Briefing Note

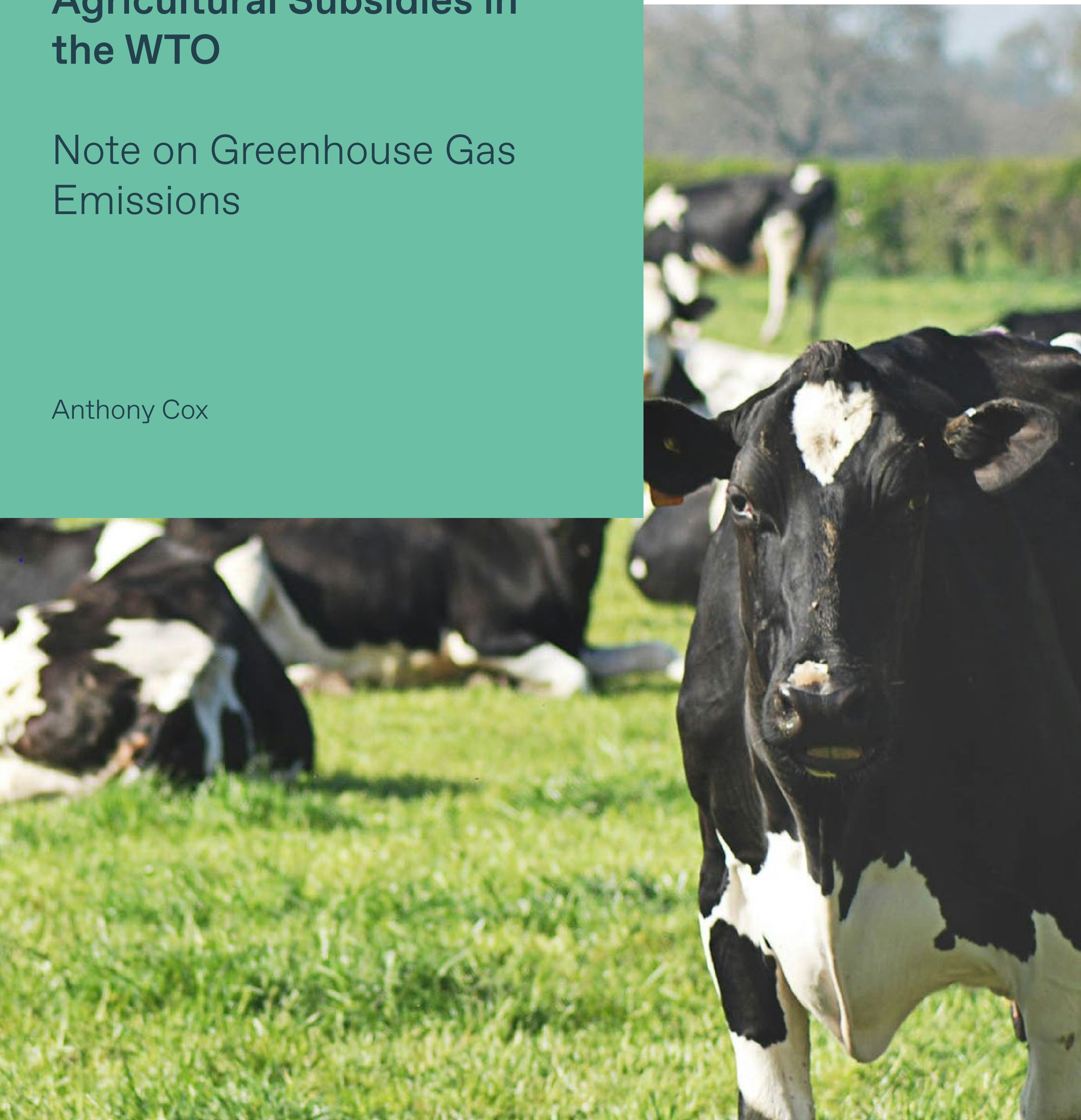
May 2025

TESS Forum on Trade, Environment, & the SDGs

Identifying and Tackling Environmentally Harmful Agricultural Subsidies in the WTO

Note on Greenhouse Gas Emissions

Anthony Cox



TESS Forum on Trade, Environment, & the SDGs

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Acknowledgements

The author wishes to thank TESS for the invitation to participate in the International Expert Group on Environmentally Harmful Agriculture Subsidies.

