Food Security
https://doi.org/10.1007/s12571-025-01533-9

REVIEW

Impacts of international food trade on natural resources

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Received: 14 January 2024 / Accepted: 18 March 2025

Abstract
The rapid expansion of global food trade over the last decades has intensified the debate about its environmental impacts and the role of trade policies in resource conservation. This paper examines whether trade restrictions can effectively address environmental pressures by analyzing the complex linkages between international trade and natural resource exploitation. Through a critical review of the existing evidence, the paper shows that while trade-induced specialization does not always lead to a more efficient and sustainable use of resources, trade restrictions alone often represent a second-best solution. Because they do not address the market failures that shape resource exploitation in the first place, such restrictions risk being not only ineffective but potentially counterproductive. Successful environmental protection requires integrated policy approaches that recognize the intricate relationships between trade liberalization, resource management, and food security.

Keywords Food trade · Specialization · Natural resources · Water · Land · Biodiversity

1 Introduction

During the last decades, trade in agricultural goods has increased sixfold, determining the emergence of a global food system (Robinson, 2018) and playing a vital role in the food security of several countries. Around 25% of agricultural production is nowadays traded across borders (D'Odorico et al., 2014) and more than 80% of world population lives in countries that are net importers of calories (Kastner et al., 2021).

Against this backdrop, some scholars have warned against the potential increase in the environmental pressures triggered by trade (Lenzen et al., 2012; Wiedmann & Lenzen, 2018; Pendrill et al., 2019), calling for a global governance of natural resources and even for outright limits to cross-border flows (Hoekstra, 2011; Mekonnen & Hoekstra, 2020). On the other end, economists (e.g. Frankel & Rose, 2005) and international organizations (see for instance OECD, 2019) tend to highlight the potential contribution of international integration to environmental protection.

Concerns are often motivated by the observation that international exchanges entail a de-coupling of consumption from local production and the domestic availability of natural resources, leading to their unsustainable exploitation. However, the fact that a large part of the footprint of the food system is related to goods that are exchanged internationally does not imply that trade *causes* environmental damages (Copeland et al., 2022): in the absence of trade, resources that are used to produce goods that are exported would find other uses, and there is no guarantee that this will reduce environmental damages.

This paper investigates the role of international food trade in contributing to or mitigating the environmental footprint of the global food system. More specifically, it asks whether trade restrictions (a general term encompassing different measures meant to reduce import and export flows) are an effective way to address the environmental pressures associated with food production. The research question is addressed by analyzing the economic mechanisms at play and critically reviewing the associated empirical evidence, which stems from various disciplinary backgrounds and approaches (Baylis et al., 2021). One contribution of the paper is therefore to bridge the gap between natural sciences and economic

The paper builds on a longer review essay that served as background paper for "The State of Agricultural Commodity Markets 2022", published by FAO. The opinions and views expressed in this paper are solely those of the author.

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Published online: 28 March 2025

research. The latter focuses on general mechanisms rooted in the abstract notion that by increasing efficiency trade ought to reduce the global use of natural resources, but often fails to adequately account for market imperfections, externalities, localized negative effects that might be significant (above and beyond average effects), or for the presence of irreversibilities and tipping points. On the other hand, natural sciences have developed increasingly sophisticated methods to map environmental degradation to a very fine level of detail, but often concentrate on a specific form of environmental pressure (e.g., water or land use, GHG emissions), do not always consider trade-offs among competing goals (saving water may require using additional land), and disregard the proper identification of a causal nexus between trade and the natural resources based on well-defined counterfactuals.

The paper claims that, although efficiency and sustainability need not go hand-in-hand, so that international trade can exacerbate pressure on natural resources in contexts where environmental governance is weak, trade restrictions are often a second-best solution as they do not affect the ultimate source of the negative externalities. Indeed, the imposition of trade barriers may simply lead to goods being produced elsewhere and to factors of production (including natural resources) finding alternative uses: this can result in more or less pressure on the environment than the world is experiencing today, while at the same time jeopardizing food security in some regions.

