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D4.4 – INVENTORY OF BARRIERS AND OPPORTUNITIES RELATED TO SOCIAL INNOVATION ASPECTS

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LIST OF ABBREVIATIONS

Abbreviation	Definition
ToC	Theory of Change
FEBA	The European Food Bank Federation
FEAD	European Aid to the Most Deprived
ESF	European Social Fund
VET	Vocational Education and Training
DIHs	Digital Innovation Hubs
STEM	Science Technology Engineering & Mathematics
CBE	Circular Bioeconomy





1 EXECUTIVE SUMMARY

This document, identifies critical social barriers and opportunities for developing a sustainable bioeconomy. While the bioeconomy is vital for sustainability, its social dimension is often overshadowed by economic and ecological aspects. Addressing these social challenges is crucial for successful and equitable bioeconomy implementation.

Key social barriers include:

- **Consumer and Citizen Acceptance:** Despite general appreciation for the principle of renewables, public understanding of bioeconomy concepts remains limited. Scepticism about the functionality of new bio-based alternatives, such as bioplastics, and novel food products like algae, is prevalent. Acceptance is heavily influenced by cultural values, local context, perceptions of "naturalness," trust, and knowledge gaps, making consumer education a significant challenge.
- **Stakeholder Involvement:** Broad stakeholder engagement is often lacking, with decision-making dominated by a "triple helix" of government, academia, and industry. Primary producers and civil society are often marginally included, or their valuable knowledge is underutilized. Structural barriers like fragmented land ownership also hinder coordinated efforts in sectors like forestry.
- **Lack of a Long-Term Vision:** Many EU countries lack comprehensive national bioeconomy strategies, leading to challenges such as competition for land use (e.g., "food vs. fuel" dilemma), insufficient structural funding for vital initiatives like food redistribution platforms, and a shortage of professional education and expertise building in the sector. Monitoring frameworks for social impact are also underdeveloped.
- **Risk of Increased Inequality:** There is a concern that the economic benefits of the bioeconomy may disproportionately accrue to large corporations, potentially exacerbating global geographical inequalities (e.g., sourcing from the Global South) and socioeconomic disparities. Furthermore, issues of gender inequality and discrimination are often overlooked, and vulnerable consumers may face higher prices for bio-based products. Primary producers also struggle to access new markets and benefit meaningfully.
- **Lack of Data and Data Sharing:** Obtaining reliable social data for Social Life Cycle Assessment (S-LCA) is difficult due to the sensitive nature of the information, companies' lack of data collection structures, and scepticism about sharing. Key data gaps include fair wages and salaries across industries. There is a significant need for updated, open-access databases and improved dissemination of research results, as well as better sharing of biological data and standardized national monitoring systems for bioeconomy indicators.

To overcome these barriers, we draw inspiration from existing social innovations, which involve new ideas, relationships, and collaborations to fulfil social needs. Examples include food redistribution initiatives and various social innovations within the forest sector, such as "Social Biomass Farms" and cooperative district heating systems. Digital Innovation Hubs are also





highlighted as tools to boost biomass valorisation by engaging diverse stakeholders. Coordinated efforts, including targeted education, fostering stakeholder collaboration, developing long-term policies, and improving data availability and exchange, are essential for a truly sustainable and socially just bioeconomy.





2 INTRODUCTION

2.1 GOAL AND THEORETICAL FRAMEWORKS

ToBeReal aims to support bioeconomy innovations to further develop, scale and become flagship projects. The social dimension is recognized as one of the **crucial success factors**. It is therefore integrated as a pillar of structural support services for the selected bioeconomy innovations. This means that the innovations will be evaluated on their social readiness and potential to increase the social impact and a sustainable use of resources. Similar as for the other pillars we will describe the social dimension of bioeconomy and map the barriers related to social innovations in bioeconomy. This mapping will allow us to better understand the needs of our selected projects and support the development of structural support services and suitable capacity building activities.

In the following sections of this chapter we will explain the theoretical frameworks and the methodology used to understand and map the barriers of bioeconomy followed by a description of what bioeconomy is and how it can be regarded from a social perspective. In **chapter three** we will examine social barriers and opportunities first from the consumer/citizen perspective and next from a broader stakeholder perspective. The remainder of chapter three will focus on three social barriers and look at them from a mixed stakeholder perspective. The three identified barriers are the lack of a long term vision, the risk of increased inequality and finally the lack of data sharing. In **chapter four** we will distil the main research gaps and limitations on the topic of the social dimension of bioeconomy. **Chapter five** will describe some existing social innovations in bioeconomy to provide inspiration for our projects and suggestions for capacity building activities that are described in **chapter six**.

2.2 THEORETICAL FRAMEWORKS USED

This document aims to examine the bioeconomy from a **systemic perspective**. By “systemic,” we refer to social-ecological systems that form the foundation of a bioeconomy and need to be considered as complex (adaptive) systems. The dynamics of these systems are characterized by indeterminacy and non-linear feedbacks, necessitating a holistic understanding of the various factors and actors influencing developments on the ground (Spies, Zuberi, Mähliis, & Zakirova, 2022). Since D4.1, D4.2 and D4.3 are focusing on the other relevant dimensions we will keep a focus on the social dimension but whenever relevant we will include insights from other dimensions to fully understand the social aspect.

In order to engage stakeholders in a structured but flexible approach and facilitate meaningful discussions on social sustainability we will follow a **Theory of Change (ToC)** approach throughout the ToBeReal project. The ToC is a structured framework used for planning, monitoring, and evaluating projects, particularly those focused on social and environmental impact. It helps organisations define their long-term goals and map out the necessary steps to achieve them. The key elements of ToC include the:

- Impact, which represents the ultimate change the project aims to achieve;





- Outcomes, which are the intermediate changes required to reach the impact, such as behavioural, social, or economic improvements;
- Outputs, which are the direct results of project activities; Activities, referring to the specific actions taken to produce the outputs;
- Inputs, which are the resources needed for implementation;
- Assumptions, which are external factors influencing success, and Indicators, which serve as measurable signs of progress toward achieving the desired impact.

In ToBeReal we will support projects in identifying key impact areas, defining desired outcomes, mapping activities that contribute to these outcomes, and establishing indicators to track progress. This implementation will take place through various engagement formats such as workshops, B2B meetings, in-person discussions, and collaborative sessions during the project's execution.

2.3 METHODOLOGY

This document aims to **bring together existing scientific and grey literature** on the social dimension of bioeconomy as well as knowledge from the field via three expert interviews. Literature was selected using the search terms in Table 1 in different scientific search engines, elicit and in google. Additionally, WP4 partners shared relevant documents.

Table 1: search terms used

Search terms used
Bioeconomy social barriers
Bioeconomy social innovation
Social innovation framework
Social dimension bioeconomy
Consumer acceptance of new products in EU
Cultural influences on Bioeconomy adoption
Social LCA bioeconomy
Educational gaps bioeconomy
Data sharing bioeconomy

Expert interviews were conducted with three industry experts from three different countries. They were selected via the ToBeReal consortium network in widening countries. The semi-structured interviews consisted of open-ended questions and prior to the interviews, these questions were shared with the WP4 partners for feedback. The interviews were transcribed and summarized. In each summary we start with providing the context of the region of expertise of the interviewee to continue with the main barriers for bioeconomy and we conclude with opportunities for the future. Transcriptions are available upon request, and the summaries are included in annexes II, III and IV. Interview summaries were shared with the interviewees so that they could correct potential misinterpretations. Throughout the document, we refer to the content of these interviews where





relevant and always clearly indicating the exact interview that we are relying on. These are the three interviews:

- Interview 1: Expert on biomass valorisation, industry association, Greece
- Interview 2: Professor in Biotechnology, University, Slovenia
- Interview 3: Social sciences researchers, International consulting company, Portugal & EU wide. For this interview two social scientists from the same company were interviewed at the same time. Their expertise was more EU wide even though the company is situated in Portugal.

2.4 WHAT IS BIOECONOMY?

Within the scope of the ToBeReal project, bioeconomy is defined as *“an economy based on biological resources that works in tandem with natural capital and industrial sectors to meet the needs of European citizens while protecting the environment for future generations”*. (Neill, O'Donoghue, & Stout, 2023). It should be noted that there is **no singular definition of bioeconomy** to date. According to the EU's Bioeconomy strategy (Updated Bioeconomy Strategy, 2018) *“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, i.e. 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. It cuts across these sectors and systems, interlinking them and creating synergies.”*

ToBeReal is focused on using renewable resources like animals, plants, micro-organisms and related biomass, organic waste, biogenic CO₂, in a sustainable way. Pharmaceutical and biomedical sectors are out of scope for ToBeReal. The following **bioeconomy sectors** are in scope for the ToBeReal project:

- Food and animal feed;
- Biobased products;
- Bioenergy Services.

Bioeconomy thus includes and interlinks land and marine ecosystems and the **ecosystem services** that are provided by them. It is interesting to look at the different services that are provided by healthy ecosystems to grasp the importance of a sustainably developed bioeconomy (Updated Bioeconomy Strategy, 2018):

- Habitat maintenance;
- Sustaining food and biomass production;
- Pollination;
- Regulation of fresh water quantity and quality;





- Soil formation;
- Balanced nutrient cycling;
- Regulation of floods;
- Climate regulation.

In order to safeguard the balance and health of these ecosystems, it is paramount to **avoid overexploitation and to maintain a balanced ecosystem supply chain**. For example, EU forests supply wood to existing wood-processing industries to meet the growing demands from bio-based materials and products, but they also provide important functions such as carbon sequestration, nature conservation, recreation and soil protection. In the agri-food industry, this would mean supporting farming systems that make efficient use of ecosystem services and follow the principles of agroecology (organic farming, mixed farming, agroforestry) (Updated Bioeconomy Strategy, 2018).