Disclaimer

Recommended citation: Cox, A. (2025). *Identifying and tackling environmentally harmful agricultural subsidies in the WTO – Note on Greenhouse Gas Emissions*. Forum on Trade, Environment, & the SDGs (TESS).

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Contents

This briefing note was prepared in May 2024 to inform the discussions of the International Expert Group on Environmentally Harmful Subsidies. The expert group was mobilized by TESS in 2024 and tasked with identifying a set of environmentally harmful subsidies for priority action at the international level. A final expert group report was published in 2025. The findings are intended as guidance to policymakers and to serve as a basis to promote open discussion on possible cooperative action in this area at the WTO, OECD, FAO, G20, and in the context of the Kunming-Montreal Global Biodiversity Framework.

For more information on the expert group visit: tessforum.org/initiatives/expert-group-on-environmentally-harmful-agriculture-subsidies

Abbreviations

CH4	Methane
CO2	Carbon Dioxide
CO2eq	Carbon Dioxide Equivalent
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse Gas
GWP	Global Warming Potential
Gt	Gigatonne
kg	Kilogramme
N2O	Nitrous Oxide
OECD	Organisation for Economic Co-operation and Development

This briefing note provides a brief overview of the main impacts of the agricultural sector on greenhouse gas (GHG) emissions, identifies context-specific considerations for these impacts as well as broader social, economic, and environmental trade-offs, and briefly discusses possible priorities and directions for reform of agricultural subsidies.

The note draws on the latest data and recent reviews of existing literature together with major reports from international organizations.[1] The scope is restricted to agricultural activities within the farm gate, including crop and livestock activities, and to agricultural land use change, such as deforestation for agricultural activities. It does not include the pre- and post-production processes in the agrifood system, such as food manufacturing, retail, household consumption, and food disposal. Furthermore, GHG emissions include the component gases—carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)—expressed as their carbon dioxide equivalents (CO_2eq).[2]

1. Introduction

Agriculture is a major source of global GHG emissions, both directly (through on-farm emissions linked to production) and indirectly (through land use change due to agricultural expansion). Most **carbon dioxide** emissions from agriculture result from disturbance of soil organic matter (plant residues in various states of decomposition), that serves as an emissions repository, or "sink." Tilling the soil (turning it over and otherwise preparing it for cultivation) accelerates the decomposition of the organic matter by microbial activity, and CO_2 emissions increase from greater exhalation by the microbes. **Nitrous oxide emissions** predominantly come from chemical reactions between the atmosphere and nitrogen put onto soils via fertilizers, with a much smaller quantity of emissions resulting from animal manure. These emissions may be released directly from fertilizer application to fields, or from water runoff from fields. N_2O formation also depends strongly on the amount of nitrogen applied to soils, which has increased significantly over time. **Methane** is formed from "enteric fermentation" in the digestive systems of certain types of ruminant livestock, from decomposition of animal manure, and in lesser quantities from rice cultivation. All livestock (not just ruminants) contribute to CH_4 emissions from the decomposition of manure.

Based on FAO (n.d.) data, overall GHG emissions from agriculture, forestry, and other land use were 10.9Gt CO_2eq in 2022, representing around one-fifth (20%) of global anthropogenic GHG emissions. On-farm emissions were 7.8 Gt CO_2eq in 2022 while emissions from agricultural land use change were 3.1Gt CO_2eq. These figures represent a 14% increase in on-farm emissions since 2000 but a 30% decrease in emissions from land use change (although emissions in this area have fluctuated over the period 2000–2021 due to changes in fire conditions in different regions of the world).

