

Perspective

Integrating sufficiency in the trade and biodiversity agenda of the European Union

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SUMMARY

In the European Union (EU), the scale of biomass extraction and use—particularly for livestock products, feed crops, and biofuels—overshoots the planetary boundary for biosphere integrity, jeopardizing biodiversity within and outside the EU territory. While EU policy occasionally acknowledges the need for sufficiency measures to limit biomass use, its ongoing trade liberalization agenda incentivizes the production and consumption of critical commodities, such as feed crops, meat, dairy, wood, and ethanol. We argue that the EU's biodiversity and trade liberalization agendas contradict each other from a sufficiency perspective. Here, we highlight how sufficiency-oriented trade measures—such as quotas and tariffs on critical commodities and sufficiency provisions in trade agreements—could reconcile these agendas. These measures, if paired with fair compensation for affected producers, could reduce trade-induced ecological pressures while avoiding protectionism. Integrating sufficiency in trade policy could substantially reduce global pressures on biosphere integrity and help the EU effectively meet its biodiversity objectives.

INTRODUCTION

The escalating extraction and consumption of biomass for food, feed, materials, and energy have surpassed sustainable limits, threatening terrestrial ecosystems and biodiversity.^{1–10} Recent research shows that solely improving agricultural and forestry production practices and technologies is, although necessary, unlikely to be sufficient to reestablish a sustainable state of ecosystems.^{11–16} Researchers and policymakers are hence increasingly recognizing the need to limit the overall use of biomass, especially in Western and industrialized countries.¹⁷ In the European Union (EU), intensive production and consumption of biomass for food, especially animal-sourced products, have catapulted the use of land to unsustainable levels, a phenomenon exacerbated by the recent ambition of replacing the tremendous use of fossil fuels and non-renewable resources with wood and other biological raw materials for a biomass-based economy—hereafter, bioeconomy.^{18–20}

Preserving and restoring ecosystems hence requires wealthy regions such as the EU to introduce sufficiency measures.^{21–23} In this context, sufficiency refers to measures aiming at an absolute limit to or even a reduction in total biomass extraction and consumption per year at a level that would allow for the fulfillment of basic needs for all while restraining the scale of production

and consumption within natural limits of the planet's carrying capacity.^{22,24} Sufficiency implies that the reduced use of biomass is driven by a reduction in the overall use of energy and resources through changes in provisioning systems, such as food, housing, and mobility, to avoid increases in other fuels and resources.^{12,25,26} The literature sometimes uses the term “demand-side measures.” We, here, opted for the term “sufficiency measures,” reflecting the fact that reducing the production and consumption of biomass is the responsibility of all actors involved in the supply chain and, per extension, of governance institutions affecting all actors of the supply chain, rather than solely relying on actors from the “demand side,” which are often set equivalent to consumers.

Table 1 lists examples of sufficiency measures related to biomass production and consumption, such as reducing the production and consumption of animal products, reducing food losses and excessive calories, and limiting the use of biomass-based fuels and materials (along with other fuels and materials). These can be implemented through regulations and financial incentives, for example, reducing the strong financial support for animal products in the EU's Common Agricultural Policy, increasing subsidies for the production of alternative protein sources, and reallocating the subsidies for biodiversity conservation measures.^{27–29} Furthermore, a binding cap on using



Table 1. Main literature-based examples of biomass-related sufficiency measures

Sufficiency measure	Examples	References
Reducing the production and consumption of feed and animal products	incentives and regulations to shift from meat-heavy toward plant-based protein provision	Roux et al., ³² Mayer et al., ³³ Clark and Tilman, ³⁴ Springmann et al., ³⁵ Laroche et al., ³⁶ Theurl et al., ³⁷ Rööös et al., ³⁸ and Dulunins and Baret ³⁹
Limiting the use of biomass-based fuels and materials (wood, rubber, bioplastics, biodiesel from palm oil and other oil crops, bioethanol, ...)	ending subsidies for bioenergy from primary biomass, incentives and regulations for insulation, smaller housing, and environmentally friendly mobility (sparing rubber tires and biofuels)	Andersen et al., ¹⁷ Stubenrauch and Garske, ³¹ Le Noë et al., ⁴⁰ Rockström et al., ⁴¹ Erb et al., ⁴² Laroche et al., ⁴³ Soimakallio et al., ⁴⁴ and Peng et al. ⁴⁵
Reducing excessive calorie intake and food losses, as well as food and stimulants with high environmental pressure and little nutritional value such as sugar, chocolate, coffee, or tobacco	incentives and regulations for smaller food portions, healthy diets and lifestyles (e.g., quit/reduce smoking and eating and drinking sugary beverages and foods and chocolate)	Clark et al. ⁴⁶ and Sporchia et al. ⁴⁷

primary biomass for energy conversion and ending subsidies for primary biomass under the Renewable Energy Directive³⁰ would be a significant step toward fostering sufficiency in the wood sector.³¹

The commodities mentioned in Table 1, hereafter called critical commodities, and their required feedstock are increasingly traded internationally.^{48–50}

Figure 1 shows that, in addition to multilateral trade liberalization achieved through the General Agreement on Tariffs and Trade (GATT) rounds and the World Trade Organization (WTO), the number of regional trade agreements (RTAs) involving the EU has increased rapidly over the past decades, now totaling approximately 60. RTAs of the EU often include provisions about direct biodiversity impacts, such as trade in endangered species, but they frequently lack or only partially cover indirect impacts such as invasive species, deforestation, destruction and modification of habitats, species' mortality, and soil and water pollution.⁵¹ Trade agreements such as the EU-Canada Trade Agreement (CETA), the Transatlantic Trade and Investment Partnership (TTIP), EU-Australia, and the EU-MERCOSUR Association Agreement occasionally reference broader factors affecting ecosystems and biodiversity, but quantifications of these impacts are missing.⁵² The EU-New Zealand agreement faced criticism for its potential impacts on biodiversity.⁵³ On the other hand, the EU-Central America, EU-South Korea, EU-Mexico agreements were found to have induced small or ambiguous effects on biodiversity, due to the limited scope of land-use changes or prevailing regulations in partner countries.⁵³ However, studies examining the impacts of these RTAs on ecosystems and biodiversity are scarce and rarely compare these impacts to counterfactuals without the trade agreement.

International trade and its liberalization have multiple and ambiguous effects on ecosystems and biodiversity (see Box 1). In this article, we focus on one peculiar effect of trade liberaliza-

tion, namely, how the liberalization of international trade increases the overall scale of extraction and consumption of biomass, intensifying associated pressures on ecosystems.^{55,56,57} The liberalization of international trade increases the production and consumption of meat and other livestock products^{58–63} as well as wood products and biofuels,^{64–66} which exert important pressures on ecosystems. Despite the robust empirical evidence, the scale effect is seldom critically mentioned in policy documents.⁶⁷

We are therefore confronted with the following contradiction. On the one hand, the EU aims to reduce its pressures on biodiversity and ecosystems⁸⁹ but, as illustrated above, achieving this goal would require sufficiency measures to limit or reduce the overall production and consumption of animal products, wood, and various other inputs for the bioeconomy. On the other hand, the EU has been negotiating trade agreements that lower trade barriers on these very commodities, incentivizing their increased production and consumption both within and outside the EU. Given this tension, we address the following question: "Are the EU's policies aiming at reducing pressure on ecosystems and biodiversity inconsistent with its multiple trade agreements that remove tariffs and other trade barriers on imports and exports of feed, animal products, and inputs for the bioeconomy?" We address this question by combining quantitative data on the pressure on ecosystems linked to EU production, consumption, and trade of biomass products and a screening of various EU policy documents and trade agreements (see appendix in the supplemental information).