Economic analysis can help characterizing the mechanisms through which trade affects natural resources and identifying the conditions under which the impact is unambiguously negative. From a policy perspective, a combination of targeted, context-specific measures supported by international coordination are best suited to minimize the mismatch between the scale of governance and that of environmental problems (Coenen et al., 2023), tackle the negative externalities that lead to the over-exploitation of natural resources, and avoid the displacement of environmental damage to areas that enjoy lower degrees of protection (Berlik et al., 2002; Aichele & Felbermayr, 2015; Ingalls et al., 2018).

The paper is organized as follows: the next Section provides readers with a brief overview of the main (economic) mechanisms though which international trade can affect the use of natural resources. Rather than marginally updating existing (excellent) reviews on the topic (see for instance Cherniwchan et al., 2017; Copeland et al., 2022; Baylis et al., 2021; Anderson, 2022), the main aim of Section 2 is to provide a concise framework for understanding the different views in the debate. As the impact of international trade on the environment remains ultimately an empirical question, Section 3 reviews existing evidence pertaining to the various channels discussed in the paper, while Section 4 focuses on the benchmarks used to evaluate the effects of international trade, shedding light on some critical issues. Finally, Section 5 addresses the potential tension between global rules and local needs, arguing in favor of a multilevel governance structure that combines international coordination with context-specific initiatives, and Section 6 offers some concluding remarks.

2 Theoretical framework: the mechanisms at play

International flows of agricultural products have always been at the center of the debate on the merits of international trade, from the 19th century repeal of the Corn Laws in Britain (Findlay & O'Rourke, 2003) to recent trade negotiations (Laborde & Martin, 2012), to the debate on food self-sufficiency or sovereignty (Burnett & Murphy, 2014; Clapp, 2017). Because the effects of international trade have been and remain contentious, and food production relies extensively on natural resources, it is almost immediate to blame trade for environmental degradation (Lenzen et al., 2012; Wiedmann & Lenzen, 2018; Wood et al., 2018; Pendrill et al., 2019). On the other hand, properly identifying a causal nexus is not straightforward (Meyfroidt et al., 2013; Copeland et al., 2022), and it is not clear whether limiting trade would necessarily have a beneficial effect on the pressures that agricultural production places on natural resources. This Section discusses the main mechanisms through which international food trade affects the environment, starting from a very simple setup and then adding complexity by relaxing key assumptions.

2.1 Baseline: composition vs. scale effects

In the simplest setup —where markets are perfect and integrated, property rights completely allocated, and there are no distortions— trade has the potential to enhance global efficiency (and thus contribute to conservation) as long as goods are sourced from places featuring lower resource intensity per unit of production. This *composition effect* is a standard result from economic theory and is driven by comparative advantages, that is the opportunity cost of production, which ultimately depends on differences in resource endowments and/or technology across countries. Provided that resource availability and efficiency drive sourcing patterns, the localization of production according to comparative advantages therefore reduces the global environmental footprint of the food system.

On the other hand, trade can increase pressure on natural resources if new opportunities created by access to foreign markets and liberalization trigger an expansion of production that leads to, say, unsustainable agricultural practices, deforestation or the loss of biodiversity due to land use change. In fact, Taylor and Weder (2023) note that globalization can increase pressure on the resources needed to produce a relatively narrow range of products, with environmental hot-spots often featuring weak institutions. This is a *scale effect* whereby higher (agricultural) output requires more inputs such as land, water, fertilizers and it is often the main mechanism that is emphasized in the environmental and natural science literature (Lenzen et al., 2012; Wiedmann & Lenzen, 2018). Jevons paradox, or the rebound effect, whereby lower prices induced by increased efficiency lead to higher demand and more consumption, with adverse environmental effects, can also be framed as a scale effect. In this case the analysis is complicated by the fact that different foods feature a wide range of elasticities of demand, so that consumption responds differently to variations in prices for, say cereal staples or red meat. Lastly, scale economies can increase efficiency by reducing the per-unit impact of production, although the intensification of agricultural production alone is unlikely to benefit the environment unless it is coupled with system redesign (Garnett et al., 2013; Pretty et al., 2018).

2.2 Getting real: externalities, transport costs and additional mechanisms

Beside pointing in different directions, the two main channels just described hinge upon a set of rather stringent assumptions. A natural question is then what happens when one leaves the "trade economists' nirvana" (Hertel, 2018) and incorporates elements such as externalities, transport costs, differences in technologies, heterogeneity in the quality of land and other natural resources, or non-homothetic preferences.