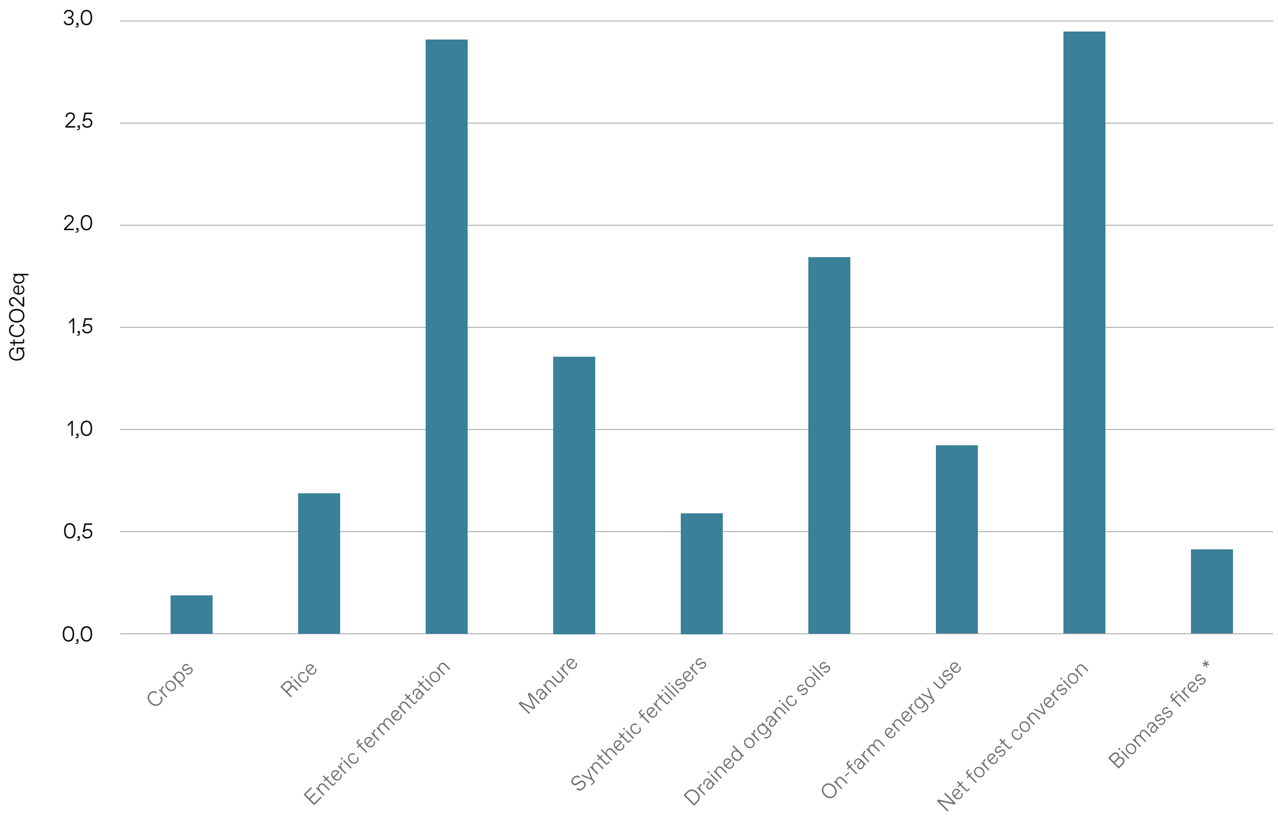
Breaking down the total agricultural GHG emissions into the component gases highlights their relative contribution. The share of CO_2 emissions has been gradually declining over the years to around 43% of total emissions, while the shares of CH_4 and N_2O have been gradually increasing to 37% and 20%, respectively.

1. See for example Ash and Cox (2022), OECD (2022), FAO et al. (2021), and Gautam et al. (2022).
2. Greenhouse gases differ in how long they remain in the atmosphere and how much climate-warming energy they will absorb for a given time. Methane, for example, has a global warming potential (GWP) 27–30 times greater than carbon dioxide over 100 years, and nitrous oxide has a GWP 273 times greater than carbon dioxide on that timescale. These figures underscore the mitigation benefits from reducing agricultural methane and nitrous oxide. Typically, figures for total GHG emissions are presented as "CO2-equivalents," using the GWPs to express other GHGs in comparable terms. Thus, 1 tonne of methane is equivalent to between 27 and 30 tonnes of carbon dioxide in warming potential, and 1 tonne of nitrous oxide is equivalent to 273 tons of carbon dioxide in warming potential.

A further breakdown of the total agricultural GHG emissions highlights the relative importance of different production and process activities in the sector in terms of emissions (Figure 1). In 2022, the most important contributors to global agricultural emissions were CO2 emissions from deforestation (2.9Gt CO2eq) and CH4 emissions from ruminant livestock (2.9Gt CO2eq). These two activities represent 54% of the total emissions. Other important activities in terms of GHG emissions in 2021 were CH4 emissions from livestock manure (12.3% of agricultural emissions), on-farm energy use (8.5%), and the draining of organic soils (8.5%).

