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IN FOCUS

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Greenhouse Gas Emissions and Sinks in U.S. Agriculture

Agriculture and land-use activities continue to play a central role in the broader debate about energy and climate policy options in the United States and abroad. Such activities offer opportunities to remove greenhouse gases (GHGs) from the atmosphere, potentially reducing the nation's net emissions: the metric of emissions targets for the Paris Agreement (PA), the binding international climate change treaty. Pursuant to the PA, the Biden Administration released a Nationally Determined Contribution (NDC) in 2021 specifying a new U.S. target of reducing net GHG emissions by 50%-52% below 2005 levels by 2030.

Most federal legislative proposals to reduce U.S. GHG emissions would not require reductions in agriculture. However, the recently enacted Inflation Reduction Act (P.L. 117-169) provides the U.S. Department of Agriculture (USDA) with funding for voluntary conservation programs to reduce, capture, avoid, or sequester GHG emissions.

Agriculture is both a *source* and a *sink* of GHGs (**Figure 1**). Sources generate GHG emissions that are released into the atmosphere and contribute to global climate change. Sinks remove carbon dioxide (CO_2) from the atmosphere and store carbon through physical or biological processes. Agricultural emissions include many GHGs of interest to policymakers: CO_2, methane (CH_4), and nitrous oxide (N_2O). Agricultural sinks remove CO_2 through photosynthesis and store carbon in plants and soil. Despite these sinks, U.S. agriculture is a net GHG source. This In Focus discusses emissions from the agriculture sector, as defined by the Environmental Protection Agency (EPA) and the most recent data available (from 2020).

U.S. GHG Inventory

Since the 1990s, EPA has prepared an annual *Inventory of U.S. GHG Emissions and Sinks*. USDA and other federal agencies contribute data and analyses. The *Inventory* reports GHG estimates by sector, source, and GHG type. The *Inventory* presents GHG estimates as CO_2-equivalents, aggregated to millions of metric tons ($MMTCO_2e$). CO_2-equivalents convert an amount of a GHG, such as N_2O, to the amount of CO_2 that could have a similar impact on global temperature over a specific duration (100 years in the *Inventory*). This common measurement can help compare the magnitudes of various GHG sources and sinks.

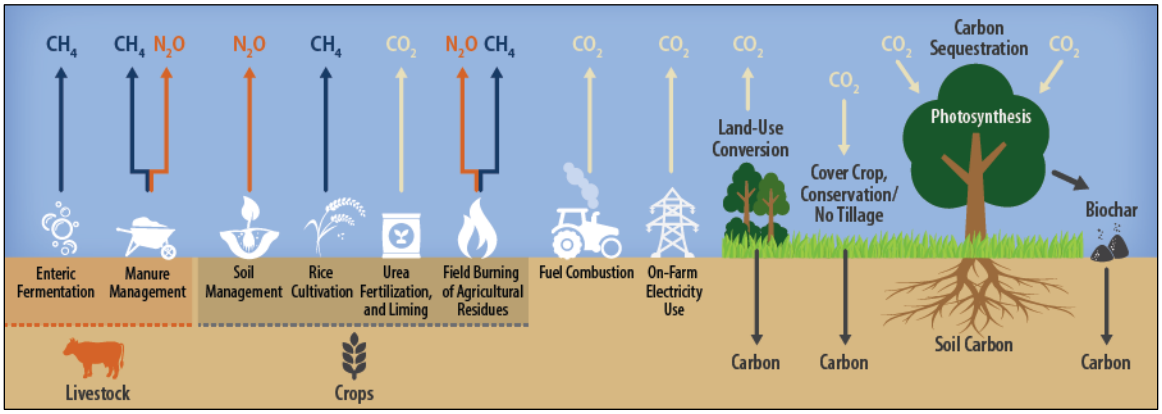
The *Inventory* presents GHG estimates for two types of sector classifications, one of which follows international standards. Every country preparing its national inventory considers the same GHG sources and sinks for the same standard sectors. These include an agriculture sector and a *land-use, land-use change and forestry* (LULUCF) sector. The *Inventory* reports estimates for several EPA-defined economic sectors, including agriculture, transportation, electricity, industry, commercial, and residential. Under this format, the agriculture sector includes emissions from fuel-combustion by farm equipment (e.g., tractors) and the emission sources accounted for in the international standard sector for agriculture.

Agricultural GHG Emissions

EPA reports that agriculture sector emissions totaled 635.1 $MMTCO_2e$ in 2020 (**Table 1**), equal to 11% of total U.S. GHG emissions (**Figure 2**). This estimate is based on certain assumptions and includes direct emissions from agricultural activities (see text below for major emissions sources in agriculture). It does not include