THE EU OVERSHOOTS SUSTAINABLE BIOMASS LIMITS

We describe pressures on ecosystems and biodiversity in terms of embodied human appropriation of net primary production, or eHANPP (Box 2). Although the direct effects of consumption and

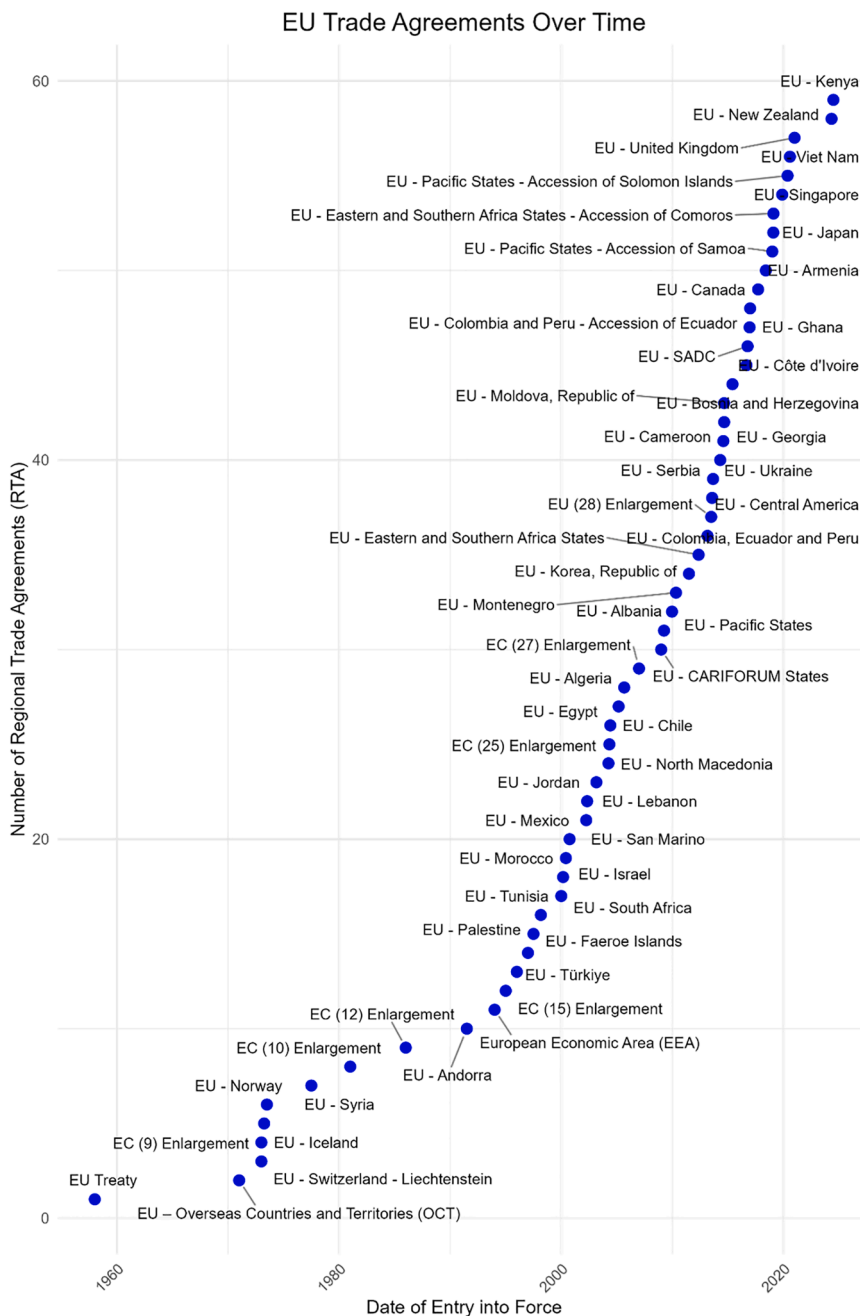


Figure 1. Evolution of regional trade agreements signed by the EU

Data source: Regional Trade Agreements Database of the WTO.⁵⁴

The greatest share of ecosystem pressure embodied in the consumption of biomass in the EU stems from the high production and consumption of meat and other animal products (Figure 2A). However, between 1997 and 2017, the increasing use of crops and forestry products for materials or energy (“other uses” in the terminology of FAOSTAT) became the primary driver of ecosystem pressure linked to the EU’s biomass consumption, partly offsetting decreases in food-related pressure (Figure 2B). Therefore, the following discussion will primarily focus on critical commodities from these two sectors, namely feed-livestock supply chains and biomass for materials and energy.

Between 2015 and 2017, the average biomass consumption in the EU was 0.92 t C/capita/year in primary biomass equivalents, including the feed embodied in animal products (Figure 3, left bar). To stay within the planetary boundary while maintaining the current primary biomass per unit of HANPP (hereafter called HANPP efficiency), biomass consumption would need to be decreased to less than 0.32 t C/cap/year across food, materials, energy, and other uses. Conversely, if biomass use is not reduced, staying within the planetary boundary would require a 3.9-fold increase in HANPP efficiency (from 0.51 to 2.0 t C of primary biomass per tonne of carbon of HANPP). For context, the global HANPP efficiency increased by ca. 30% (including harvesting residues) over the entire 20th century,¹⁰⁸ a period with important yield increases and technological innovation in many regions of the world. While a

trade activities on biodiversity are limited, the provision of traded and consumed products often results in substantial pressures⁹⁰ on biodiversity that act through complex supply chains. These can be traced using the eHANPP concept as recently shown in Semenchuk et al. and Matej et al.^{91,92}

Despite the high technological advancement and efficiency increases in biomass production in the EU,¹⁰⁷ the pressure on ecosystems embodied in the EU’s consumption of biomass—expressed in eHANPP terms—still overshoots the EU’s fair share¹⁰² of the planetary boundary for the biosphere¹⁰ by a factor of 3 in 2017 (Figure 2A).

balanced approach—combining efficiency gains with an overall reduction in biomass use—is essential to mitigate the challenges of both strategies, relying solely on efficiency improvements appears unrealistic for achieving eHANPP levels below the EU’s fair share of the planetary boundary. Even in the optimistic case where the EU’s HANPP efficiency for biomass consumption were to double, the EU’s consumption of primary biomass would still be nearly 1.5 times the upper threshold for biomass use within the planetary boundary. This highlights an issue with the biomass overconsumption in the EU.

