollo et al., 2018). In practice, our cases reveal institutions that remain rigid, fragmented, and risk-averse; networks that are episodic and overly reliant on project logic; and cognitive frames that continue to privilege expert and centralized perspectives over local, experiential knowledge. Against this backdrop, the role of citizens emerges as both constrained and potentially transformative. On the one hand, their capacity to act as co-producers of bioeconomy trajectories is limited by information asymmetries, uneven access to digital tools, and the absence of stable markets for many bio-based products (Gaffey et al., 2021). On the other hand, the evidence around short supply chains, regional quality schemes, and local brands aligns with research on circular and regional bioeconomy pathways (Korhonen et al., 2018; Uršič et al., 2024; Buruleanu et al., 2025). These asymmetries contradict the Industry 5.0 assumption that industrial and bioeconomic transitions should be co-shaped by those most affected by their outcomes.

Taken together, the chapter's comparative perspective across Slovenia, Montenegro, and Baden-Württemberg supports the view that aligning rural bioeconomy strategies with Industry 5.0 is fundamentally a governance challenge, not a technological one. Industry 5.0 has been conceptualised as a normative and institutional framework that links competitiveness to sustainability, circularity, and human-centricity (Breque et al., 2021; Alves et al., 2023), while the bioeconomy has been framed as a systemic transition towards renewable, circular use of biological resources (European Commission, 2018b; Wreford et al., 2019). Our findings suggest that these agendas can only converge if multi-level stakeholder governance is strengthened along three dimensions: (i) reducing administrative and regulatory barriers that disproportionately affect small producers; (ii) moving beyond project-based collaboration towards more institutionalised, long-term network structures; and (iii) addressing social and generational divides through targeted support for skills, civic engagement, and rural entrepreneurship. These are not marginal "accompanying measures", but preconditions for realising a human-centred, sustainable and resilient bioeconomy, consistent with recent calls for more reflexive, justice-oriented understandings of circular and bio-based transitions (Korhonen et al., 2018; Uršič et al., 2024).

At the same time, the study has limitations that delimit the scope of its conclusions. The empirical base is limited to three European regions and relies on qualitative expert discussions combined with grey literature, which restricts representativeness and fails to capture the full diversity of rural bioeconomy trajectories within or beyond the EU. The coding framework, while systematic, reflects specific theoretical choices – stakeholder governance, Industry 5.0, and bioeconomy – and may underplay other relevant dimensions such as land-use conflicts or global value-chain dynamics. Nonetheless, the cross-case patterns identified here highlight governance bottlenecks that are likely to be

relevant in other rural contexts and provide a conceptual and empirical basis for more fine-grained, future research on how consumers and citizens can be meaningfully integrated into bio-based, Industry 5.0-aligned development pathways. Thus, the empirical evidence confirms that Industry 5.0 can only function as a meaningful orientation for the rural bioeconomy if stakeholder governance arrangements are capable of translating normative ambitions into territorially embedded practices.

7 Conclusions

There are numerous chances to further sustainability objectives at the nexus of Industry 5.0 and rural bioeconomy development. However, comprehending the major enablers and barriers that influence governance frameworks is essential for successful implementation.

The objective of this paper is to highlight that the implementation of the rural bioeconomy in line with Industry 5.0 primarily hinges on the quality of multilevel stakeholder governance—rather than technology—and that without institutional, network, and cognitive conditions, Industry 5.0 remains a normative ambition without real-world implementation.

The chapter identifies several governance enablers that align closely with Industry 5.0 principles of human-centricity, collaboration, resilience, and sustainability. These enablers include institutions capable of implementing strategies rather than merely designing them, stable stakeholder networks that persist beyond short-term project cycles, trust-based collaboration and shared cognitive frames, and the emergence of tangible innovations with pathways toward market uptake.

At the same time, the analysis clearly outlines governance barriers that hinder effective implementation. These include persistent strategy–implementation gaps at the institutional and policy levels, weak digital and administrative capacity, uneven power distribution among stakeholders, and fragmented systems that rely heavily on informal arrangements. Where such barriers dominate, innovation tends to remain confined to pilot projects, coordination across governance levels is constrained, and the rural bioeconomy struggles to scale in a systemic and durable manner.

The findings indicate that the development of rural circular bioeconomies does not fail at a single spatial or organizational level, but rather at the interface between institutions, networks, and dominant cognitive frames. Meaningful innovation and progress toward market uptake emerge when institutions possess the capacity to implement strategies rather than merely formulate them, when cooperation networks remain stable beyond short-term project cycles, and when trust-based collaboration prevails among relevant actors.

In contrast, innovation frequently stagnates at the pilot stage in contexts characterized by persistent gaps between strategic planning and implementation, limited digital and administrative capacity, and asymmetrical power relations among stakeholders. In these situations, local initiatives are often supported by informal agreements rather than formal support systems, and the governance structure remains disjointed.

In conclusion, the findings imply that inclusive stakeholder governance improves efficiency and is normatively desirable. It increases implementation feasibility and improves the alignment between policy instruments and context-specific challenges, consequently strengthening long-term systemic resilience.

Advancing the rural bioeconomy within an Industry 5.0 framework, therefore, depends less on technological readiness and more on the redesign of governance systems that can sustain collaboration, embed trust, and translate strategic ambition into durable territorial transformation.

An organized approach to governance can mitigate the detrimental impacts of conflicting interests that often impede progress within industrial sectors (Bingham et al., 2005). By pursuing collaborative initiatives while reinforcing regulatory frameworks, the EU can ensure that the transition to Industry 5.0 addresses not only technological advancements but also the socio-economic dimensions of industrial development. The analysis reinforces the notion that effective rural circular bioeconomy development requires governance frameworks that can sustain collaboration, trust, and strategic alignment. Strategies must aim to bridge implementation gaps and empower local stakeholders, making inclusive governance not only desirable but essential for ensuring the alignment of policy instruments with local challenges.

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