Emission intensities for agricultural commodities, defined as the GHG emissions within the farm gate per unit weight of product (CO2eq/kg), have steadily declined over time reflecting increases in crop and livestock production efficiency. In 2022, the emission intensity of beef was very high at 28kg CO2eq/kg, largely due to methane production by ruminant fermentation. The emission intensity of sheep meat was also relatively high at 24kg CO2eq/kg while the emission intensities of pig meat and chicken meat were much lower at 1.6 and 5kg CO2eq/kg, respectively.

Figure 1. Composition of Agricultural GHG Emissions, 2022



* Includes peat fires.

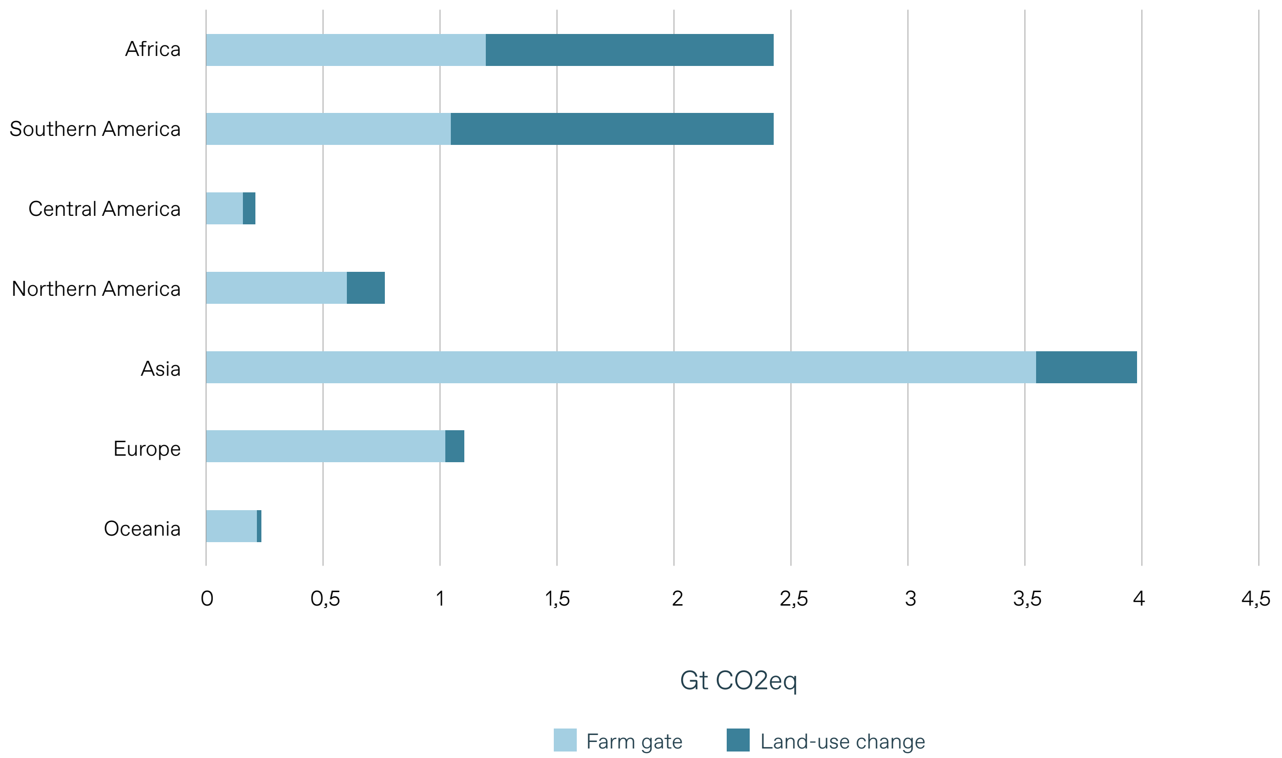
Source: FAO (n.d.).

2. Looking Behind the Broad Data

The overview in the previous section only provides a broad perspective on the GHG profile of the agricultural sector. The highly aggregated data and indicators do not reflect variations in GHG emissions and emission intensities that occur across different geographies, production methods and practices, and across different agro-ecological conditions. It is beyond the scope of this short briefing note to provide a detailed review of how such differences impact GHG emissions. However, a number of key points are worth highlighting.

