Environmental Sustainability in Agriculture 2023

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1. Introduction

Producing sufficient safe, affordable and nutritious food sustainably to feed a growing and more urban global population was a daunting challenge to agrifood systems already prior to the outbreak of the COVID-19 pandemic and the war in Ukraine. Food insecurity was already on the rise, affected by the slowdown in global economic growth, climate change and conflicts.[1]

In the long term, a growing population, economic growth and the structural transformation many economies are undergoing will continue to affect food demand. Rising incomes and urbanization rates drive the demand for high value foods and contribute to accelerate the dietary transition away from staples and toward greater consumption of fruits, vegetables, animal products and processed foods.

This has important implications for the environmental sustainability of global agrifood systems. Meeting a growing demand for food through more intensive systems or extensive land use change could increase the already severe pressure upon the environment. Indeed, agriculture is an active contributor to climate change, while at the same time suffering greatly from its adverse effects. Agriculture production can provide ecosystem benefits but also occupies most land and uses most freshwater and is a significant source of water and air pollution in many regions of the world. At the same time, sustainable farming systems are generally more knowledge- and process-intensive, and can come at higher costs.

Considering the dual objective of food security and environment requires enhancing the synergies and limiting the trade-offs between productivity and environmental objectives. Countries will need to step-up their efforts to truly incorporate environmental sustainability into farming practices. These efforts will also need to ensure farming is profitable and creates decent jobs.

This issues note provides a brief overview of the environmental impacts of agriculture, discusses how agricultural policies affect the environment, and identifies policy responses to foster agricultural productivity while reducing the sector's environmental footprint.

2. Agriculture and the environment

Agricultural production is a key driver of resource use, and agricultural practices directly affect natural resources and ecosystem services. Agriculture accounts for 72% of freshwater withdrawals worldwide and contributes to water stress.[1] Soil degradation – the diminishing capacity of the soil to provide ecosystem goods and services – is also worsening due to unsustainable agricultural practices, overgrazing, deforestation and improper land use. At present, the majority of the world's soil resources are in only fair, poor or very poor condition, with 33% of land being moderately to highly degraded due to the erosion, salinisation, compaction, acidification, and chemical pollution.[2]

Agricultural expansion is a leading cause of deforestation. Agricultural production of cattle, soybeans and palm oil accounted for 40% of tropical deforestation between 2000 and 2010. Biodiversity loss is strongly linked to land use changes and loss of forest cover. Forests host most of the world's terrestrial biodiversity, containing over 60 000 different species of trees. They are habitats for 80% of the world's amphibian species, 75% of bird species and 68% of mammal species. Tropical forests contain about 60% of all the world's vascular plants.[3]

Agrifood systems emissions amounted to 16 billion tonnes of carbon dioxide equivalent (Gt CO2eq) in 2020, an increase of 9% since 2000. While the share of agrifood systems' emissions declined from 38% in 2000 to 31% in 2020 (due to an increase in other global emission sources), agrifood systems remain a

[1] This report was first prepared as an issue note to the G7 Presidency of Japan in January 2023.

contributor to climate change and must be an integral part in the global response to address global warming.[4]

The depletion of soil, water and biodiversity, coupled with climate change, is already holding back the agricultural productivity growth needed to meet increasing food demand. Further pressure on natural resources and ecosystems can hinder food production and food security, amplify food-price volatility, contributing to increasing hunger and poverty. There is a pressing need to step up efforts that address productivity and environmental trade-offs in an effective way.

Defining sustainability in agriculture is challenging, since it must account for a number of indicators (Box 1) and because agriculture is a highly localized activity with agricultural practices differing greatly between countries due to a myriad of agro-climatic conditions. Solutions to the sustainability challenge will therefore need to be tailored to local conditions.

Box 1. Defining sustainable agriculture

Broadly, sustainable agriculture can be defined along the three dimensions of sustainable development, namely environmental health, profitability and social and economic equity. These imply ensuring agriculture is not harmful for the environment (thus soil, water, air, and other natural resources are preserved), while simultaneously guaranteeing a fair remuneration for all the stakeholders involved, securing livelihoods, ensuring equity, diversity and inclusion.

Sustainable Development Goal (SDG) indicator 2.4.1, Proportion of Agricultural Area under Productive and Sustainable Agriculture, was coined to measure global progress towards sustainability in agriculture. SDG indicator 2.4.1 is the result of computing and aggregating 11 sub-indicators namely: land productivity, profitability, resilience, soil health, water use, fertilizer risk, pesticide risk, biodiversity, decent employment, food security, and land tenure. This enables policy makers to track the progress of sustainability in agriculture across all three dimensions of sustainable development, namely ensuring environmental health, profitability, and social and economic equity.

However, significant methodological challenges need to be overcome to measure sustainability in agriculture meaningfully. The first lies in the definition of agricultural sustainability itself, which is dynamic and extremely site-specific, calling for an understanding of the underlying local environmental and socio-economic context, challenges and drivers of change. A second and related challenge is the choice of indicators to calculate, which have to be tailored to the context, and the number of indicators. The need to capture multidimensionality also adds complexity to the measurement, which does not automatically imply being exhaustive. A third challenge is the lack of a data collection system to directly measure the sub-indicators in many countries, which has to yet be developed. Other challenges include the choice of the scope of the analysis, either small-scale, or at local, regional or national level, among others.

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3. Fostering environmental sustainability in agriculture

Actions under three main areas can bring countries closer to managing the trade-offs imposed by the simultaneous need to increase agricultural production and safeguard environmental protection. These include: i) fostering the adoption of sustainable technologies and improved farming practices (subsection 3.1); ii) setting the right incentives domestically (see subsection 3.2); and iii) leveraging international trade for sustainable development (see subsection 3.3). Further policy options are also reviewed in subsection 3.4,

3.1 Improving technologies and practices

Most governments provide support to the agricultural sector. According to the OECD, support to the agricultural sector averaged USD 817 billion a year in 2019, 2020 and 2021 across 54 key producing countries.[2,5] Most of this support – USD 500 billion a year – was financed by governments via budgetary transfers, with the remaining taking the form of price transfers. In OECD countries, agricultural support amounted to USD 346 billion a year in this period, with the European Union and the United States of America accounting for two thirds of this amount.[3]

Despite the notable efforts to sustain the sector, the bulk of support is directed to production (73%) with only a small share of budgetary transfers being destined to measures that have the potential to increase environmental sustainability. While support to agricultural knowledge and innovation systems increased over recent years, their share in total agricultural support declined over ten years. Among OECD countries, of the USD 346 billion a year of total support, only USD 14 billion were destined to agricultural knowledge and innovation systems.[4]

Much policy and fiscal space remains available to governments to tailor incentives in a way that fosters innovation and environmental sustainability in both the short and long term. Agricultural innovation is central to both overcoming productivity constraints and to farming sustainably, and is essential to sustain long-term Total Factor Productivity (TFP) growth.