Box 1. The multiple effects of trade liberalization on ecosystems and biodiversity

The effects of international trade of biomass products on ecosystems are complex and widely debated.^{8,68–73} Direct impacts of international trade include trade in endangered species and the introduction of invasive species.^{74,75} A large body of literature quantifies indirect impacts and pressures on biodiversity embodied in the international trade of agricultural and forestry products.^{32,49,76–80} For example, Lenzen et al.⁷⁶ attribute 30% of global species threats to international supply chains. Current patterns of international trade also result in a more resource-efficient allocation of land-related resources compared to scenarios without trade, assuming constant consumption patterns.^{49,70,81} However, the global reallocation of biomass production over the past decades, especially the expansion of exports from tropical regions, has globally been detrimental for ecosystems.⁷¹ Export orientation and openness to trade also correlate with forest loss in the tropics.^{82,83} The environmental economics literature often attempts to decompose the effect of trade liberalization into scale, composition, and technique effects.^{55,56,84,85} Other effects include technology transfers, opening of biochemical cycles, and disruptions to ecological feedback loops.⁷² Studies assessing the causal relationships between trade liberalization and biodiversity are scarce. Among these, Abman and Lundberg⁸⁶ found a significant increase in net deforestation and biodiversity loss in the 3 years following the enactment of regional trade agreements. Trade agreements are also found to increase the outsourcing of ecological impacts.^{87,88}

If food consumption in the EU were to align with the Planetary Health Diet recommended by the EAT-Lancet Commission (“Lancet-Diet”¹⁰⁹), implying a stark reduction of meat, animal products, and calories, food provision alone would require 0.30 t C/cap/year of primary biomass, based on losses and feed conversion ratios of 2017 (Figure 3, right bar). To stay within the planetary boundary, this would leave less than 0.02 t C/cap/year of primary biomass available for material, energy, and other non-food uses, whether from agriculture or woody biomass. Even if HANPP efficiency was doubled, only 0.16 t C/cap/year would remain for material, energy, and other non-food uses. This contrasts with the 0.29 t C/cap/year of wood and agriculture biomass consumed on average between 2015 and 2017 for material, energy, and other non-food uses.

Between 2015 and 2017, a large share of the EU’s pressure on ecosystems embodied in the production and consumption of biomass was linked to its international trade with countries outside the EU. About a quarter of the HANPP embodied in the EU’s consumption of biomass was offshored to countries outside the EU (Figure 2), especially through imports of soybeans used for feed from Brazil, Argentina, the United States, and Paraguay (respectively 9%, 8%, 5%, and 2% of eHANPP imports); cattle meat from Brazil (3%); sunflower seeds used for feed from Ukraine (2%); inputs for biomaterials and energy, notably rubber and palm oil from Indonesia (4%); and stimulants, such as cocoa

from Ivory Coast (2%) and coffee from Brazil (2%) (Figure 4). Similarly, 15% of the HANPP embodied in the production of biomass products in the EU was linked to products that were exported to countries outside the EU, especially pig meat, dairy, and beef to the United Kingdom (8% of eHANPP exports), China (7%), and Japan (2%); wheat to Algeria (3%), Egypt (1%), Saudi Arabia (1%), and Morocco (1%); and wood products to the United Kingdom (2%) and China (2%). The pressures on ecosystems associated with the EU’s import and export of biomass are hence most pronounced for the critical commodities, for which sufficiency measures hold the greatest relevance (Table 1).

EU POLICY DOCUMENTS SPORADICALLY ACKNOWLEDGE SUFFICIENCY MEASURES

The EU has set ambitious biodiversity goals in its Biodiversity Strategy for 2030 aiming to halt biodiversity loss. These efforts include restoring degraded habitats and expanding the network of protected areas. However, the Biodiversity Strategy goes beyond addressing biodiversity within the EU; it also includes global ambitions and seeks to reduce the negative impacts of EU resource use on biodiversity-rich regions around the world.¹¹⁰

Nonetheless, the EU’s biodiversity agenda has also been criticized, notably for increasing the risk of offshoring biodiversity pressures.^{111,112} Sufficiency measures hold significant potential

Box 2. The eHANPP indicator

The human appropriation of net primary production (HANPP) is a proxy for human pressures on ecosystems (or biosphere integrity) induced by land use.^{93,94} Net primary production (NPP) is the difference between the carbon uptake of plants during photosynthesis and the carbon plants release during respiration.⁶ NPP provides the main source of food for non-photosynthetic organisms, including humans. The HANPP is the amount of NPP humans remove from ecosystems through land-use conversion and harvest. In most cases, the more NPP is appropriated by humans (measured in energy, carbon, or dry matter of biomass), the less energy is available for other species, with negative consequences on biodiversity,^{91,95–97} the water cycle, the carbon balance of ecosystems, and other ecosystem functions.^{20,93,98,99} The HANPP linked to the supply chains of biomass products is called “embodied HANPP” (eHANPP), referring to the spatial disconnect between locations of production and consumption.¹⁰⁰ HANPP and eHANPP indicators are increasingly being used to measure human-induced pressures on ecosystems in relation to the planetary boundary for biosphere integrity.^{10,101–103} Some EU policy advisory documents suggest using HANPP and eHANPP to assess pressure on ecosystems linked to European production and trade.^{104,105} Note that HANPP and eHANPP do not attempt to measure biodiversity itself, but are helpful as indicators of pressures on biodiversity resulting from human activities. eHANPP data used in this article are described in Roux et al.¹⁰⁶ and have been extended in L.K. et al. (unpublished data). The data will be available at <https://zenodo.org/records/8384359>.

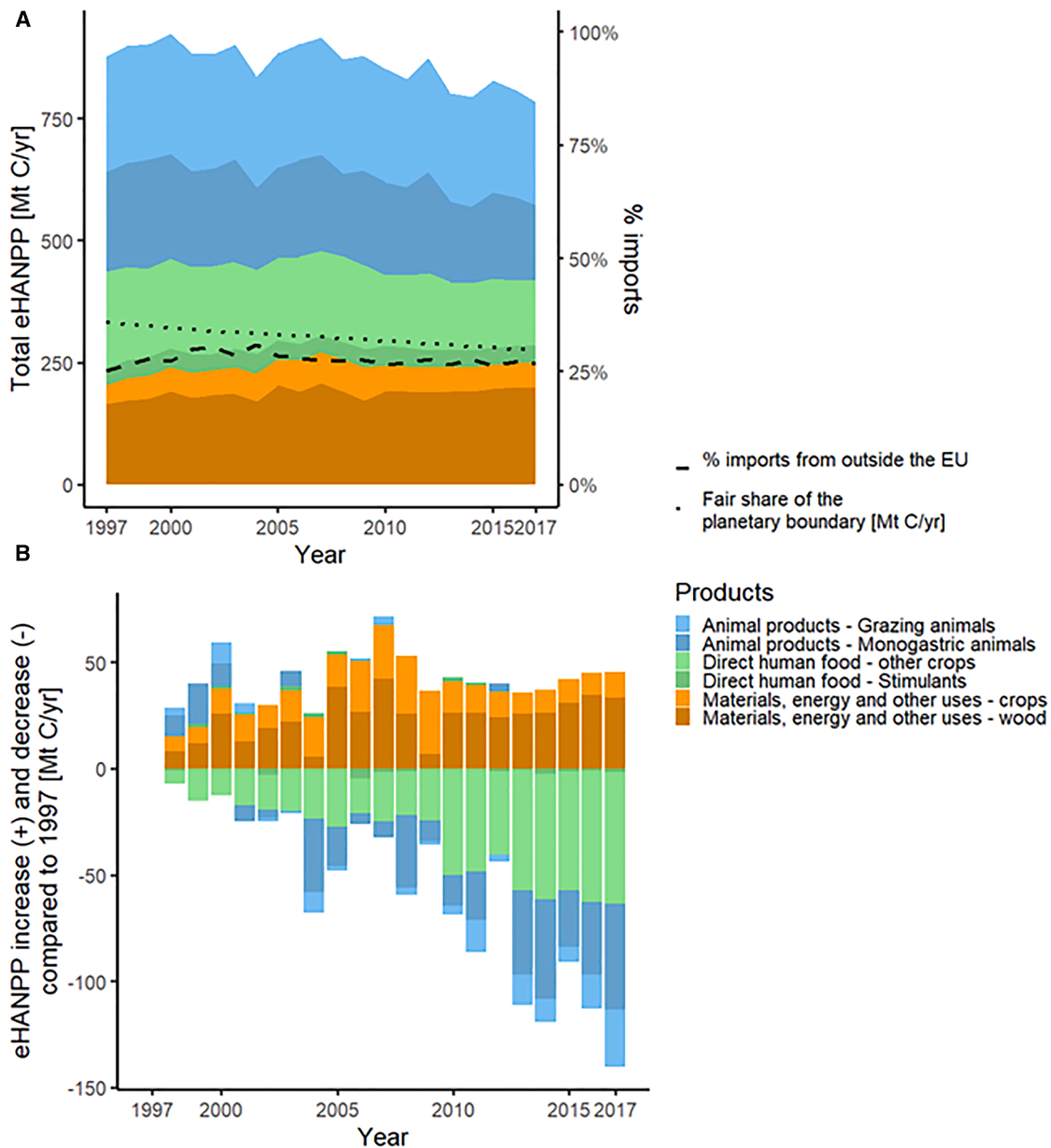


Figure 2. HANPP embodied in the consumption of agriculture and forestry products of the EU27 between 1997 and 2017