To come to a holistic understanding of bioeconomy, it is important to understand the **objectives of the European Bioeconomy Strategy**. The EU lists the following five objectives:

- Ensuring food and nutrition security: Food and farming systems account for about three-quarters of the overall bioeconomy employment and about two-thirds of bioeconomy turnover. However, their sustainability is challenged by a growing world population, changing consumption and nutrition practices, unsustainable biomass use and waste, and climate change threats.
- Managing natural resources sustainably: This is more important than ever in the current context of increasing environmental pressures and biodiversity loss.
- Reducing dependence on non-renewable, unsustainable resources, whether sourced domestically or from abroad.
- Mitigating and adapting to climate change, i.e., reducing greenhouse gas emissions.
- Strengthening European competitiveness and creating jobs is a core policy objective of the bioeconomy.

2.5 EXAMINING BIOECONOMY FROM THE SOCIAL DIMENSION

The social dimension of the bioeconomy has traditionally received less attention compared to its economic and ecological aspects (Ferreira, Fabregat-Aibar, Pié, & Terceno, 2022). However, interest in this area is increasing. Existing research primarily addresses **job creation, regional development, and the acceptance of bioeconomy products**. Nonetheless, topics such as social justice, the impact of bioeconomy on local communities, cultural values and perceptions related to bioeconomy, and stakeholder power dynamics warrant further investigation (Rebolledo-Leiva, Moreira, & Gonz'alez-García, 2023).

The bioeconomy is considered to have the potential to help address climate change and biodiversity challenges while bringing social benefits and being economically compatible with the current system (Neill et al., 2023). According to the most recent figures, however, we still see that countries with a





high share of bioeconomy jobs often have a lower value added generated by bioeconomy (Lasarte-López, Ronzon, & M'barek, 2023) and vice versa. This indicates that the social benefits in terms of job creation are not directly proportional to the value created by the bioeconomy. How much value is created varies for different bioeconomic sectors. Typically, those sectors that provide a lot of employment are less productive. This observation points out that when looking at measures like added value or job creation alone, we cannot assess the social impact of the bioeconomy. We need to **take into account the local context to understand the social dimension of the bioeconomy**. It is important to note that there are large differences between European countries in terms of the most active bioeconomic sectors; there is not one European bioeconomy. That is why it is important to have country-specific bioeconomy strategies. Currently, there are over 60 different national bioeconomy strategies (Teitelbaum, Boldt, & Patermann, 2020).

So, how can we assess the social dimension of bioeconomy? In terms of monitoring the social impact of the bioeconomy, the main instrument is the **Social Life Cycle Assessment (S-LCA)**. S-LCA studies often group social concerns by stakeholders (local community, workers, society, consumers, value chain actors, and children). Indicators and subcategories mentioned in S-LCA discussions include:

- Working Conditions: wages, health and safety at work, working hours, training and education, and employment. Employment is one of the most analysed social variables.
- Local Community: land use and development, access to natural resources, cultural heritage, community engagement, local employment, and infrastructure. Access to material resources is important due to its implications for the bio-economic model and the social repercussions for local communities.
- Society: human rights (including non-discrimination and gender equality), peace, and governance. However, issues like corruption, poverty, and respect for indigenous rights are underrepresented.
- Consumers: health and safety for end-users, transparency, and responsibility for end-of-life management. Consumers are one of the least studied stakeholders in S-LCA within the bioeconomy.
- Value Chain Actors: fair competition and intellectual property rights.
- Children: education, health issues, marketing concerns. This stakeholder category was introduced only recently.

However, there is currently **no clear indication of a standardised set of social indicators** being officially used for EU-wide monitoring of the bioeconomy; this area is rather characterised by ongoing research and the development of methodologies (Rebolledo-Leiva, Moreira, & González-García, 2023). They are currently not user-friendly enough to be offered as a service to the ToBeReal projects. However, we will offer a service in which the selected ToBeReal projects will be able to identify the desired (social) outcomes of their project and map them using the Theory of Change (see section 2.2). We will further assist in attributing weights to the different outcomes with the aim of triggering a qualitative discussion on the social sustainability of the developed solution.





Another assessment framework for the social dimension of bioeconomy is the **Integrated Sustainability Assessment Tool**: The Integrated Assessment Tool (IAT), a framework for circular bioeconomy indicators that includes 48 sustainability indicators and is designed to quantify social and environmental impacts. It is considered an indicator of integrated sustainability performance encompassing environmental, economic, and social dimensions (Mesa, Sierra-Fontalvo, Ortegón, & Gonzales-Quiroga, 2024).

What we often see, however, is a **conflict between diverse sustainability goals and economic reality**. The economic drive for large-scale biomass production can lead to competition for land traditionally used for food production (the "food vs. fuel" dilemma) (Alexia, Esteban, & Garrido, 2019). This has direct social consequences, such as impacts on food security and land rights, particularly for small farmers in both the Global North and South (Spies, Zuberi, Mähliß, & Zakirova, 2022).

It is also important to realise that **some sustainability dimensions or objectives** cannot be substituted or traded for others: they are **non-compensable**. The SDG goals should be viewed as a whole, and assuming a compensatory character among them should be avoided. Environmental impacts cannot, for example, compensate for hunger, despite their complex relationship. This underscores the complexity of sustainable development and the need to consider the interconnectedness of different goals without assuming they are simply interchangeable based on assigning weights or scores (Zeug, Bezama, Moesenfechtel, Jähkel, & Thrän, 2019).

To allow a sustainable and socially fair approach to bioeconomy, it is crucial that we use our limited resources in the best possible way. This is in line with the philosophy behind the **waste cascade**, a core concept in the Circular Bioeconomy. In essence, the waste cascade aims to enhance sustainability by transforming organic waste into valuable resources through systematic, prioritised, and sequential utilisation, enabled by technological and organisational advancements, with the aim of achieving resource efficiency and closed loops (Gaëtan, 2022). The cascade implies a hierarchy or sequence of applications. This hierarchy prioritises using organic materials for applications that offer the highest potential value (whether economic, environmental, or social) before they are channelled into less valuable uses. For example:

- Priority might be given to food and feed production where there is a conflict with land use for other purposes.
- Residues can be directed towards high-value products like bioactive compounds or bioplastics through processes such as biorefinery.
- 'Upcycling' food waste into products for human consumption is positioned high in the hierarchy, after direct redistribution or donation, but before uses like animal feed or energy recovery.
- Lower-value applications like energy recovery (e.g., biogas production through anaerobic digestion) or use as fertiliser are considered later steps in the cascade, although they are still significantly better than landfilling or incineration without energy recovery.





In the wood sector, the **Cascade Factor** is used to monitor and quantify the flow and utilisation of wood resources, emphasising cascading use. Its methodology involves detailed wood flow analysis (Mesa, Sierra-Fontalvo, Ortegon, & Gonzales-Quiroga, 2024). Such monitoring would also be useful for other sectors, such as food waste valorisation. In Flanders, for example, a quite straightforward cascade index is calculated for different actors in the food chain (Braekevelt, et al., 2023). Although metrics are being developed, there is no universally adopted “cascade index” yet that systematically measures how well biomass follows the cascading use principle.

In conclusion, **interdisciplinary approaches and a systems perspective on bioeconomy** are needed. Developing a sustainable bioeconomy is not only a technological challenge but also a organisational and societal one. To make this transition possible we need to transform existing sectoral and societal structures to create new sustainable value chains (Gottinger, Ladu, & Quitzow, 2020). It is important to keep in mind that the social dimension is strongly context-based, which limits the generalisation of the findings. To fully understand the local context, stakeholder involvement is key. It is also paramount in order to develop the bioeconomy in a community-supported way. But involving stakeholders is very challenging. We will discuss some relevant stakeholders’ roles in the bioeconomy, the challenges they face and the resulting barriers in the following chapters.

3 SOCIAL BARRIERS AND OPPORTUNITIES IN DEVELOPING THE BIOECONOMY

This chapter starts with an exploration of the multifaceted factors influencing consumer and citizen acceptance of the bioeconomy. It highlights how cultural values, perceptions of naturalness, trust, knowledge, and perceived benefits versus risks shape public attitudes toward bio-based innovations. The discussion emphasizes the importance of understanding regional differences, social perceptions, and educational gaps, which are critical for fostering broader acceptance and sustainable development. Additionally, the chapter examines the roles of other stakeholders, long-term strategic visions, social impacts, and data sharing challenges, all of which are essential components in building an inclusive and effective bioeconomy framework. By addressing these social and cultural dimensions, this chapter aims to guide stakeholders in developing strategies that are socially acceptable, equitable, and aligned with long-term sustainability goals.

3.1 CONSUMER/CITIZENS ACCEPTANCE: CULTURAL VALUES AND PERCEPTIONS

Research indicates a **general appreciation** in citizens for the principle of replacing fossil resources with renewables in the bioeconomy and a perceived urgent need to reconsider consumption styles for environmental protection (Dallendörfer, Dieken, Henseleit, Siekmann, & Venghaus, 2021). **Consumer acceptance** of bioeconomy products or services is however influenced by cultural values, local context, perceptions of naturalness, trust, knowledge & awareness, and perceived benefits versus risks. These key factors are discussed in more detail in the following sections.





3.1.1 Cultural Values and Local Context

Research on consumer acceptance of novel food technologies and bioeconomy innovations highlights the importance of cultural values, local context, trust, and individual perceptions. The bioeconomy literature recognizes consumers as **active participants rather than passive recipients**, emphasizing their shared responsibility in shaping sustainable practices (Ulrich Wilke et al., 2021). However, there is a need for more holistic exploration of consumers' roles and responsibilities in the bioeconomy, considering local contexts and cultural factors to better understand and promote acceptance of novel technologies and practices. This was also mentioned in interview three where the acceptance of the taste and texture of aquaculture-based food production like algae is mentioned as a challenges.

