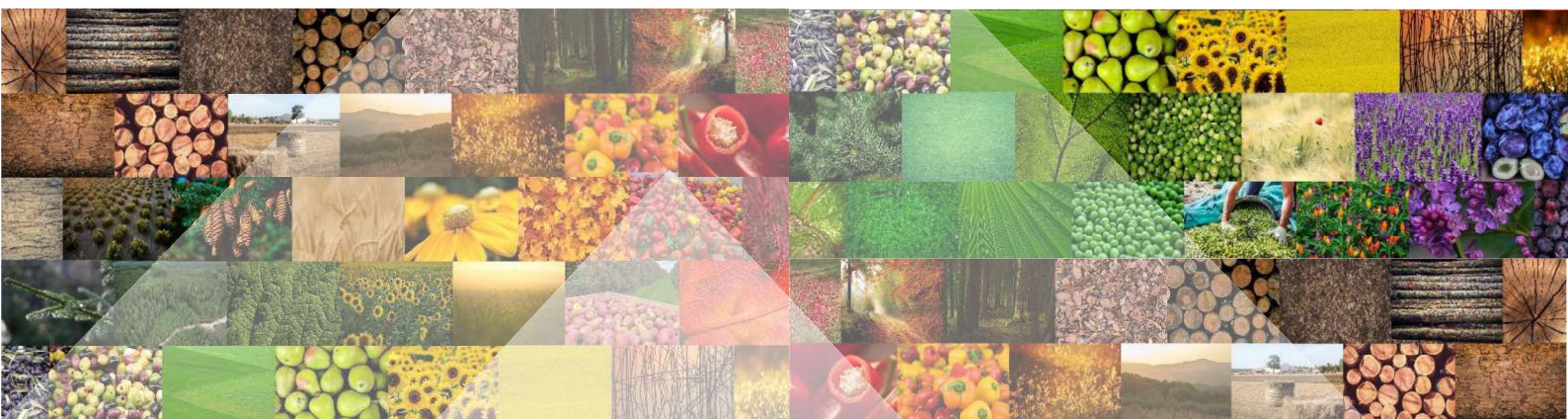


Scaling up biobased production within ecological boundaries – Recommendations for an updated EU Bioeconomy Strategy



KEY POLICY RECOMMENDATIONS:

- **Consideration of ecological boundaries must be prioritised in parallel to increasing the efficient and circular use of biological resources.** The EU Bioeconomy Strategy must anchor efficiency improvements within ecological limits to avoid rebound effects and protect natural capital.
- **Understanding ecological boundaries requires improved monitoring and data availability at the regional level.** Improved regional monitoring and data are essential to define ecological boundaries and guide sustainable bioeconomy practices.
- **Monitoring systems should be designed to incorporate precautionary principles for environmental protection.** Strategic, forward-looking monitoring can ensure bioeconomy development remains within environmental limits and policy frameworks are aligned.
- **Full chain development and supply chain efficiency can support the availability and sustainability of biomass resources.** Strategic supply chain development and proactive governance can balance biomass demand with environmental limits.



The challenge: Prioritising environmental sustainability within bioeconomy development

A thriving bioeconomy rests on a steady and sufficient supply of biomass to produce an economic system that utilizes biological resources to generate products and services. **Environmental sustainability is not an intrinsic characteristic of the bioeconomy** (Zeug et al. 2020). It is therefore imperative to develop Europe's understanding of the environmental impacts of the bioeconomy; to not only capitalize on the potential opportunities it offers for social and economic development, but also to keep ecological boundaries from being overstepped.

Understanding the dynamics of these elements is vital for a sustainable, circular bioeconomy. The natural environment provides essential inputs, like biomass, water, and soil, and acts as a sink for non-valorised byproducts and waste. For instance, biomass serves as feedstock for bioenergy, fertilizers, chemicals, and other products. However, natural resources are finite, and the adequate functioning of ecosystems is bound by ecological limits, requiring careful monitoring over time and space. Nutrient recycling maintains soil health and productivity, which in turn is needed to protect water quality and biodiversity.

