ZEF POLICY BRIEF NO 45

TOWARDS A BIOECONOMY WITHIN PLANETARY BOUNDARIES

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Key message

- Substituting fossil with bio-based resources in the EU involves sustainability tradeoffs at the global scale and requires appropriate safeguards
- Safeguarding food prices and the conservation of natural ecosystems must be a priority
- Despite progress, data gaps and methodological challenges have to be overcome to inform the design of globally coherent enabling and regulating policies for bioeconomic transformation

I. Background

Countries worldwide, and EU members like Germany in particular, consider the bioeconomy an opportunity for sustainable development. The sharp rise in energy and food prices is making many bio-based alternatives to fossil resource-based technologies even more attractive. And yet, the EU bioeconomy produces large internal and external footprints, particularly in the Global South. Policy action is needed for the EU and its member states to align these footprints with Sustainable Development Goals (SDGs), but significant gaps must be overcome in the development of forward-looking tools for policy and technology impact assessment in the bioeconomy. As new bioeconomy monitoring frameworks and related data sets become available, we reviewed the current state of research on modelling and simulation tools for the bioeconomy in an international workshop conducted in November 2022. This policy brief summarizes the main workshop outcomes in terms of (1) sustainability threats currently associated with bioeconomic production and consumption patterns as well as (2) science-based opportunities to support policy design towards a bioeconomy within planetary boundaries.

II. Bioeconomy partly oversteps planetary boundaries

Human development is exceeding planetary boundaries in terms of land use, global greenhouse gas (GHG) emissions, nitrogen and phosphorus nutrient flows, freshwater use, and species biodiversity loss. In 2017, total biomass demand was almost three-times higher than in the 1970s, and by 2019, biomass production was responsible for over 80% of water stress and land use-related biodiversity loss (UNEP 2020). Global food production alone uses about half of global habitable land, more than two-thirds of available freshwater, and emits 23-34% of global GHG emissions (Rosegrant et al. 2009; Ellis et al.

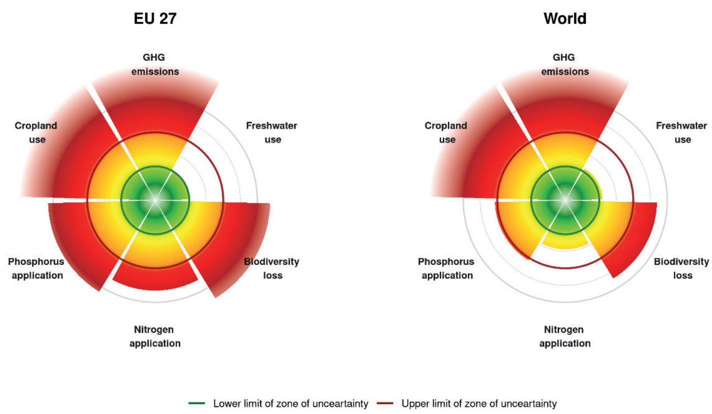

Figure 1: Consumption and planetary boundaries from the perspective of the EU27 and globally
Note: Calculations based on FABIO v1.2 (Bruckner et al. 2019), EXIOBASE v3.8 (Stadler et al. 2018), and environmental data from various sources (GHG emissions: Frey und Bruckner 2021, land use: FAOSTAT 2022, water consumption: Mekonnen and Hoekstra 2011, biodiversity loss: Chaudhary und Brooks 2018). For further details on the methods and data sources please refer to WWF (2023).

2010; Tubiello et al. 2015; Crippa et al. 2021). In addition, aquatic ecosystems are threatened by the pollution of watersheds and coastal seas with nutrients and the harvesting of aquatic food from rivers, lakes, and oceans (McIntyre et al. 2016; Lee et al. 2016).

Figure 1 depicts the current impacts of consumption in the main bioeconomy sectors, such as food and non-food biomass products, on indicators of key planetary boundary dimensions. A sustainable bioeconomy must rely on consumption and production patterns that remain within the lower range of the uncertainty zone. Currently, however, EU consumption exceeds the upper limit of the uncertainty zone for all, but one (i.e. freshwater), indicator. Clearly, food and non-food biomass will have to be used much more efficiently in the future.