Different cultures emphasise different priorities, shaping attitudes towards sustainability and technology. For instance, **collectivist cultures** may be more accepting of policies or technologies that support environmental goals if they align with the common good, while **individualistic cultures** may focus more on personal benefits or freedom of choice (Rahman, Kabir, Talukdar, & Anwar, 2023).

Another example is **rural communities** with strong agricultural backgrounds. They may have different views on bio-based agriculture or GMOs compared to **urban consumers**, who might focus more on product packaging or the energy consumption of new technologies (Banovic and Grunert, 2023). Furthermore, in **lower-income regions**, where price sensitivity is a major consideration, acceptance of bioeconomy products may be lower if these products are (perceived as) too expensive or difficult to access.

3.1.2 Perceptions of Naturalness and Trust

Consumers' attitudes towards new technologies such as prevalent in bioeconomy are influenced by heuristics, perceived naturalness, and trust in the industry (Siegrist & Hartmann, 2020). **Trust** emerges as a critical factor in high-income countries for biogas project acceptance, while education and women's living conditions are more significant in low-middle-income countries (Mancini & Raggi, 2022). The **perception of naturalness** translates into a strong consumer preference for products that are perceived as "natural," often associating them with better health and safety. This "naturalness bias" can influence the acceptance of bioeconomy products, even when synthetic alternatives may be more sustainable or efficient (Giacalone and Jaeger, 2023). A challenge that was also mentioned in interview 3.

Furthermore, **trust in institutions** is a critical determinant of acceptance. According to (Gaffey, et al., 2021) consumers are more likely to embrace bio-based innovations when they trust the stakeholders involved, be it government agencies, scientific organisations, or private companies. Without this trust, scepticism may arise, especially if there is a perception that bioeconomy innovations are driven by profit motives rather than environmental concerns (OECD/Eurostat, 2018).

3.1.3 Knowledge and awareness





A social media (Twitter) analysis by (Neill, O'Donoghue, & Stout, 2023) revealed that there is a **broad societal discourse on bioeconomy** that is characterised by a positive sentiment with aspirational ideas on biotechnological discovery, innovations and social prosperity. The broader environmental, social and sustainability challenges receive less attention on social media, with the exception of the climate topic. The study supported the view that bioeconomy can connect stakeholders from different disciplines and countries, but points out that this is primarily true **in well-educated contexts** and for actors that are already engaged in bioeconomy. There was no evidence that a wider community is engaging on this topic via Twitter. Even though 21% of the active Twitter accounts that join in the bioeconomy conversation are from civil society, these were primarily industry associations or other organisations that have bioeconomy as a core in their mission and who share the same positive sentiment as the other stakeholder groups active on Twitter. This suggests that the current stakeholder groups active on Twitter are not actively supporting a critical debate on the topic or giving it legitimacy with the general public. When looking at the topics that are discussed, we see that conventional economic terms, such as production, business, work, and industry, are used a lot. This demonstrates alignment with the “pro-growth ” narrative of bioeconomy that is commonly associated with the economic status quo. **Social and environmental topics were less prevalent.**

When considering consumer awareness of the value for money of bioeconomy products, it's important to understand that this perception is multifaceted, encompassing both the product itself and the underlying concept. The level of **knowledge and awareness about bioeconomy** products and their potential advantages is thus a significant factor in determining consumer acceptance. In many regions, there is limited understanding of what the bioeconomy entails, leading to reluctance to support new technologies (Dallendörfer, Dieken, Henseleit, Siekmann, & Venghaus, 2021). Without proper awareness campaigns and public engagement, consumers may remain unconvinced about the benefits of bio-based solutions. This was mentioned in all three expert interviews. In interview three, the experts mentioned that consumer education is a major challenge. Difficulties arise in raising awareness about issues such as dangerous chemicals and sustainability. Simplifying technical aspects of new bioeconomy alternatives, such as bioplastics, is necessary, as people can be sceptical about their functionality compared to familiar products. Public understanding of bioeconomy concepts remains limited, despite its growing importance. Also, in Slovenia, a limited understanding of bioeconomy potential among the wider public and policymakers is mentioned as a knowledge and mindset barrier (interview two). In Greece, "Insufficient environmental education" and low consumer willingness to pay for bio-based products are also named as social factors, potentially related to limited awareness and trust (interview one).

3.1.4 Perceived benefits versus risks

Consumer acceptance of bioeconomy innovations is also determined by how consumers perceive the benefits and risks associated with these technologies. On the one hand, the **environmental benefits** - such as reduced waste, lower emissions, and resource efficiency - are compelling arguments for bio-based solutions. On the other hand, **perceived risks** - such as concerns about





health impacts, food supply security, product safety, or environmental consequences - can undermine public support (Dallendörfer, Dieken, Henseleit, Siekmann, & Venghaus, 2021).

To reach a wider social acceptance the circular bioeconomy should **shift away from using crops that are in competition with agriculture/food markets** and move towards residual bio-based feedstock and waste. Particular food waste streams are a valuable option to achieve these goals since it can be used for various biobased products ranging from biofuel to bioplastics (Piergiuseppe & Imbert, 2020). This should of course only be done with **food waste streams** that are not fit for human consumption, respecting the waste cascade.

Similarly, the social acceptability of a wood-based bioeconomy can be challenged when timber production competes with forests' functions for recreation, cultural heritage, or biodiversity conservation (Ranacher, Sedmik, & Schwarzbauer, 2020). Finding a balance between economic utilisation and the **preservation of forests' social and ecological functions** is essential for long-term public support.

3.2 STAKEHOLDER INVOLVEMENT IN THE DEVELOPMENT OF NEW BIOECONOMY PROJECTS AND STRATEGIES

Stakeholders in the bioeconomy include government and policy makers, academia and research institutions, industry and businesses, primary producers, civil society and the public, and intermediary and support organisations. Despite growing recognition of the importance of broad stakeholder involvement, government and academic institutions often form the core of bioeconomy social networks. Alongside them, industry actors (particularly from fields like biotechnology) are regarded as key players as well, with large corporations often driving technological innovation. This **"triple helix" of policy, industry, and academia** tends to dominate decision-making processes (López Hernández & Schanz, 2019; Harrahill, Macken-Walsh, & O'Neill, 2023; González Escobar, Granobles Torres, & Villa Rodríguez, 2024). As a result, bioeconomy strategies are often shaped by top-down approaches, rather than participatory ones.

The involvement of **primary producers** is quite often overlooked in bioeconomy strategies, while they have a crucial role to play (Spies, Zuberi, Mähliß, & Zakirova, 2022). Primarily, their role is to produce biomass (growing crops for food, feed, bioenergy, and bio-based products) in the right quantity, quality, and at the right time. But they are also managers of the waste streams coming from agriculture, transforming them into biogas or fertilisers, and applying them on their fields (Haque, Fan, & Lee, 2023). Furthermore, we need them to invest in new crops or technologies to process agricultural waste streams and act as managers of soil health (Girard, 2022 and Spies et al., 2022). These roles come with a lot of challenges. Making the required investments entails financial risks, while farmers are already subject to unpredictable weather conditions and market demand. Furthermore, individual farmers often lack the capacity to organise logistics or ensure a stable biomass supply on their own, requiring collaboration among farmers. Unfortunately, farmers are





frequently excluded from the development of bioeconomy strategies, and their knowledge and expertise are rarely consulted. As a result, the bioeconomy is not adapted to their needs, and their willingness to participate is rather low (Harrahill, Macken-Walsh, & O'Neill, 2023). Farmers' low participation rate can also be linked to interview two (Annex III) where the interviewee mentioned a "traumatic past experience with large state subsidized biogas installations that disturbed the agricultural and land market, making them (farmers) sceptical of new bioeconomy initiatives" in Slovenia.

Similarly, **civil society and local communities** are crucial as well, but are often marginally included or simply targeted for acceptance rather than active participation. Studies on public perceptions often focus on product acceptance, rather than viewing citizens as social and political actors capable of influencing the bioeconomy discourse (Eversberg & Fritz, 2022). Public engagement efforts commonly take the form of one-way communication rather than fostering genuine dialogue and shared decision-making (Starke, Metze, Candel, & Termeer, 2024). Moreover, what is sometimes labelled as a "lack of knowledge" may actually be a misinterpretation of genuine objections, which could lead to technocratic solutions rather than democratic debates (Eversberg & Fritz, 2022). Without the participation of civil society in bioeconomy discussions, efforts to promote sustainable economies may not provide expected outcomes or could even fail (Sanz-Hernández, Encarna, & Piedad, Transition to a bioeconomy: Perspectives from social sciences, 2019).

Sometimes, involving stakeholders can be a challenge due to **structural barriers**, such as scattered land ownership. A concrete example is the forestry sector, where some forests are publicly owned, while others (often a large proportion, e.g., 80% in Slovenia) are privately owned. Effective bioeconomy implementation would require all owners to agree and work together for infrastructure development, such as road access for harvesting. However, many landowners are inactive or unidentifiable, making it difficult to coordinate forest management and organise efficient biomass collection and processing (Annex III: Interview 2). The difficulty in engaging final users and those involved in end-of-life strategies was also mentioned in Interview three (Annex IV). In the Italian region Friuli-Venezia Giulia there are examples of public interventions that support collaboration and cooperative use of uncultivated or abandoned agricultural land. In this way the region aims to increase trust in private land owners to join collaborative efforts or cooperative land use models. (Autonomous Region of Friuli Venezia Giulia, 2025)

Lastly, González Escobar, Granobles Torres, & Villa Rodríguez (2024) mention several general **social barriers** that can hinder the effective participation of stakeholders in new bioeconomy initiatives. Many stakeholders have a somewhat resistant attitude toward risk-taking and innovation, typically favouring proven, incremental innovations over more disruptive ones. Short-term financial gains are often prioritised over long-term societal and environmental benefits, which discourages investment in transformative innovations. In general, there seems to be a lack of shared visions between organisations and sectors, and limited inter-stakeholder coordination and alignment. This highlights the importance of developing a regional bioeconomy strategy that actively





involves all key stakeholders, brings their interests together, and promotes cooperation, which brings us to the next barrier.