When markets are imperfect or incomplete, the price system ceases to convey all relevant information to economic agents, and the private value of resources (upon which they base their decisions) may be lower that the social value, leading to an unsustainable over-exploitation of the environment. Such an outcome is especially likely if new opportunities created by trade increase the private value from using natural resources and are not accompanied by actions that tackle externalities and stimulate resource-saving investment. Ecosystem services, for example, are not priced and therefore subject to true externalities (Xu et al., 2020), while irrigation charges paid by farmers seldom reflect water scarcity (Garrido & Calatrava, 2010; Giannakis et al., 2015).

Chichilnisky (1994) shows that the lack of well-defined property rights can be a source of comparative advantages even among otherwise identical countries, giving rise to trade flows that are not efficiency driven. While trade exacerbates the problem of excessive exploitation of natural resources in the least regulated economy, taxes and tariffs may not solve the problem if they induce more production to compensate for lower prices, an outcome that is theoretically possible. In this setup, Chichilnisky (1994) finds that property-rights policies are more effective in reducing pressures on resources.

The environmental costs associated with the transport of goods (known as food miles) are an example of externality and the most obvious burden directly placed by trade on the environment. In fact, when fuel and other transport costs do not adequately reflect the negative impact from GHG emissions or pollution, the efficiency gains from the relocation of production must be weighted against the social costs of transportation.

When the environmental value of natural resources is heterogeneous across the world, specialization patterns induced by international trade affect the environment through yet another channel (Farrokhi et al., 2023). In fact, standard trade theory postulates that if specialization induces greater efficiency, this ought to be inherently good since an integrated system can produce the same amount of output using fewer inputs. This simple equation gets more complex once heterogeneity in, say carbon storage ability or biodiversity is factored in (Farrokhi et al., 2023). In fact, if the environmental values of land (or water, or forest) is not homogeneous (because carbon storage ability or biodiversity content differ), savings in one location may not compensate for additional pressures elsewhere, even if the sheer amount of resources that are used is globally lower. Complexity is further increased by the fact that some environmental effects are nearly irreversible once certain thresholds are reached.

A further departure from the baseline trade model comes from the interaction between trade and innovation, which takes the form of technology diffusion and the strengthening of incentives for the adoption of modes of production that save on scarce factors, but can also lead to a rebound effect. Hertel (2018) discusses theoretical conditions under which an increase in productivity due to technological improvement would affect world demand and supply in a closed versus integrated equilibrium. When markets are segmented, an increase in productivity increases output and depresses prices, reducing the incentive to expand production. When markets are integrated, on the other hand, prices are less sensitive to local conditions and therefore agricultural expansion is more likely to occur. However, as long as technology diffuses globally, import competition is also likely to increase and this indirect effect dampens the profitability of increased production. Hertel (2018) shows that the net effect depends on the interplay between demand and supply elasticities, suggesting that results will vary across food items and remain ultimately an empirical matter.

Finally, trade is also likely to increase income (on average, despite important redistributive issues) and this is known to affect diets and demand for certain types of food. This is a further departure from the baseline trade model, which assumes homothetic preferences by consumers. As income rises, people tend to consume more animal-based food which has a higher environmental impact and follows different sourcing patterns. On the other hand, food consumption as a share of income declines as affluence increases, tempering the negative impact of this scale effect, while demand for environmental protection also increases with income (Chaudhary & Kastner, 2016; Baylis et al., 2021) and can reduce the footprint of production.

3 Insights from the empirical literature

Section 2 makes clear that the impact of food trade on the environment remains ultimately an empirical question, as many of the channels potentially cut both ways. What does the empirical evidence suggest with respect to the relative importance of the various effects?

The idea that market integration leads (resource-intensive) food production to relocate to countries that are abundant in natural resources is the starting point of the large body of literature that looks at the "virtual" flows of land, water or fertilizers, defined as the factor content of goods. This, in turn, comes from the notion that trade in goods is a substitute for trade in the various inputs used to produce them (Leontief, 1953; Leamer, 1980). This process of specialization has positive effects on the global use of resources, with annual savings estimated at around 230–350 billion m^3 of water (D'Odorico et al., 2019; Kastner et al., 2014) and almost 90 million ha of land (Kastner et al., 2014; Qiang et al., 2020), relative to a notional scenario where each country produces domestically the food it consumes.