Looking forward and in consideration of the political guidelines of the new EU Commission, **principles surrounding resource-efficiency and circular use of biomass will continue to play increasingly important roles in the development of the bioeconomy** (von der

Leyen, 2024). Further, the new EU Bioeconomy Strategy is positioned as a “flagship action” under the Competitiveness Compass, aiming to enhance the global position of the EU bioeconomy sector (EC, 2024a). Ongoing efforts to make the EU a leader in pharmaceuticals, agriculture, energy, and food, aim to create a supportive environment for innovation, including health technologies and advanced materials. Furthermore, in 2026, a new EU Biotech Act is expected to be adopted, reinforcing the strong and strategic focus on the biotechnology sector throughout these developments. At the same time, the growth of the bioeconomy requires an adequate supply of biomass. **The overarching question is: How can the EU Bioeconomy Strategy adequately prioritise ecological boundaries in its goal of increasing biobased production?** While the consideration of the ecological boundaries is a priority area of actions in the EU Bioeconomy Strategy of 2018, it is **not explicitly mentioned in the planned revision of the Strategy** (EC, 2024b). The four new pillars appear to put a stronger emphasis on economic and geopolitical aspects such as promoting economic growth and green jobs, reducing dependency on fossil resources, and boosting EU competitiveness. **Environmental sustainability, though still present, is treated as a cross-cutting topic embedded implicitly in the four pillars and deserves more explicit visibility and political commitment.**

Addressing the challenge: Evidence from six pilot regions

The SCALE-UP project (2022-2025) has brought together six regions across Europe to support the acceleration of bioeconomy development: Northern Sweden, Mazovia (Poland), the French Atlantic Arc, Upper Austria, Andalusia (Spain), and Strumica (North Macedonia). In each region, SCALE-UP extended existing infrastructures to establish regional platforms for innovation support and stakeholder engagement as a means of further developing regional bioeconomies. These platforms not only enabled exchange within the region but also promoted cross-regional knowledge brokerage to recognize and consider important differences between EU Member States and regions.

Understanding the ecological boundaries of the bioeconomy has been a key action area of the EU Bioeconomy Strategy as adopted in 2018. The SCALE-UP project responded to this call for action by investigating in its six pilot regions how the knowledge on biodiversity and ecosystems can be enhanced, how progress towards a sustainable bioeconomy can be monitored, how good practices to operate the bioeconomy within safe ecological limits can be promoted, and how the benefits of biodiversity in primary production can be enhanced.

A key output of the project carried out with the regional platforms was a detailed assessment

of biomass availabilities, nutrient balances, and ecological boundaries in each of the six pilot regions. To determine the state of the environment (water, soil, biodiversity) and identify the impacts that increased bioeconomy activities might have on the regional ecological systems, an innovative “sustainability screening” tool was applied (Groenestege et al., 2024), building on indicators and data available and accessible at the regional level (NUTS-3). Despite sparse data availability, the sustainability screening was able to produce indicative results in all six regions. For example, they showed that the state of surface water bodies and the multiple pressures they are subject to is of moderate to high concern across all pilot regions. Soil erosion and other forms of degradation remain a considerable risk in two out of the six regions. And concerns on biodiversity are indicated by the relatively large number of species categorised as endangered and critically endangered in half of the pilot regions.

On the basis of these results, the practical lessons learned during the application of the sustainability screening tool, and the discussions held with regional stakeholders, the following policy recommendations have been derived.

Key policy recommendations

Consideration of ecological boundaries must be prioritised in parallel to increasing the efficient and circular use of biological resources.

To avoid overexploitation and unintended environmental impacts, an EU Bioeconomy Strategy must prioritise the concept of ecological boundaries. Efficiency should not be narrowly defined in terms of maximizing economic returns, but rather in ensuring that resource use remains within the regenerative limits of ecosystems. Increased efficiency of resource use presents the risk of increased resource use overall; these efficiency gains must remain in the environment, preserving the ecological dimension of the bioeconomy, rather than favouring economic returns. Similarly, the preservation of water, soil and biodiversity is a fundamental requirement for long-term competitiveness and resilience, not an optional service for which primary producers are exceptionally rewarded. Achieving this depends on improved data availability, transparency, and robust monitoring systems that can track resource flows and ecological impacts at regional scales.

