



# Key results of the MonBio project: Improving monitoring of environmental aspects of the bioeconomy

“Weiterentwicklung des ‚Monitoringsystem Bioökonomie‘ unter besonderer Berücksichtigung von Aspekten des vorsorgenden Umweltschutzes“

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Aaron Best, Ecologic Institute

**Berlin, 31 October 2024**





# Contents

- 1. Project overview**
- 2. Overview of monitoring systems**
- 3. Main project results**
- 4. Recommended actions and research**



# Project objectives

- 1. Identify existing monitoring systems:** Gather the latest information and create a comprehensive and standardized overview of various monitoring initiatives (international, European, and national).
- 2. Analyze indicators:** Evaluate indicators and monitoring systems in order to learn from existing approaches and practical experiences.
- 3. Identify suitable indicators:** Find gaps in monitoring, identify indicators that could improve bioeconomy monitoring, and do a deeper analysis of promising environmental indicators for improving German bioeconomy monitoring.
- 4. Recommend actions:** Make recommendations for the further development of bioeconomy monitoring and for the implementation of the bioeconomy strategy

# Literature

## Analysis of existing monitoring and indicator systems

- ▶ 50 reports/publications from 42 studies/projects were compiled
- ▶ 22 studies analyzed in detail using the questionnaire and summarized
- ▶ Internal project report - quick access to relevant details in the literature; basis for further analyses of selected indicators



**Product Biodiversity Footprint – A novel approach to compare the impact of products on biodiversity combining Life Cycle Assessment and Ecology**

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**ARTICLE INFO**  
**ABSTRACT**  
 Product impacts on ecosystem quality have been addressed by the top-down approach known as Life Cycle Assessment (LCA). Despite its merit, the LCA approach does not cover the richness of biodiversity as identified by the Millennium Ecosystem Assessment (2005) (MEA). Only land acquisition and transformation, pollution, and climate change are covered, while species extirpation and invasive species are not. Besides, ecologists work on the ground to measure concrete impacts from given practices on biodiversity in specific areas. In some parts of the value chain of the product (e.g. production of agricultural raw materials), the Product Biodiversity Footprint (PBF) approach aims at bridging the gap between LCA and ecology by identifying the other components of nature of a given product to support knowledge gathering. The Review of MEA, The methodology combines LCA and ecology current knowledge and organizes them through practical indicators and recommendations for business decision. PBF has been tested on three business case studies. The use for LCA and personal benefits shows that the integration of ecological data enables to refine and complement LCA results. This method of product level is our knowledge. We first address the five MEA drivers on biodiversity along the value chain with a combination of quantitative and semi-quantitative indicators. Secondary from an LCA, added information and approach, the energy coverage with conventional fuel enables to distinguish between different energy sources and better informed decision making.  
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**1. Introduction**  
 Biodiversity is a complex topic with different dimensions (genetic, species and ecosystem) and varying spatial and temporal scales (Peters, 2010; Pimm, 2010; Rabaud et al., 2019). The main drivers of biodiversity loss have been identified in the Millennium Ecosystem Assessment (MEA) (Millennium Ecosystem Assessment, 2005): habitat change, pollution, climate change, overexploitation and invasive alien species. Metrics on biodiversity have been developed for over a decade (Peters et al., 2010), inspired by the adoption of Environmental (2012, 2013), regional (European Environment Agency, 2012) and national targets. Most of these metrics are addressed around national accountability, with some of the main objectives being to monitor the "Aichi Biodiversity Targets" (Convention on Biological Diversity, 2010).

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**THE GLOBAL BIOENERGY PARTNERSHIP SUSTAINABILITY INDICATORS FOR BIOENERGY**  
 FIRST EDITION

**GBEP**  
 Global Bioenergy Partnership

**biomonitor**

**D1.1: Framework for measuring the size and development of the bioeconomy**

Date of document – 09/2019 (10/1)  
 D1.1:  
 Authors: Maximilian Kardung (WU), Ortwin Costenoble (NEN), Lara Dammer (nov), Rolf Dalhayer (CBS), Marco Lorenz (EFI), Myrta van Leeuwen (WEaR), Robert M Berek (JRC), Hans van Meijl (WEaR), Stephan Potrowski (nova), Tevescia Ronzon (JRC), David Verhoog (WEaR), Hans Verkerk (EFI), Maria Vracholi (TUM), Justus Wesseler (WU), Benz Kempf (TUM)