TFP is used to indicate the efficiency of agricultural production by estimating the relationship between agricultural inputs and outputs. A growing TFP can reflect an increase in the use of innovation in the agricultural sector. It can also indicate more environmental sustainability as it leads to higher output per unit of inputs, particularly if this reflects a lower use of natural resources and polluting inputs.[6]

Developed countries had sustained TFP growth up until the 1990s, with TFP growth decreasing after that. For developing countries, TFP growth was strong in Brazil and China, but remains weak in Least Developed Countries.[7] Recent estimates indicate that TFP growth has slowed during the period 2011-2019. A slowdown in the growth of TFP would indicate slowing productivity growth, which combined with growing demand, risks putting the world onto a problematic trajectory for global food security.[8]

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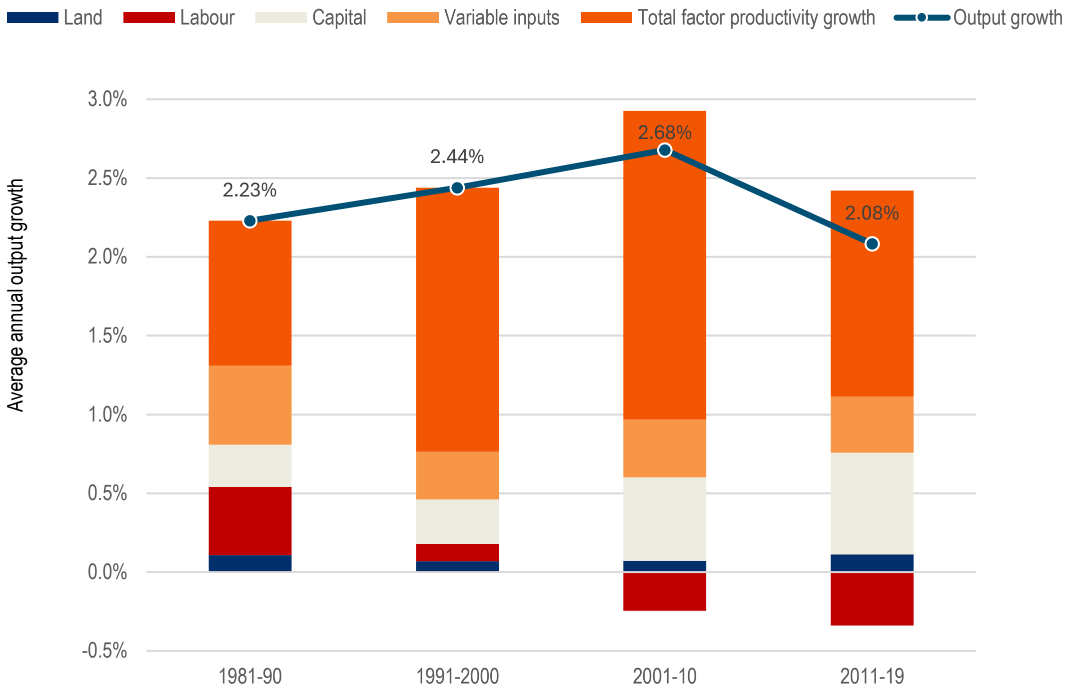
[2] This amount refers to the support given by a total of 54 countries, including all OECD countries, five EU countries that are not EU Members, and 11 key emerging economies.

[3] Agricultural support by the 11 emerging economies included in the report amounted to USD 464 billion, with China accounting for 60% of this amount.

[4] In emerging economies, USD 11 billion were destined to agricultural knowledge and innovation systems.

Figure 1. Total Factor Productivity growth slowdown since the early 2000s



Source: Bureau, J. C. & Antón, J., 2022 based on data from the US Department of Agriculture Economics Research Service.

More than ever, future demand will need to be met mainly through yield increases, rather than expansion of the cultivated area or increased input use.[9] In the long term, productivity growth in agriculture requires continuous technological progress and improved managerial efficiency, as well as social and institutional innovations and new business and investment models. Institutional innovation is important to facilitate the access of small producers to an array of services and information. Such progress needs to be steered towards also enhancing sustainability. Box 2 provides examples of institutional innovations that aim at increasing environmental sustainability in agriculture.

Technological innovation is at the centre of the solutions to global environmental challenges. Digital technologies can be leveraged to address multiple market failures and facilitate smallholder farmers' integration in markets and value chains. Digital solutions already exist to enhance farmers' access to information, financial services and inputs. Digital technologies can also promote international trade and contribute to significant gains in terms of increased efficiency, traceability and transparency in markets and value chains.[5,10] Governments are key players in ensuring digital infrastructure reaches rural areas, enabling farmers to access broadband internet and digital services.

[5] For more on how digital technologies can help overcome market failures, see Part 4: Digital Technologies and Agricultural and Food Markets, In: FAO, 2020. *The State of Agricultural Commodity Markets 2020. Agricultural markets and sustainable development: Global value chains, smallholder farmers and digital innovations.* Rome, FAO.

Box 2. Examples of institutional innovations that can foster sustainability in agriculture

International mechanisms that facilitate thematic dialogue and knowledge sharing can foster the adoption of sustainable practices at the national level. They do so by facilitating access to technical information, connecting officials and facilitating the formation of partnerships, and encouraging information sharing and lessons learned.