The total (A) and increase (B) in eHANPP are shown. The time period was determined by data availability. eHANPP data were taken from Roux et al.¹⁰⁶ and extended in L.K. et al. (unpublished data). The planetary boundary was taken from Richardson et al.¹⁰ and the “fair share” was calculated on a per-capita basis following Fanning et al.¹⁰² Most of the HANPP embodied in the EU’s consumption of biomass was linked to animal products, but the increase between 1997 and 2017 was almost entirely linked to materials and energy uses (left axis). About a quarter of the HANPP embodied in the EU’s consumption of biomass was linked to imports (right axis).

to mitigate this threat, hence addressing the global pillar of the EU’s Biodiversity Strategy aimed at reducing pressures on ecosystems worldwide.^{113,114} Despite this potential, sufficiency measures are seldom touched upon in the current EU policy agenda and could potentially even be at odds with the green growth paradigm dominating in EU environmental agendas.^{115–118}

Nevertheless, EU policy documents also sporadically deviate from pure growth imperatives.¹¹⁹ With regard to biomass utilization, glimpses of this detachment can be found in the EU’s bioeconomy strategy, mentioning “the need to have an in-depth

knowledge of the sustainable biomass supply limits at the local, regional and global level.”¹²⁰ The EU’s bioeconomy strategy aims to tackle the potential conflict between the increasing demand for biomass for biobased energy and materials and the production of food for human consumption, as well as the necessity of ecosystem preservation. The 2022 Bioeconomy Progress Report highlights that replacing fossil fuels and materials with biomass would induce a “biomass gap” between supply and demand, thus recognizing the limited availability of sustainable biomass for the production of materials and energy.¹²¹ This report

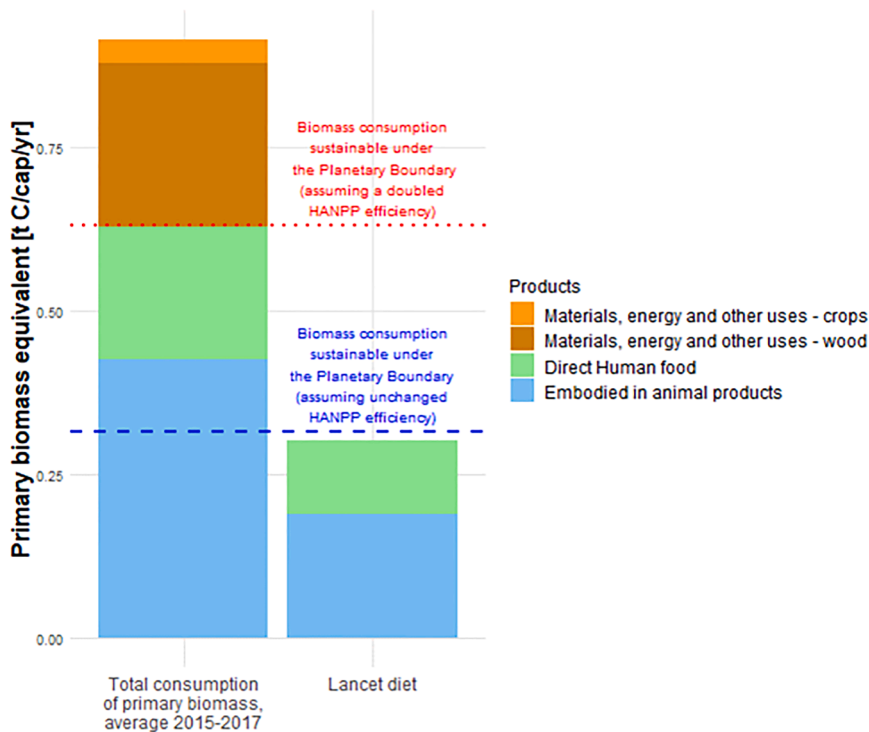


Figure 3. Biomass (over)consumption compared to the planetary boundary

On average in 2015–2017, the biomass use in the EU, in primary biomass equivalents (left bar), was three times higher than what would be sustainable under the EU’s fair share of the planetary boundary, assuming unchanged HANPP efficiency (blue line), and 1.5 times higher if the HANPP efficiency doubled (red line). Consuming food following the EAT-Lancet recommendation reduces the consumption of primary biomass to levels below the fair share of the planetary boundary but leaves less than 0.02 t C/cap/year of biomass for non-food uses (from wood or agricultural biomass) or 0.16 t C/cap/year if the HANPP efficiency doubled.

affirms that technological solutions need to be complemented with a shift toward “sustainable consumption patterns” (vaguely suggesting sufficiency measures) (p. 4). Other examples of sufficiency measures mentioned in EU policy documents include the need for a dietary change (i.e., reducing the production and consumption of animal products)—which was mentioned in the EU Farm to Fork Strategy¹²² but revoked in the 2025 EU Vision for Agriculture and Food¹²³—or the restriction of single-use biobased plastics.¹²⁴ In its report on “Exploring new visions for a sustainable bioeconomy,” the Joint Research Center of the European Commission refers explicitly to sufficiency and pledges to incorporate strategies in the EU’s bioeconomy strategy, aiming at reducing overall production and consumption.¹²⁵

Although none of these EU strategies explicitly articulate how to implement supply limits within bioeconomy policies along the supply chain, we argue that the recognition of the limits to biomass supply, the explicit restrictions on certain products such as single-use bioplastics, and the goal of dietary change can act as a starting point for sufficiency measures to limit or even reduce the EU’s overall biomass use.

THE CURRENT EU TRADE AND BIODIVERSITY AGENDA DOES NOT CONSIDER SUFFICIENCY AND SCALE EFFECTS

The EU acknowledges that a large share of its land footprint is linked to international trade¹²⁶ and started recognizing the links between its trade policy and pressure on distal ecosystems (Table 2). The European Commission has also committed to a better assessment of the EU’s free trade agreements on biodiversity with the development of a strict methodology to identify

and systematically apply “a set of indicators that capture changes in biodiversity status and trends.”¹⁰⁵

The strategies and policies outlined in Table 2 aim to change practices related to imported and exported products and are laudable achievements to reduce biodiversity impacts along international supply chains.^{130,131} However, none of these policy documents address how trade increases the extraction and consumption of biomass. For instance, the

Regulation on Deforestation-free Products seeks to limit imports of commodities that lead to deforestation by shifting to “deforestation-free” commodities and products but does not address the need for a reduction in the overall production, consumption, and trade of these commodities.¹³²

Rather than aiming to reduce resource use, the EU trade policy documents often praise the promise of economic growth offered by trade liberalization. One of the most prominent narratives behind trade policy documents is the premise that trade liberalization and economic growth will facilitate the development and exchange of “green (or environmental) goods,” i.e., those goods and technologies that may reduce certain environmental problems (solar panels, etc.). This narrative is reflected in the EU’s 2021 Trade Policy Review, claiming that “the EU’s vast network of bilateral trade agreements facilitates trade in green technologies, goods, services and investments”¹²⁷ (p. 12). Similarly, the sustainability impact assessment (SIA) of the EU–Japan Economic Partnership Agreement¹³³ states that “Negative effects (if any) would be offset by the increased exchange of environmentally friendly technologies” (p. 250). The extent to which the full-scale liberalization of trade in feed and livestock products, wood products, palm oil, rubber, and other inputs for biofuels and biobased materials may contradict the objectives of keeping the bioeconomy within sustainable limits appears to remain largely undebated.