Monitoring the Bioeconomy

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TEXTE  
 45/2020

**Nexus Ressourceneffizienz und Landnutzung – Ansätze zur mehrdimensionalen umweltpolitischen Bewertung der Ressourceneffizienz bei der Biomassebereitstellung**  
 Abschlussbericht

Für Mensch & Umwelt

**Umwelt Bundesamt**

**INTERNATIONAL STANDARD ISO 13065**

First edition 2015-09-15

**Sustainability criteria for bioenergy**

Création de durabilité pour la bioénergie

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 1019 2019 4812

**INDICATORS TO MONITOR AND EVALUATE THE SUSTAINABILITY OF BIOECONOMY**

Overview and a proposed way forward

**Monitoring Bioeconomy Transitions with Economic-Environmental and Innovation Indicators: Addressing Data Gaps in the Short Term**

Walter Jander <sup>1\*</sup>, Sven Wydra <sup>2</sup>, Johann Wackerbauer <sup>3</sup>, Philipp Grundmann <sup>1,4,5</sup> and Stephan Potrowski <sup>1</sup>

**Abstract:** Monitoring bioeconomy transitions and their effects can be considered a Herculean task, as they cannot be easily captured using current economic statistics. Distortions are easily made between bio-based and non-bio-based products when official data is collected. However, production along bioeconomy supply chains and its implications for sustainability require measurement and assessment to enable considered policy making. We propose a starting point for monitoring bioeconomy transitions by suggesting an adapted framework, relevant sectors, and indicators that can be observed with existing information and data from many alternative sources, assuming that official data collection methods will not be modified soon. Economic-environmental indicators and innovation indicators are derived for the German surfactant industry based on the premise that combined economic-environmental indicators can show actual developments and trade-offs, while innovation indicators can reveal whether a bioeconomy transition is likely in a sector. Methodological challenges are discussed and low-cost, high-benefit options for further data collection are recommended.

**Keywords:** Bioeconomy monitoring; transition framework; surfactant industry; bio-based chain; fossil resource substitution; diffusion of innovation

**Highlights**

- Findings indicate growth in innovative, bio-based products and possibly a beginning transition from a fossil-based economy to a bio-based economy.
- Despite considerable innovation potential, stagnating patent indicators reflect declining market optimism.
- Limitations in data for monitoring the bioeconomy can be overcome in the short-term by integrating diverse data sources.
- A modified Driver-Pressure-State-Response framework is proving beneficial for the analysis of high-resolution sectors and indicators for an initial monitoring of the bioeconomy.
- Fossil resource saving may be in the order of 21 MJ per t of production costs.

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 www.mdpi.com/journal/sustainability

Forschungsbericht BWPLUS

von  
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Development of the Circular Bioeconomy: Drivers and Indicators

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Abstract: The EU's 2018 Bioeconomy Strategy Update and the European Green Deal recently affirmed that the bioeconomy is high on the political agenda in Europe. Here, we propose a concept analysis framework for quantifying and analyzing the development of the EU Bioeconomy. Bioeconomy has several related concepts (e.g., bio-based economy, green economy, and circular economy) and there are clear synergies between these concepts, especially between the circular and circular economy concepts. Analyzing the driving factors provides important information monitoring activities. We first derive the scope of the bioeconomy framework in terms of bioeconomy sectors and products to be involved, the needed geographical coverage and resolution, and its period. Furthermore, we outline a set of indicators linked to the objectives of the EU's bioeconomy strategy. In our framework, measuring developments will, in particular, focus on the bio-economy within the bioeconomy as biomass and food production is already monitored. The selected indicators conform to the EU Bioeconomy Strategy objectives and conform with findings from prior studies and stakeholder consultation. Additionally, several new indicators have been suggested if they are related to measuring the impact of changes in supply, demand, resources, or available and policies on sustainability goals.