Globally, the largest agricultural exporters are countries with large land masses, such as Argentina, Canada, Australia and the US (joined by Brazil, Russia and Ukraine during the 2010s), while importers often feature per capita land endowments that are below the world average (Qiang et al., 2020). On the other hand, water availability seldom emerges as a critical determinant of *virtual water* flows in the empirical literature, casting doubts on the notion that trade-induced specialization is driven by resource endowments, and that it is environmentally friendly. There are, however, several explanations for this apparent puzzle. First of all, from a theoretical point of view, the framework of reference (the textbook neo-classical trade model) focuses on *relative* factor endowments, whereas most empirical applications use absolute water availability instead (Fracasso, 2014; Wichelns, 2015). Second, differences in endowments should be reflected in different opportunity costs of factors of production and thus in different prices. If this is not the case, then the connection between factor abundance, comparative advantage and trade unravels. In fact, most natural resources are seldom priced to reflect scarcity. While this may be a sensible choice (as much as it reflects concerns about conservation of, or fair access to, natural capital), it also implies that factor endowments cannot play a crucial role in determining production costs, comparative advantages, and food trade. In the case of water, Kumar and Singh (2005) find that either forcing users to pay for water, or limiting water usage, induce large improvements both in water efficiency (yield per unit of input) and water productivity (which has to do with the allocation of water across different crops and types of use). Interestingly though, the body of work that uses CGE analysis to study the interaction between agricultural trade and water (see for instance Berrittella et al., 2008; Calzadilla et al., 2011) finds that trade liberalization stimulates production in water-rich regions and water-saving in water-scarce areas even if water markets do not exist. However, this benign result is at least partly attributable to the way natural resources such as land and water are incorporated into CGE models. The third and last point to consider is that agricultural production depends on a host of complementary factors, so that countries with a lot of water but, say, little land may not be able to produce and export crops.

Evidence that global integration is associated with increased efficiency is not limited to water and land. Huang et al. (2019) find that Chinese imports of agricultural goods save around 6Tg of Nitrogen per year, since domestic production is less efficient that international sourcing, while Chen et al. (2023) show that trade flows induce a global saving in both Nitrogen and Phosphorus usage. Crippa et al. (2021) focus on CO2 intensity and CO2 per capita, finding reductions that are consistent with specialization and technology diffusion lowering the environmental impact of the food system at the global level, although some specific countries do show the opposite tendency.

In case markets were well functioning and complete, trade would beget efficient use of natural endowments and induce a pattern of specialization that has positive effects on the global use of resources. However, the widespread presence of externalities implies that real-world outcomes often depart from this benchmark. Ecosystem services and biodiversity are an important case in point, because they are not priced. Computations by Chang et al. (2016) suggest that the total loss from the destruction of ecosystem services (attributed to trade) amounts to roughly 1.5% of world GDP, with net gains accruing to only a handful of countries and tropical exporters such as Brazil and Indonesia being particularly vulnerable. In fact, although domestic consumption accounts for most of production even in fragile export-oriented areas like the tropics (Green et al., 2019; Lambin & Furumo, 2023), for some cash crops the opportunities generated by market integration rank high among the determinants of land use change (West et al., 2010).

Hence, the presence of incomplete markets and uneven rules on the exploitation of natural resources may lead the globalization of agriculture to increase the environmental footprint of the food system if it drives the relocation of production toward countries with laxer standards or weaker governance of natural resources. Overall, the estimated scale effect dominates the composition effect, at least when it comes to pollution and GHG emissions (Copeland et al., 2022), both of which represent typical (negative) externalities that are not factored in production and consumption decisions.