3.3 LACK OF A LONG-TERM VISION ON BIOECONOMY

While several EU countries have adopted dedicated national bioeconomy strategies, others are still in the process of developing such strategies or have none (Marcone, Schmid, & Meylan, 2023). Developing a cohesive long-term vision for the bioeconomy is very complex, as innovations in this domain involve many stakeholders (see section 3.2) and tend to be more ambiguous than traditional innovations. While each member state has its specific (social) challenges (see also D4.2 Inventory of Policy opportunities and barriers) the following three systemic issues are broadly observed across Europe.

3.3.1 European and local vision on competition for land use

The **competition for land use** within the bioeconomy in Europe and the different approaches of the EU and member states to manage this pose a significant challenge for the development of the bioeconomy in Europe. It primarily occurs between the production of **food, feed, energy, and materials**. A specific concern is the potential conversion of biodiversity-rich habitats for biomass production. For instance, land is needed for food production, energy production (e.g., biofuels and biogas), and materials, creating a challenge in balancing these demands (Agora Agriculture, 2024).

While the EU Bioeconomy Strategy (2018) emphasizes the need for sustainable management of natural resources, food security, and balancing different biomass applications, it does not explicitly acknowledge the need to reduce the use of biological resources due to natural ecological limits. Additionally it seems to prioritize economic considerations and neglect ethical, social, and broader sustainability issues (McCormick & Kautto, 2013).

The **current approach of soil management is fragmented**, requiring a more holistic approach and tools that support integrated decision-making to capture trade-offs and synergies. There is a lack of continuous soil research due to project dependence, despite the long-term nature of soil research. Also, there's insufficient support for integrated decision-making by practitioners and policymakers (Agora Agriculture, 2024). An interesting example to mention here relates to cereal residues in Italy. In the Italian bioeconomy, cereal residues, representing over 60% of total crop residue production, hold significant potential for energy generation and carbon sequestration (Voccia, et al., 2025). However, current Italian Common Agricultural Policy (CAP) regulations, specifically the SRA03 - ACA3 intervention for "Techniques for Reduced Soil Tillage," (Ministero dell'agricoltura) present a direct conflict to the widespread removal of straw for these bioeconomy applications. The core commitment of this intervention, applicable nationwide with regional specificities, is to ensure soil cover by maintaining crop residues and stubble on the land as a protective mulch layer. This practice is explicitly aimed at combating soil degradation, improving soil structure, reducing erosion, and enhancing carbon sequestration directly within the agricultural field. While some regions allow for





the partial removal of straw, the primary intent and design of these regulations incentivize the retention of residues on the field for on-farm environmental benefits, thereby potentially limiting the large-scale availability of straw as a feedstock for off-farm bioeconomy installations like biogas plants, unless specific regional derogations are obtained, and even then, these regulations do not explicitly promote the bioeconomy use of removed straw.

The **Circular Bioeconomy (CBE)** approach integrates these competing uses and proposes to limit non-food applications of biomass to organic waste and non-food sources, such as forestry residues. The CBE distinguishes itself by asserting that not all waste is equal, emphasizing that only organic resources are truly renewable on a human scale, unlike fossil resources. Therefore, it calls for an in-depth consideration of valorising all biomass constituents, regardless of whether they are classified as waste, transforming them into valuable resources rather than merely managing them. This concept is often realized through "cascading," which involves optimizing resource use by sequentially reusing the remaining qualities of commodities and materials (see also section 2.5). The technologies required to process organic waste for these purposes, such as those found in biorefineries, are often already in use for non-waste biomass within the broader bioeconomy (Gaëtan, 2022).

3.3.2 Limited structural funding of Food Redistribution Platforms

As discussed above, **food redistribution** (via, for example, circularity brokers) is an important aspect of a fair and just bioeconomy. Households, food service establishments such as restaurants and cafés, and food retailers including supermarkets—collectively responsible for 73% of food waste—can utilize food banks and redistribution networks to allocate their surplus food to those in need. These actions sit between reduce and reuse and **should be given high priority** (Green Deal Projects Support Office, Food waste – reducing, reusing, and recycling by the Green Deal Call-funded projects, 2025). However these actions receive very fragmented and limited public funding and need to rely on charity organisations

We observe a major policy related barrier when implementing food redistribution platforms. On the one hand, the European Union's Bioeconomy Strategy does mention that we need to reduce food waste by 50%, but then refers to re-using food surplus as animal feed (Updated Bioeconomy Strategy, 2018, p. 6) which is not the most effective way of reducing food waste. **Redistribution of food surplus is not even mentioned in this strategy.** This is especially striking since the **need for food redistribution appears to increase.** The European Food Bank Federation (FEBA) reports an increase in the number of beneficiaries receiving food aid from 9.520.832 beneficiaries in 2019 to 12.860.788 in 2023 while the amount of food distributed increased from 781.280 ton in 2019 to 839.942 ton in 2023. (European Food Bank Federation, 2024). This means that the amount of food available for each beneficiary went down from 82kg to 65kg per year.

A longitudinal analysis of media data in Finland showed that the increase of charitable food aid and linking food waste reduction to food redistribution has in fact impacted the perception of food aid overall in a positive way. However it has also led to a transition in where the responsibility for food





aid should lie from a more **state welfare oriented view towards a more liberal welfare regime** (Tikka, 2019).

Food aid in Europe is funded via the European Social Fund (ESF+) which has taken over the previous European Aid to the Most Deprived (FEAD). The ESF+ program runs until 2027 and there is no news on its continuation after 2027 thus making this important source of funding for food aid insecure. In a report on food redistribution in Europe by Wageningen University it is concluded that **charities face many challenges in terms of logistics and infrastructure** when redistributing the large food surplus streams that come their way. (Wageningen Economic Research and Ecorys in association with Deloitte, 2020). Note that only a portion of the ESF+ financing is reserved for logistics and distribution and can only be used for the distribution of ESF+ purchased food products. This leaves the redistribution of surplus food from retailers, auctions and the food industry over charity.

3.3.3 Lack of professional education and expertise building

A sustainable bioeconomy necessitates an inherently interdisciplinary approach. Therefore, educational methodologies that integrate STEM (Science Technology Engineering & Mathematics - disciplines with the social sciences and humanities are essential. Although **interdisciplinary programs** have increased in recent years, many programs remain discipline-specific, which can limit students' ability to tackle complex, real-world challenges (Paris, et al., 2023). According to Sacchi, Lotti, & Branduardi (2021), developing an effective educational framework that connects life sciences and social sciences is one of the main challenges for bioeconomy education. An additional challenge today is the rapid advancement of digitalisation and biotechnology, which may outpace the development of existing curricula (Ryymän, 2021).

Another and perhaps the most important gap is the lack of practical, especially vocational, education approaches that foster the development of relevant skills and competences within bioeconomy sectors. There seems to be a **mismatch between industry needs and current educational offerings**. Training opportunities are particularly lacking for small enterprises and for workers at lower skill levels, potentially leaving the labour force underprepared for the transition to a bioeconomy. To address this, research is required on how to develop and integrate vocational education and training (VET) programs on bioeconomy into existing educational structures (Paris, et al., 2023).

These general challenges are complicated by **regional disparities** in the development of bioeconomy education across Europe. While Western and Northern European countries are often at the forefront of bioeconomy education initiatives, Eastern and Southern regions are still in the earlier stages of development. In certain countries, such as Greece and Malta, there remains a significant shortage of specialised training programs in bioeconomy-related fields (see also D4.1 – Open report: emerging innovative technologies and feedstock availability). Considering the size of the European Union and the scale of the transition required, bioeconomy education offerings should be expanded, particularly those focused on specific thematic areas (Paris, et al., 2023).





3.3.4 Lack of a coherent framework to monitor the social impacts of bioeconomy

A key barrier is the **lack of coherent, widely accepted frameworks and indicators** to monitor social impacts of the bioeconomy. While the EU Bioeconomy Monitoring System includes a set of social indicators (concerning employment, income, education, health,...), there is insufficient data to measure many of them in practice (Pantani, et al., 2024). This data gap prevents a robust assessment of how the bioeconomy affects communities, workers, and vulnerable groups. In contrast to environmental and economic metrics, social dimensions remain loosely defined, inadequately measured, and often excluded from funding criteria.

Social Life Cycle Assessment (S-LCA) is a promising tool to assess the social impact of (biobased) products or projects. However, the application of S-LCA in bioeconomy contexts is still limited and faces several methodological challenges. Sustainability assessments from a life-cycle perspective have traditionally focused on environmental (E-LCA) and economic (LCC) aspects, while the social dimension has received less attention. Consequently, the methodology for S-LCA remains less developed. The main challenges identified in current S-LCA studies (Rebolledo-Leiva, Moreira, & González-García, 2023; Zarauz, Sanz-Hernández, & Rivera-Lirio, 2024) are:

- A lack of standardisation of impact categories, social themes and methods, leading to a lack of harmonisation and comparability across studies;
- The functional unit and system boundaries are often not defined, due to which a clear link between social impact results and the quantity or output of what is being assessed is absent;
- The use of activity variables (= measurable indicators, e.g., working hours) and social databases (e.g., SHDB, PSILCA) is scarce. More datasets are needed;
- Uncertainty in scoring and weighting factors (used to translate qualitative data into quantitative results) is often not addressed, and sensitivity analysis is not performed;
- Little attention is paid to positive social impact assessment;
- An uneven representation among stakeholders, with a major focus on the worker stakeholder (likely due to easier access to quantitative data), while stakeholders like consumers and children are underrepresented;
- Multifunctionality, relevant in multi-product bio-based systems (e.g., biorefineries), and allocation issues are generally not addressed;
- S-LCA studies often neglect the evaluation of social transformations and the extent to which the bioeconomy fosters a transition towards social sustainability. Aspects like social norms, values, attitudes, or the role of decision-makers are not incorporated;
- The current social sustainability is heavily influenced by Eurocentric values and perspectives, with limited contributions from the Global South, and often comes from technical fields rather than social sciences. There is also a lack of global perspective studies, needed for assessing broader strategies and regulations;
- A lack of consensus on how to transparently and fairly integrate environmental, economic, and social dimensions in Life Cycle Sustainability Assessment (LCSA).