Keywords: bioeconomy; monitoring; indicators

1. Introduction In the last twenty years, policymakers of the European Union (EU) have placed high priority on a sustainable and circular (bio)economy with the aim to reduce the use of petrochemicals, to mitigate climate change, to reduce the dependency on import natural resources, and to promote local economies. This focus on the bioeconomy emerged from a multitude of EU policy initiatives, spearheaded by the European Green Deal, and research programs, including the recent European Bio-based Industries JU Undertaking [1,2]. Many bioeconomy strategies on a regional and national level have been developed, most of them in Europe, but also in the United States, South Africa or Thailand. Those countries are also willing to intensively promote the development

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THÜNEN logo and SCP HOTSPOT ANALYSIS tool description. Includes text: 'HOT SPOT ANALYSIS TOOL FOR SUSTAINABLE CONSUMPTION AND PRODUCTION to support science-based national policy frameworks'. Buttons: 'TAKE A SURVEY', 'WATCH INTRO VIDEO'.

Susanne Iost, Natalia Geng, Jörg Schweine, Martin Basse, Simone Brüning, Dominik Jochem, Andrea Machmüller, Holger Weimar

Thünen Working Paper 149

REVIEW Open Access

Indicators and tools for assessing sustainability impacts of the forest bioeconomy

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Abstract: The sustainable use of renewable resources has become an important issue worldwide in the move towards a less fossil-fuel intensive future. Mainstream method for fulfilling this aim is to increase the share of renewable energy and materials to substitute fossil fuels and to become fully independent from fossil fuels over the long term. However, the environmental sustainability of this endeavor has been questioned. In addition, economic and social sustainability issues are also much debated topics in this particular context. Forest resources are often thought to contribute partially to achieving a so-called 'carbon neutral society'. In this review, we discuss sustainability issues of using forest biomass. We present several sustainability indicators for ecological, economic and social dimensions and discuss the issues in applying them in sustainability impact assessments (SIAs). We also present a number of tools and methods previously used in conducting SIAs. We approach our study from the perspective of the Finnish forestry. In addition, various aspects regarding the application of SIAs in a broader context are also presented. One of the key conclusions of the study is that although sufficient data are available to measure many indicators accurately, the impacts may be very difficult to assess (e.g. impact of greenhouse gases on biodiversity) for conducting a holistic SIA. Furthermore, some indicators, such as 'woodiness', are difficult to quantify in the first place. Therefore, a mix of different methods, such as Multi-criteria Assessment, Life-cycle Assessment or Cost-Benefit Analysis, as well as different approaches (e.g. thresholds and strong/weak sustainability) are needed in aggregating the results of the impacts. SIAs are important in supporting and improving the acceptability of decision making, but a certain degree of uncertainty will always have to be tolerated.
Highlights: Forest bioeconomy involves a range of multidimensional impacts. A variety of methods exist to assess and evaluate sustainability. Social sustainability is the most case-specific dimension to assess. Indicators used in SIAs need case-specific considerations. More consistency is needed regarding the concept and terminology of sustainability.
Keywords: Forest bioeconomy; Sustainability; Indicators; Impact assessment; Decision support

Introduction Climate change is one of the most significant threats facing the world today, and mitigation of it has been recognized as an issue requiring urgent and extensive actions on the part of the global community. At the Paris Climate Conference in December 2015, 195 countries adopted the first ever universal, legally binding global climate agreement. They agreed to take global measures in order to "put the world on track" and to

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JRC SCIENTIFIC INFORMATION SYSTEMS AND DATABASES REPORT. Implementation of the EU Bioeconomy Monitoring System dashboards. Natural resources and bioeconomy studies 18/2018. Synthesis on bioeconomy monitoring systems in the EU Member States. Indicators for monitoring the progress of bioeconomy. Authors: Marius Lier, Martti Aarne, Leena Käähkinen, Karl T. Kottmann, Anja Yli-Virtanen and Tuula Paakkari.

S2Biom logo and project information. Delivery of sustainable supply of non-food biomass to support a 'resource-efficient' Bioeconomy in Europe. S2Biom Project Grant Agreement n°608622. D5.4 Consistent Cross-Sectoral Sustainability Criteria & Indicators. Final Report. March 2015. Includes images of agricultural fields and a bee.