GHG emissions from transportation represent an obvious concern about international trade in food. While the consumption of domestically-produced products seems a straightforward way to reduce the carbon footprint of the food system, once differences in production practices are taken into account, the picture is less clear. For some food items, in particular those of animal origin, the fall in transport-related emissions are dwarfed by the increase that would take place if all countries were to completely re-shore food production (Avetisyan et al., 2014). Crippa et al. (2021) find that transportation accounts for less than 5% of food system emissions (which represent around 25-30% of total GHG emissions, see Poore & Nemecek, 2018), although recent results by Li et al. (2022) put the share at a much higher 19%. In any case, scholars agree that emissions related to food miles are dominated by local road transport from retailers to consumers (see Enthoven & Van den Broeck, 2021; Li et al., 2022), with some notable exceptions such as bananas or sugar cane. The relatively small effect of transportation and shipping is consistent with results from more general work that does not focus on agricultural goods (Cristea et al., 2013; Shapiro, 2016). Yet, in some cases the direct emissions from transport more than offset the gains due to higher agricultural productivity (Cristea et al., 2013). All in all, even considering the highest estimates for the carbon footprint of food miles, a hypothetical entirely domestic consumption scenario would reduce food-system emissions by only 1.7-2.4% (Li et al., 2022), with other results suggesting that there is no guarantee that local food systems have a smaller environmental footprint (Enthoven & Van den Broeck, 2021) or that they are inherently more sustainable (Stein & Santini, 2022).

A further mechanism that is associated with geographic distance is the spread of invasive alien species (Westphal et al., 2008; Epanchin-Niell et al., 2021), which depends on the number of international transactions taking place rather than on the specific products being exchanged, and has strong adverse effects on biodiversity (IPBES, 2023).

For what concerns the role of innovation and technology diffusion, existing studies suggest that the mitigating impact of technical change (thanks to improved efficiency) can be as large as the scale effect (Kagohashi et al., 2015; Dang & Konar, 2018; Copeland et al., 2022). However, Kastner et al. (2021) distinguish between cereals, for which the beneficial technique effect indeed dominates, and cash crops, where the opposite is true. In fact, palm and vegetable oil represent an important case in which improved efficiency is trumped by higher demand induced by lower prices and by the heavy impact of production in biodiversity-intensive regions (Többen et al., 2018; Kastner et al., 2021). Rodríguez García et al. (2020) confirm that the magnitude of the rebound effect differs across commodity types: negligible for staples, it can become substantial for crops with a high price elasticity of demand.

Villoria (2019) further explores the hypothesis that technical advances can have adverse effects if it creates incentives to produce more either by lowering prices and increasing demand, or simply by reducing costs and thus raising returns (Hertel, 2018). He finds that over the period 2001–10, productivity expansion has led to substantial savings in cropland (-125 Mha) and trade has mediated this effect by fostering competition, so that the combined role of trade and productivity growth has been positive to the environment. As mentioned in Section 2, these results fail to account for the specific environmental value of different land, which are likely to differ markedly in terms of biodiversity and carbon storage ability (Farrokhi et al., 2023).

Halpern et al. (2022) find large cross-country variation in the environmental efficiency of food production for the same type of food, largely due to differences in technology and farming practices. This suggests both that technology diffusion can play an important role, and that trade could improve the geographic distribution of agricultural production. Against this backdrop, Roux et al. (2021) find that the changes in food sourcing patterns, likely associated with international trade flows, have a smaller impact on the environment than other determinants such as population growth or per capita consumption. On the other hand, sourcing patterns contributed to dampen environmental pressures during the 1990s, but have had the opposite effect in more recent years, challenging the notion that trade-induced specialization is always beneficial to the environment. In fact, resource productivity does not amount to sustainability, so it is possible that trade increases efficiency while simultaneously putting additional pressure on scarce resources in some specific locations (Dalin & Rodríguez-Iturbe, 2016). Whether this happens or not crucially depends on local conditions that directly shape incentive for agricultural production and determine how economic agents respond. For instance, trade appears to provide a positive contribution toward achieving Sustainable Development Goals, but the effect is heterogeneous across countries: positive for high-income economies, negative for developing and emerging ones, mainly due to a weak regulatory framework (Xu et al., 2020).