The Global Soil Partnership was established in 2012 to improve soil governance and promote sustainable soil management. The Partnership, hosted by FAO, promotes awareness and knowledge acquisition, develops global soil assessments, shares data, guidelines, and is an important resource to governments, international and regional organizations, institutions, and other stakeholders.

The Tropical Agriculture Platform (TAP) was launched in 2012 at the 1st Meeting of the G20 Agriculture Chief Scientists (MACS) to foster capacity development for agricultural innovation in the tropics. TAP, hosted by the FAO, works to strengthen agricultural innovation capacities at country level. The platform also provides *TAPipedia*, an information sharing portal of resources related to capacity development for agricultural innovation. These resources include good practices, innovation outputs, success stories and lessons learned. A special focus is given to facilitation, learning and documentation to enable innovation.

The Global Alliance for Climate-Smart Agriculture (GACSA) was launched in 2014 to accelerate the scaling up of Climate-smart Agriculture and bring actors together to share knowledge on climate-smart technologies and practices. GACSA is a voluntary coalition, and is open to governments, intergovernmental entities, civil society, research bodies, farmers' organizations, and businesses.

The OECD Cooperative Research Programme (CRP) was launched in 1979 to facilitate international co-operation among research scientists and institutions. The programme seeks to strengthens scientific knowledge and innovation with a view to achieving globally agreed policy objectives. CRP findings provide valuable evidence and information to support policy makers in promoting the sustainable use of natural resources in food, agriculture, forestry and fisheries. Activities facilitated and supported by the CRP relate to one of the three research pillars of the CRP: managing natural capital, strengthening resilience in the face of multiple risks in a connected world; and transformational technologies and innovation.

Governments will also continue to occupy a central role in the development and adoption of new technologies. Through its role in setting incentives, regulations and funding, governments continue to shape private sector actions in this area. Research and Development (R&D) remains a key driver of productivity growth. R&D is also indispensable in the transition to a more sustainable pathway. Yet, the resources that are targeting R&D and knowledge transfer programs are volatile. Between 1981 and 2014 volatility of public R&D in developing countries continued to be high, whereas for the OECD countries it increased in 2000s compared to the end of the 20th century.[11] Overall, volatile R&D expenditures have negative consequences on innovation; in particular Johnstone et al. (2011) show that volatility in public R&D in environmental technologies have an adverse impact on innovation.[12]

Despite the spike of the private interest in agricultural research, these investments are not primarily focused on environmental sustainability. From early 2000s the private agricultural R&D surpassed public expenditure in high-income countries. Globally, private sector agricultural R&D expenditures increased from USD 5.1 billion in 1990 to USD 15.6 billion in 2014.[13] From 2010s resources dedicated to crop and livestock production, nutrition, food safety and overall social benefits of the land based sectors have decreased as opposed to a growth in R&D in crop genetics, farm machinery, agricultural chemicals and food processing.[14,15]

There are, however, some notable examples of additional support to green agricultural R&D. Canada spent USD 234 million for the Agricultural Clean Technology Program to support R&D, adoption and commercialization of new clean technologies for the agricultural sector.[16] The United States of America recently announced that it will finance agricultural production and marketing of climate-smart agricultural crops through the USDA, via the Partnerships for Climate-Smart Commodities initiative.[6] India, through its Council of Agricultural Research (ICAR), focuses on developing farming systems that utilize natural resources effectively and more sustainably, generate more profit and employment, and enhance food and nutrition security for households. Since 2018, a total of 765 field crop varieties have been developed, most of which can increase resource use efficiency by improving resilience and productivity in unfavourable climatic conditions or by increasing nutritional value. Of the 765 varieties developed, 578 are climate resilient, 98 are drought/moisture tolerant, 41 are short-duration varieties, and 47 are biofortified varieties.[17]

Adopting more sustainable production practices is another important resilience-enhancing strategy for agricultural households. Farming practices required to conserve and make more efficient use of natural resources will differ according to local conditions and needs. Improved practices that create synergies between enhancing resilience and improving productivity sustainably and do not entail large and risky investments are highly relevant to small-scale farms.

The adoption of improved practices has increased over time. One-quarter of the global coffee and cocoa areas are certified through sustainability standards developed by both non-governmental organizations and the private sector.[18] Similarly, the area covered by conservation agriculture reached approximately 12.5% of global cropland across 78 countries in 2015-2016.[7] The largest extents of adoption are in South and North America.[19] In France agroecology, an approach that comprises a set of practices that aim at reducing input use and conserving, protecting and enhancing the natural resource base, gained space over the past two decades. This was attributed to a shift in the national policy framework in the early 2010s, which paved the way for the adoption of agroecological practices and the conversion to organic farming in the country. France has also championed agroecology in international fora and dialogue.[20] Box 3 cites practices that can help farmers conserve natural resources, reduce GHG emissions, and safeguard productivity.[8]

[6] For more information on this, see https://www.usda.gov/climate-solutions/climate-smart-commodities.

[7] Kassam, A., Friedrich, T. & Derpsch, R. (2018) estimate that the area covered by conservation agriculture grew from 106 million hectares in 2008-2009 to 180 million hectares in 2015-2016 across 78 countries.

[8] For a review of the productivity and sustainability potential of organic farming, agricultural biotechnology, precision farming, or conservation agriculture, see also OECD (2016), *Farm Management Practices to Foster Green Growth,* OECD Green Growth Studies, OECD Publishing, Paris.

Box 3. Examples of improved practices that can foster sustainability in agriculture

Agroforestry systems contribute to income and risk diversification, increasing the resilience of farming systems. They yield environmental benefits through carbon sequestration (tree biomass, soil), reduce soil erosion and improve nutrient management. Examples of agroforestry practices include multistrata systems, silvo-pastoral systems, alley cropping, biological nitrogen fixation, intercropping, and hedgerows/windbreaks.

Conservation Agriculture practices promote minimum soil disturbance, maintenance of a permanent soil cover, and diversification of plant species. Examples of conservation agriculture practices include zero-till, cover cropping and crop rotation.

Climate-smart agricultural practices aim at increasing agricultural productivity and incomes sustainably, adapting and building resilience to climate change and reducing and/or removing GHG emissions where possible. Stress-tolerant seed varieties, improved livestock husbandry practices, nutrient management, fertigation, water management, rainwater harvesting, and alternate wetting and drying are all actions that can significantly enhance productivity under growing climate-related constraints.