Addressing these threats to planetary health arising from the global food and biomass systems requires transformative change. In this spirit, the United Nations Biodiversity Conference (COP15) held in Montreal in December 2022 ended up with a landmark agreement to guide global action on biodiversity and nature protection by 2030, including concrete measures to protect 30% of global land and sea. At the EU level, ambitious targets had already been formulated as part of the European Green Deal through, for instance, its Farm to Fork strategy and its Circular Economy Action Plan.[1]

As much as it is part of the problem, the bioeconomy is also frequently touted as a key to planetary health. As a result, many countries and regions have developed ambitious bioeconomy strategies.

III. From national strategies to global governance

Research on national bioeconomy strategies has identified relevant governance gaps (Dietz et al. 2018). For example, few strategies place sufficient emphasis on sustainable consumption patterns or specify required changes in land management and biomass production (EU 2022). Moreover, reducing agricultural production volumes in the EU implies that technological progress must be aligned with increased biomass imports to meet future demand (Bremmer et al. 2021). Importantly, the biologization of the economy beyond the traditional bioeconomic sectors, for example through increased use of biotic substances in the chemical industry or more wood in the construction industry, is likely to increase biomass demand in the EU. The IEA estimates that the energy supply from biomass use is expected to double or triple by 2050 compared to 2021 (IEA 2022). If not offset by a boost in the productivity of primary sectors and biomass conversion efficiency, growing demand for biomass is likely to compromise SDG targets related to food security and life on land.

In fact, national bioeconomy strategies tend to take insufficient account of their potential effects in other parts of the world. Harmonization is currently hampered by varying interpretations and conceptualizations of bioeconomy (Siegel et al. 2022). In addition, countries in the South often set different priorities than countries in the North and the assessment of impacts beyond national boundaries is challenging due to knowledge and data gaps. For example, complexity in the globalized trade and innovation system implies that leakage and spillover effects can render unilateral sustainability policies ineffective (Meyfroidt et al. 2020).

A global approach to bioeconomy governance may remain a far-fetched goal, but progress must be made towards mainstreaming bioeconomy-related sustainability concerns in international agreements on trade, the environment, and technology transfer. Doing so would improve global coordination in terms of how and where bio-based innovation can most effectively contribute to achieving SDG targets and thus planetary health. Such coordination must build on rigorous scientific evidence and requires monitoring as well as forward-looking assessment tools for decision support.

IV. New science-based tools to support policymaking

Over the past decade, substantial progress was made in the development of ex post (e.g., footprinting) and ex ante (e.g. partial and general equilibrium models) evaluation and assessment tools for the bioeconomy. This includes models that explicitly quantify global footprints of the German bioeconomy (Bringezu et al. 2021; Egenolf et al. 2022) and frameworks that different stakeholders can use to monitor and measure the bioeconomy (Sanchez-Jerez et al. 2023). Generally, there is evidence from many EU member states that the contribution of the bioeconomy to total value added is on the rise and often underestimated due to methodological challenges (Cingiz et al. 2021).[2] Kardung and Drabik (2021) modelled the dynamic evolution of various performance indicators for the bioeconomies of ten selected EU member states and

[1] All Fachsheets related to the European Green Deal can be consulted at https://commission.europa.eu/publications/factsheets-european-green-deal_en (accessed on April 17, 2023)

[2] The authors calculate each industry's' (defined by the International Standard Industrial Classification of All Economic Activities (ISIC), Revision 4) bioeconomy value added shares. They follow the BioMonitor project scope and include the relevant industries of the economy following the EU sectorial definition of the bioeconomy.