4 Benchmarking

A crucial yet often overlooked point is that with less trade, resources would be redirected to alternative uses and production would shift to different locations (Copeland et al., 2022). This can either increase or decrease environmental pressure depending on local conditions. While some specific examples exist where a surge in foreign demand can be properly identified as the leading cause of the over-exploitation of a poorly-regulated natural resource (see for instance Taylor, 2011 or Erhardt & Weder, 2020), a number of recent works find that a more local food system *per se* is unlikely to be beneficial to the environment (Ortiz et al., 2021; Enthoven & Van den Broeck, 2021; Stein & Santini, 2022). Since the use of more suitable locations to grow food or better technology reduce the required amount of inputs, too little trade could be harmful to the environment if global sourcing is substituted by less efficient local production (Roux et al., 2021).

One critical point in the debate on the environmental costs and benefits of international trade (and the potential merits of trade restrictions) is therefore the lack of appropriate benchmarks against which compare current data. As Kastner et al. (2021) nicely put it, “we are missing a scenario of how agricultural production and land use would look without these trade flows”.

Most of the literature dealing with the virtual trade of natural resources (e.g., Hoekstra & Chapagain, 2008; Qiang et al., 2020; Kastner et al., 2021) compares the current situation with a notional scenario in which all countries produce domestically the food they consume, finding that trade generates large savings in the amount of natural resources used in agriculture. This ought to be overly optimistic because in case trade were limited, price changes would influence production and consumption patterns, tilting them toward products more easily and cheaply produced at home. By keeping the specialization pattern as given then, the analysis makes it easier for trade to contribute to conservation.

At the opposite side of the spectrum lie works building on multi-regional input-output tables (e.g. Wiedmann & Lenzen, 2018; Pendrill et al., 2019), that allocate environmental pressures across sectors and countries, but do not establish any causal effects (Felbermayr et al., 2024). Because the structure of the economy –as well as technology and prices– are kept fixed, no adjustment takes place and shutting down international flows (for instance with an export ban) forces all foreign demand to zero, as if the world would not need to produce the same amount of food irrespective of the location of production. In other words, this approach disregards all channels other than the scale effect and implies that by reducing trade flows one automatically lowers world demand by the same amount. While it is true that trade restrictions would put upward pressure on international prices and could therefore reduce demand, food items tend to display low price elasticity. This is especially true for staples, but holds for animal-based food as well (see the meta-analysis by Green et al., 2013, who report values between -0.35 and -1 for all countries and food groups). As a consequence, the reduction in demand is likely to be less than proportional to any price increase.

Computable General Equilibium (CGE) models collate supply and demand adjustments to (notional) policy shocks (such as trade liberalization or restrictions) and therefore can simulate *ex ante* their impact on the local or global system, accounting for adjustments across the entire economy. While this feature makes CGE models attractive to understand the channels at work, the required aggregation in terms of both geography and economic sectors hampers their ability to adequately capture heterogeneity in the effects of trade shocks (Berrittella et al., 2008). Moreover, CGE models often focus on a single environmental pressure at a time, being it water, land, or GHG emissions. Finally, because technological change is mostly exogenous in this setup, the technique effect cannot be properly captured (Felbermayr et al., 2024). A survey by Barros and Martínez-Zarzoso (2022) finds mixed results for the effect of trade on the environment, depending on the way trade liberalization is modeled and the level of geographic and sector-level aggregation used in CGE models.

To sum up, the literature has yet to develop an appropriate benchmark to assess the impact of trade on natural resources. Existing studies either compare the current situation to a notional autarky scenario that is infeasible, or attribute to trade the entire effect of foreign demand, without establishing a proper causal nexus. While the associated results are too far apart even to represent useful upper and lower bounds, being aware of the issue is a necessary first step to avoid being led astray. Building a scenario describing how environmental pressures would look in presence of smaller (or absent any) trade flows is an area of research where interdisciplinary collaboration could yield important and impactful results.

5 The challenges of governance

While Section 2 suggests that it is very difficult to determine *ex ante* the impact of trade on natural resources, the empirical evidence presented in Section 3 shows that the effects vary across countries, food types and specific conditions. Even in a critical context such as the internationally-oriented production of soy in Brazil, the footprints differ widely depending on regional agricultural practices (Green et al., 2019). Indeed, Baylis et al. (2021) stress that governance and the institutional context are key determinants of land use changes and conservation versus production decisions, a finding that echoes results from the case studies discussed in Meyfroidt et al. (2014).