3.2 Redirecting agricultural support

The greater part of the USD 346 billion per year of agricultural support in OECD countries is still focused on production and includes measures that are unsustainable from both the socio-economic and environmental perspective.[21] Support provided to agricultural sectors of emerging economies is also targeted to promoting production, and support levels can vary greatly. In Brazil, this support amounted to 2.3% of gross farm receipts in 2019-2021, while in China it averaged 14.8%.[22] In the Russian Federation, producer support averaged 9% a year in 2018-2020, and 70% of this support was considered most-distorting by the OECD, being either output based or tied to input use.[23] Market price support, border protection, supply controls, output-based payments and support based on the unconstrained use of variable input are examples of policies that induce to inefficiencies and contribute to environmentally unsustainable practices. These policies increase agricultural production, but reduce producers' incentives to use inputs efficiently and thus increase pressures on natural resources and raise GHG emissions. Commodity-specific support often favours products not adapted to a changing climate, undermining the shift toward more efficient and sustainable production.

Many of the existing agricultural policies support production of commodities with a high carbon footprint (particularly livestock and rice).[24] A recent estimate by the OECD over 54 countries indicated that livestock accounts for two-thirds of direct emissions from agriculture, through enteric fermentation, manure management and manure left on pasture. Rice cultivation is a significant source of methane, responsible for 11% of direct agricultural emissions across all 54 countries.[25]

Input support for staples is globally concentrated among lower-income countries and is often implemented to promote productivity growth among resource-constrained farmers and to improve national food security, are typically focused on a narrow range of crops that are key staple foods. These subsidies are being implemented under conditions where productivity levels are low by global standards and where food insecurity is widespread. While such socio-economic considerations remain critical factors, they also obstacle sustainability in many of developing countries.

Promoting environmental sustainability to supplement the economic and social considerations requires critical thinking on the current forms of support. There is no one-size-fits-all strategy for redirecting agricultural producer support, as countries' endowments and national contexts differ. There is limited information on the effects of policy support on sustainability, however studies within single country settings have found that policies providing support that is coupled to production inputs or outputs, contribute to environmental externalities.[26] [27] At the global level, studies show that budgetary support coupled to production increases GHG emissions from agriculture, while the effects of market price support are more ambiguous and can slightly reduce global emissions in some cases.[28,29] At present, there are limited policies in place to correct for the negative externalities, however it is likely that pursuing the green policies will have a positive effect on long-term productivity of the sector.

According to OECD (2021),[30] three specific actions could enable agricultural policies to better support sustainable productivity growth and increase resilience: (i) phase out price interventions and market distorting producer support; (ii) target income support to farm households most in need and where possible incorporate them into economy-wide social policies and safety-nets; (iii) re-orient public expenditures towards investments in public goods. In particular, simultaneous benefits for food security, social outcomes and the environment can be reached by repurposing existing agricultural support towards investment in green technologies and innovations, and combining them with incentives for their adoption (e.g. through ecoservice payments) that both increase productivity and reduce emissions intensities. A modelling exercise conducted by the World Bank Group and IFPRI suggests that repurposing just 15% of current support levels in this way could contribute to a reduction in overall emissions from agriculture by 40%, increase world real income by about 1.6%, reduce extreme poverty by 1%, and reduce the agricultural land use footprint by over 100 million hectares. Higher agricultural productivity would produce more food at a lower cost, driving down the cost of nutritious diets by about 19%.[31]

Depending on how the shifting of support is constructed, modelling frameworks generate a range of simulated results. For example, a global coupled modelling framework consisting of economic, environmental and health models indicates that reallocating current agricultural subsidies to promote the production of foods with beneficial health and environmental characteristics can lead to increased production of horticultural products globally and a moderate reduction in GHG emissions brought about due to reductions in animal source foods and staple crops.[32] FAO, UNEP and UNDP (2021) propose a six-step approach to change the paradigm in the agrifood sectors. First step is to measure the support provided; second one to understand which measures have most detrimental effects on sustainability; third step is to identify alternative policy options and forecast their impact (step four); step five is to refine current agricultural strategies and step six to implement and monitor the changes.[33]

3.3 Leveraging trade for sustainable development

Agriculture will need to produce more food, fibre and biofuel to meet growing demand, driven by population and income growth. Yet, the global distribution of land and water resources does not necessarily match the expected distribution of future demand. Some countries with a rapidly growing demand for food, such as China and India, already face land or water constraints.[34] Climate change is projected to have uneven impacts on agriculture across countries, negatively affecting low-latitude regions, while high-latitude regions are expected to experience mostly positive impacts.[35]

Well-functioning food and agricultural markets can foster food security under the appropriate policy settings. Regions that are already affected by increasing land or water scarcity are likely to increase their reliance upon trade for food security. At the global level, trade can enhance the efficiency of natural resource use by agriculture by helping countries overcome national constraints in land and water, and allowing them to meet their food requirements in terms of quantity and diversity at levels above what domestic production could sustain.[9,36] Globally, trade can result in water and land savings, as production

[9] A study suggests that, in the absence of trade, many countries would need to double their water consumption, cropland area, or both, to produce nationally the food and agricultural products they currently import. See Fader et al. (2011), “Internal and external green-blue agricultural water footprints of nations, and related water and land savings through trade”, *Hydrology and Earth System Sciences*, Vol.15: 1641–1660.

takes place in regions with relatively more efficient water and land use. Policies that promote open global food and agricultural markets can help alleviate pressure on natural resources and biodiversity.[37] More open agricultural markets have advantages for food security and could offset some of the undernutrition caused by climate change.[38]

However, the impacts of trade liberalisation on natural resources and GHG emissions, in particular, can be ambiguous. Trade channels economic incentives to producers across countries and, combined with weak or inadequate regulatory frameworks, can lead to negative environmental outcomes.[39] Due to the nature of agricultural production, the majority of negative (non-GHG) environmental externalities associated with agricultural production are highly localized. It is important that trade reforms are supported by adequate environment regulatory settings, particularly in countries that stand to gain from these reforms and expand their agricultural production and exports.