ONGOING TRADE LIBERALIZATION IS DRIVING THE EXTRACTION AND CONSUMPTION OF BIOMASS WITHIN AND OUTSIDE THE EU

As discussed earlier, decreasing tariffs on critical commodities such as feed crops, livestock products, wood, and inputs of

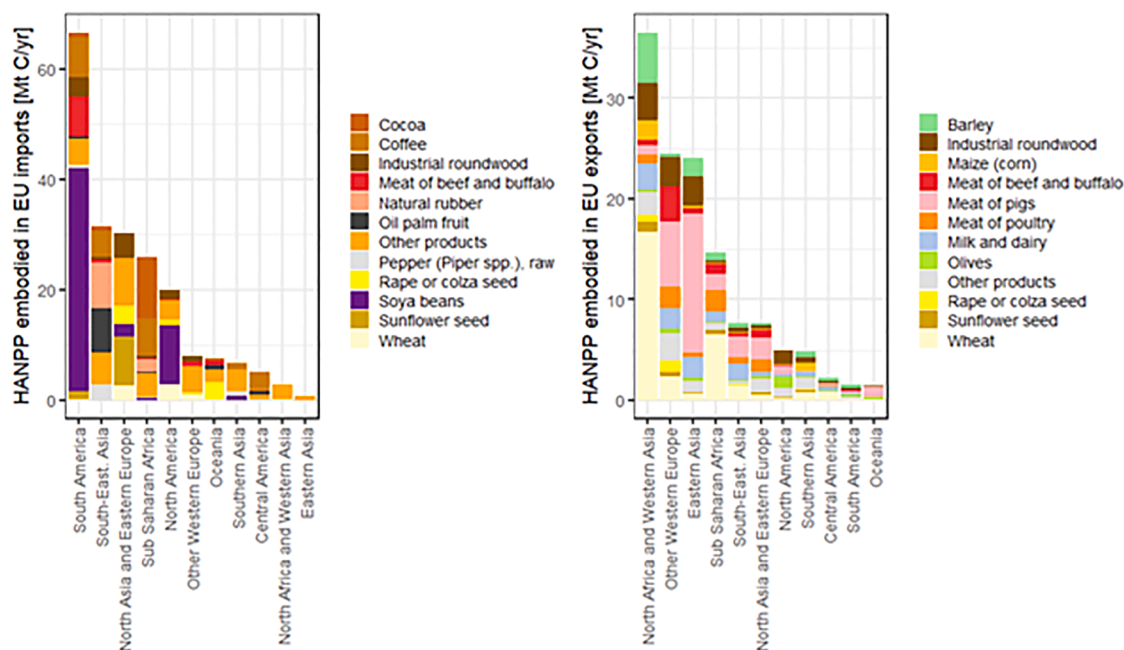


Figure 4. HANPP embodied in EU imports and exports, average 2015–2017

Most of the HANPP embodied in the EU’s imports and exports of biomass products was linked to products where sufficiency measures hold the greatest relevance (Table 1), namely feed crops (imports of soybeans), livestock products (imports of cattle meat and exports of pig meat, cattle meat, and dairy), feedstock for biomaterials and energy (imports of rubber, palm oil, and wood products and exports of wood products), and stimulants (imports of cocoa and coffee).

the bioeconomy drives the extraction and consumption of these commodities in the EU and globally. Figure 5 shows that, since the 1990s, tariffs decreased for most critical commodities, especially for meat, animal products, stimulants (coffee, tea), and palm oil.

A study by the European Commission’s Joint Research Centre finds that if currently negotiated free trade agreements (FTAs) are concluded, the EU’s imports of poultry (+21.8% to +29%) and beef (+21.3% to +25.5%) and exports of dairy and pork would grow significantly.¹³⁵ Based on the empirical findings mentioned earlier, it is dubious whether these additional imports and exports would solely substitute for the domestic production of the EU and its trading partners without increasing the overall production and consumption of livestock products.^{59–62,136}

Academics have notably raised concerns about the tariff-rate quota on 99,000 tonnes of beef from MERCOSUR countries, which could have been imported with zero or minimal customs duties in the initial EU-MERCOSUR Association Agreement.^{69,135,137} This initial agreement was expected to raise EU imports of beef from South America by 30%–64%.^{137,138} In the latest version of the agreement, finalized in 2024, the duty for the same quota was raised to 7.5%, which is still substantially lower than the 16.6% to 79.3% Most Favored Nation (MFN) tariffs applied by the EU prior to the agreement.¹³⁸ This evolution is of primary concern, considering the high environmental impacts linked to cattle meat.⁴⁶ In scenarios of global liberalization of agricultural trade, the increase in cattle meat imports from South America is shown to be the consequence of agricultural trade liberalization inducing the highest rise in global greenhouse gas emissions.¹³⁹

Similarly, the EU-Japan Economic Partnership Agreement entered into force in 2019, removing tariffs on meat and dairy. Consequently, within the first year of the agreement, dairy and meat exports from the EU to Japan increased by 10.4% and 12%, respectively, with a tripling of frozen beef exports.¹⁴⁰ Other approved and currently negotiated trade agreements with New Zealand and Australia have also removed trade barriers for beef and other livestock products. One can expect that these trade agreements will induce an overall increase (or slow down the ongoing decrease) in the production and consumption of livestock products and associated pressures on ecosystems in the EU and its trade partners.

A similar argument can be made for non-food biomass, especially bioenergy. Despite scientific concerns about the effect of using biomass for energy,^{141–143} the EU has become the leader in bioenergy use worldwide.¹⁴⁴ This high level of bioenergy has been enabled by high imports, notably wood pellets from North America; bioethanol from North, Central, and South America; biodiesel (palm oil) from Southeast Asia (over 60% of the total EU consumption of palm oil is used as energy); charcoal from Africa; and roundwood from Eastern Europe.¹⁴⁴ Ongoing trade negotiations seek to reduce barriers to bioenergy and feedstock imports. For example, the EU-MERCOSUR Association Agreement opens a duty-free quota for ethanol from MERCOSUR of 650,000 tonnes per year, compared to the 50,000 tonnes per year currently imported.^{69,145} Mandley et al.¹⁴⁶ found that Europe’s total bioenergy consumption would rise by 24% under a free trade scenario, primarily due to increased imports of wood pellets and ethanol.