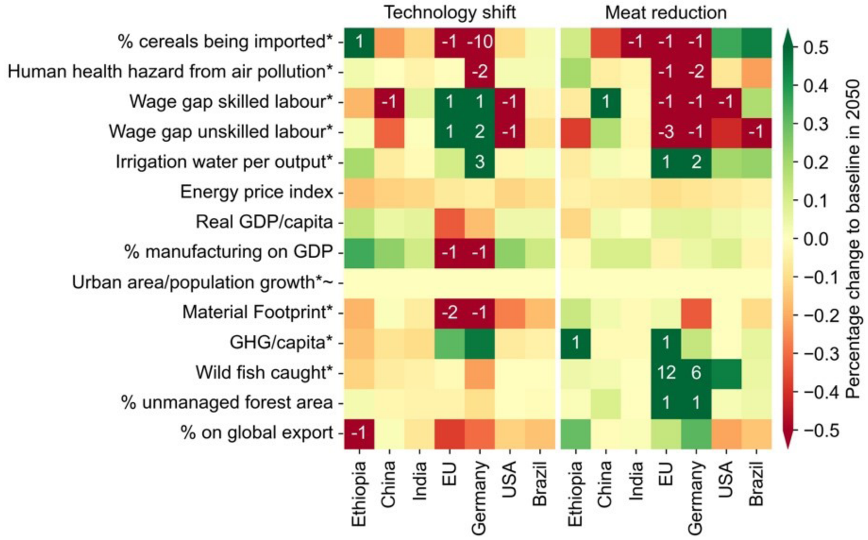

Figure 2. Heatmap of biosphere-related SDG indicators in terms of their change to the baseline in 2050.

Note: The color bar is fixed to values between 0.5 and -0.5 for better readability. Values exceeding these range are shown as rounded numbers in the respective cell. * = inverted indicators (multiplied by -1) such that rising indicators represent a positive development. Calculations based on the Computable General Equilibrium Model platform CGEBox (Britz and van der Mensbrugghe, 2018), in a long-term setting of G-RDEM (Britz and Roson, 2019) and several GTAP extensions (McDougall and Golub, 2009; Keeney and Hertel, 2005; Baldos and Corong, 2020; Lee, 2005; Chepeliev, 2020a; Chepeliev, 2020b; Chepeliev, 2020c) following SSP2 (Riahi et al., 2017) projections from the GTAP v10 database (Aguiar et al., 2019) reference year 2014. Data for gender-differentiated labor are based on World Bank (NN) and wild fish is split from total fish production using data from FAO (2021).

found heterogeneous levels of improvement and consistent growth in private sector R&D for the circular bioeconomy. Still, the impacts of the EU's bioeconomy transition on a broader set of performance indicators linked to the UN SDGs remain understudied.

Below, we present some key insights generated from our analysis based on two complementary and forward-looking modeling approaches, which both point to significant tradeoffs between several dimensions of sustainable development of the EU bioeconomy.[3]

Figure 2 summarizes the simulated impacts of two hypothetical bioeconomy policy scenarios for the EU in selected EU and non-EU countries up to 2050. The technology shift scenario explores the impact of a higher share of biomass use in the rubber and plastics sector, the chemical sector, and the petroleum and coal sector. The substitution of fossil fuels and fossil-based chemicals for bio-based alternatives, decreases CO_2 emissions from combustion in the EU and possibly avoids carbon taxes depending on how indirect agricultural emissions are taxed, which potentially improves international competitiveness of EU economies. These positive impacts which concentrate on the EU are offset by negative social and environmental impacts driven by increased biomass demand outside the EU. The increased biomass demand from EU countries leads to higher simulated prices for agricultural products threatening food security outside the EU. Moreover, increasing biomass demand could result in overall negative effects for biosphere-related SDG indicators, such as land and water use, which exceed planetary boundaries already today. The potential future impacts of these environmental pressures on biodiversity and ecosystem functioning are highly uncertain. According to research on current environmental footprints of the global food system, eco-efficiency can vary enormously across space and time even within groups of relatively homogeneous commodities (Escobar et al., 2020; Halpern et al., 2022). Future impacts will thus also depend on how land abundance and environmental governance moderate the supply of new agricultural land from the conversion of natural ecosystems, such as tropical forests (Miranda & Börner, 2023).

To alleviate these sustainability tradeoffs, the EU bioeconomy needs technological innovation and regulatory action to maximize biomass use efficiency and curb total biomass demand. For example, our model simulations suggest that a 75% reduction in meat consumption (Figure 2) would significantly reduce pressure on unmanaged forests in most countries (including EU and Germany) and improve other biosphere-related SDG indicators, such as per capita GHG emissions and wild fish catch.