Several types of policy interventions can limit these externalities. This includes limiting environmentally harmful subsidies, as discussed above, but also limiting illegal trade in wildlife and environmentally sensitive goods.[40] Part of the ongoing debate about globalization and sustainable development revolves around how to ensure that trade policies and environment policies are mutually supportive. The European Parliament, for instance, is actively pursuing enhanced synergies between trade and environmental policies by rendering illegal the commercialization of products linked to deforestation within the European Union, as discussed in Box 4. Similarly, Japan's Strategy for Sustainable Food Systems, adopted in 2021, also aims to reach sustainable sourcing for its imports by 2030.[10]

Box 4. Trade and deforestation

In December 2022, the European Parliament reached preliminary agreement on legislation that seeks to enforce due diligence by private sector companies to guarantee that products sold within the European Union do not contribute to deforestation in third countries. The legislation requires that supply chain operators working in the European Union ensure that products entering the European market are deforestation-free, and respect human rights and the rights of indigenous people. Products covered by the legislation include palm oil, soy, wood, cocoa, coffee, cattle, rubber, charcoal and printed paper products.

Companies infringing the regulation could be fined up to 4% of their total annual turnover in the European Union country of the company. The legislation is pending formal approval and shall entry into force 180 days after it is published officially by the European Union Official Journal.

This legislation differs from previous initiatives in two important ways. First, it goes beyond the concept of illegal deforestation by imposing a zero-deforestation requirement. Second, it places significant weight upon the private sector. The exact outcomes of such a policy framework are yet to be determined, and its impacts will be closely followed going forward.

Sources

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FAO. 2022. The State of Agricultural Commodity Markets 2022. The geography of food and agricultural trade: Policy approaches for sustainable development. Rome, FAO.

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[10] In addition, the strategy aims at zero CO_2 emissions from fossil fuel combustion in agriculture, forestry and fisheries by 2050, reducing the use of pesticides and chemical fertilizers, and increasing the share of organic agriculture. For more details, see https://www.maff.go.jp/e/policies/env/env_policy/meadri.html.

Regional Trade Agreements (RTAs) have progressively advanced from facilitating purely economic exchanges to promoting deeper integration and are becoming instruments to foster policy convergence in partner countries, particularly related to labour standards, human rights and environmental conservation.[41] Environment-related provisions (ERPs) in RTAs have been on the rise, and are especially relevant for those negotiated by some developed countries, such as Canada, the European Free Trade Association (EFTA) countries, the European Union, and the United States of America. Evidence on the effects of ERPs in RTAs suggests they can foster environmental sustainability and help lower GHG emissions.[42] Research shows that CO_2 emissions in countries that are parties to an RTA with ERPs tend to be lower than in countries that are parties to RTAs without such provisions.[43]

Third-party voluntary sustainability certification schemes are alternative mechanisms to foster environmental protection. They are gaining importance in global markets, especially for high-value products with well-established links to global value chains. For example, one-quarter of the global coffee and cocoa areas are certified through sustainability standards developed by both non-governmental organizations and the private sector. Private standards aim to address environmental, social or economic challenges in agricultural markets and respond to consumer concerns. They do so by seeking and securing price premiums based on the sustainability attributes of products, to support the adoption of improved practices. Organic standards incentivize producing crops without synthetic fertilizers and pesticides. The Rainforest Alliance's Roundtable on Sustainable Palm Oil (RSPO) includes a range of requirements for environmentally friendly farm practices to promote agroforestry, the use of organic fertilizers and pesticides, and safer treatment and disposal of waste. Sustainability certification schemes provide consumers information on both the quality and safety of food, environmental sustainability, and social norms such as child labour, gender equality and the welfare of producers.[44] Such schemes can complement existing policies in multiple ways. Governments can play a significant role in third-party voluntary sustainability certification schemes as supporters, facilitators and users (Box 5).

Trade can help countries adapt to short-term supply disruptions and long-term changes in comparative advantage triggered by climate change. However, the use of trade restrictions and other barriers to trade could undermine the adaptive role of trade in ensuring food security. Trade reforms to address these barriers need to be balanced with adequate policy measures to tackle local and global externalities. Multilateral cooperation is also indispensable to tackle global externalities, related to mobile resources (such as transboundary fish stocks) or shared resources (such as GHG emissions into the global atmosphere).[45]

Policy incentives address climate change by improving emissions efficiency and lowering GHG emissions. Taxing GHG emissions can 'internalize' their full environmental cost to the society and provide incentives for the adoption of technologies and practices that promote climate change mitigation. If carbon taxes were imposed individually, countries that try to internalize the cost of GHGs may inadvertently confer an advantage on others that do not impose a similar measure, potentially leading to emissions leakage and misallocation. This would imply the risk of increasing production and exports from countries without mitigation policies resulting in emissions leakage. However, global studies show that leakage rates are typically well below 100%, which implies that not all of the emission reductions achieved by a country, or a group of countries will be offset by leakage. More R&D and knowledge transfer to increase the availability and affordability of mitigation technologies and practices can significantly lower the incidence of leakage under carbon pricing.[46,47] Specific trade policies can contribute towards addressing the trade-off between food security and emission reduction targets. To even out disparities between domestic and international levels of carbon taxes, border measures, such as border tax adjustments based on food products' carbon footprints, could be implemented.[48]