sustainability logo and MDP logo. Article: The Contribution of Sustainable Development Goals and Forest-Related Indicators to National Bioeconomy Progress Monitoring. Authors: Steinar Lier and Marlene Lier. Abstract: A sustainable and circular bioeconomy is a pathway to the achievement of the United Nations Sustainable Development Goals (SDGs) by 2030 because the bioeconomy aligns to a number of SDGs. We review the use of indicators for the analysis of SDG progress in a national bioeconomy strategy, and on their indicator-based progress monitoring and assessment. This paper is based on eight countries that already have elaborated indicators in their national bioeconomy strategies. We analysed the coverage of SDG issues in national bioeconomy strategies and the indicators used. We focused on how the different national indicators used to monitor the progress of the bioeconomy as a whole fit the SDG indicators and the already well-established and widely applied strategies related to environmental forest-related indicators, as the forest sector is one of the key sectors in the development of a bioeconomy. Our main goal and objective was based on a comparative review as a qualitative study of national bioeconomy strategies and their relevant indicator sets for progress monitoring. Based on our findings on the coverage of SDG-related issues of up to 14 out of the 17 SDG in the bioeconomy strategies and of the high share of forest-related indicators within the bioeconomy indicators used, we derive recommendations for the further development of bioeconomy indicators. Our paper does not contribute to progressing the most suitable indicators but it does encourage nations and regional actors to carefully and individually develop their bioeconomy monitoring systems using experiences from the already existing SDGs and forest monitoring programs. Keywords: bioeconomy; circular economy; SDG; Agenda; Sustainable Development Goals; indicators; forest; sustainable forest management; strategic; progress monitoring; assessment.

ifo FORSCHUNGS-BERICHTE logo and title: Ermittlung wirtschaftlicher Kennzahlen und Indikatoren für das Monitoring des Voranschreitens der Bioökonomie. Authors: Johann Wackerbauer, Tillmann Rave, Lara Dammer, Steffi Wiebke Jander, Philipp Grundmann, Sven Wydra, Ulrich. Includes image of a forest landscape.





## **Precautionary environmental protection: key aspects**

- ▶ Environmentally sound biomass potentials
- ▶ Additional demand for biomass
- ▶ Changes in use and flows
- ▶ Biodiversity
- ▶ Environmental impacts of expansion
- ▶ Evaluation of the environmental benefits



## Expert interviews

### Topics frequently identified by experts as insufficiently covered by indicators

- ▶ **Biodiversity** / quality of ecosystems / species richness / landscape and habitat fragmentation
- ▶ **Biomass potential** - replacement of non-renewable materials/energy but at risk of exceeding biomass potential
- ▶ **Spatial resolution / accuracy** is required but difficult - link to specific land use - important but difficult to assess - Index intensity of use - problematic as the issue varies from place to place
- ▶ **Land use / Land use change** - indirect land use change
- ▶ **Impacts in exporting countries** - sustainability based on local conditions (including social issues: land rights)
- ▶ **Effects on planetary boundaries**
- ▶ **Bioenergy** – ensuring that only actual waste is diverted into bioenergy

# Important question: what taxonomy?

## *EU Bioeconomy Monitoring System*

Highlighted categories are those that have indicator data in the *EU Bioeconomy Monitoring System* (as of 2023).

- 1 Ensuring Food and Nutrition Security
  - 1.1 Food security and nutrition are supported
    - 1.1.a Availability
    - 1.1.b Access
    - 1.1.c Utilisation
    - 1.1.d Stability
- 2 Managing Natural Resources Sustainably
  - 2.1 Ecosystem capacity to produce services is maintained or enhanced
    - 2.1.a Environmental quality
    - 2.1.b Structural and functional ecosystem attributes
    - 2.1.d Species diversity and abundance
    - 2.1.e Conservation status of habitats and species
  - 2.2 Primary production sectors are managed sustainably
    - 2.2.a Pressures from Forest Management
    - 2.2.b Pressures from marine fisheries & aquaculture management
    - 2.2.d Pressures from agroecosystems
  - 2.3 Ecosystem services contribution to human well-being is maintained or enhanced
    - 2.3.a Provisioning services
- 3 Reducing dependence on non-renewable unsustainable resources, whether sourced domestically or from abroad
  - 3.1 Resource efficiency, waste prevention and waste-re-use along the whole bioeconomy value chain is improved
    - 3.1.a Resource efficiency (Material footprint)
    - 3.1.b Energy efficiency
    - 3.1.c Biogenic waste prevention, re-use/recycling, and recovery
  - 3.2 Food loss and waste is minimised and, when unavoidable, its biomass is reused or recycled
    - 3.2.a Food loss and waste minimization
  - 3.4 Consumption patterns of bioeconomy goods match sustainable supply levels of biomass
    - 3.4.a Consumption and demand for biomass and bio-based products
    - 3.4.c Reduced dependence on non-renewable resources
- 4 Mitigating and adapting to climate change
  - 4.1 Climate change mitigation and adaptation are pursued
    - 4.1.a Climate change mitigation
    - 4.1.b Climate change adaptation
- 5 Strengthening European competitiveness and creating jobs
  - 5.1 Economic development is fostered
    - 5.1.a Contribution of bioeconomy to economic development
    - 5.1.b Value of raw and processed biomass, value added in bioeconomy sectors
  - 5.2 Inclusive economic growth is strengthened
    - 5.2.a Employment in bioeconomy
  - 5.6 Demand and supply-side market mechanisms and policy coherence between supply and demand of food and non-food goods are enhanced
    - 5.6.b Resource competition among sectors of the bioeconomy and Biomass demand for new value chains