[3] The methodology and results of one study are briefly summarized in Figure 2, while the other study employed an innovative hybrid econometric Input-Output model developed in Többen et al. (2022). We expect to publish the results in the coming months so that they can be shared with both the scientific community and decision-makers.

Generally, synergies often arise among SDGs in the economic and social dimensions, but advances in these two dimensions tend to compromise environmental SDGs. The magnitude of the trade-offs largely depends on socioeconomic development pathways and climate change as main drivers of wealth, food demand, and changes in land cover and land use intensity.

Forward-looking modelling tools like the ones used here can improve the scientific basis for coordinated policy design, but significant challenges remain. In particular, detailed data for crops and other bioeconomy feedstocks as well as on household income and consumption is missing especially at subnational scales for large parts of the world[4]. In addition, access to information on technology development and innovation, including from the private sector, must be improved to enable realistic scenario design for bioeconomic technology impact assessments.

Addressing these knowledge and data gaps will enable future research to achieve the following: (1) Measure the costs of alternative policy options and identify strategies (including global coordination efforts) to mediate sustainability trade-offs, e.g. between land-use for non-food biomass production and affordable food; (2) Quantify the impacts of alternative policy mixes and their implications in terms of costs and benefits across relevant groups of stakeholders; (3) Evaluate impacts of shifts in consumer behavior (e.g. with regard to food waste, diets, and environmental or social product attributes) or production structures (e.g. concerning cascade use or biorefineries); (4) Gauge the effects of technology leaps and breakthroughs, such as genome editing or enhanced biomass production and processing technologies; (5) Assess the impacts of climate-related or geopolitical shocks to the food and biomass systems.

V. Policy Recommendations

Bioeconomic innovation bears enormous potential for transformation towards global consumption and production patterns that remain within planetary boundaries. The research summarized above suggests that action is needed to realize this potential.

First, technological innovation must be accompanied by effective governance frameworks and global policy coordination to avoid that the benefits of bioeconomic transformation in one part of the world are offset by deteriorating environmental and social conditions in other world regions.

[4] Some but not all such gaps are addressed by recently published data products (like GLORIA, (Lenzen et al. 2022)). The BioSAMs of EU member states can serve as an example of what is needed to expand current disaggregated modelling efforts to other major biomass producing countries (EU 2021).

Second, bioeconomy strategies must be expanded to include sustainability safeguards. For example, policies that encourage more sustainable consumption patterns can play a significant role in reducing negative externalities of the current bioeconomy. This potentially includes taxing meat and dairy products more heavily than plant-based food items which could also result in significant health benefits. In addition, the environmental footprints of internationally traded biomass could be taxed directly to avoid environmentally harmful relocation of biomass production.

And third, major gaps in the science and knowledge base to inform coordinated policy design remain. Many of these gaps are due to data limitations and regional 'blind spots' that reflect major asymmetries in research funding and R&D capacities at a global scale. Addressing these gaps requires a systematic approach to building global research alliances that allow collaboration at eye level, for example, via appropriate financial support for research partner organizations in the Global South. Additionally, forward-looking policy tools, comprehensive databases, and monitoring systems should be further expanded and used to inform policy decisions.

In sum, moving towards a bioeconomy within planetary boundaries requires a comprehensive and globally coordinated process that leverages sustainability science, capitalizes on the full range of policy instruments at all governance levels, and involves relevant stakeholders. The EU, and large members as Germany, can lead the way in this process by identifying and upscaling 'best practices' from almost two decades of investments in developing its bioeconomies.

VI. References

Aguiar, Angel; Chepeliev, Maksym; Corong, Erwin, L.; McDougall, Robert; van der Mensbrugghe, Dominique (2019): The GTAP Data Base: Version 10. Journal of Global Economic Analysis, 4(1), 1-27.

Bremmer, Johan; Gonzalez-Martinez, Ana; Jongeneel, Roel; Huiting, Hilfred; Stokkers, Rob; Ruijs, Marc (2021): Impact assessment of EC 2030 Green Deal Targets for sustainable crop production. LEI Datalab. Wageningen.