First, not only are there significant regional differences in agricultural GHG emissions between regions, there are also significant differences in the emission profiles. For example, land use change makes up a significant proportion of the overall GHG emissions in southern America and Africa relative to the other regions (Figure 2).

Figure 2. Regional GHG Emissions, 2022



Source: FAO (n.d.).

Second, the emission intensities of individual commodities can vary significantly across regions and over time. For example, improvements in production technologies has generally reduced the GHG emission intensities of agricultural production by more effectively targeting fertilizer, pesticide, energy, and water use. Higher yields lead to lower GHG emissions per unit of product. Whether agricultural systems depend on rainfed or irrigated water supply will be key as will the soil structures in different regions within countries. Farm operations and management, ranging from traditional and mixed systems to modern agriculture, will also have a significant impact on emission intensities.

The FAO (2024) uses the examples of the farm gate emission intensities of beef and cow milk to illustrate the issue. Emission intensities for livestock vary considerably around the world and are highest in regions with low yields of animal agriculture. According to the latest FAO (n.d.) data for 2022, the emission intensity of beef was highest in Africa (59 kg CO2eq/kg), an increase of 6% since 2000. In contrast, the farm gate emission intensities of beef have declined over the last two decades in North America (13kg CO2eq/kg in 2022), South America (42kg CO2eq/kg), Asia (28kg CO2eq/kg), Oceania (26kg C2Oeq/kg), and Europe (17kg CO2eq/kg). In the case of cow milk, the 2022 emission intensity was the highest in Africa (3.2kg CO2eq/kg) and about three times more than in the other regions (1.1kg CO2eq/kg in Asia, 0.8kg CO2eq/kg in Oceania, 0.7kg CO2eq/kg in the Americas, and 0.6kg CO2eq/kg in Europe).

The heterogeneity in regional and country GHG emissions, the components of emission sources, and commodity-level emission intensities reflects significant variations in natural resource endowments, the diffusion of modern technology and farm practices, policy settings, stages of economic, social, and political development, and the prevailing trade regime. It underscores the challenge in providing definitive answers to questions concerning the identification of the most environmentally harmful agricultural subsidies, as well as questions around the speed, scope, and form of reform to agricultural subsidies.

3. Trade-Offs With Other Objectives

Reducing GHG emissions from the agricultural sector is an increasingly important focus for policymakers given that the sector accounts for around a fifth of global GHG emissions. However, emission reductions policies can come into conflict with other broad policy objectives that are also high on the economic, social, and environmental agenda. The potential synergies and trade-offs between objectives are increasingly recognized in policy discussions. The OECD (2021), for example, frames this as a “triple challenge” focusing on a food systems approach to analyse trade-offs between food security and nutrition, livelihoods, and environmental sustainability. There are also trade-offs within these individual objectives. For example, unless carefully designed and implemented, policies to reduce GHG emissions can adversely impact other environmental domains such as biodiversity and water.

The complexity of food systems and the high degree of heterogeneity in agricultural production and socio-economic systems around the world make it challenging to generalize. However, in the case of GHG emission reductions, a couple of cases can be used to illustrate the policy issues involved.

An obvious first example is that of ruminant livestock. These are the major source of GHG emissions in the agricultural sector and have by far the highest GHG emission intensities. The numbers of livestock are increasing globally, they are the largest user of land worldwide with an estimated one-third of the world’s surface used for grazing and feed production. Livestock productivity varies considerably between regions and countries. At the same time, ruminant livestock plays an important role in food security and nutrition, with a third of global protein intake and nearly 20% of calories coming from animal sources (mostly ruminants). They are also key for the livelihoods of a large proportion of the world's population and for many countries' economic development and export opportunities.

Mitigation actions to GHG emissions from ruminant livestock will inevitably bump into these other objectives. Reducing livestock numbers will reduce GHG emissions but can also lower protein availability and reduce farm incomes. Changing herd grazing and management practices can impact both GHG emissions and soil carbon stocks but, if poorly implemented, can affect the incomes and livelihoods of farmers and communities. Demand-side policies that encourage shifts towards lower emission intensity diets (i.e. with less meat consumption) can have potential co-benefits for public health but may also pose a threat to farmers living from livestock production.

