Inclusive Innovation in the Bioeconomy

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Fig. 33.0 Inclusive innovation in the bioeconomy. (© Ricardo Vargas-Carpintero) (► https://doi.org/10.1007/000-hve)

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Contents

The bioeconomy offers a vision of economic prosperity and ecological sustainability by substituting fossil resources with biomass. The use of biomass is essential to achieve global sustainability targets and novel technologies emerge to exploit biomass in increasingly efficient ways. However, these technological advancements raise critical questions about economic and environmental justice, including the distribution of benefits, ownership rights and their impact on global inequalities. Particularly, concerns arise about the sourcing of biomass from the Global South for processing in the Global North, and how these practices affect sustainability and biodiversity. This chapter explores the concept of inclusive innovation as a solution to these uncertainties, emphasising the engagement of diverse stakeholders in the design and development of technologies to enhance their legitimacy and acceptance. Inclusive innovation aims to improve the livelihoods of the most vulnerable by integrating their perspectives into innovation strategies. Environmental justice, focusing on distribution, processes, recognition and capabilities, is essential for achieving fair and sustainable bioeconomic practices. By applying these concepts to both regional and global value chains, this chapter demonstrates how meaningful inclusion can enhance opportunities for disadvantaged groups and align bioeconomic practices with local capacities. Inclusive design can also generate support among European farmers to deliver to bio-based value chains. Ultimately, embracing inclusive innovation and environmental justice ensures that the bioeconomy fosters equitable and sustainable development for all.

Learning Objectives

After studying this chapter, you will…

- …be able to explain the concepts of inclusive innovation and environmental justice (see ► Sects. 33.2 and 33.3).
- …be able to explain why these concepts are relevant to the bioeconomy (see ► Sects. 33.2, 33.3, and 33.6).
- …be able to illustrate this relevance with examples from current practices around the use of biomass (see ► Sect. 33.6).

33.1 Introduction

The bioeconomy is an appealing concept that integrates the promise of economic prosperity with that of ecological stability by replacing fossil resources with biomass. Recent advances in bioengineering, such as CRISPR-Cas and synthetic biology approaches, offer novel pathways to modify microorganisms into high-performing production platforms for a wide range of products (Straathof et al. 2019). Novel bioprocessing technologies increase the efficiency of using biomass, which is essential to meet the global energy demand in a sustainable manner (Alazaiza et al. 2024).

Such increasingly advanced technologies give rise to questions about economic and environmental justice: Who will benefit from these sophisticated technologies? Who will own and distribute them? How will they affect global economic inequalities, especially considering the fact that a lot of the biomass will be sourced from the global south and processed in the global north (Lühmann 2021)? And how can they contribute to sustainability?

These questions emerge against a background of multifaceted uncertainties. As explained in ► Chap. 1, Biomass encompasses a wide range of feedstock including plants, trees, algae, marine organisms, microorganisms and animals. Each of these feedstocks emerges from its own societal context, in which specific challenges may complicate the quest to arrive at sustainable products. Crops are grown in various agricultural practices, each of which has its own unique set of circumstances. Furthermore, the collection of residues from various areas is impacted by local infrastructures or local social structures. Often changes may be required in existing agricultural practices to achieve an efficient and sustainable sourcing of biomass (Robaey et al. 2022).

Additionally, it may not always be clear what the most sustainable approach is with regard to the utilisation of feedstocks. Is it always more sustainable to use residues, or is it sometimes more efficient to use dedicated energy crops? Does the use of novel

technologies lead to more sustainable farming practices or does it undermine traditional practices that are actually more sustainable? All these questions require dedicated approaches to deal with them.

In this chapter, we will discuss the concept of inclusive innovation as a way to manage these uncertainties, while at the same time addressing economic and environmental justice (Asveld 2021). We will explain these concepts in more detail and show how they are relevant to current developments in the bioeconomy.