Finally, concerns have been raised that the environmental benefits of limiting biomass production and consumption in

Table 2. Examples of policy documents mentioning the link between international trade, biodiversity, and ecosystems

EU policy document	Quote mentioning the link between trade and pressures on ecosystems	Mentions scale effects or trade-related sufficiency measures?
2021 Trade Policy Review ¹²⁷	“Climate change and environmental degradation is the EU’s top priority [and] trade policy will have an important supporting role” (p. 12).	no
Biodiversity Strategy ⁸⁹	“Trade policy will actively support and be part of the ecological transition” (p. 21). The EU aims to measure the “footprint of products” and “better assess the impact of trade agreements on biodiversity” (p. 18).	no
Regulation on Deforestation-free Products ¹²⁸	[The regulation aims to] “minimis[e] the Union’s contribution to deforestation and forest degradation worldwide [and] reduc[e] the European Union’s contribution to greenhouse gas emissions and global biodiversity loss” (p. 34).	no
Directive on Corporate Sustainability Due Diligence ¹²⁹	[The directive requires large companies to] “identify and assess,” “prioritise,” “prevent” or “adequately mitigate,” “bring to an end,” and “provide remediation for” adverse impacts (articles 8 to 12), including the “degradation of land, or other impact on natural resources, such as deforestation [...] that substantially adversely affects ecosystem services through which an ecosystem contributes directly or indirectly to human wellbeing” and “adverse impacts on biological diversity, interpreted in line with [...] the 1992 Convention on Biological Diversity and applicable law in the relevant jurisdiction” (Annex I.1.15 and II.1).	no

None of these documents mentions how trade increases the extraction and consumption of biomass or the role of trade policy in implementing sufficiency measures.

the EU could be undermined if imports and exports were not reduced at the same time.^{111,147} Achieving the goals of the European biodiversity agenda, notably the Nature Restoration Law,¹⁴⁸ would therefore become difficult if imports and exports were not restricted alongside domestic production and consumption.^{33,149} This highlights an inconsistency between the EU’s biodiversity and trade liberalization agendas (Figure 6).

SUGGESTIONS FOR A SUFFICIENCY-ORIENTED EU TRADE AGENDA

Much of the literature has been discussing sufficiency measures from a consumption and domestic policy perspective; see Table 1.^{150–152} However, less attention has been paid to how to integrate sufficiency measures in EU trade relations to limit the total amount of biomass extracted and consumed in the EU (Figure 7).

To begin with, EU trade policy documents such as the EU Trade Policy Review could prominently and explicitly incorporate considerations of sufficiency. This step would enhance the recognition of the imperative for sufficiency, particularly on a

discursive and strategic level. On an operational level, SIAs of trade agreements could further emphasize the scale effects induced by trade liberalization and depict the closures of the agreement potentially impeding a transition to sufficiency.

Another step toward a sufficiency-oriented EU trade agenda would be, in the short term, to stop eliminating tariffs or expanding quotas on critical commodities, such as feed and animal products, wood, biofuels (and feedstocks), and biomaterials, at least until quantitative limits for the production and consumption of these products have been set. In the longer term, in the absence of measures restricting the total production and sales of animal products, increasing tariffs and restricting quotas could be considered as a “second-best option”^{153,154} to limit the scale of biomass production and consumption.^{155,156}

However, these suggested steps could be considered trade-distorting, facing potential legal conflicts with the international rules of the GATT and the WTO. Nevertheless, there are legal provisions within the WTO framework that could allow for their justification, depending on how they are implemented and argued.^{157,158}

First, the proposal to stop eliminating tariffs or expanding quotas on critical commodities, or even increasing tariffs, could

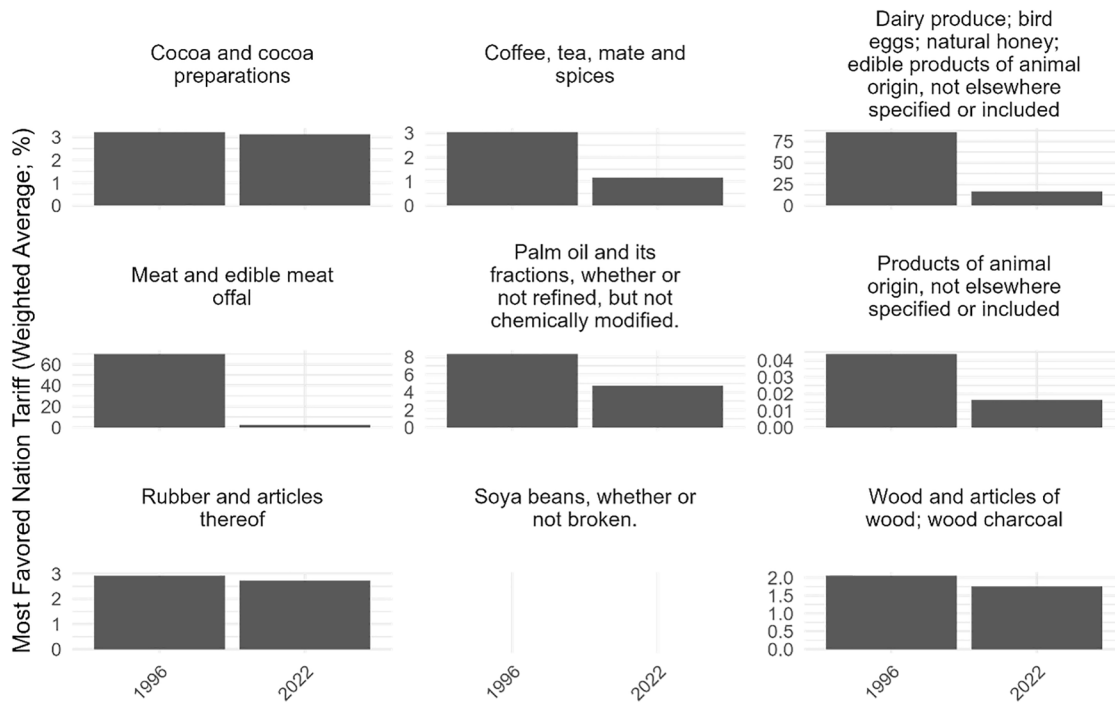


Figure 5. Most Favored Nation tariffs, 1996 and 2022

Most Favored Nation tariffs (weighted average) applied for critical commodities for the years 1996 and 2022 from the WTO Tariff Analysis Online Database.¹³⁴ Tariffs on critical commodities were low (null for soybeans) or have decreased substantially (especially meat and animal products) since the 1990s. Note the different y axes.

conflict with the WTO’s principle of non-discrimination (GATT Article I), particularly under the MFN principle. The MFN principle requires that a WTO member apply the same tariff rates to all other members except where specific exceptions apply (such as in RTAs). Moreover, the introduction of quotas could conflict with the prohibition of import restrictions under GATT Article XI. However, GATT Article XXVIII allows for the renegotiation of tariff commitments. The Report on Trade and Biodiversity,¹⁵⁷ commissioned by the Committee on International Trade of the European Parliament (INTA), argues that “the increase [of MFN tariffs] could be envisaged, but it would necessitate the opening of negotiations with ‘contracting parties primarily concerned’ to determine whether compensations are warranted and which form they might take.”¹⁵⁷ This could involve complex negotiations, compensation, or reciprocal trade adjustments, but it is a legally available route.

Second, emphasizing sustainability concerns in the EU’s SIAs and focusing on the environmental impact of trade liberalization aligns with the GATT Article XX exceptions. Specifically, Article XX(b) allows for trade restrictions that are “necessary to protect human, animal, or plant life or health,” and Article XX(g) allows for measures “relating to the conservation of exhaustible natural resources.” These exceptions could be used to justify measures that are designed to protect biodiversity or limit environmentally harmful practices, such as limiting biomass production and consumption. The challenge would be proving that the trade measures were necessary and that they met the requirements of being non-discriminatory and not arbitrary in their application.