Further development of the S-LCA method, with a focus on the abovementioned gaps, presents a significant opportunity to create a more comprehensive sustainability framework that reflects the social complexities of bioeconomy initiatives and encourages more socially inclusive strategies.

3.4 RISK OF INCREASED INEQUALITY

As S-LCA (and LCSA) are still under development and do not yet fully account for social transformations, there is, at this point in time, no clear measurement tool to evaluate whether a bioeconomic innovation is a 'good' innovation across all sustainability dimensions (economic, social, and ecological). Thus, social transformations resulting from the bioeconomy are not clearly mapped and could pose a risk of increased inequality.

3.4.1 Power dynamics of stakeholders: new value chains develop, but who is in power?

The development of the bioeconomy can be influenced by **existing power structures** and may thus be managed in a top-down manner. Failure to address this can lead to certain interests dominating decision-making processes, while the needs of the most vulnerable people are overlooked (Sanz-Hernández, Jiménez-Caballero, & Zarauz, 2022; Harrahill, Macken-Walsh, & O'Neill, 2023).

In addition, concerns exist that the economic benefits of the bioeconomy might be temporary or mainly captured by large corporations, rather than providing long-term benefits to local communities or small farmers (Leibensperger, Yang, Zhao, Wei, & Cai, 2021). For example, strong, consolidated firms are often in the best position to develop industrial-scale biorefineries and benefit from value-adding opportunities (Juvančič, Osojnik Črnivec, Berne, & Oven, 2023). And of course, the increasing number of patents on genes, traditional knowledge, and organisms by large biotech companies, as well as the dominion of a few agribusiness giants over the market, raise concerns about further monopolisation of bio-innovation and high barriers for smaller players. Powerful stakeholders can influence the allocation of economic resources, such as loans and subsidies, or steer policy agendas to direct public investments towards themselves (González Escobar, Granobles Torres, & Villa Rodríguez, 2024). As a consequence, **wealth generated through bioeconomy activities may not be distributed equitably**, and the transition to a bio-based economy may exacerbate existing inequalities rather than alleviate them.

Furthermore, bioeconomy-related sectors are generally male-dominated, and a transition to a biobased economy does not inherently reduce these inequalities (Sanz-Hernández, Jiménez-Caballero, & Zarauz, 2022). Indicators such as employment and income by gender, age and educational level would be useful to assess equity and inclusion in bioeconomy sectors, but are **currently not being monitored** in this context. Consequently, issues related to gender and discrimination are largely absent in S-LCA studies as well (Rebolledo-Leiva, Moreira, & González-García, 2023).

3.4.2 Access to new markets for primary producers





While the development of the bioeconomy offers potential for income diversification and new business models for primary producers, **failure to include primary producers** in the development of bioeconomy projects and strategies (see also section 3.2) risks them being viewed merely as biomass providers, without having a meaningful role in the bioeconomy or gaining access to the resulting financial benefit (Harrahill, Macken-Walsh, & O'Neill, 2023).

A major barrier for primary producers is the **lack of established local markets** for bioenergy crops and bio-based products. As transportation costs are often high, bioenergy crop cultivation is often closely linked to the geographic location of refineries (Leibensperger, Yang, Zhao, Wei, & Cai, 2021). Increasing efforts are made to support rural and coastal bioeconomy initiatives, as these hold significant potential to strengthen regional economies, create local jobs, and promote a more inclusive bioeconomy (Updated Bioeconomy Strategy, 2018; European Commission, 2023). Connecting primary producers to intermediary organisations and the formation of cooperatives present opportunities to help farmers access (new) markets as well. In the Italian region Friuli-Venezia Giulia launched the "Io Sono FVG" label which helps consumers identify and choose sustainable, locally sourced product. It promotes transparency through traceability tools like QR codes, encouraging responsible consumption and supporting the regional bioeconomy by highlighting ethical, eco-friendly producers committed to environmental and social values (Friuli Venezia Giulia Region, 2025).

The creation of new markets for bio-based products can be quite difficult, and this particularly holds true for waste-derived products such as upcycled food. While the production cost of such products is often high, consumers may only be willing to pay a lower price (due to unfamiliarity, neophobia and technophobia), creating a supply-demand imbalance. **Targeted market strategies** are needed to create a new and proper market for recovered products, with an improved supply chain and the right consumers (Rakesh & Mahendran, 2024). The existence of such markets and strategies to promote them are severely underrepresented in existing literature and should be better explored (Braca & Cecchi, 2021).

3.4.3 Access to the products for vulnerable consumers

Advancements in certain bio-based sectors might not be equally available to all segments of society, with unequal access to new biomedical treatments being among the most famously debated examples (Sanz-Hernández, Encarna, & Piedad, 2019). Many **bioeconomy products are more expensive than their counterparts from traditional production systems**. Although this is partly because negative externalities (such as pollution, energy use, waste, etc.) are not reflected in the prices of classical products (Aguilar & Twardowski, 2022), it presents a significant barrier for consumers with lower incomes. A Low consumer willingness to pay for bio-based products in Greece was also mentioned in interview 1 (Annex II). In addition, competition for water, energy and land can generate conflicts between interested parties and territories, driving up prices and potentially leading to critical social inequalities related to access to these resources (Sanz-Hernández, Encarna, & Piedad, 2019).





3.4.4 Geographical and Socioeconomic Disparities

The development of the bioeconomy seems to imply a considerable rise in the demand for biomass. As biomass is often sourced from (semi-)peripheral regions and exported to processing centres in wealthier countries, there is a risk of reinforcing global geographical inequalities by deepening extractive relations between the Global South and North. This dynamic can contribute to a persistent global division of labour, where **some regions primarily serve as suppliers of raw materials for others who focus on value-added processing and technological innovation**. Furthermore, this reliance on biomass sourcing risks exacerbating socioeconomic disparities through the exploitation of cheap and disciplined labour (Backhouse, et al., 2021). Such patterns may lead to environmental pressures, land-use changes, and limited local benefits in producing regions. So far, these aspects have received limited focus in European bioeconomy strategies. A sustainable European bioeconomy should therefore not only prioritise substituting fossil-based raw materials, but also focus on reducing overall biomass consumption (see also section 3.3.1) and developing cooperative and balanced international relations (Lümann, 2021).

3.5 LACK OF DATA AND DATA SHARING

The lack of data on social indicators to monitor the bioeconomy and data to assess the social performance of a specific innovation form an overarching barrier that impacts all of the previous barriers. We will zoom in on different types of data and briefly discuss how member states attempt to monitor their local bioeconomy.

3.5.1 Social data

In Annex IV: Interview 3, the experts highlighted the **difficulty in obtaining reliable data for S-LCA**. Social information is often more sensitive than environmental data. Many companies either lack the internal capacity to collect social data or are reluctant to share it due to concerns about confidentiality and reputational risk. In the research sector, privacy restrictions can also limit data sharing. Fair wages and salaries are identified as major data gaps across various industries, from primary producers to pharmaceuticals. When primary data is unavailable, practitioners often rely on secondary sources such as academic literature and databases. However, **many of these databases are not open access**, restricting their use (especially for smaller actors) and limiting transparency. This emphasises the need for regularly updated, freely accessible databases and better dissemination of research results. Building trust with data providers by clearly communicating how data will be used is essential. The development of open, collaborative data-sharing platforms is seen as an important step toward overcoming these challenges and supporting more robust social assessments across the bioeconomy (Annex IV: Interview 3; Updated Bioeconomy Strategy, 2018).

3.5.2 Biological data

The reluctance to share biological data (such as genetic sequences, metabolites, breeding lines, growth rates,...), which is crucial for the development of the bioeconomy, can be seen as a social barrier as well. Some biological data is not shared due to regulatory and legal constraints (e.g., the





Nagoya Protocol or national biodiversity protection laws) aimed at preventing misuse. However, access to biological data is also often constrained by companies, and even research institutes, in order **to maintain a competitive advantage**. Additional difficulties with the sharing of biological data lie in the **heterogeneity of data types, metadata standards, and the repositories used**. This fragmentation of data slows scientific progress and limits the ability to develop integrated, cross-sectoral bio-based solutions. Given the urgent global challenges, there is a need for wide adoption of the FAIR data principles, as well as the development of solutions to share biological knowledge, data, and the benefits of the bioeconomy (Wilson, et al., 2021; World Economic Forum, 2021).

3.5.3 Data on bioeconomy indicators

The lack of reliable and accessible data is also clearly demonstrated when analysing the **national bioeconomy strategies and their related bioeconomy indicators**. This hinders the monitoring and effective implementation of bioeconomy strategies (Marcone, Schmid, & Meylan, 2023). Marcone et al. conclude that this is especially true when looking at Spain and Finland where the indicator sets are described as rather small and simplistic, lacking many essential elements of high-quality and functional monitoring tools. While Germany and Italy do provide extensive and versatile indicator sets with a high overall quality rating, combining both theoretical and political aspects of the bioeconomy. Other EU countries did not have a bioeconomy strategy, referred to sources that were not verifiable or simply did not have a monitoring set at all at the time of data collection (Marcone, Schmid, & Meylan, 2023).