# EU Bioeconomy Monitoring System

## Good practices of the EU BMS

- ▶ **Comprehensive taxonomy** – 1 Objective, 1.1 Normative criteria, 1.1.1 Components → *Logic, clarity*
- ▶ **Several types of indicators** – basic indicators, derived indicators, system-level indicators, composite indicators, headline indicators  
→ *Various uses and scales*
- ▶ **Inclusion of components without indicators**  
→ *Transparency regarding open gaps*
- ▶ **Annual overview of all EU BMS indicators** - „published“, „data available“, „data gap“, „in development“, „to be deleted“  
→ *Transparency regarding status*
- ▶ **Reference to several political frameworks** – UN SDGs, Green Deal  
→ *Relevance, Synergies*
- ▶ **Coordination with other monitoring systems**  
→ *Comparability, efficiency, systemic approaches*

# Indicator screening

(potential to fill gaps)

## 2 Managing Natural Resources Sustainably

**Irreversibility risk identifier (a label on issues where irreversibility is a factor)**  
**Detailed spatial maps, showing land use types, intensities, and land use change**  
**Planetary boundaries**

### 2.1 Ecosystem capacity to produce services is maintained or enhanced

#### 2.1.a Environmental quality

Area of land (ha) restored from a degraded state (e.g. contaminated, salinated, eroded)

#### 2.1.b Structural and functional ecosystem attributes

2.1.b.2, Landscape fragmentation index, index, data available (no DE data; Nov 2022)

2.1.b.6, Forest fragmentation and connectivity index, percent, data available (no DE data; Nov 2022)

2.1.b.8, Share of forest area, percent tot land area, data available (no DE data; Nov 2022)

#### 2.1.d Species diversity and abundance

Biodiversity footprint (Symobio)

Biodiversity footprint (Chaudhry & Brooks 2018)

Biodiversity Value Increment (BVI) oder Inputs an N, Pestizide etc. von Produkten

#### 2.1.e Conservation status of habitats and species

### 2.2 Primary production sectors are managed sustainably

**Certification, taking into account landscape conditions**

#### 2.2.a Pressures from Forest Management

2.2.a.3, Change in ecosystems extent: Forest and woodland, hectares, data available (no DE data; Nov 2022)

2.2.a.4, Land use / land cover type taken over by forest, hectares, data available (no DE data; Nov 2022)

#### 2.2.d Pressures from agroecosystems

2.2.d.2, Land use / land cover type taken over by agricultural land, hectares, data available (no DE data; Nov 2022)

2.2.d.3, Change in ecosystems extent: cropland & grassland, hectares, data available (no DE data; Nov 2022)

### 2.3 Ecosystem services contribution to human well-being is maintained or enhanced

#### 2.3.b Regulating services

2.3.b.2, Air quality, [no units identified], no known data

#### 2.3.c Cultural services

# Indicator screening

(potential to fill gaps)

Blue text: Taxonomy of the EU Bioeconomy Monitoring System

## 3 Reducing dependence on non-renewable unsustainable resources, whether sourced domestically or from abroad

### LCA for substitution effects (esp. system change)

#### 3.1 Resource efficiency, waste prevention and waste-re-use along the whole bioeconomy value chain is improved

##### 3.1.a Resource efficiency (Material footprint)

3.1.a.3, Land footprint in EU of EU consumption (for non-food&feed), [no units identified], **no known data**  
(focus of analysis: connection to bases for decisionmaking (thresholds, targets, etc.))