Third, restrictions on trade in feed, animal products, or biomass for environmental or health reasons could potentially be justified under the WTO’s Sanitary and Phytosanitary (SPS) Agreement or the Technical Barriers to Trade (TBT) Agreement. These agreements allow members to implement measures to protect human, animal, or plant health and the environment, but they must be based on scientific evidence or risk assessments. For example, to justify SPS measures, the EU would need to provide robust scientific evidence showing the environmental harm caused by certain products or practices. Similarly, under the TBT Agreement, the EU could impose technical regulations that have environmental objectives, provided they are not more trade restrictive than necessary and are applied fairly across all trading partners.¹⁵⁷

Besides tariffs and quotas, sufficiency measures could also be included in non-tariff measures of EU trade agreements and in the WTO. The EU aims to achieve the “full implementation and enforcement of biodiversity provisions in all trade agreements.”⁸⁹ Such biodiversity provisions could include sufficiency measures, such as the reduction of subsidies supporting intensive and large-scale livestock farming.¹⁵⁹

Regarding international institutions, the EU could also promote sufficiency measures in the WTO’s Trade and Environmental Sustainability Structured Discussions, which notably have been discussing the effect of agricultural subsidies on trade and the environment. International cooperation with other major importers of products that have significant biodiversity impacts could aim to prevent leakage effects to other markets, such as China.¹⁶⁰

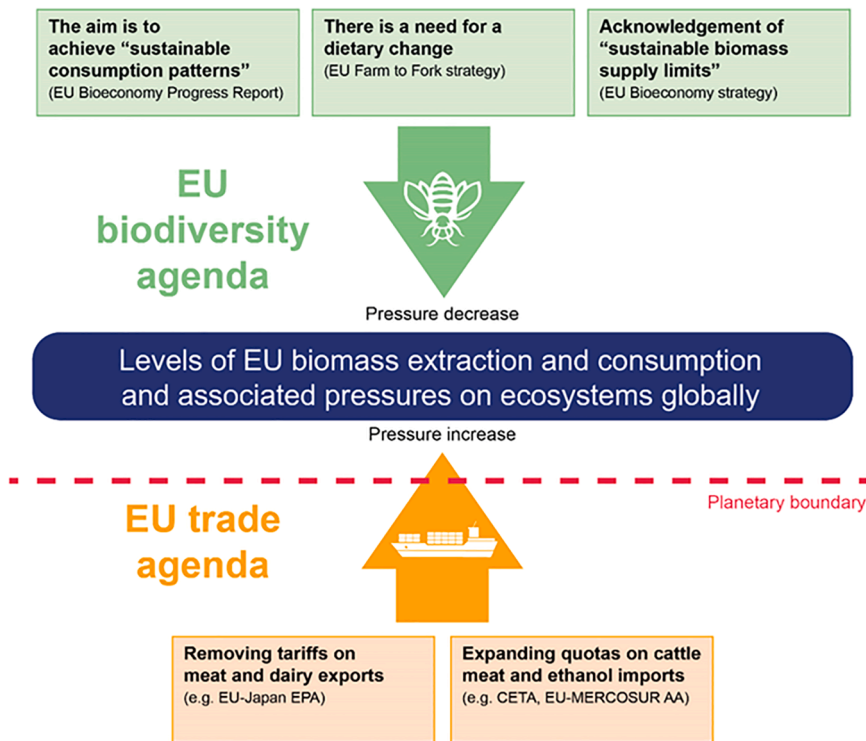


Figure 6. Inconsistency between the EU biodiversity agenda and the full liberalization of international trade of feed, livestock products, and inputs of the bioeconomy

While achieving biodiversity objectives requires limiting the overall use of biomass, the current trade liberalization agenda provides incentives to raise the scale of biomass production and consumption in the EU and its trade partners.

ation aimed at improving natural resource governance that protects the rights and livelihoods of smallholders, Indigenous peoples, and local communities. Additionally, the EU could promote the trade of forest-friendly products, which are raw or minimally processed goods that can act as drivers of environmental conservation, forest regeneration, and the inclusion of forest dwellers, such as crops that can be harvested in agroforestry systems.¹⁶⁷

Finally, addressing conflicting interests and unequal power distribution and changing the modes of extraction and exploitation in producing countries, from export-profit toward livelihood-oriented

production, may also help to achieve an equitable transition toward a sufficient use of biomass.^{163,168,169}

Political feasibility

We acknowledge that the political feasibility of our proposed measures is uncertain. Examining the roles of actors, political negotiations and conflicts, and the global geopolitical landscape^{170–172} reveals both potential and hurdles for fostering sufficiency in the EU’s trade agenda.

In the EU, a coalition of non-governmental organizations (NGOs) and academics advocates for a sufficiency-oriented bioeconomy that requires substantial reductions in domestic resource use through changing provisioning systems and stricter regulations.^{117,173,174} However, some EU member states and powerful interest groups from forestry, agriculture, and industry continue to defend growth-based agendas, often obscuring stronger EU regulations on biomass use.^{173,175,176} By fostering collaboration across diverse sectors, overcoming resistance against necessary regulations, and acknowledging the urgent need for ecological sustainability, the EU and other affluent nations have the potential to lead the way in creating a trade agenda that respects planetary boundaries, considering sufficiency measures.

Furthermore, trade agreements have been increasingly politicized over the past two decades.^{177,178} For example, the TTIP negotiations sparked protests from civil society across Europe due to concerns about the lack of transparency and attenuated European laws and standards in health, labor, the environment, and consumer protection. These protests have influenced the European Parliament to amend its resolution on the TTIP.^{177,179} There has been also resistance to the EU’s trade

Leave no one behind

It is important to make sufficiency equitable. In a trade system that seeks to reduce production and consumption in the EU, strategies are to be developed to avoid negative impacts on smallholder incomes and poverty in producing countries. First, trade agreements could consider specific funding mechanisms, such as taxing products with high pressure on biodiversity at the border but redistributing the tax income to producers, potentially also through biodiversity programs.^{156,157}

Furthermore, commodities need to be differentiated according to production scale (with accompanying socioenvironmental implications and distributive benefits) and producing country context. While beef and soybean supply chains from South America tend to be dominated by large producing companies, coffee and cocoa supply chains from Asia and Africa are largely dominated by smallholders who are more vulnerable to sudden demand shocks.^{161–163} The context may also vary by country. For example, in the case of palm oil, large producers dominate in Indonesia, whereas smallholders are more common in Malaysia and other Southeast Asian nations.^{164,165}

Reducing imports of critical commodities risks affecting smallholders, Indigenous peoples, and employment in local communities in producer countries. Following the suggestions of Zhunsova et al.,¹⁶³ we argue that these impacts can be mitigated by assessing impacts on smallholders, Indigenous people, and local communities; supporting producers in the transition to alternative income sources; and promoting jurisdictional and integrated landscape management approaches. The EU could combine its “do no harm” policies with “do good” policies to leave no one behind.¹⁶⁶ This could include development cooper-