4 RESEARCH GAPS/LIMITATIONS

Based on the literature study and interviews, the following research gaps in social sciences need to be addressed to promote the development of a sustainable bioeconomy:

4.1 CONSUMER/CITIZENS ACCEPTANCE AND STAKEHOLDER INVOLVEMENT IN THE DEVELOPMENT OF NEW BIOECONOMY PROJECTS AND STRATEGIES

- The bioeconomy literature recognizes consumers as active participants rather than passive recipients, emphasizing their shared responsibility in shaping sustainable practices (Ulrich Wilke, Schlaile, & Urmetzer, 2021). However, there is a need for more holistic exploration of consumers' roles and responsibilities in the bioeconomy, considering **local contexts, trust, perceptions and cultural factors** to better understand and promote acceptance of novel technologies and practices.
- The **development of participatory frameworks** would be useful, as farmers' practical knowledge is currently underutilised, and civil society rarely gets to actively participate in bioeconomy discussions.

4.2 LACK OF A LONG-TERM VISION ON BIOECONOMY

- **Standardised monitoring of biomass cascading**: although the waste cascade is a key concept in bioeconomy, data on biomass cascading is limited and fragmented. The





development of a dedicated methodology for data collection and cascade index calculation is needed.

- Research on **integrating vocational education and training (VET) programs** into existing educational structures, as well as on **connecting life sciences with social sciences**, is needed for the development of high-quality bioeconomy education initiatives.
- **Further development of the S-LCA method** is necessary to accurately assess the social impacts of bioeconomy products and initiatives and to create a more comprehensive sustainability framework.

4.3 RISK OF INCREASED INEQUALITY

- **Power dynamics in new bioeconomy value chains:** concerns regarding top-down decision making and monopolisation, as well as issues concerning gender and discrimination, are underrepresented in the literature.
- More research is necessary on **new markets for biobased products and strategies to promote them, particularly for waste-derived products** such as upcycled food.
- Issues concerning **access to biobased products for vulnerable consumers** should be better explored.
- The lack of research on how the development of the European bioeconomy may **impact the Global South**, where a large proportion of the biomass is sourced, needs to be addressed, as there is a **risk of reinforcing global geographical inequalities**.

4.4 LACK OF DATA SHARING

- The (further) **development of widely accessible, trusted databases** is necessary to facilitate data sharing within the bioeconomy.
- Standardised **national monitoring systems** that include clearly defined and measurable indicators are needed to allow adequate policy development.

5 SOCIAL INNOVATIONS IN BIOECONOMY

This chapter starts with providing a definition of social innovation and makes explicit how we will evaluate this within the ToBeReal project. Next we provide several examples drawn from the food and forest industry. Finally we dive into Digital Innovation Hubs that can support social innovation in different sectors.

5.1 DEFINITION OF SOCIAL INNOVATIONS?

According to the EU Commission social innovations are **new ideas that meet social needs, create social relationships and form new collaborations**. These innovations can be products, services or models addressing unmet needs more effectively (Directorate-General for Internal Market, 2022). The Oslo Manual 2018 defines innovation, including social innovation, by its "(social) objectives to





improve the well-being of individuals or communities" (OECD/Eurostat, 2018). The Oslo manual lists the following objectives under the category 'Economy, society or environment':

- Reduce negative environmental impacts /deliver environmental benefits
- Improve public health, safety or security
- Improve social inclusion
- Improve gender equality
- Improve quality of life or well-being
- Comply with mandatory regulations
- Comply with voluntary standards

In order to achieve these goals it is paramount that a Social innovation **involves societal actors** to bring about structural change in innovation dynamics (Ludvig, Rogelja, & Asame, Governance of Social Innovation in Forestry, 2020). Social innovation is distinct from purely profit-driven motives, as social enterprises and NGOs may prioritize environmental/social missions over financial goals in waste recovery initiatives (Ciulli, Kolk, & Boe-Lillegraven, 2019).

When looking for social innovations in the framework of the ToBeReal project we identified the following aspects to be relevant:

- Social Innovation Potential: The project's capacity to unlock their potential in promoting greater social impact and driving meaningful social change.
- Potential to engage with the right stakeholders: clear mapping of the relevant stakeholders and meaningful interactions with them.
- Fairness of the value chain: do all actors in the value chain receive a fair benefit relative to their input and risk assumed.
- Potential to communicate the benefits of the innovation to the general public.
- Internal evaluation of the social impact of the developed solution
- Inclusivity: accessibility of the solution to a wide group of consumers / sharing the benefits of the solution with a wide group of stakeholders

5.2 FOOD REDISTRIBUTION AS A SOCIAL BIOECONOMY INNOVATION

Food redistribution projects are generally not taken into account when discussing the bioeconomy. However, they are very relevant and do comply with the definition of bioeconomy as proposed by the European Union (see section 2.1). Therefore, we would like to zoom in on some examples of circular social innovations in the food supply chain.

An interesting social innovation in bioeconomy in this respect is the concept of **circularity brokers** identified by Ciulli, Kolk, & Boe-Lillegraven (2019). Not all circular economy projects are bioeconomy projects - only when the resources that are managed in a circular way are also biological. The principle of circularity brokers often relates to digital platform organisations that connect actors with goods at risk of becoming waste. In this way, 'circularity holes' are bridged, and the transfer and





recovery of discarded resources between supply chain actors is facilitated. When this concept is applied to the food supply chain, we can talk about a food redistribution project within the bioeconomy. According to Ciulli, Kolk, & Boe-Lillegraven (2019), there are six brokerage roles in the food supply chain:

- ➔ Connecting: Creating linkages between waste generators and potential receivers.
- ➔ Informing: Providing information about waste and potential uses.
- ➔ Protecting: Ensuring safe and ethical waste recovery practices.
- ➔ Mobilising: Engaging third parties like volunteers and partner organisations to facilitate connections for waste exchange.
- ➔ Integrating: Incorporating the platform within firms' existing logistics to synchronise waste uploading with food management processes.
- ➔ Measuring: Assessing the social and environmental impact of saved food to encourage continuous waste recovery actions.

Ciulli, Kolk, & Boe-Lillegraven (2019) consider the identification of these six different roles as an indication that overcoming the barriers for food waste recovery via circular supply chains is complex and requires multidimensional solutions that incorporate a set of different activities. It also clearly shows the potential of social innovations in bioeconomy - more specifically, the identification of the right stakeholders and the ability to have meaningful interactions with them. Or, when looked at from an organisational perspective, it demonstrates **the importance of adopting an interorganizational supply chain perspective to close the loop in the supply chain** (Lüdeke-Freund, Gold, & Bocken, 2019).

An interesting platform to mention in this respect is the [B2BE facilitator](#), a platform that connects Flemish players from the agricultural sector with industrial partners from the (food) industry to find connections between supply and demand for organic side streams. This platform is funded by the Flemish government and managed by EV ILVO. It can be considered **a type of circularity broker** that operates in all agricultural sectors (not limited to the food industry). They actively connect, inform and connect actors and even supports the first steps of mobilisation. BEBE also supports the monitoring of the Flemish bioeconomy via the Monbio reporting (ILVO, 2025). [Valbiom](#) and [B4C](#) are similar platforms active in Wallonia and France respectively.

5.3 SOCIAL INNOVATIONS IN THE FOREST SECTOR

The forest sector is an important supplier of bioeconomic resources in Europe and several very interesting examples of social innovation in forest bioeconomy are described by Ludvig, Zivojinovic, & Hujala, 2019:

- **Social Biomass Farms**, also known as "sozialer Biomassehof SOBIO", have been established in Austria and Slovenia. These initiatives were funded between 2007 and 2013 by the EU's Territorial Employment Pacts (TEP) program and utilize a common management system. The primary goal of these social biomass farms is to employ long-term unemployed





individuals from the respective regions. These initiatives fall under broader concepts such as "Green Care Forest" or "Social Farming," which aim to provide health, employment, education, and therapy. They integrate individuals with physical, mental, or emotional limitations, young delinquents, persons with learning disabilities, and drug addicts into meaningful work, often on farms or in forest areas. These projects contribute to rural and regional development through forestry-related, cultural, tourism, and commercial activities. They foster economic stability for forest owners and generate income for the region. By diversifying the use of private forest land, they offer broader benefits, such as creating "marketable products" alongside social services.

- An Austrian cooperative of traditional farmers and forest owners established a **biomass-based district heating systems** in rural villages. This has created new business opportunities for forest residues and simultaneously addressed air pollution. The success of such initiatives, according to the authors, lies in their bottom-up nature and collaboration with various local actors, including municipalities and both public and private clients.
- Another Austrian example involves an association of nature parks that developed the **"Nature Park Specialties" brand**, promoting traditional products from local farmers in nature park regions to complement the parks' biological, recreational, and cultural functions
- The **"Charcoal Land Initiative"** in Slovenia, launched in 2003, is a similar initiative. It began by revitalizing traditional charcoal production in an economically weak region. Over time, this initiative expanded, with local residents offering tourism activities related to charcoal production, such as hiking trails and local food offerings, which led to new income streams and employment. The municipal and provincial governments recognized and promoted the value of this initiative.
- The "Associazione Tutela del Marrone di Castione" is an initiative in Northern Italy that focuses on the revival of chestnut production and its associated cultural traditions. It is located on the Brentonico Plateau in a small valley near Trentino. The initiative was formed by hundreds of associated chestnut growers and supporters. Its primary goal was to keep the abandoned cultural tradition of chestnut production alive. To achieve this, they organized various activities, services, and gourmet events centred around chestnuts. This initiative has successfully contributed to regional development. It has led to the creation of jobs related to the production, processing, and marketing of chestnuts, as well as associated tourism services.
- The mountain bike case in Switzerland. Formerly 'illegal' mountain bike trails were discussed with all stakeholders and legalized. This initiative represents communal engagement for woodland management, specifically falling under the theme of participation and collective action. The development of officially accepted mountain bike trails provides recreational activities around ecosystem services, demonstrating how the forest sector can offer intangible services and contribute to social and cultural benefits beyond traditional products. It involved collective activities of multiple stakeholders focused on a communal goal, which fosters cooperation and trust-building among all actors involved. These types of innovations are crucial for sustainable rural and regional development, helping to keep people in rural





areas by offering economic, educational, and cultural opportunities. The focus extends beyond mere business and profit, aiming to create social value through the involvement of civil society actors in the innovation process.