33.2 Inclusive Innovation

The concept of inclusion has garnered attention as a crucial element of Responsible Research and Innovation (RRI). It emphasises engaging a diverse range of voices in developing new technologies to enhance both the legitimacy and acceptance of innovations (Stilgoe et al. 2013). This approach shifts away from an innovation system dominated by technological experts. Inclusion, in this context, is viewed primarily as a process where multiple stakeholders provide input on the desirability of a specific innovation's design. Such inclusion is generally seen as essential for achieving societally desirable outcomes.

Some authors, however, emphasise inclusion as an outcome of innovation rather than just a prerequisite. In the bioeconomy context, inclusive innovation is described as a "new way of doing things that may improve the lives of the most needy" (Bryden et al. 2017). Here, the actual benefits of an innovation are central. This focus on enhancing the livelihoods of the most vulnerable is also evident in the approaches of inclusive agricultural value chains (Devaux et al. 2018) and inclusive innovation for development in general (Heeks et al. 2014). These approaches demonstrate a progression from merely providing products tailored to the most needy (e.g., frugal innovation) to more comprehensive strategies that consider the living conditions and overall well-being of vulnerable groups (Ros-Tonen et al. 2019).

Broadly, inclusive innovation aims to expand both the target audience of an innovation, and the range of stakeholders involved in its development and design. The focus can be on the product design itself, incorporating various stakeholders' perceptions to create a more inclusive design or taking a comprehensive approach that also considers the local context of production (Asveld 2021).

> ***Inclusive innovation*** aims to broaden both the target audience as well as the stakeholders involved in the development and design of an innovation, through tailored design, inclusion of diverse perspectives or a comprehensive design approach that encompasses the local context of all stakeholders involved.

Involving local producers or potential users offers both moral and epistemic benefits. This implies that inclusion can provide a basis to increase knowledge as well as legitimacy. Engaging local stakeholders in bio-based production systems can address numerous uncertainties (Rist et al. 2007). Local producers often possess valuable knowledge about land management, their natural environment and related biomass (Šūmane et al. 2018). While inclusion can lead to more sustainable bio-based products and value chains, it also promotes environmental justice, which will be discussed in more detail below.

33.3 Environmental Justice

Environmental justice plays a crucial role in any technological development related to sustainability, particularly within the bioeconomy. This concept can be broken down into four key elements: distribution, processes, recognition, and capabilities (Schlosberg 2007). Each of these aspects is integral to the bioeconomy, as we will explore below.

Distributive justice involves the equitable allocation of burdens and benefits within society (Lamont 2017), closely aligning with eco-

nomic justice. For simplicity, we will treat these concepts interchangeably. Economic incentives designed to promote the bioeconomy often disproportionately benefit established agribusinesses or urban consumers (Bastos Lima 2022). Meanwhile, the burdens, such as monoculture expansion and environmental risks, are primarily borne by resource-poor rural populations (Bastos Lima 2022). Furthermore, smallholders frequently struggle to integrate into and reap the benefits of global bio-based value chains (Balkema and Pols 2015; Robaey et al. 2022). In the bioeconomy, distributive justice necessitates prioritising the needs of vulnerable local stakeholders and ensuring a fair distribution of environmental, economic and social risks (Gupta and Lebel 2020).

While distributive justice focuses on how impacts are allocated, recognition justice addresses the unique needs and potential harms facing vulnerable groups (Dillman and Heinonen 2022). This aspect emphasises acknowledging the social, cultural, historical and economic structures that underlie unequal distributions (Velasco-Herrejon and Bauwens 2020). Relevant questions include who is affected and which sections of society are under- or misrepresented. Ignoring the concerns, views and needs of vulnerable stakeholders affects both distributive and procedural justice, as these communities are often excluded from bioeconomy governance and the benefits of expanded bio-based production (Bastos Lima 2022). Implementing environmental justice in the bioeconomy should begin with recognising these stakeholders and their perspectives on rural development.