Calls for using trade policy to reduce the environmental footprint of agricultural production are often based on the fact that trade allows for a de-coupling of consumption from production and from the availability of natural resources, so that consumers in one country ends up eating food grown thousands of miles away (DeFries et al., 2013). This phenomenon is seen as problematic (Carr et al., 2013; Meyfroidt et al., 2013) as distance reduces awareness and could create a sort of *out of sight-out of mind* effect. However, food production and consumption are almost always separated geographically, even within national borders. For example, Guan and Hubacek (2007), Cazcarro et al. (2013) and Dang et al. (2015) provide evidence of uneven water footprint of agricultural production and consumption within China, Spain and the US. Yet, environmental pressures in, say, one American state or Chinese province are not addressed by restricting shipments to the rest of the country or by taxing consumption. Rather, it is often more efficient to work through a mix of regulation, subsidies and incentives that shape production decisions or stimulate natural resource saving and environmental sustainability. Moreover, albeit increasing, the external footprint of nations is (in most cases) small relative to the domestic one (O'Bannon et al., 2014; Chaudhary & Kastner, 2016; Lambin & Furumo, 2023), so that trade restrictions would address only a part of the problem.

Coenen et al. (2023) offer an effective framework to discuss the most appropriate level of governance of environmental problems in a global world. While cross-border transactions are not by themselves a problem, they can create a mismatch between the scale of (environmental) problems and the reach of policy levers. Mismatches can occur either because the processes to be governed transcend governance boundaries, or because interventions are designed at a scale that is too broad to be effective. On the one hand, the presence of global externalities and displacement effects call for some form of coordination. On the other, export restrictions and other supply chain interventions are likely to be ineffective if they do not alter the local incentives that have led to the overexploitation of natural resources in the first place (Pendrill et al., 2022; Muradian et al., 2025). Recent policy initiatives –such as the EU Regulation on Deforestation-free Products (EUDR)– make market access conditional on compliance with environmental standards at production sites. Rather than directly restricting import volumes, in this case trade policy aims to reshape incentives governing natural resource extraction in exporting countries. However, the effectiveness of such measures –particularly when implemented unilaterally by a limited number of countries– depends critically on how easily non-compliant products can be redirected to alternative markets with laxer environmental standards (Lambin & Furumo, 2023; Muradian et al., 2025).

In principle, a global phenomenon (because of the interlinkages created by trade) does not necessarily imply a global impact. As long as the effects of agricultural production on the environment are local or are driven by local choices, they are best dealt with at the local level, following a subsidiary principle that caters at the specific context. Reducing foreign food consumption does not necessarily alleviate environmental pressures if most agricultural production is driven by domestic demand or the resources that are saved find an alternative use because of a lack of local regulation and oversight. In more general terms, unless appropriate measures to protect natural habitats are put in place –which help balance the trade-off between short-term private gains versus longer-term sustainability– reducing international trade does not guarantee that food production takes place where environmental pressures are minimal.

On the other hand, global externalities cannot be tackled at local level. Deforestation, and the associated GHG emissions, is a foremost example, because the worst effects of climate change may well occur very far away from where GHGs are released into the atmosphere. Moreover, carbon emissions can feed a vicious circle since they hasten climate change and thus lead to further environmental problems. The loss of biodiversity and ecosystem services can also have trans-boundary effects (beyond more localized impact such as reducing pollination services) through water and climate regulation, or by increasing animal-human interactions and facilitating zoonotic disease transmission (Johnson et al., 2020). This is indeed the rationale behind international initiatives that address the issue of deforestation in the tropics either by imposing due diligence requirements on importers (see for instance the 2008 Lacey Act Amendment in the US, or the 2013 EU Timber Regulation), or by pushing exporting countries to develop systems to guarantee the legality of their timber exports (as in the case of the EU Forest Law Enforcement, Governance and Trade Action Plan). Although export market requirements may drive improvements in the governance of an entire economic sector (zu Ermgassen et al., 2020), so far commitments to end tropical deforestation have had limited success due to weak enforcement and imperfect implementation, which have lead to displacement effects (Jonsson et al., 2015; Lambin & Furumo, 2023).