5.4 DIGITAL INNOVATIONS THAT LINK TO SOCIAL INNOVATION

Digital Innovation Hubs (DIHs) are explicitly designed to boost biomass valorisation and reshape regional bio economies by enhancing the **efficiency of high-potential value biomass supply chains**. DIHs actively involve diverse groups, including private companies, universities, public administration, and Non-Governmental Organizations (NGOs) (Macias Aragonés, et al., 2020) and thus emphasise multi-stakeholder and multi-sectoral engagement. This aligns with social innovation's focus on civil society engagement and the formation of novel coalitions of actors. For instance, projects within frameworks similar to DIHs, such as AGRIMAX, conducted a "Societal & Ethical analyses" that involved stakeholders in assessing health, safety, training, employment, and local community engagement (Cecchi, 2021). The importance of **inclusion and participation** in collective decision-making, particularly from citizens, is highlighted as crucial for a responsive bioeconomy (Mustalahti, 2017).

6 TRANSLATE BARRIERS AND OPPORTUNITIES TO IDEAS FOR CAPACITY BUILDING ACTIVITIES

Based on the identified social barriers for developing a sustainable bioeconomy we have distilled suggestions for capacity building activities and policy. These activities focus on disseminating existing practical and theoretical knowledge but also on building new knowledge and networks together with stakeholders. Furthermore we distilled some suggestions for communication strategies as well as some first suggestions for policy advice.

- Educational initiatives that clarify the science behind bioeconomy products and demonstrate their real-world benefits can greatly increase consumer acceptance. Transparency and consistent communication from stakeholders are crucial in fostering a well-informed public.
- Dive deeper into consumers' perceptions and attitudes to better understand them and to take this into account as well in communication & development of new products.

Theoretical knowledge dissemination tasks

- Bridging knowledge gaps through webinars, training sessions, and documents on the fundamentals of the bioeconomy, circular bioeconomy, and their relationship with the circular economy.
- Explaining sustainability principles and ecological limits, emphasizing the importance of these boundaries and reducing the use of biological resources.
- Addressing technological innovations, biomass valorisation processes, and economic aspects such as funding and business models.





- Clarifying regulations, standards, certification schemes, and legal challenges involved.

Practical knowledge dissemination

- Organizing workshops and training on new technologies, valorisation processes, and sustainable agricultural and forestry practices.
- Implementing demonstration projects and field visits to showcase practical applications, economic benefits, and new business models.
- Creating digital platforms and web portals as information hubs, including sharing best practices and success stories, with visual communication tailored for local dissemination (e.g., farmer-to-farmer) environments.
- Facilitating co-creation and demonstration workshops to generate new ideas and promote stakeholder engagement.

Building new knowledge together with stakeholders

- Co-create participatory frameworks to evaluate and monitor bioeconomy projects
- Promoting multi-actor approaches and networks by encouraging collaborations between farmers, research institutions, industry, and policymakers.
- Establishing living labs and localized demonstration projects for hands-on innovation and stakeholder involvement.
- Facilitating co-creation workshops aimed at developing new solutions collectively and increasing stakeholder participation.
- Supporting knowledge exchange through shared experiences, success stories, and joint project evaluations, including site visits.

Building trusted networks among stakeholders

- Facilitating regional and international networks and clusters to strengthen trust and cooperation.
- Engaging primary producers, SMEs, policymakers, investors, and technology providers in long-term partnerships.
- Actively encouraging dialogue and participation, especially to involve underrepresented groups like farmers and civil society stakeholders.
- Creating platforms for continuous interaction and knowledge sharing, such as advisory networks and collaboration platforms.

Communication strategies

- Developing effective communication through digital platforms, visual aids, and accessible information for a broad audience, including farmers and consumers.
- Using targeted communication methods (for example, farmer-to-farmer) and on-site demonstrations to share practical and economic knowledge.





- Promoting operational groups and collective initiatives for social learning and increasing societal acceptance.
- Informing and educating citizens and producers about the benefits, risks, and ecological boundaries of the bioeconomy to foster support and awareness.

Policy advice

- Supporting the development of coherent, stable policy frameworks at regional, national, and European levels, including advocating for a national bioeconomy strategy.
- Advising on harmonization of standards, certification, and labelling schemes, and on navigating legal and regulatory challenges.
- Promoting long-term strategies and support mechanisms to ensure consistent policy development for sustainable growth.
- Encouraging research and innovation aimed at revenue generation and strengthening business models, including the use of decision-support systems.

This structured approach not only enhances knowledge and skills but also promotes sustainable and inclusive development of the bioeconomy through active collaboration, network-building, targeted communication, and policy strengthening.

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8 ANNEXES

8.1 ANNEX I QUESTIONS FOR EXPERTS ON THE SOCIAL DIMENSION OF BIOECONOMY

Experts do not need to have expertise on Bioeconomy in all EU regions, we would like to have a minimum of three experts with each expertise in at least one widening region (Portugal, Greece, Slovakia, Slovenia,...) and considerable knowledge of the EU bioeconomy strategy.

They need to have experience in social sciences and understand the bioeconomy sector in their region. Ideally they have insights on both the consumer/citizens perspective, primary producers perspective and the perspective of the industry/bioeconomic players in their region. Our ambition is to be able to zoom in on some of the most important sectors: wood, agrifood, urban biowaste and aquatic.

The interview will take place online and will last for 90 minutes. It will be recorded with their permission and be part of a public deliverable. Their contributions can be made anonymous, that is, we do not need to mention their name.

Please find the questions below.

Please describe your expertise:

- ➔ On which regions do you have knowledge?
- ➔ In which bioeconomy sectors?

Do the current bioeconomy strategies in you regions of expertise address social sustainability?

- ➔ Long term vision
- ➔ Environmental justice
- ➔ Welfare for local communities and indigenous people
- ➔ Fair working conditions
- ➔ ...

What key factors prevent or facilitate new systems and collaborations in bioeconomy projects?

How would you describe the general awareness and understanding of bioeconomy with the wider public in your regions of expertise?

How would you evaluate the consumer acceptance in your region of expertise?

- ➔ Are there any communication strategies in your region(s) of expertise that help to foster greater public awareness and participation in the bioeconomy?

Are the perspectives of local stakeholders (citizens) and biomass producers visible to bioeconomy actors and policy makers in your regions of expertise?





- ➔ How was this achieved/why not?
- ➔ Do you see opportunities for the bioeconomy to capitalize on the knowledge held by primary producers to foster innovation? How so? Could you give some examples?

Do you think a growing bioeconomy would impact the inequality?

- ➔ How can social aspects and collective action be better combined with economic interests and income security for primary producers?

In what ways does the EU Bioeconomy Strategy need to evolve to consider intangible services and a wider range of actors beyond its focus on production?

8.2 ANNEX II: INTERVIEW 1

Expert on biomass valorisation, industry association, Greece.

Greek bioeconomy context

The main types of biomass that is collected in Greece are cotton sides streams, olive pomace from agro-industrial activities and lignocellulosic biomass from pruning trees and managing forests. The focus is on the residual biomass from agriculture and energy crops. These inputs are transformed into solid biofuels (eg briquettes, pellets), biochar and bio-products. This happens through combustion, pyrolysis and gasification.

There is a lot of biomass available and currently it is often not valorised at all. For example, many farmers still use open fires to clean up wood from pruning trees. Setting up a supply chain to process these prunings into woodchips and use them to produce energy, increase carbon matter in the soils etc proves to be difficult. There are no investments because there is no supply chain in place and there is no supply chain because it requires high investments. This chicken and egg problem has many dimensions that are summed up below:

- Business case is challenging
 - High minimal quantities needed
 - The minimal amount of biomass that is needed to keep a biomass processing plant running is quite high
 - The type of biomass that you need depends on the end products you want to make. The lower on the waste pyramid the easier it is to obtain this critical mass because you can mix different biomass streams. For biogas production you can mix all sorts of waste but not if you want to make products for human consumption.
 - High investment cost for biomass valorisation
- Challenges in demonstrating economic viability of bioeconomy projects
- Operational/supply chain challenges
 - Small-scale agricultural operations making biomass collection challenging





- Insufficient infrastructure for biomass processing
 - Geographical positioning of bio-economy plants: it is important to determine the location based on the availability of the biomass streams but it is not always possible to obtain permits to build them there.
- Political and regulatory framework
 - Lack of a comprehensive national bioeconomy strategy
 - Lack of financial incentives for farmer to participate
 - Lack of legislation to mandate biomass collection and processing
 - Open fires to clean up tree pruning biomass are still allowed but limited in time
- Social factors
 - Farmers are getting older and older farmers are less willing to change
 - "Not in my backyard" syndrome among local communities
 - Low consumer willingness to pay for bio-based products
 - Insufficient environmental education
 - Common practice to burn household waste
 - Low social support for regulatory measures towards farmers

The interviewee mentions several benefits of a sustainable bioeconomy:

- It could be a change agent for rural development:
 - Job creation in rural area's (collection and pre-processing of biomass)
 - Generate investments in rural infrastructure
 - Maintenance of rural environment: forest management to prevent wild fires
 - Develop high quality consumer products that are interesting for agrotourism
- It would reduce the environmental impact of current mismanagement of surplus biomass
- Applying biochar or woodchips would improve soil quality and create carbon sinks

There are some conditions that need to be fulfilled before these benefits can be generated:

- A bioeconomy strategy that is adapted to regional needs, strengths and potential resources
- The realisation that not managing biomass efficiently also incurs a cost for society. The environmental damage that is done by for example open fires needs to be monetized in terms of social and environmental impacts in order to make a fair comparison to the investments needed in bio economy.
- Win-win cases to demonstrate that producers can benefit from bio economy projects via for example producer schemes or reciprocal investments
- Not only focus on the main product but support the valorisation of side streams via vertical integration
 - Eg make soap out of olive pomace or briquettes out of the vineyard pruning's and market them towards foreign tourists
- Environmental education, mainly for young children





It is pointed out that bioeconomy needs to be implemented in a sustainable way. It could become unsustainable if it is done at a very intensive scale. Sustainability criteria to assess bioeconomy project investments are needed, similar to the ones available under the Renewable Energy Directives.