In addition to distributive and recognition justice, it is essential to examine the processes that lead to fair or unfair distributions (Velasco-Herrejon and Bauwens 2020). Procedural justice pertains to participation in the design process and decision-making about future directions (Bastos Lima 2022). In developing the bioeconomy, it is vital to consider who is involved in decision-making and how these decisions are made. By including local stakeholders in these processes, their knowledge is mobilised, potentially leading to alternative designs and viewpoints that better reflect specific needs and circumstances. Beyond justice claims, involving local stakeholders can also enhance the effectiveness and sustainability of bio-based products and value chains, as producers often possess valuable knowledge of land management and cultivation practices (Asveld et al. 2023).

Any inclusive and just approach to the bioeconomy must consider the disparities in skills and knowledge among individuals, as well as economic, social and institutional inequalities. It must also account for the diverse cultural contexts and norms that influence global value chains and shape individuals' opportunities (Alsop and Heinsohn 2005). The concept of capabilities is helpful here, as it identifies the distribution of opportunities among various actors. These opportunities represent more structural elements of inclusion compared to narrower indicators like increased income or improved sanitation (Oxoby 2009).

The capability approach emphasises individual human capabilities, or "a person's real freedoms or opportunities" (Robeyns 2017) to achieve what they value. Examples include the capability to become educated, live a healthy life and grow one's own food (Nussbaum 2000). The availability of these capabilities depends on a range of interconnected inputs, such as institutions, public goods, social practices, resources and skills, collectively known as "conversion factors" (Robeyns 2005). When people exercise their agency, they make choices about which capabilities to develop into "functionings" (states or activities that create well-being, such as getting educated or living a healthy life). Thus, capabilities represent options not outcomes.

Environmental justice refers to the equitable distribution of environmental benefits and burdens, inclusive decision-making processes, recognition of the unique needs of vulnerable groups, and the enhancement of individuals' capabilities. It aims to address and rectify the social, cultural, historical, and economic inequalities that impact on how environmental resources and risks are shared within society.

33.4 Environmental Justice and Inclusion in the Bioecononomy: Global and Regional Value Chains

In this section, we will apply the aforementioned concepts to a central element of the bioeconomy: namely global and regional value chains. Bio-based value chains often build on biomass derived from a biomass-rich region, from where it is exported to a technology-intensive region, sometimes after pre-processing at the site of production. The raw or pre-processed biomass is processed further into a chemical product, for example, base chemicals or fuels or products such as plastics or bio-based lubricants. As discussed above, inclusion of biomass producers in the set-up of value chains can be beneficial for both moral and epistemic reasons. However, many biomass producers are located in the *Global South*, where conditions for inclusion can be suboptimal, for instance, because of weak institutions (Postal et al. 2020; De Gelder and Asveld 2024).

> ***The Global South*** refers to countries that are usually considered as 'less developed', which is often due to colonialisation and its continuing impact.

Additionally, cultural values and practices between producers and other actors in agricultural (and bio-based) value chains may vary widely (Ros-Tonen et al. 2019), as may access to resources (Devaux et al. 2018). Historically, these differences have not always been well addressed in the setting up of bio-based value chains, and this has contributed to their failure (Romijn and Caniëls 2011) or created new economic dependencies, making local biomass producers more vulnerable (Bottazzi et al. 2018).

For meaningful inclusion, opportunities for local actors should be central to the set-up of the value chain. For this, enabling the involvement of local actors and values at the start of new value chain development projects is essential (Palmeros Parada et al. 2020, 2021). Inclusion should revolve around increasing opportunities for those least well off (Bryden et al. 2017). Increased opportunities not only provide individuals with the option to shape their lives as they see fit by reducing stifling economic dependencies but also allow for diversity and human flourishing, which is what inclusion should be about. At the same time, the value chain should be designed in alignment with existing local capacities and resources, such as skills and knowledge, to increase its chance of operating effectively and successfully.

The capability approach offers a lens to tailor value chains to the skills, knowledge and preferences of local stakeholders. This contributes to all aspects of environmental justice because it leads to more equal distribution of benefits, to recognition of the views of all stakeholders and to procedural justice because it takes these views into account while also considering the diversity in the capability to participate in decision-making.