Understanding ecological boundaries requires improved monitoring and data availability at the regional level.

The sustainability screening exercises in the SCALE-UP project reflect the current data capacity for environmental monitoring and assessment in each region to an extent and give a rough indication of where ecological boundaries could lie. Ongoing efforts at EU level to support and improve the monitoring of environmental parameters in the context of the bioeconomy nature, soil and water quality is essential and should be encouraged. This includes, for example, expanding the coverage and scope of the EU Bioeconomy Monitoring System and the European Commission's Knowledge Centre for Bioeconomy to consider ecological boundaries and set relevant target indicators. Additionally, regional level data availability on water resources and soil should be harmonized with Water Framework Directive and Common Agricultural Policy approaches. This can support the establishment of regionalized key performance indicators to measure progress and impact effectively and accompany them with support to regional administrations to develop enforcement capacity.

*In the Normandy region of France, the regional chamber of agriculture is engaged in an initiative to develop and implement a **biomass and bioeconomy observatory**. This observatory will aim to support monitoring available biomass resources and map existing and future bioeconomy projects in the territory. Additionally, the tool will support the decision-making process for biomass mobilisation with respect to the hierarchy of uses and ecological boundaries.*

*This will build on existing tools in the region, like the **OBDEC** (Observatory for Waste, Resources and the Circular Economy) which collects data on waste, material flows and resources to guide regional policies.*

*Similar observatories exist in other regions of France, such as the **ORBE** Hauts-de-France (Observatory of Biomass and Bioeconomy), a regional initiative which aims to enhance knowledge of agricultural biomass resources and flows across the region. ORBE provides tools to support bioeconomy project developers by mapping biomass availability, visualizing existing projects, and analyzing resource flows.*

Monitoring systems should be designed to incorporate precautionary principles for environmental protection.

Based on work that has been carried out in Germany (Best, 2024; Best, et al. *under review*), several priority areas for action can be identified to ensure that environmental considerations are properly integrated in bioeconomy monitoring systems – be it at European, national or regional level. A central recommendation is to establish more integrated and multi-layered monitoring frameworks, which explicitly assess whether bioeconomy activities remain within sustainable biomass limits and are aligned with broader environmental boundaries. Setting clear sustainability objectives for the bioeconomy is equally important to ensure strategic coherence across sectors and scales. Maintaining and further developing the ecological footprint concept as a core analytical tool can enhance the monitoring systems' ability to link production and consumption patterns with global environmental pressures. Forward-looking scenario analyses should become an integral part of monitoring efforts, allowing for the assessment of potential environmental and social impacts of future bioeconomy pathways. Effective coordination with related national and international policy frameworks is needed to avoid duplication and

foster synergies. Finally, targeted research is required to close existing data and knowledge gaps, strengthen methodologies, and provide a robust evidence base for informed policymaking.

Full chain development and supply chain efficiency can support the availability and sustainability of biomass resources.

Biomass resources can be made better available in terms of quantity and quality, when the entire chain from collection, transport, feedstock storage, biomass processing and the application of bio-based products is well developed and gives serious consideration to environmental sustainability. Information exchange between stakeholders with a wide range of interests and specialized knowledge should be promoted (e.g. via regional platforms and multi-actor partnerships). Furthermore, the implications of increased demand for goods and services on resource availability and environmental sustainability should be seen from a regulatory lens and in a timely manner. Local and regional authorities can and should play an important planning and administration role in this respect, linking bioeconomy activities to either national or regional legislative frameworks.

In Northern Sweden, a focus on efficient regional biomass logistics and infrastructure has been critical to the further development of the bioeconomy. Costs related to harvesting, transporting, storing, and handling of biomass are key determinants of the overall biorefining cost, with raw material supply costs representing over half of the final cost. The focus on logistics must consider not only the flow of biomass, but also the flow of information between different actors in a value chain. Regional platforms and multi-actor partnerships can be of vital importance to efficient information flow. In Northern Sweden, a business centre “BioHub” has been designed to ensure the delivery of the appropriate biomass assortment to the correct end-user, acting as a link between traditional forestry operations and emerging biorefinery industries.

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