##### 3.1.c Biogenic waste prevention, re-use/recycling, and recovery

Waste and residues - Circularity factor (Anteil primärer und sekundärer Biomasse)

#### 3.4 Consumption patterns of bioeconomy goods match sustainable supply levels of biomass

**Sustainable potentials, Identification of biomass potentials in line with nature recovery and biodiversity**

**Sankey diagrams to visually communicate biomass flows coupled with biomass potentials**

## 4 Mitigating and adapting to climate change

#### 4.1 Climate change mitigation and adaptation are pursued

##### 4.1.a Climate change mitigation

CO<sub>2</sub>-Opportunity costs (Nature recovery opportunity costs)

% of biomass obtained from land with high carbon stock (e.g. peatland or wetland)

Carbon intensity as measured through Life cycle GHG emissions (gr eq. CO<sub>2</sub> / product unit)

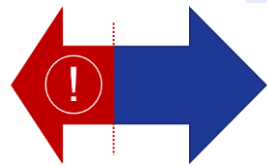
4.1.a.1, net GHG emissions (emissions and removals) from bioenergy (absolute and relative vs. total sector emissions), tCO<sub>2</sub>e and %, **data may be available**

4.1.a.2, net GHG emissions (emissions and removals) from BBI (absolute and relative vs. total industrial emissions), tCO<sub>2</sub>e and %, **data may be available**

4.1.a.4, net GHG emissions (emissions and removals) from bio-waste (absolute and relative vs. total waste emissions), tCO<sub>2</sub>e and %, **data may be available**

4.1.a.5, GHG emissions from fishing and aquaculture, 1000 tCO<sub>2</sub>e, **no known data**

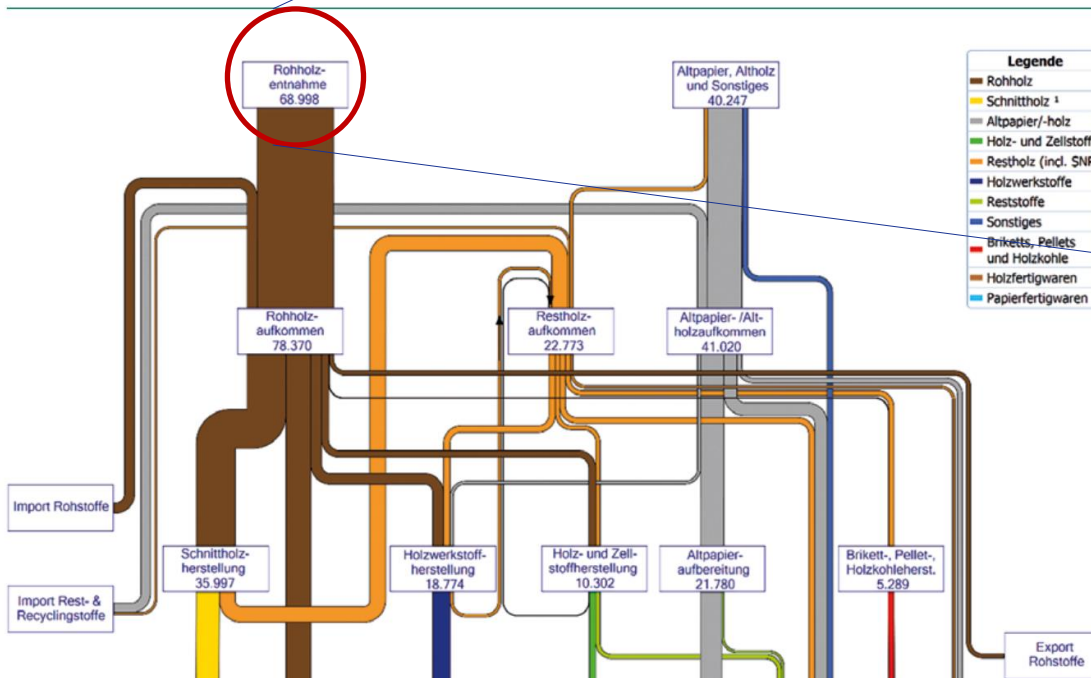
# High-potential indicators to fill identified gaps



