



# The BioMonitor model toolbox for addressing critical knowledge gaps in support of the implementation of European Bioeconomy Strategy

## Abstract

The implementation of the EU Bioeconomy Strategy is “on track” to achieve most of its objectives and to advance a circular and sustainable economy in the EU.

However, the European Commission and bioeconomy stakeholders have highlighted critical knowledge gaps that will hinder further progress. These include sustainability impacts, especially regarding effects on natural resources, but also tensions between demand and supply of land and biomass, and the more systemic effects as negative trade-offs. BioMonitor toolbox addresses such gaps in an integrated way, providing quantitative and qualitative insights into the future of the EU bioeconomy under alternative scenarios.

In this policy brief, we introduce the critical knowledge gaps and how the toolbox will develop insights about the possible futures of the bioeconomy. These insights will inform policy making in support of further implementation of a circular and sustainable bioeconomy in the EU.

## Key points

The BioMonitor toolbox simulates a range of future scenarios of the EU bioeconomy

It addresses critical knowledge gaps highlighted by the European Commission and stakeholders of the EU bioeconomy

Although the future is uncertain by definition, scenario-based modelling is an important tool for robust policy making

## Introduction

The EU Bioeconomy Strategy adopted in 2012 emerged from the realisation of the impelling need to cope with an increasing global population, rapid depletion of natural resources, increasing environmental pressures and climate change. The Strategy calls for a sustainable approach to production, consumption, processing, recycling and disposal of biological resources in Europe. Such ambitions were formalised into five objectives.

In 2022, the European Commission (EC) reported on the progress achieved in implementing the Strategy. It confirmed that implementation was on track to achieve the main objectives. However, the EC highlighted important gaps, especially, with regard to the management of land and biomass demands, the potential trade-offs between environment and economic impacts and the transition towards more sustainable consumption. These implementation gaps have their roots in a limited understanding of the complex interactions between the com-

ponents of the bioeconomy. The BioMonitor project has developed a model toolbox with the aim of providing integrated knowledge of such complex system. This policy brief provides an overview of how the BioMonitor toolbox contributes to addressing knowledge gaps that hinder further progress with the implementation of the Strategy. It illustrates policy relevant knowledge gaps and how they have been introduced in the model toolbox to explore, through scenario analysis, different futures of the EU bioeconomy.

## Knowledge gaps in the policy arena

In the BioMonitor project we identified a set of critical knowledge gaps that will need to be addressed to progress further with the implementation of the EU bioeconomy Strategy and its Action Plan. The gaps were grouped into three broad categories: sustainability impacts, tensions between supply and demand of land and biomass, and systemic effects.

- Sustainability impacts are those caused by bioeconomy activities on the natural environment, the economy and society in EU countries. Knowledge gaps remain on how to better manage biosphere use to meet environmental and economic requirements in a climate-neutral Europe, and how to promote more sustainable consumption patterns to guarantee environmental integrity.
- Tensions between supply and demand of land and biomass emerge from multiple pressures on resources for climate change mitigation, nature protection, ecosystem services and supply of biomass for existing and emerging uses, e.g., bio-based chemicals.
- Systemic effects cover impacts across economic sectors and supply chains generated by bioeconomy activities. Effects include potential win-win situations (i.e., synergies) and trade-offs (i.e., situations in which progress achieved on one aspect produces effects detrimental to other aspects). Systemic effects may occur between sustainability impacts on the environment, economy and society, or between the (five) objectives of the Bioeconomy Strategy, or between competing uses of land and biomass.

### Exploring bioeconomy futures with the BioMonitor model toolbox

The need for knowledge, foresight capacities and tools which can provide a better understanding of the complexity, trade-offs, and potential future pathways of the bioeconomy addressing its economic, social and environmental dimensions has been broadly recognised. However, despite the existence of important modelling capacities and experiences, the BioMonitor project revealed important modelling gaps largely aligned with the knowledge gaps recently highlighted by the EC and the stakeholders of the bioeconomy.

To overcome these modelling gaps, the BioMonitor project developed a model toolbox integrating four existing simulation models – AGMEMOD, EFISCEN, EFIGTM and MAGNET, and a purpose-built model named BioMAT. In addition, four scenarios were designed for the toolbox to explore future pathways of the bioeconomy for the period up to 2050. A ‘Baseline Reference Scenario’ (BRS) was designed following a “business-as-usual” path of development. It assumes the continuation of both policies already introduced and past market trends for production, use and trade of bio-based products. Three alternative scenarios were developed to explore possible futures which might diverge from a business-as-usual path. Alternative scenarios include “Go-it-alone”, which considers the promotion of the bioeconomy as a policy objective for social, economic and environmental reasons and aims to test the responsible limits of ‘bio-centric dependence’ in terms of its contribution to a more sustainable circular bioeconomy pursued unilaterally by the EU. The “Hand-in-hand” scenario follows a similar approach but expects the bioeconomy to be pursued by a larger group of industrialised countries beyond the EU. Finally, the “BioEco-Resilience” scenario sees all key nations worldwide participate in efforts to reduce GHG emissions, in the spirit of the pledges made within the Paris agreement.

### Policy-relevant knowledge

The next table illustrates how the BioMonitor model toolbox has been used to address the critical knowledge gaps of relevance for EU policy making. Starting from the column furthest on the left, we list the three categories of gaps identified in the policy arena. Each category of knowledge gaps is linked to one topic considered of policy prominence. These (policy) topics are then linked to the topics covered by the model toolbox. Finally, each (toolbox) topic is matched with one or more output indicators of the toolbox.

Category	Policy Topic	Toolbox topic	Indicator
Sustainability impacts	Environment	Climate-change mitigation	Total GHG emissions by sector
	Society	Employment	Employment generated by sector
	Economy	GDP	Real GDP generated by sector
Demand & supply of biomass and land	Management of biological resources	Land	Total land use for crop production
	Sustainable consumption	Food-waste minimization	Land use for crop production & GHG emissions
	Food security	Food prices and trade	EU prices of agrofood commodities compared to world market prices
	Biomass gap	Supply – demand ratio for (bio)energy and materials	EU net trade position for fossil and bio-based chemicals
Systemic effects	Trade-offs & synergies	Bio-economy policy objectives	Five-point scale indicators of interactions
		Bio-economy sustainability impacts	Five-point scale indicators of interactions
		Land uses	Five-point scale indicators of interactions
	Leakage	International trade	Virtual trade of land

Based on the approach outlined above, the team will investigate questions of key relevance for policy makers. Among these questions, we can highlight here those concerning the role of the bioeconomy and its sectors on climate change mitigation in the EU, the impacts of changes in food consumption on land use and GHG emission levels, or the size of the potential biomass gap due to demand for energy and materials under different future scenarios.

### Conclusions and Policy Recommendations

The BioMonitor toolbox quantifies, in an integrated way, the bioeconomy's environmental, economic, and social impacts in the EU and its Member States. A com-

prehensive set of impacts is evaluated for a range of future scenarios in which the EU bioeconomy might be developing. The results of the toolbox simulations will provide policy makers with the critical knowledge that is currently hindering further progress toward the goal of a circular and sustainable bioeconomy. The toolbox represents one of the most complete tools available for the EU bioeconomy due to its ability to capture several cross-cutting issues of a bioeconomy transition considering competition and interactions between economic sectors. However, additional modelling tools will have to be employed to integrate the results of the Biomonitor toolbox, especially, with regard to knowledge of ecosystem health and biodiversity.

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This project has received  
funding from the European  
Union's Horizon 2020  
research and Innovation  
programme under grant  
agreement N°773297.

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