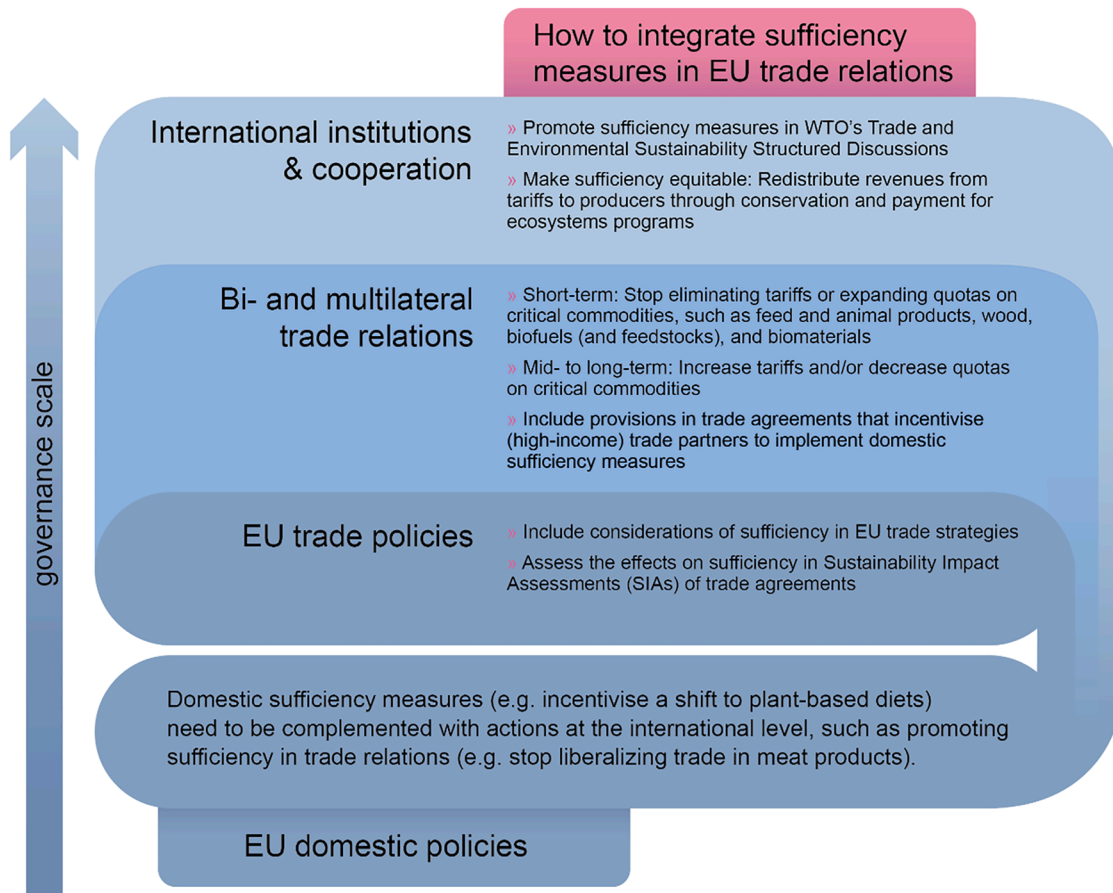


Figure 7. Suggestions for a sufficiency-oriented trade agenda

agenda among its major trade partners for biomass products. For example, in Brazil, environmentalists, academics, small-holding farmers, and Indigenous communities, together with labor unions, strongly criticized the EU-MERCOSUR agreement, arguing that it would exacerbate environmental damage, threaten food security, and reproduce unequal trade relations through centralization of high-value production in Europe. The last concern especially was adopted by the current Brazilian administration.^{180,181} These protests might open new paths to link trade negotiations to discussions about sufficiency.

In response to an evolving geopolitical landscape, the EU has moved away from a purely neoliberal to a more geopolitical trade agenda,¹⁸² presenting both opportunities and challenges for fostering sufficiency. Due to severe threats to the EU's economic security from the COVID-19 crisis, Russia's attack on Ukraine and the following energy crisis, and aggravating geopolitical tensions, the EU has increasingly acknowledged the necessity to safeguard its markets with selective protectionism while still promoting open global markets and free trade whenever feasible and economically advantageous.^{171,183,184} Furthermore, the Green Deal Industrial Plan¹⁸⁵ and the Net-Zero Industry Act¹⁸⁶ "include explicit goals and measures to attract or keep green industries in the Union."¹⁷² It remains to be seen whether this dynamic will continue in the direction of protectionist and competition-oriented policies or whether there will be opportunities for a reorientation toward

more sustainability and social equity. Finally, it is difficult to envision the EU forgoing opportunities to sustain its economic power as long as other major economies do not follow and collaborate. The current tense geopolitical landscape and rising protectionist agendas hence present an obstacle to constructive discussions about sufficiency in trade negotiations.

We are aware that the administration of the United States has recently used tariffs as a nationalist protectionist and coercive tool. In contrast to such strategies, our proposal is not a call for protectionism but a plea for a sufficiency-oriented trade agenda. The emphasis here is on the usefulness of such measures to limit the total amount of biomass extracted and consumed in the EU, which is vital for achieving biodiversity goals. This development could be carried out in close collaboration with trade partners and local communities that rely economically on biomass exports to and imports from the EU, fostering innovative solutions and compensation schemes. This ensures that the measures are fair and do not unduly harm those who rely on these exports for their livelihoods, as opposed to nationalism-motivated and conflict-oriented protectionism. Furthermore, trade has multiple impacts on ecosystems, with positive effects seen, for example, in the trade of fruits, vegetables, legumes, and nuts, contributing to health benefits.¹⁸⁷ We do, therefore, not advocate for a protectionist policy agenda banning all trade for all commodities.

CONCLUSION

Given the persistently high overshoot of the planetary boundary for biosphere integrity, we concur that for the EU to substantially alleviate pressures on ecosystems and biodiversity within and outside its territory, sufficiency measures are needed; mainly reducing the production and consumption of feed and animal products and limiting the use of biomass-based fuels and materials. We therefore contend that removing all trade barriers on these commodities and their feedstock contradicts the biodiversity goals of the EU, pointing to an inconsistency in the EU's trade and biodiversity agenda. This concern extends to other affluent countries, which often pursue economic and material growth through trade liberalization without fully acknowledging the biophysical limits to growth imposed by the biosphere.¹⁸⁸ Building on the examples we presented, further research is needed to explore the practical implementation of a sufficiency-oriented trade agenda for the EU and other affluent nations.

POSITIONALITY STATEMENT

As authors of this article, we acknowledge our positionality within the academic and social landscapes. Originating from Western Europe and identifying as individuals of white ethnicity, we recognize that our backgrounds, experiences, and societal privileges inherently shape our perspectives and influence the lens through which we approach our research, introducing biases, blind spots, and limitations to our work. We are committed to critically examining our own perspectives, interrogating power dynamics, and engaging in reflexivity throughout the research process to mitigate potential biases and enhance the validity and relevance of our findings. We hence invite readers to critically consider our positionality and its implications for the interpretation and application of our findings, welcoming constructive feedback and dialogue that contribute to an inclusive, equitable, and robust scientific discourse.

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AUTHOR CONTRIBUTIONS

N.R., lead, conceptualization, formal analysis (quantitative analysis, screening of policy documents), and writing – original draft; J.C., co-lead, conceptualization, formal analysis (screening of policy documents), and writing – original draft; B.F., co-lead, conceptualization, formal analysis (screening of policy documents), and writing – original draft; B.C., conceptualization and writing – review & editing; C.D., conceptualization and writing – review & editing; K.-H. E., conceptualization, writing – review & editing, supervision, acquisition, and project administration; H.H., conceptualization, writing – review & editing, supervision, and project administration; L.K., conceptualization and writing – review & editing; A.M., conceptualization and writing – review & editing; J.N., conceptualization, writing – review & editing, and supervision.

DECLARATION OF INTERESTS

The authors declare no competing interests.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work the authors occasionally used ChatGPT in order to improve the formulation of pre-formulated single sentences. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

SUPPLEMENTAL INFORMATION

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