Bringezu, Stefan; Distelkamp, Martin; Lutz, Christian; Wimmer, Florian; Schaldach, Rüdiger; Hennenberg, Klaus Josef et al. (2021): Environmental and socioeconomic footprints of the German bioeconomy. In Nat Sustain 4 (9), pp. 775–783. DOI: 10.1038/s41893-021-00725-3.

Britz, Wolfgang; Roson, Roberto (2019): G-RDEM: A GTAP-Based Recursive Dynamic CGE Model for Long-Term Baseline Generation and Analysis, Journal of Global Economic Analysis, 4(1), 50-96.

Britz, Wolfgang; van der Mensbrugghe, Dominique (2018): CGEBox: A Flexible, Modular and Extendable Framework for CGE Analysis in GAMS, Journal of Global Economic Analysis, 3(2), 106-176.

Bruckner, Martin; Wood, Richard; Moran, Daniel; Kuschnig, Nikolas; Wieland, Hanspeter; Maus, Victor; Börner, Jan (2019). FABIO–The Construction of the Food and Agriculture Biomass Input-Output Model. Environmental Science & Technology 53 (19), 11302–11312. DOI: 10.1021/acs.est.9b03554

Chaudhary, Abhishek; Brooks, Thomas M. (2018): Land Use Intensity-Specific Global Characterization Factors to Assess Product Biodiversity Footprints. Environ. Sci. Technol. 52 (9), 5094–5104. DOI: 10.1021/acs.est.7b05570

Chepeliev, Maksym (2020a): GTAP-Power Data Base: Version 10. Journal of Global Economic Analysis, 5(2), 110-137.

Chepeliev, Maksym (2020b): Development of the Non-CO2 GHG Emissions Database for the GTAP Data Base Version 10A (No. 5993). Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University.

Chepeliev, Maksym (2020c): Development of the Air Pollution Database for the GTAP Data Base Version 10A (No. 6163). Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University.

Cingiz, Kutay; Gonzalez-Hermoso, Hugo; Heijman, Wim; Wesseler, Justus H. H. (2021): A Cross-Country Measurement of the EU Bioeconomy: An Input–Output Approach. In Sustainability 13 (6), p. 3033. DOI: 10.3390/su13063033.

Crippa, M.; Solazzo, E.; Guizzardi, D.; Monforti-Ferrario, F.; Tubiello, F. N.; Leip, A. (2021): Food systems are responsible for a third of global anthropogenic GHG emissions. In Nat Food 2 (3), pp. 198–209. DOI: 10.1038/s43016-021-00225-9.

Dietz, T.; Börner, J.; Förster, J.J.; von Braun, J. (2018). Governance of the Bioeconomy: A Global Comparative Study of National Bioeconomy Strategies. In Sustainability 10(9), p.3190. DOI: 10.3390/su10093190

Egenolf, Vincent; Distelkamp, Martin; Morland, Christian; Beck-O'Brien, Meghan; Bringezu, Stefan (2022): The timber footprint of German bioeconomy scenarios compared to the planetary boundaries for sustainable roundwood supply. In Sustainable Production and Consumption 33, pp. 686–699. DOI: 10.1016/j.spc.2022.07.029.

Ellis, Erle C.; Klein Goldewijk, Kees; Siebert, Stefan; Lightman, Deborah; Ramankutty, Navin (2010): Anthropogenic transformation of the biomes, 1700 to 2000. In Global Ecology and Biogeography, no-no. DOI: 10.1111/j.1466-8238.2010.00540.x.