This may result, for instance, in a value chain that starts from the relatively small plots of coffee producers in Colombia instead of opting for a more centralised version in which these small plots are concentrated into one bigger plot. By respecting the ownership of farmers of their small plots, and hence collecting residues from each of them individually, their capability of controlling their environment is acknowledged and maintained (Van der Veen et al. 2024).

Developing value chains based on local capabilities requires a nuanced approach. While aligning technologies with existing skills—such as designing a hand bike for individuals with paralyzed legs—is logical, the broader goal of inclusion entails creating opportunities for people to expand their capabilities. This raises a critical question: Should we design technologies to match current capabilities, such as existing levels of education, by using relatively simple solutions? Or should we aim for future, desirable capabilities, such as access to higher education and the development of advanced technological skills? These future capabilities could arise through

increased income and inclusion in global value chains.

For example, while a hand bike directly enhances mobility opportunities for someone with paralyzed legs, the technological choices in bio-based value chains offer a broader spectrum of possibilities, either by adapting to current skills or fostering future growth. Addressing this dilemma requires diverse strategies. Three overlapping, complementary approaches for designing inclusive bio-based value chains can be applied (see Asveld et al. 2023 for a further elaboration and discussion of these strategies and the case-study):

1. Design for existing capabilities.
2. Provide adaptive designs to foster new capabilities.
3. Invest in enabling conditions for novel capabilities.

Integrating these strategies allows for the accommodation of both existing and evolving capabilities.

Excursus 33.1 Case Study: Jamaican Sugar Cane Farmers

Many Jamaican farmers seek to diversify their income sources. One potential avenue is selling sugar cane to bio-based value chains for biofuel production. When designing such a value chain, how can the farmers' current financial needs and existing conversion factors be considered?

1. **Respecting Existing Practices**
   One approach is to retain sugar cane as the primary feedstock, even if alternative crops might yield higher returns. This decision allows farmers to build on their existing practices, respecting local traditions and social norms while minimising the need for new, unfamiliar practices.
2. **Leveraging Established Technologies**
   Ethanol production from sugar cane is a globally established process. By choosing ethanol as the main product, Jamaican farmers and industry actors can adopt proven practices already in use elsewhere. This approach aligns with the conservative stance of many stakeholders in Jamaica's long-established sugar cane industry, which dates back to colonial times. Utilising familiar practices and technologies ensures a smoother transition and offers a stable opportunity to diversify income.
3. **Integrating Advanced Bagasse-to-Energy Solutions**
   Bagasse, a byproduct of sugar cane processing, can be converted into energy. While current machinery in Jamaica is outdated, introducing modern high-efficiency steam turbines and mills could significantly enhance the economic and environmental sustainability of the sugar industry. The feedstock, technology and market for bagasse-to-energy production are already accessible, making this an immediate and practical opportunity to create value from waste.
4. **Limitations of Advanced Technologies**
   However, adopting highly advanced technologies—such as on-site enzyme production for ethanol fermentation, wastewater treatment systems, or the production of bio-based chemical building blocks—may be impractical at this stage. These technologies require advanced skills, significant investment and a supportive business climate, all of which are currently limited in Jamaica. Implementing such solutions prematurely risks failure and inefficiency.

Excursus 33.2 EU Project: Circular Bio-Based Business Models to Create High-Value Bio-based Products in Integrated Value Chains (C4B)

Inclusive Innovation is also promoted and supported in the context of the development of new regional bio-based value chains in Europe, for instance, within the EU-funded research project C4B. While primary producers are essential stakeholder of the European circular bioeconomy, their involvement in innovative bio-based business models is still limited. In most cases, the benefits are not fairly distributed along the value chain, to the disadvantage of primary producers.