A second example is that of intensification of cropland and livestock production. The increased use of inputs such as nitrogen, phosphorous, and potassium fertilizers, pesticides, and irrigated cropland has dramatically increased the yields of croplands around the world with major benefits for food security, incomes, and livelihoods. Intensification can also reduce the pressure on land use change and deforestation. However, synthetic fertilizers remain responsible for around 13% of direct GHG emissions from the sector and also have major implications for local water systems through agricultural runoff of fertilizers. In the case of intensive livestock production, the use of concentrated animal feed has increased yields but has also increased the challenge of manure management with implications for GHG emissions (emissions from manure account for around 12% of the sector's emissions) as well as for water quality in local water systems.

4. Implications for Reform of Agricultural Subsidies

While this briefing note cannot do justice to the increasing amount of research and analysis that has been undertaken on the issue of climate change and agriculture in recent years, there are a number of issues that are particularly relevant in the context of discussions around GHG emissions and the reform of agricultural subsidies. This final section provides some initial thoughts for consideration, drawing on the available literature.

Before doing so, it is worth recalling that support to agriculture is at a historical high and is continuing to grow. According to the latest data from the OECD (2023), total support to agriculture reached $851 billion per year during 2020–22 for the 54 countries covered in their analysis. Of this amount, $630 billion (74% of total support) went to producers individually either directly from government budgets or implicitly through market price support. The remainder of support was split nearly equally between support for general services ($106 billion, 12.5%) and budgetary transfers to consumers of agricultural products ($115 billion, 13.5%). Support remains highly concentrated in a few large producing economies: China, India, the United States, and the European Union.

Environmental Pathways Matter

The conceptual pathways through which subsidies can impact climate (and the environment more generally) are relatively well established. Support changes the economic incentives facing participants in the agricultural sector and influences environmental outcomes through:

- The volume of agricultural goods produced, traded, and consumed
- The mix of agricultural goods produced, traded, and consumed
- Where the agricultural goods are produced, traded, and consumed in terms of local, regional, and international spatial scales, since the same amount of agricultural goods produced in different regions may have different environmental impacts
- The extent to which sustainable techniques and technologies are employed when agricultural goods are produced, traded, and consumed

Understanding these pathways and how they interact with subsidies is critical to determining the GHG emission consequences of subsidy reform. How these pathways interact with the emission intensities of different products in a global market where many agricultural goods are traded will determine the net impact on emissions of policy actions. Such an interplay is complex and requires further analysis.

Furthermore, it is essential to enhance the understanding of how these pathways impact other objectives such as food security, livelihoods, and other environmental sustainability objectives. A systems approach, while complex and highly context-specific, is required to effectively assess such synergies and trade-offs.

Focus on Coupled Support and Market Price Support

The types of agricultural support provided also play an important role in determining the extent of the impact on GHG emissions.[3] The available literature is quite clear that coupled subsidies and market price support are among the potentially most environmentally harmful support policies, including with respect to GHG emissions.[4] Such policies are linked with farmers' production decisions, thus providing incentives for the intensification of input use, the allocation of land for supported crops, and the entry of land into the agricultural sector. Production-linked support coupled with output of emission-intensive goods generally increases output in the region providing support and the associated GHG emissions.

Use of coupled subsidies will be particularly damaging for the environment if the GHG emission intensity (emissions per unit of output) is higher in the region providing support than in other regions, or if it encourages the use of emission-intensive practices or technologies. Similarly, subsidies coupled with specific inputs will encourage greater use of those inputs and may generate increased GHG emissions, particularly if the input is emission-intensive.

Reform Support to Emission-Intensive Products

The most emission-intensive products, notably livestock, should be a particular focus for reform. Not only is ruminant livestock responsible for the largest individual commodity share of emissions (especially the particularly potent methane emissions), it is by far the most emissions-intensive product in the sector and also receives the highest share of support for a specific commodity. As a result, it has the highest implicit carbon subsidy attached to its production of all the agricultural commodities. As a result, a combination of reductions in support coupled with changes to herd management, manure management, and farm operations, and with research and development into technological options, could reap significant reductions in GHG emissions. However, the role of support for livestock is particularly sensitive from a social and political perspective, as well as from a trade perspective. Moreover, the net impact of reductions to subsidies for livestock production will depend on whether displaced production shifts to a more or less emission-intensive location.