Box 5. Embedding voluntary sustainability standards into trade agreements

An interesting case of an RTA with third-party voluntary sustainability certification schemes embedded in its implementation is the European Free Trade Association-Central America Free Trade Agreement (EFTA-CEPA Agreement), which entered into force in 2021. Article 8.10 of the agreement notes that trade in vegetable oils should support the dissemination and use of sustainable standards, practices and guidelines for sustainably produced vegetable oils. Switzerland, which is the largest consumer market within EFTA, requires that all palm oil imports comply with one of the three globally recognized certifications: Roundtable on Sustainable Palm Oil (RSPO), the International Sustainability and Carbon Certification Plus (ISCC Plus) and the Palm Oil Innovation Group. In order to facilitate traceability, palm oil should be imported in 22-tonne tanks. These conditions of Article 8.10 of the agreement are specified in national law with the Swiss Federal Council adopting this specific implementation of sustainability certificates. The details are regulated in the federal ordinance on the importation of sustainably produced palm oil from Indonesia, which entered into force at the same time as CEPA in August of 2021. What makes this case unique is that, taken together, the trade agreement and the national legislation effectively make imports of palm oil and its derivatives into Switzerland conditional upon a specific set of sustainability certification schemes, compared to simply encouraging the adoption of such schemes, and in a way defers the enforcement of sustainable production to a foreign country. In line with this trend, negotiations started in 2020 between Costa Rica, Fiji, Iceland, New Zealand, Norway and Switzerland on an Agreement on Climate Change, Trade and Sustainability (ACCTS), which would also encourage the adoption of such voluntary sustainability standards. Early information indicates that under this agreement, work is underway to develop "principles-based guidelines for voluntary eco-labelling programmes, alongside institutional mechanisms to support their implementation." This could indicate a new step towards deeper integration of voluntary sustainability certification in trade agreements.

Source: FAO. 2022. The State of Agricultural Commodity Markets 2022. The geography of food and agricultural trade: Policy approaches for sustainable development. Rome, FAO.

Mitigation policies implemented through a uniform global carbon price would curb emissions but also reduce agricultural production, raise agricultural commodity prices, and impact food security. One alternative is to use abatement subsidies or carbon offset mechanisms to pay farmers for their emission reductions. These policies that apply the "beneficiary pays principle" have the advantage of avoiding the food price increases and producer income losses associated with carbon pricing policies that apply the "polluter pays principle". However, the abatement subsidies are about half as effective as carbon taxes and they require significant government budget outlays, which can limit their scale of use and lower their overall economic welfare relative to carbon taxes.[49 50] In addition to taxing GHG emissions, labelling of final products with respect to GHGs emitted during their production can help shape consumer preferences towards less-emitting production practices.

All of the policies that price emissions at their source would require accurate estimates of the GHGs emitted during agricultural and food production. For the labelling of food products according to their embodied emissions and for a border carbon adjustment scheme, a reliable estimate of the direct emissions involved in the production process of different foods would be needed – i.e. their carbon footprints. In either case, the consistent accounting of GHG emissions in agriculture implies several challenges, including methodological issues and significant data requirements. Carbon footprints need to be quantified encompassing the emissions generated in the production and supply of inputs used by farmers, direct and indirect emissions generated in agricultural production processes, and subsequent emissions associated with transportation, processing, storage, and delivery of products to consumers.

Agricultural production involves many different sources of emissions that need to be covered and these sources of emissions are often diffuse, difficult to monitor and can vary by location.[51]

Carbon accounting mechanisms would also need to be agreed upon internationally to avoid trade disputes. Alternative policy approaches to reduce GHG emissions from agriculture center on domestic measures to incentivize climate-smart agricultural practices. These can be indirectly related to trade by altering traded volumes and market signals.[52]

3.4 Other measures

3.4.1 Environmental programmes

Measures such as direct payments under environmental programmes can foster farmers' adaptation to climate change and increase environmental protection. Importantly, such policies fall under *Green Box* measures within the WTO's Agreement on Agriculture, as they are deemed to have no or minimally distortive impacts on markets.

Payments to environmental programmes and ecosystem services can foster environmental protection and reduce agriculture's footprint. These programmes reward farmers for supplying environmental goods and for addressing some of the negative external effects of agricultural production. Programmes designed to encourage the adoption of practices that reduce emissions or encourage carbon sequestration could also fall under this heading, as long as payments are limited to the extra costs or loss of income incurred in complying with the programme. In Japan, farmers qualify for direct payments for environmentally friendly agricultural practices that enable biodiversity conservation or reduce their GHG emissions.[53]

A study published in 2018 reviewed 33 instances of Payment for Ecosystems Services across 19 sites in Italy. The study found that the evaluated PES schemes contributed to local economies, fostered active participation of local stakeholders in conservation activities, and increased site management effectiveness by 14%.[54] The European Union's revised Common Agricultural Policy (CAP), due to start implementation in 2023, includes the requirement that Member States make available at least one eco-scheme for farmers.[55] Eco-schemes will respond for 25% of direct payments to farmers to foster the adoption of environment and climate friendly practices. This is an important development and may be instrumental in the mainstreaming of payments to farmers for their role in environmental protection across the European Union. The revised CAP is one of the pillars of the European Green Deal, a broader policy package aimed at making the EU climate neutral by 2050.

The United States of America has introduced initiatives providing preferential credit and grants to promote the adoption of GHG mitigation practices, while Ireland's Afforestation Scheme, established in 2014, provides grants and financial support to encourage the establishment and maintenance of new forests and woodlands. This initiative shall offset some of the agricultural-related emissions.[56]

Payments for ecosystems services can also be utilized to restore biodiversity. In Japan, the local government of Toyooka City re-introduced the oriental white stork, a species no longer present in the area. The city then granted payments for ecosystems services to farmers who adopted farming practices that favored the species' habitat. These practices included flooding paddy fields in the winter, enabling these to serve as wetlands.[57]

While evaluation of such schemes remain limited, it is believed that they can contribute to achieving various agri-environmental goals, and wider implementation would also facilitate assessing their effectiveness.

3.4.2 Governing land use change

Land use change is strongly connected to habitat loss, land degradation and GHG emissions. Governing land tenure systems and land use changes are important aspects of sustainable agricultural development, and have been integral part of international policy efforts to curb climate change.

A recent study estimated that land use change affected nearly one third of global land area between 1960 and 2019. The study also finds that forest cover has increased during this period in the northern hemisphere, and decreased in the southern hemisphere, which corresponds to developing countries. It indicates that land-use changes are characterized by a single change (such as deforestation) in developing countries, and multiple changes (such as crops rotation) in developed ones.[58]

As illustrated in Box 6, policy makers may choose to lift limitations around land use in order to increased food production. Because policies that affect farmers' decisions around land use have a direct impact upon the environment, these must be weighed carefully against trade-offs.