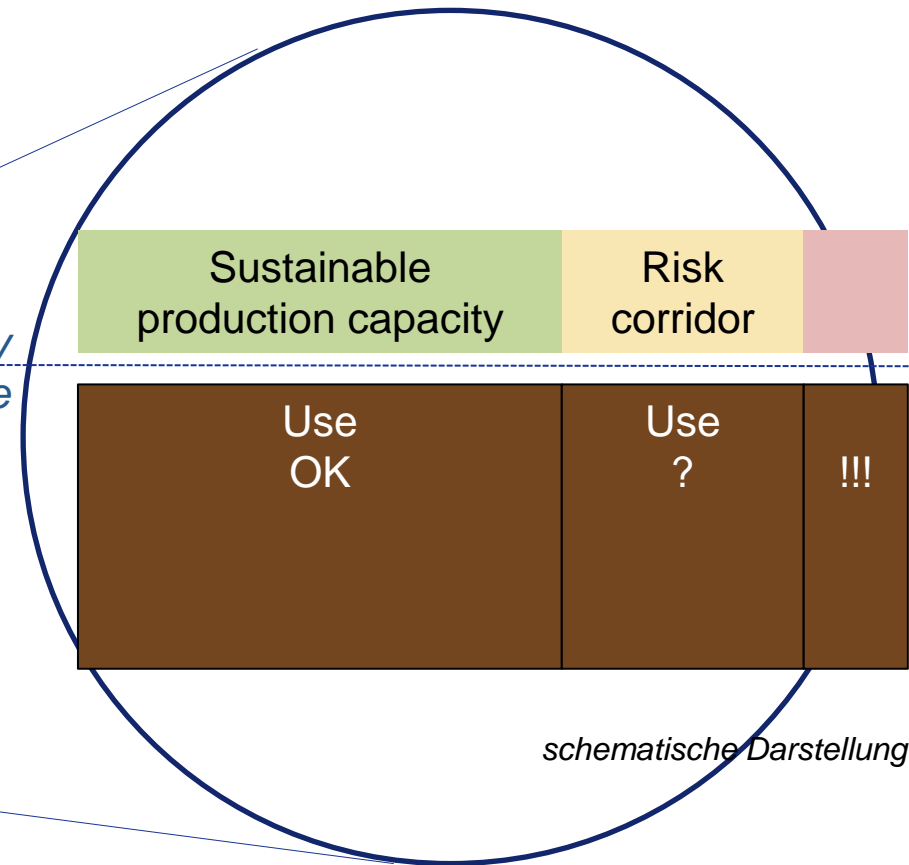
1. **CO<sub>2</sub> opportunity costs** - compares the officially reported CO<sub>2</sub> reduction potentials of bioeconomy activities (e.g. biofuels) with alternative approaches and explicitly includes renaturation as an alternative in the analysis. **Units:** *Tonne CO<sub>2</sub>-eq. or land use in hectares.*
2. **Integrated Sankey diagrams (coherent comparisons of sustainable production capacities and utilisation)** - combines Sankey diagrams of material flows by biomass category with representations of sustainable production. Where no capacity calculation is available, this is indicated in the diagram. Capacity ranges can be used to communicate uncertainties or disagreements. **Units:** *Various (e.g. tonne of dry matter).*
3. **Irreversibility risk label** - a label that draws attention to irreversibility risks. This label could be used in conjunction with other indicators to ensure that a higher level of precaution is applied when setting targets.

# Sankey+ Sustainability

Abb. 2.7 | Holzfluss in Deutschland für das Jahr 2015 in m<sup>3</sup> Holzfaserequivalente [m<sup>3</sup> (f)]



Production capacity  
Use



Sankey-Diagrammes could be extended to show production capacities and uncertainty

Quelle: Abb 2.7 wiedergegeben aus Bringezu et al. (2020): Pilotbericht zum Monitoring der deutschen Bioökonomie, S. 29

# High-potential indicators to fill identified gaps



- 4. Planetary Boundaries** - a scientific-political concept consisting of 9 main indicators that are intended to map the Earth's planetary biocapacity. It can be used to show whether and to what extent planetary biocapacities have already been exceeded, what room for maneuver is still available and in which areas urgent and far-reaching action is required. *Units: different target values (and comparisons with the actual values).*
- 5. Systemic LCA methods** - a variety of life cycle assessment (LCA) methods offer possibilities for estimating and interpreting the effects of certain products, processes and production systems by means of input/output modelling of micro- and meso-economic processes (ecological LCA (E-LCA), social LCA (S-LCA), business LCA (LCC) and combined or integrated LCA (LCSA) can be used to analyse the ecological, social and economic aspects; also absolute LCA methods in relation to Planetary Boundaries. *Units: various.*