The goal of the project C4B is to build fair and sustainable business models that create opportunities for rural entrepreneurship and allow farmers to participate in value-adding activities. The project comprises nine case studies across Europe, including forestry in Sweden and Italy, vineyards in Greece and Italy, cereal production in Greece and Italy, apple production in the DACH region, potato production in southern Germany and wetlands in northern Germany. During the first phase of the project, different biomass conversion pathways of harvest residues are explored with primary producers and other stakeholders. The focus is on developing high value-added products, including biochar, platform chemicals, and products for the food and cosmetics industries. In the second phase, inclusive business models will be design and evaluated based on scalability and replicability, as well as sustainability.

Sharing of power and profits across novel bio-based value chains may accelerate the development of rural communities, the local addition of value and farmers' economic diversification, as well as enhance the cooperation among farmers, foresters and bio-based industries (► www.c4b-project.eu).

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33.4.1 Adapting for Future Capabilities

Should the bio-based value chain succeed, it could enhance the local community's capabilities by providing access to investment funds and higher education opportunities. This, in turn, could create favourable conditions for incorporating advanced technologies. For instance, a biorefinery initially focused on first-generation production can later be expanded with more complex, second-generation technologies to optimise energy use and diversify outputs. This adaptability makes biorefineries particularly well-suited for fostering new capabilities and enabling a gradual shift towards higher-tech applications.

By combining strategies that respect existing capabilities, foster new skills and invest in future potential, actors can create sustainable, inclusive value chains that adapt to local realities while laying the groundwork for growth and innovation.

33.5 Conclusion

The bioeconomy promises economic prosperity and ecological sustainability by replacing fossil resources with biomass. However, these developments raise critical questions about economic and environmental justice. Key concerns include who benefits from these technologies, ownership and distribution rights, their impact on global inequalities, especially given that much biomass will come from the Global South and be processed in the Global North, and their contributions to sustainability.

For developers of emerging bio-based value chains, this implies the need for careful consideration of local circumstances and the skills, needs and values of local producers of biomass. Focusing solely on participatory exercises is not sufficient (De Gelder and Asveld 2024). Insights from local stakeholders need to be translated to actual design choices. Key choices in the development of inclusive value chains comprise feedstock

selection, biorefinery design and often also type of contracts (Robaey et al. 2022). Relevant aspects that need to be considered include local learning practices, local farming culture, local access and ownership of technology, infrastructure, and access to markets and access to information. All these elements determine the level of inclusion that is feasible for local producers of biomass (De Gelder and Asveld 2024).

There is a risk that sustainability is understood mainly as efficient production; however, truly sustainable and reliable value chains need to accommodate the capabilities of local stakeholders. Local contexts can be complex, and many different factors play into the quest for effective inclusion. Understanding this context and integrating it into the design of value chains can be a daunting task. Commercial parties have a role to play, but considering the sometimes substantial risks in developing inclusive value chains, as well as the potentially great benefits, governmental bodies should also step in and shoulder some of the burdens.

Do you want to learn more about the concept of responsible and inclusive innovation? Take a look at Supplementary Material 33.1, a video from our MOOC "Concepts of Sustainable Bioeconomy" (2021).

Questions

1. What is the relevance of environmental justice for the bioeconomy?
2. What would inclusive innovation imply for biobased products?

Answers

1. The bioeconomy has the potential to create jobs and foster economic growth. Environmental justice ensures that these opportunities are distributed equitably, providing marginalised groups with training, resources and infrastructure to participate in and benefit from bio-based industries. Environmental justice frameworks stress the importance of including affected communities in decision-making processes regarding bioeconomy projects and policies. This ensures that their voices are heard, and their needs and concerns are addressed. The transition to a bioeconomy must not perpetuate the exploitation of land and labour in vulnerable communities. Environmental justice frameworks help identify and mitigate risks of land grabs, unsustainable practices or unequal labour conditions that disproportionately harm these groups.
2. Inclusive innovation aims to expand both the target audience of an innovation and the range of stakeholders involved in its development and design. The focus can be on the product design itself, incorporating various stakeholders' perceptions to create a more inclusive design or taking a comprehensive approach that also considers the local context of production.

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