Escobar, Neus; Tizado, E. Jorge; zu Ermgassen, Erasmus K.H.J.; Löfgren, Pernilla; Börner, Jan; Godar, Javier (2020). Spatially-explicit footprints of agricultural commodities: Mapping carbon emissions embodied in Brazil's soy exports. In Global Environmental Change 62, pp. 1-17.DOI: https://doi.org/10.1016/j.gloenvcha.2020.102067

European Commission, Directorate-General for Research and Innovation, European bioeconomy policy: stocktaking and future developments : report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2777/997651

European Commission, Joint Research Centre, Mainar Causape, A., Philippidis, G., BioSAMs 2015: estimation and basic considerations, Philippidis, G.(editor), Publications Office, 2021, https://data.europa.eu/doi/10.2760/622777

FAO (2021): FAO Aquaculture, Capture and Global production databases – Online Query Panels. Available online: http://www.fao.org/fishery/topic/16140/en last accessed:July 8, 2021

FAOSTAT (2022): FAO Statistical Databases: Agriculture, Fisheries, Forestry, Nutrition. Available at http://faostat.fao.org. Hg. v. Statistics Division, Food and Agriculture Organization of the United Nations. Rome. Available at https://www.fao.org/faostat/en/#data/

Frey, Verena; Bruckner, Martin (2021). The global carbon footprint of Austria's consumption of agricultural (food and non-food) products. Ecological Economic Papers, 41/2021. https://epub.wu.ac.at/8371/

Halpern, Benjamin S.; Frazier, Melanie; Verstaen, Juliette; Rayner, Paul-Eric; Clawson, Gage; Blanchard, Julia L. et al. (2022): The environmental footprint of global food production. In Nat Sustain 5 (12), pp. 1027–1039. DOI: 10.1038/s41893-022-00965-x.

IEA (2022), World Energy Outlook 2022, IEA, Paris https://www.iea.org/reports/world-energy-outlook-2022, License: CC BY 4.0 (report); CC BY NC SA 4.0 (Annex A).

Kardung, Maximilian; Drabik, Dušan (2021): Full speed ahead or floating around? Dynamics of selected circular bioeconomies in Europe. In Ecological Economics 188, p. 107146. DOI: 10.1016/j.ecolecon.2021.107146.

Keeney, Roman; Hertel, Thomas (2005): GTAP-AGR: A framework for assessing the implications of multilateral changes in agricultural policies. GTAP Technical Papers, 25.

Lee, Huey-Lin (2005): The GTAP Land Use Data Base and the GTAPE-AEZ Model: incorporating agro-ecologically zoned land use data and land-based greenhouse gases emissions into the GTAP Framework.

Lee, Rosalynn Y.; Seitzinger, Sybil; Mayorga, Emilio (2016): Land-based nutrient loading to LMEs: A global watershed perspective on magnitudes and sources. In Environmental Development 17, pp. 220–229. DOI: 10.1016/j.envdev.2015.09.006.

Lenzen, Manfred; Geschke, Arne; West, James; Fry, Jacob; Malik, Arunima; Giljum, Stefan et al. (2022): Implementing the material footprint to measure progress towards Sustainable Development Goals 8 and 12. In Nat Sustain 5 (2), pp. 157–166. DOI: 10.1038/s41893-021-00811-6.

Mekonnen, M. M.; Hoekstra, A. Y. (2011): National water footprint accounts: the green, blue and grey water footprint of production and consumption, Value of Water Research Report Series No. 50, UNESCO-IHE, Delft, the Netherlands.

Meyfroidt, P.; Börner, J.; Garrett, R.; Gardner, T.; Godar, J.; Kis-Katos, K.; Soares-Filho, B.; Wunder, S. (2020): Focus on leakage and spillovers: informing land-use governance in a tele-coupled world. In Environmental Research Letters 15 090202. pp. 1-9 DOI: 10.1088/1748-9326/ab7397.

McDougall, Robert; Golub, Alla (2009): GTAP-E: A Revised Energy-Environmental Version of the GTAP Model (GTAP Research Memorandum No. 15). Purdue University, West Lafayette, IN: Global Trade Analysis Project (GTAP).

McIntyre, Peter B.; Reidy Liermann, Catherine A.; Revenga, Carmen (2016): Linking freshwater fishery management to global food security and biodiversity conservation. In Proceedings of the National Academy of Sciences of the United States of America 113 (45), pp. 12880–12885. DOI: 10.1073/pnas.1521540113.

Miranda, Javier; Börner, Jan (2023): Agricultural commodity prices, governance, and land supply in the Tropics.IN: ZEF – Discussion Papers on Development Policy No. 327, Center for Development Research, Bonn, April, pp. 41.