Box 6. Environmental impact of the war in Ukraine in the European Union

With the outbreak of the war in Ukraine, trade disruptions and the uncertainty surrounding the conflict prompted a significant increase of commodity prices in global markets on top of already high food and energy prices. The impact of the war was particularly significant for trade networks that were highly concentrated, such as wheat. To address the food security implications of high food prices, policy makers across the globe enacted a number of measures to address the effects of the war. These ranged from policies targeted at ensuring food affordability, to increasing production where possible.

In the European Union, the European Commission allowed farmers to bring fallow land into production (on a temporary basis); delayed the entry into force of the Green Deal requirement to halve the use of pesticides in agriculture by 2030 and encouraged reducing biofuel blending requirements. The latter enables agricultural land and crops to be destined for human consumption rather than biofuel production. These polices were adopted with the objective of increasing food production and availability within the European Union, thus contributing to food security within the EU as well as abroad.

While contributing to food security, these measures can impact on the environment negatively. Keeping agricultural land fallow enables the recuperation of soil, and shortening fallow periods reduces its natural fertility. Pollinators play an important role in food production. The reduction of natural pollinators is connected to pesticide use, habitat loss and intensive agricultural land management. Carbon emissions through the burning of fossil fuels negatively affects the environment and contributes to climate change.

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3.4.3 Incorporate climate policies in agriculture

Despite the fact that the land based sectors are capable of reducing and sequestrating greenhouse gas emissions, up to date there are a limited number of policies that target primarily environmental benefits of agriculture. Emission pricing instruments aim at influencing consumers' and producers' incentives. They include carbon pricing through emission taxing, emission trading schemes, carbon offsets, and auction-based abatement payment schemes.

Such policies to reduce agricultural emissions are limited, however some countries stimulate farmers to reduce GHGs emissions. A prominent example is New Zealand's Emissions Trading Scheme, which covers forestry emissions by increasing the incentives for farmers and landowners to reduce deforestation and store carbon by converting pastureland to forests.[11] Australia's Emissions Reduction Fund (ERF), established in 2015, is a voluntary scheme providing incentives for businesses to undertake emissions reductions and carbon sequestration projects. Similar to Australia, Canada opted for a CAD 200 million On-Farm Climate Action Fund to help farmers adopt climate-friendly practices.[12] New Zealand is currently considering different options for pricing emissions form agriculture by 2025. In November 2021, the He Waka Eke Noa – Primary Sector Climate Action Partnership between the Government of New Zealand, the food and fibre sector and Māori released a draft document outlining three agricultural emissions pricing options, including a farm-level levy, a processor-level hybrid levy, and the NZ ETS presented as the counterfactual option.[59] Under Japan's climate change mitigation plan for the agriculture, forestry and fishery sectors, Japan is taking action to sequester 38 $MtCO_2eq$ in forest sinks and 8.5 $MtCO_2eq$ through grassland management.[60]

Taxation of the highest carbon footprint food is being discussed in many developed countries, as a way to incorporate the environmental externalities in the food prices and to encourage consumption of products with lower emission intensities. The True Animal Protein Prices (TAPP) Coalition, for example, examined how to align the European meat industry with the Green Deal.[13] Using FAO data on meat consumption in the European Union, it estimates that the introduction of 'fair meat prices' would lead to a price increase of EUR 0.47 per 100 grams of beef or veal, EUR 0.36 per 100 grams of pork, and EUR 0.17 per 100 grams of chicken by 2030. This reflects the fact that the environmental costs of beef production are highest. By 2030, such price increase would lead to a reduction in chicken, pork, and beef consumption of 30%, 57% and 67%, respectively. The Coalition proposes public policy support to foster sustainability of the sector in the form of setting up a *sustainability charge* on these products.[61]

With regards to other environmental costs related to the livestock sector, Japan has taken measures to improve livestock manure management since 1999. Japan has established mandatory standards for manure management, requiring farmers to install facilities for manure management. The government in turn finances these on-farm facilities. This policy led to 90% of manure being processed into fertilizer, which is a notable outcome for the sector and the environment.[62]

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[11] For more information, see https://www.mpi.govt.nz/forestry/forestry-in-the-emissions-trading-scheme/.

[12] For more information, see https://agriculture.canada.ca/en/programs/agricultural-climate-solutions-farm-climate-action-fund.

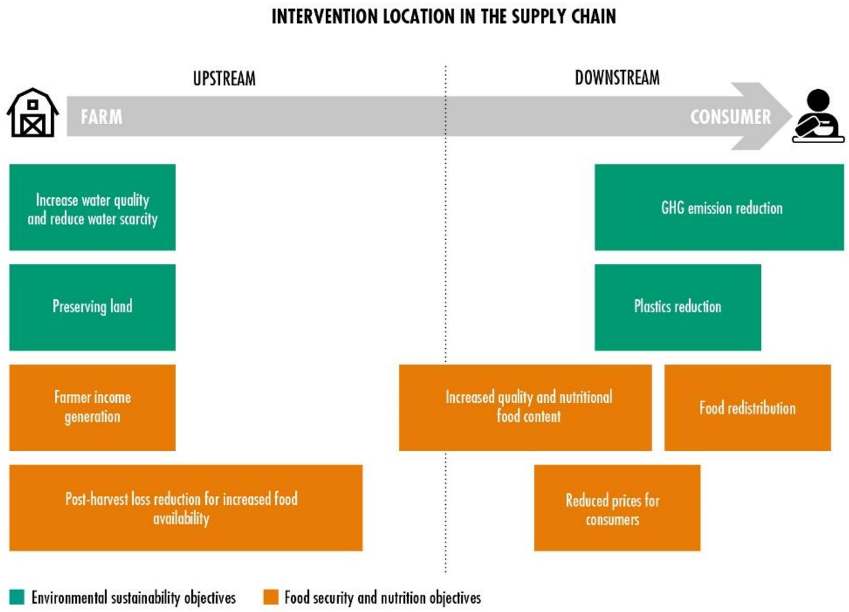
[13] The True Animal Protein Price (TAPP) Coalition is a coalition of food companies, health, farmers and youth organizations, animal welfare and environmental organizations and social ventures working towards effective policy measures aimed to lower consumption of meat and dairy by introducing fair prices for meat and dairy products, including environmental and other cost. It was established in 2018 in the Netherlands and is a non-profit foundation since June 2019.