## High-potential indicators to fill identified gaps

- 6. Biodiversity loss (potential species loss)** - The indicator is used to depict the product-specific potential biodiversity loss. It consists of the land cover (or land use change), which is multiplied by a characterisation factor that expresses the potential species loss Chaudhary et al. (2015). **Units:** *regional species loss per m<sup>2</sup>, regional species loss per year per m<sup>2</sup>, global species loss per m<sup>2</sup>, global species loss per year per m<sup>2</sup>.*
- 7. Sustainable biomass potential** - The indicator shows the amount of biomass that can be utilised within a year and within an economy in accordance with nature conservation and biodiversity. Work already exists on individual aspects of sustainable biomass potentials (e.g. bioenergy potential targets, wood potentials), but there is currently no explicit indicator that systematically covers these aspects. **Units:** *tonnes or petajoules.*

## High-potential indicators to fill identified gaps

- 8. Spatial representation of the type, intensity and change in land use** - describes the type, intensity and change in land use in a spatial breakdown; can act as an early warning system to identify regional hotspots and interactions between different types of land use. **Unit:** *Map with information on regional land use (e.g. distribution of areas by agriculture, forests, cities in % and hectares; distribution by biomass type (e.g. meadows, arable land, forest areas) in % and hectares)*
- 9. Pollutant and particulate matter emissions from the bioeconomy** - measures those substances in the air that have a negative impact on air quality; determines the gaseous pollutant emissions that are not greenhouse gases, such as ammonia, nitrogen oxides, volatile organic compounds, carbon monoxide, sulphur dioxide and the particulate matter content in the air; can show the total air pollutants emitted by a country (in tonnes) or the local air quality at specific measuring stations (in  $\mu\text{g}/\text{m}^3$ ). **Units:** *tonnes or  $\mu\text{g}/\text{m}^3$*

# Recommended actions

4.1. Include spatial information that can be used to identify bioeconomy hot spots where negative environmental impacts are particularly high or not in line with sustainable biomass production.

4.2. Included detailed maps to visually communicate how land is used, how these uses are changing and how natural systems are affected by bioeconomy activities.

1. **Develop and apply a more comprehensive, multi-layered monitoring approach** that takes into account precautionary environmental protection and monitors whether bioeconomic activity remains within the sustainable biomass potential *(3 specific actions)*
2. **Define sustainability targets** for the bioeconomy *(4 specific actions)*
3. **Maintain the footprint concept** and develop it further *(4 specific actions)*
4. **Spatial information** - Enable decision-makers and the public to see the bioeconomy as a set of activities embedded in specific locations and based on the productivity of nature *(2 specific actions)*
5. **Future pathways** - Integrate possible future bioeconomy pathways and their potential environmental and social impacts into the trend analysis of bioeconomy monitoring *(4 specific actions)*
6. **Coordinate the development of monitoring** in related policies at both national and international levels *(3 specific actions)*
7. **Address research gaps** *(5 specific actions)*

## Research gaps

1. **Sustainable biomass potentials** - Driving question: What are the sustainable biomass potentials in Germany, the EU and globally?
2. **Biodiversity** - Driving question: How can biodiversity loss be measured in the context of bioeconomic activities?
3. **Water** - Driving question: How can the water scarcity and water pollution associated with bioeconomy be monitored?
4. **Circular economy** - Driving question: how can bioeconomy and circular economy monitoring be linked?
5. **Coordination Germany/EU/International** - Example: Establish exchanges between EU Member States (also internationally) on the topic of monitoring the bioeconomy.

# Biodiversität

# Biomassepotenzial



Biodiversität

Biomassepotenzial

Landnutzungsänderung

Planetarische Grenzen

Biodiversität

Biomassepotenzial

Landnutzungsänderung

Grenzen

# Landnutzungsänderung

# Planetarische Grenzen



**Thank you for your attention**

Aaron Best, Ecologic Institute

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