8.3 ANNEX III: INTERVIEW 2

Slovenian bioeconomy context

Since 60% of Slovenia is forest land it is not surprising that the main source of biomass is wood. In agriculture animal production (ruminants) takes the lead with 60% of the agricultural land being grassland. Finally there is some arable farming and horticulture (notable for hops production). Slovenia used to have very large and vertically integrated wood processing and paper manufacturing companies that operated across Yugoslavia and international markets. Nowadays there are mostly smaller SMEs that are not vertically integrated.

Slovenia does a lot of export of raw materials in terms of timber wood (half of the conifer wood) or raw milk. Industrial processing of wood is limited. Most of the softwood is used for heating houses. This is strongly linked to the very scattered urban planning.

Main barriers for developing a bio economy in Slovenia:

- Social and Psychological Barriers:
 - Farmers have a traumatic past experience with large state subsidized biogas installations that disturbed the agricultural and land market, making them sceptical of new bioeconomy initiatives
 - Resistance to change among farmers and policy makers
 - lack of interest in long-term strategic thinking by policy makers.
- Fragmented ownership and Infrastructure Challenges:
 - 80% of forests are privately owned, with 400,000 owners for a small country
 - All owners need to agree and work together to get roads and other infrastructure required for exploiting the forest
 - Many forest owners are inactive or unidentifiable, making efficient forest management difficult.
 - Scattered land ownership prevents coordinated biomass collection and processing
- Legal and Policy Barriers:
 - Restrictive regulations preventing efficient use of agricultural waste (e.g., slurry cannot be mixed between farms)
 - Lack of a national bioeconomy strategy
 - Short-term political thinking that doesn't support long-term bioeconomy development
- Economic and Structural Issues:
 - Fragmented industrial landscape with small and medium enterprises





- Lack of vertical integration in value chains
- Limited investment in new technologies
- Preference for traditional, low-risk economic activities
- Weak cross-sector collaboration
- Knowledge and Mindset Barriers:
 - Limited understanding of bioeconomy potential with the wider public and policy makers
 - Reluctance of existing companies to share knowledge or diversify
 - Lack of interest in developing complex biorefinery technologies

The following options to overcome these barriers were suggested:

- Policy and Governance Approaches:
 - Develop a comprehensive national bioeconomy strategy
 - Create long-term, visionary policy frameworks
 - Implement more flexible regulations for biomass and waste use
 - Support cross-sector collaboration
- Economic and Structural Interventions:
 - Identify and support "regional engine" companies
 - Develop demand-driven innovation approaches
 - Create financial incentives for bioeconomy projects
 - Facilitate cross-border value chain development
- Knowledge and Awareness Strategies:
 - Demonstrate successful micro-cases of bioeconomy projects
 - Provide education and training on bioeconomy potential
- Farmer and Stakeholder Engagement:
 - Address historical traumas through transparent communication
 - Show concrete economic benefits of bioeconomy initiatives
 - Create collaborative platforms for farmers
 - Develop trust-building mechanisms
- Technological and Innovation Support:
 - Invest in applied research
 - Support technology development in bio-based materials
 - Create innovation platforms connecting research and industry
 - Provide expertise and advisory services for bioeconomy project
- Ownership and Infrastructure Solutions:
 - Develop mechanisms for coordinating fragmented land ownership
 - Create cooperative models for biomass collection
 - Improve forest management infrastructure
 - Support small-scale, distributed processing facilities





These strategies aim to systematically address the social, economic, and structural barriers to bioeconomy development in Slovenia.

Based on the interview, potential advantages of developing a bioeconomy in Slovenia include:

- Resource Advantages:
 - Abundant forest resources (60% forest coverage)
 - Significant grassland for animal production
 - Diverse biomass streams from forestry and agriculture
- Economic Opportunities:
 - Potential for cross-border value chains
 - Development of niche bio-based products
 - Technology development in areas like:
 - Biopolymers
 - Applied biotechnology
 - Composite materials
- Sectoral Potential:
 - Strengthening manufacturing sectors
 - Diversifying automotive industry supply chains
 - Creating new value-added products from wood and agricultural waste
 - Developing small-scale biorefinery networks
- Strategic Benefits:
 - Reducing dependency on imported raw materials
 - Creating new economic opportunities in rural areas
 - Improving resource efficiency
 - Potential for international technology export
- Innovation Pathways:
 - Developing technologies for:
 - Slurry processing
 - Lignocellulosic biomass utilization
 - Wood chemical extraction
 - Supporting emerging bio-based industries
- Systemic Advantages:
 - Reducing synthetic fertilizer dependency
 - Creating more sustainable agricultural practices
 - Developing circular economy approaches
 - Potential for regional economic transformation

These advantages suggest significant untapped potential for bioeconomy development in Slovenia.





8.4 ANNEX IV: INTERVIEW 3

Social sciences researchers, International consulting company, Portugal & EU wide

The interview introduces speakers from Company X who work in the social sciences team, primarily focusing on social life cycle assessment (LCA). Their background is in sociology and social research, and they also undertake tasks related to gender and ethics within their organization. The company offers various services, including guidance across social, business, legal, and technological

The speakers apply social LCA across diverse industries, including bioeconomy, energy, technology, manufacturing, and services. Social LCA is typically coupled with environmental and economic assessments. They emphasized that the social dimension, while gaining traction, is often overlooked in sustainability discussions compared to environmental or economic aspects. Methodologies for measuring social sustainability are not as advanced.

A significant barrier identified in implementing bioeconomy projects is involving stakeholders. Stakeholders include secondary partners for dissemination events (like workshops and webinars), primary producers, policy makers, industries, European clusters, and academia. It can be particularly difficult to engage final users and those involved in end-of-life strategies. Local stakeholders, such as citizens, often lack representation in decision-making processes. Strategies to involve stakeholders include organizing workshops and events, focusing on interactive sessions, demonstrating solutions, and allowing participants to experiment with new materials. It is crucial to ensure that local knowledge and experience inform project design. Local governments have been found to be very communicative and supportive.

Consumer education is another major challenge. Difficulties arise in raising awareness about issues like dangerous chemicals and sustainability. Simplifying technical aspects of new bioeconomy alternatives, such as bioplastics, is necessary as people can be sceptical about their functionality compared to familiar products. Catering to different demographics, including older generations, can be challenging but rewarding. Taste tests have been used for novel food products like algae-based alternatives to gauge social acceptance. Public understanding of bioeconomy concepts remains limited despite its growing importance.

A significant challenge highlighted is the difficulty in obtaining reliable data for social LCA. Social information is often more sensitive than environmental or economic data. Companies may lack the structure to collect this data or be sceptical about sharing it. Fair wages and salaries are identified as major data gaps across various industries, from primary producers to pharmaceuticals. When primary data is hard to acquire, secondary data sources like databases and literature are used, emphasizing the need for updated databases and better dissemination of research results. Transparency with data providers about how information will be used is essential to build trust. Data sharing platforms are seen as important for overcoming these issues.





Key social sustainability indicators included in social LCA are environmental justice, community welfare, and fair labour conditions. Community welfare is linked to ensuring local communities benefit from bioeconomy advancements, such as through job generation for local people, rather than facing negative consequences. Measuring this involves assessing the percentage of local employees and access to resources and education. Unfair working conditions, especially in sourcing materials, are a concern. Even if the final product is sustainable, the upstream working conditions must be considered for a project to be deemed socially sustainable.

When comparing bioeconomy strategies across Europe, a speaker noted that many still lack robust integration of social sustainability indicators, prioritizing technological and economic factors. Their company attempts to address this gap by incorporating comprehensive social indicators.

Regarding specific bioeconomy sectors:

- Bioplastics development is a focus, but gaining consumer trust in their functionality is a barrier.
- Aquaculture-based food production, like algae, is being explored, facing skepticism regarding taste and texture in the Western world.
- Using waste streams, such as oil waste for new packaging materials, is being studied, including its social acceptance.

The interview touched on challenges in Portugal, noting that while a national bioeconomy strategy exists, awareness among industries might be low. The speakers' expertise is more EU-wide. Portugal's forestry sector is complex, partly due to human-induced fires used as a loophole for unauthorized deforestation, creating negative public opinion that can link bioeconomy to forest destruction. In agriculture, burning of woody materials and household waste is still common in rural areas, partly due to lack of awareness and less developed waste management infrastructure. Small-scale farming is predominant in Portugal, with collaboration structures like cooperatives being more common in the south.

Systemic concerns include the potential risk that the rate of resource consumption for bioeconomy could exceed regeneration, potentially leading to sourcing resources from the Global South and impacting those regions, similar to extractive industries.

Beyond technological solutions, social innovations like the efficient redistribution of surplus food are considered part of the bioeconomy, focusing on using organic products at the highest level of the cascade (human consumption). Using food waste to create new materials is another example.

The methodological challenges of social LCA include the need for significant interpretation of qualitative data to assign quantitative values, making it less direct than environmental LCA. Effective bioeconomy implementation requires strong stakeholder collaboration, access to reliable data, and navigation of complex regulations.