3.4.4 Reduce the food loss and waste

Globally, 14% of food valued at an estimated USD 400 billion is lost from harvest to retail,[63] and another 17% is wasted at the retail and consumer levels.[64] Food loss and waste have many negative economic and environmental impacts. Economically, they represent a wasted investment that can reduce farmers' incomes and increase consumers' expenses. Environmentally, food loss and waste inflict several adverse impacts, including unnecessary greenhouse gas emissions and inefficiently used water and land, which in turn can lead to diminished natural ecosystems and the services they provide.

Reducing food loss and waste is a critical step toward generating enough food for a population set to reach more than 9 billion by 2050. Estimates indicate that cutting current food loss and waste levels in half would shrink the size of this food gap by 22%.[65] The reduction of FLW would also contribute to reaching some of the environmental and climate objectives (Figures 2 and 3). FAO has highlighted the importance of understanding the objectives behind the interventions first in order to target the FLW interventions along the food value chains.[66]

Figure 2. Objectives of food loss and waste reduction measures and their entry points along the food supply chain

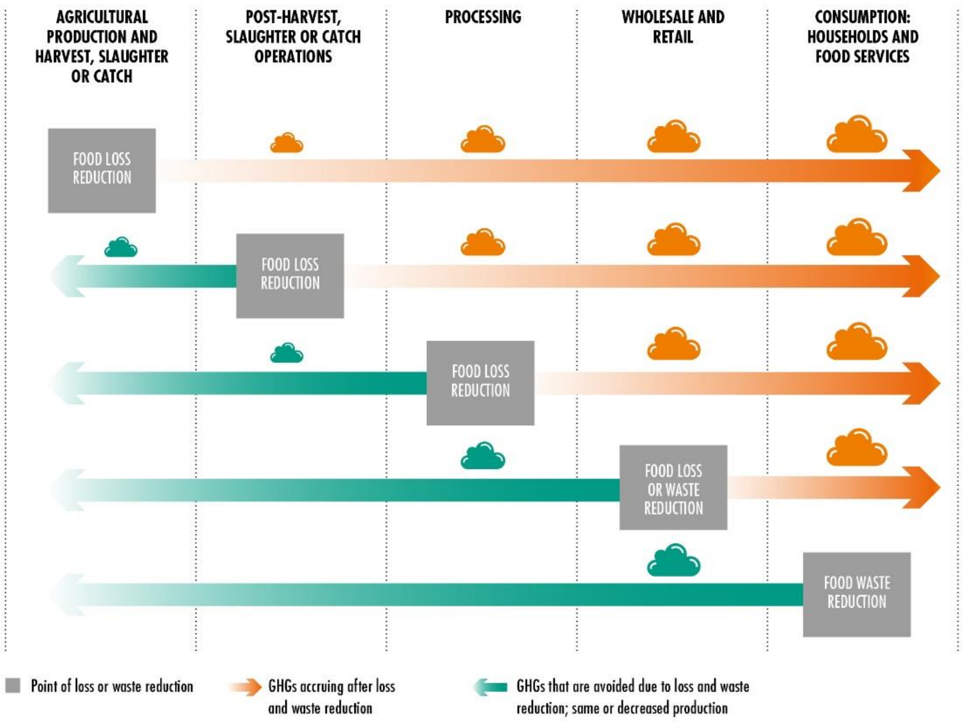


Source: FAO, 2019.

Many low-cost measures exist to reduce food loss and waste both on the farm and beyond. Improved storage methods, for example, can drastically cut food loss, especially for small-scale farmers in the developing world. In both developed and developing countries, redistributing food that could not be sold, by giving it to food banks and similar outreach groups can help to avoid food loss. Consumer awareness campaigns are particularly relevant in developed countries, where food waste on the consumption side (and over-consumption of food) is much larger as compared to the developing world.

Public policies for reducing food loss and waste target mainly two social objectives: (i) improved food security and nutrition, and (ii) environmental sustainability. There are also business cases to make where the private sector can play a big role, with many countries stepping up their actions in this area. The European Commission, for instance, created the EU Platform on Food Losses and Food Waste (FLW) to bring together stakeholders from across the European Union to rally support to identify ways to prevent food waste, share best practices and assess the progress achieved.[14] The United States of America's Environmental Protection Agency (EPA) is actively pursuing the goal of 50% reduction of FLW by 2030, outlining actionable measures for both individuals and private sector.[15] To reduce food loss and waste substantially, the global community needs to undertake cross-cutting actions at scale, involving all stakeholders in this process.

Figure 3. Carbon impact of food loss and waste reduction along the food supply chain



Source: FAO, 2019.

[14] For more information, see https://food.ec.europa.eu/safety/food-waste/eu-actions-against-food-waste/eu-platform-food-losses-and-food-waste_en.

[15] For more information, see https://www.epa.gov/sustainable-management-food/united-states-2030-food-loss-and-waste-reduction-goal#goal.

4. Key policy recommendations

Pursuing environmental sustainability in agriculture implies weighing synergies and trade-offs carefully. The policy space available to policy makers is sufficient to bring the sector closer to addressing the triple challenge that the agricultural sector faces, provided that policy makers play an active role in reforming well-stablished practices that have been widely recognized as potentially harmful to the environment.

1. ***Increase investment in Research and Development (R&D).*** Public expenditure in R&D remains indispensable to advance environmental objectives. More efforts need to be made to secure adequate long-term investments in agricultural R&D by the public sector, particularly targeting these to contemporary sustainability challenges faced by the agricultural sector.

2. ***Align policies and incentives with long-term objectives***. Public policies need to be carefully weighed against long-term costs and benefits. This should apply to both short-term incentives and exceptions, and to policies envisioned as more permanent. Resources should be aligned toward common developmental objectives to ensure efficiency and cost-effectiveness in reaching national food security and mitigation and adaptation objectives.

3. ***Roll back measures that distort markets and trade***. More efforts need to be dedicated to remove measures that reduce producers' incentives to use inputs efficiently and, thus, have negative environmental effects. Commodity-specific regulations often favor products not adapted to the context and changing climate, preventing a shift toward more efficient and sustainable production.

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