In fact, uncoordinated conservation efforts by individual countries may have unintended consequences in other regions due to leakage. In this case, the combination of heterogeneous regulatory framework and international trade may shift the environmental burden onto countries where agricultural practices have a heavier environmental footprint, and make the world worse off, especially if production shifts to areas that are particularly valuable from a natural point of view (Pendrill et al., 2019). Berlik et al. (2002) labels this phenomenon "illusion of preservation" as gains in one country may be more than compensated by increased pressures somewhere else (see Aichele & Felbermayr, 2012, 2015 for evidence on the impact of the Kyoto protocol on national versus global carbon emissions). Evidence collected by Ingalls et al. (2018) shows that the fragmented adoption of international initiatives to reduce deforestation across countries led to the transboundary displacement of environmental degradation from early adopters (of conservation measures) to neighboring regions, substantially reducing the global effect of the policy. Recent work by Farrokhi et al. (2023) provides an analytical model for this kind of mechanism. They show that multilateral trade liberalization can actually reduce global forest losses, while the opposite occurs when trade barriers are reduced on a bilateral basis. These results highlight the complex interplay between trade and environmental preservation and the role of local conditions to determine the outcome of policy actions.

One additional concern, is the possibility that globalization leads to a *race-to-the-bottom* in environmental protection, which would increase the overall pressure on natural resources as countries scramble to retain activities with large material footprints (in order to protect jobs or out of strategic considerations) and thus lower their standards and regulations, although there is little systematic evidence about this phenomenon (see Copeland et al., 2022, and references therein).

6 Conclusions and policy implications

Economic theory suggests that agricultural trade can enhance or reduce global efficiency in the use of natural resources. In presence of externalities and market failures, or in contexts where environmental governance is weak, trade can exacerbate pressures on natural resources (Baylis et al., 2021). Moreover, efficiency and sustainability need not go hand-in-hand and policy measures are needed to account for this trade-off.

At the same time, the large differences in the environmental efficiency of agricultural production within each food type (Halpern et al., 2022) suggest that trade and technology transfer can play an important role in promoting environmental conservation, provided they are accompanied by measures that are suited to different contexts around the world.

Moreover, trade represents an important tool to ease tensions among competing goals, for instance between water saving and cropland expansion, and to address the fundamental challenge of feeding a growing world population while ensuring environmental sustainability (Pastor et al., 2019).

By analyzing the different channels through which trade and natural resources interact, and providing a critical overview of the relevant literature, the paper shows that trade restrictions alone appear as a second-best solution as they do not directly affect incentives shaping production decisions, and resources previously dedicated to export markets can find alternative uses.

While preservation is best dealt with at the local level, in order to design solutions that are tailored to specific needs and contexts, international coordination is necessary to avoid that country-specific or even regional agreements simply lead to the displacement of environmental damage to areas that enjoy a lower degree of protection. Multilateral cooperation (e.g. within the WTO) is needed to address global problems such as climate change or biodiversity loss (Anderson, 2023), and trade policy can be used to promote higher environmental standards worldwide, while making sure that international exchanges contribute positively to global food security. This discussion is relevant for ongoing policy efforts –such as the EUDR– that condition market access to environment-friendly production processes. In this way, trade policy is combined with local measures that are well placed to address the key drivers of natural resource extraction.

Rather than assuming that trade naturally leads to a more efficient and sustainable use of natural resources, or that by restricting exports of certain goods one can dispense of the environmental pressures associated with their production, to assess the impact of trade on the environment and design appropriate conservation policies one should ask what happens if trade is restricted, what are the incentives shaping resource usage in exporting countries, and whether the counterfactual world is likely to entail higher or smaller environmental pressures.

Funding Open access funding provided by Università degli Studi di Trento within the CRUI-CARE Agreement. This work received financial support from the project “Food Connections. Intended and unintended consequences of trade on food and nutrition security”, funded by the European Union Next generation EU, mission 4, component 2 (CUP E53D23016430001 – Project code P202233ZTR).

Data Availability No new data were created or analysed in this study. Data sharing is not applicable to this article.

Declarations

Conflict of Interest Statement The author declares no conflict of interest

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