O'Neill, Daniel W.; Fanning, Andrew L.; Lamb, William F.; Steinberger, Julia K. (2018): A good life for all within planetary boundaries. In Nat Sustain 1 (2), pp. 88–95. DOI: 10.1038/s41893-018-0021-4.

Riahi, Keywan; Van Vuuren, Detlef P.; Kriegler, Elmar; Edmonds, Jae; O'neill, Brian C.; Fujimori, Shinichiro; ... & Tavoni, Massimo (2017). The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. Global environmental change, 42, 153-168.

Rosegrant, Mark W.; Ringler, Claudia; Zhu, Tingju (2009): Water for Agriculture: Maintaining Food Security under Growing Scarcity. In Annu. Rev. Environ. Resour. 34 (1), pp. 205–222. DOI: 10.1146/annurev.environ.030308.090351.

Sanchez-Jerez, P.J., Raftoyannis, Y. and Rihimaki, M., EU Bioeconomy Monitoring System indicator update, Mubareka, S. editor(s), Publications Office of the European Union, Luxembourg, 2023, ISBN 978-92-76-61674-0 , DOI:10.2760/19269, JRC132405.

Siegel, Karen M.; Deciancio, Melisa; Kefeli, Daniel; Queiroz-Stein, Guilherme de; Dietz, Thomas (2022): Fostering Transitions Towards Sustainability? The Politics of Bioeconomy Development in Argentina, Uruguay, and Brazil. In Bull Latin American Res 41 (4), pp. 541–556. DOI: 10.1111/blar.13353

Stadler, K., Wood, R., Bulavskaya, T., Södersten, C.-J., Simas, M., Schmidt, S., Usubiaga, A., Acosta-Fernández, J., Kuenen, J., Bruckner, M., Giljum, S., Lutter, S., Merciai, S., Schmidt, J.H., Theurl, M.C., Plutzar, C., Kastner, T., Eisenmenger, N., Erb, K.-H., de Koning, A., Tukker, A., (2018): EXIOBASE 3: Developing a Time Series of Detailed Environmentally Extended Multi-Regional Input-Output Tables. Journal of Industrial Ecology 22(3), 502–515. DOI: 10.1111/jiec.12303

Többen JR, Distelkamp M, Stöver B, Reuschel S, Ahmann L, Lutz C. Global Land Use Impacts of Bioeconomy: An Econometric Input–Output Approach. In Sustainability. 2022; 14(4):1976. https://doi.org/10.3390/su14041976

Tubiello, Francesco N.; Salvatore, Mirella; Ferrara, Alessandro F.; House, Jo; Federici, Sandro; Rossi, Simone et al. (2015): The Contribution of Agriculture, Forestry and other Land Use activities to Global Warming, 1990-2012. In Global change biology 21 (7), pp. 2655–2660. DOI: 10.1111/gcb.12865.

UNEP (2020): Global Resources Outlook 2019. Natural Resources for the Future We Want. New York: United Nations.

Worldbank (NN): Gender Disaggregated Labor Database (GDLD), Data, Tool and Guidance, https://datatopics.worldbank.org/gdld/.

WWF (2023) Ernährungspyramide 2.0 – Für eine gesunde und nachhaltige Ernährung in Österreich. WWF Österreich, Wien. Available at https://www.wwf.at/wp-content/uploads/2023/03/wwf-at_WWF_WU_Studie_Ernaehrungspyramide_2_c_WWF.pdf

ACKNOWLEDGMENTS:

We sincerely appreciate the participation and contributions of all the attendees and presenters at the Workshop „Bioeconomy and the Sustainable Development Goals (SDGs): Contributions and Trade-offs" held online on November 22, 2022, as their valuable inputs and insightful discussions were crucial in shaping the content of this policy brief. We are grateful for the support provided by the German Federal Ministry of Education and Research (BMBF) through the project „BEST: Bioökonomie in Europa und SDGs: Entwicklung, Beitrag, Trade-offs" (grant no. 031B0792B), which played a pivotal role in successfully completing the research underpinning this policy brief.

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Phone: +49-(0)228 - 73 18 46
Layout: Yesim Pacal

May 2023

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