Support to Input Subsidies

Support to the unconstrained use of variable inputs such as fertilizers, feed, and fuel is another obvious candidate for a specific reform target. These subsidies amounted to $68 billion per year between 2020–2022. Subsidies for synthetic fertilisers provided without appropriate constraints leads to increased N2O emissions. Subsidies for feed directly incentivize increased livestock production and related GHG emissions, whereas fossil fuel subsidies encourage carbon dioxide emissions from increased on-farm energy use (OECD, 2022).

3. Market price support consists of barriers to trade such as tariffs, licences, and quotas that raise or lower the domestic price relative to world prices. Coupled support are payments based on commodity output or on unconstrained variable input use. Decoupled support are payments unrelated to the area and production levels of specific commodities, livestock numbers, and input use.
4. See, for example, Henderson and Lankoski (2019), DeBoe (2020), Mamun et al. (2021), Gautam et al. (2022), and Damania et al. (2023).

Reduce Support that Incentivizes the Unconstrained Expansion of Agricultural Land

The conversion of forest land to agricultural land is a major source of GHG emissions from the sector, accounting for 27% of total GHG emissions in 2022. It is also an area where several avenues exist that could significantly reduce emissions. Policy action to support forest protection, coupled with improvements in agricultural productivity, can play an essential role in limiting the incentives to expand agricultural land and can also create opportunities to sequester carbon by restoring and reforesting marginal lands. Measures such as improved management of crop rotations, residues, vegetation, cattle stocking densities, and cropland-pasture integration are key here and should be the focus of support rather than coupling subsidies to the extensification of agricultural activities and land use. Redirecting support towards agricultural plantations, agroforestry, and afforestation on agricultural land are also promising avenues for carbon sequestration.

Focus Reform Efforts on Support for Sustainable Management Practices, Productivity Growth, Innovation, Uncoupled Payments, and Payments for Environmental Public Goods

Focusing greater policy attention on uncoupled subsidies, payments for environmental public goods, improved farm management, and innovation is a key avenue for reducing GHG emissions from the agricultural sector. Reducing direct on-farm emissions from agricultural production will require improvements in productivity, the efficiency of input use, and farm management and greater deployment of new technologies. In terms of crop production, this entails improving cultivation practices, increasing the efficiency of fertilizer use, and promoting the use of precision agriculture and integrated crop management. In terms of livestock production, emissions can be addressed through a combination of improvements in feed conversion efficiencies, better feed and pasture quality, strengthening farm and animal management, and the use of methane inhibitors such as feed supplements.

Support for innovation is also key to improving productivity by limiting on-farm losses through more resistant crops, improved harvesting equipment and techniques, and better storage infrastructure and logistics. On-farm energy consumption can also be reduced by promoting renewable energies and the adoption of greener and more efficient fuels to power agricultural machinery. Agriculture can also help reduce fossil fuel consumption via bioenergy sustainable production.

This issue lies at the heart of the current debate around repurposing agricultural subsidies. The premise underpinning this debate is that complete removal of agricultural subsidies is politically infeasible (and likely to remain so), may have adverse impacts on food security and farmer incomes in a number of regions, and may result in minimal net GHG emission reductions. Redirecting or repurposing subsidies towards sustainable practices, innovation, and research and development, and so forth, is posited as a more effective reform path forward from a political, social, and environmental perspective.

Improve Awareness and Understanding of Available Information and Analysis While Filling Strategically Important Knowledge Gaps is Essential

There is, of course, a need to empirically assess the impacts of agricultural support reform, including on GHG emissions. Actual GHG emission impacts can be expected to vary considering various factors, such as the nature and scale of support provided, location-specific physical conditions, and the risk preferences and related behaviour of farmers. Much of the empirical research to date has focused on the impacts of policy reform on agricultural production, trade, prices, and incomes. While research has more recently begun to address the climate linkages, few quantitative studies assess the climate impacts of reduced agriculture support per se. The results are highly sensitive to the assumptions employed, the data input, and the model parameters. These aspects warrant more attention.

Further attention could also be paid to the likely country and global level impacts of repurposing or redirecting savings from support reductions to new policy measures that target improved innovation and environmental outcomes. Other areas warranting further consideration include the treatment of CH_4, N_2O, and CO_2 emissions, leakage of GHG emission reductions, and land use change, as well as the system interactions with other economic, social, and environmental objectives in order to empirically assess possible trade-offs.

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