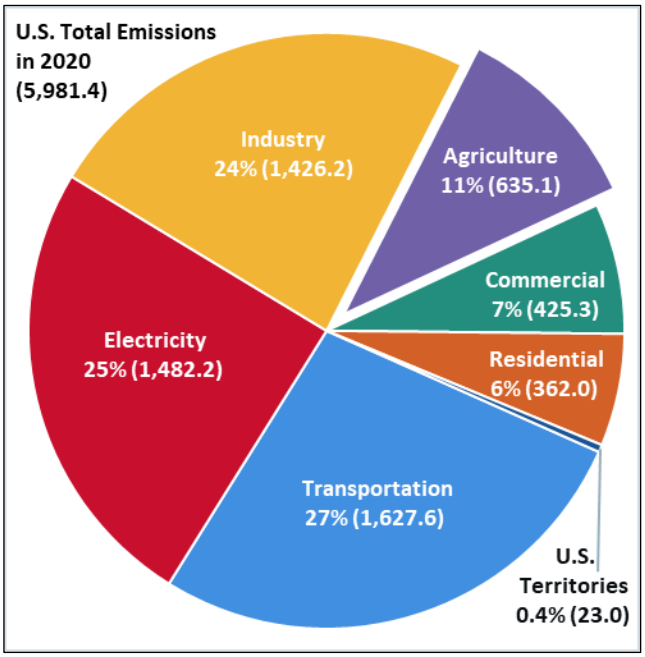
- Potentially offsetting agricultural sinks.
- Forestry activities, which are accounted for in LULUCF.
- Emissions from generating the electricity that farms use.
- Emissions from activities in the food system more broadly, such as production of agricultural inputs and post-harvest transportation and processing of foods.

Figure 1. Examples of Greenhouse Gas Emission Sources and Sinks from Agricultural Activities



Source: CRS. (*Enteric fermentation* refers to digestive processes in ruminant animals, which result in GHG emissions.)

Figure 2. U.S. GHG Emissions, by Economic Sector



Source: CRS from *EPA Inventory*, 2020 data.

Notes: Emissions are presented in parentheses in $MMTCO_2e$.

In 2020, three activity types accounted for 90% of U.S. agriculture sector emissions:

1. **Soil management (50%, 316.2 $MMTCO_2e$)**. N_2O emissions from soils, associated with agricultural practices that increase nitrogen availability, disturb soils, and increase oxidation (e.g., fertilization, irrigation, drainage, cultivation, tillage, shifts in land use, and deposition of livestock manure on soils).
2. **Enteric fermentation (28%, 175.2 $MMTCO_2e$)**. CH_4 emissions from livestock occurring as part of normal digestive process in ruminant animals during metabolism and digestion. Associated with feed nutrient content and efficiency of feed use by the animal.
3. **Manure management (13%, 79.2 $MMTCO_2e$)**. CH_4 and N_2O emissions associated with livestock and poultry manure occurring from manure/waste that is stored and treated in systems that promote anaerobic decomposition (e.g., lagoons, ponds, tanks, pits).

U.S. agriculture sector emissions were higher in 2020 despite a reduction in total U.S. emissions largely attributed to impacts of the COVID-19 pandemic on travel and economic activity (**Table 1**).

Table 1. U.S. Agriculture, Related Source Emissions

Emissions by Gas (Activity)	1990	2005	2020
Total, Agriculture Economic Sector	**596.8**	**626.3**	**635.1**
N_2O (soil and manure management)	330.1	330.3	336.1
CH_4 (enteric fermentation, manure management, rice cultivation)	214.7	235.5	250.9
CO_2 (urea fertilization, liming)	7.1	7.9	7.7
CO_2, CH_4, and N_2O (fuel use)	44.9	44.6	40.4
Total Agriculture w/Electricity	**631.9**	**664.6**	**669.5**
CO_2, N_2O, SF_6 (electricity-related)	35.2	38.3	34.4
Total Emissions, All Sectors	**6,453.5**	**7,434.8**	**5,981.4**

Source: CRS from *EPA Inventory* (emissions in $MMTCO_2e$.).

Agricultural GHG Sinks

On agricultural lands, carbon can enter the soil through plant roots, litter, cover crops, harvest residues, and animal manure. This carbon can be stored, primarily as soil organic matter (**Figure 1**). Other carbon sinks derive from a range of land-use and land-management activities, such as maintaining forested land, which primarily stores carbon in above-ground biomass (e.g., trees). LULUCF is the only *Inventory* sector to include GHG sinks. *Net sinks* in the LULUCF sector account for both emissions and sinks from land use and land-use change. Federal agencies—including USDA and the Departments of Energy, Transportation, and Defense—contribute LULUCF data to the *Inventory*.

EPA reports a LULUCF net sink of 758.9 $MMTCO_2e$ for 2020. This amount is equivalent to about 13% of all U.S. GHG emissions. Most LULUCF sinks are associated with maintaining existing forested land and converting land from other land uses to forested land. Agricultural lands account for a limited share of U.S. carbon sequestration. In 2020, "cropland remaining cropland" (23.3 $MMTCO_2e$) accounted for about 3% of LULUCF net sinks.

Practices That Reduce GHG Emissions

Farming practices that sequester carbon or reduce GHG emissions could play a role in legislation seeking to reduce U.S. GHG emissions. One approach could involve establishing a *carbon offset* or *carbon banking* program (see CRS Report R46956, *Agriculture and Forestry Offsets in Carbon Markets: Background and Selected Issues*). Other options include regulations or tax incentives. In general, converting industrial land to agricultural use or keeping land in agriculture would sequester more carbon than would other land-use types. For existing agricultural land, practices to increase carbon sequestration may include retiring or restoring land, converting it to forested land, and using conservation tillage and other practices that increase biomass in soils. Maintaining these actions is a challenge; stored carbon may be released if practices change.

Practices in animal agriculture to reduce GHG emissions include improved feed efficiency and manure management. Some livestock feed can reduce CH_4 emissions from enteric fermentation and increase productivity. Manure management systems can reduce the CH_4 that is released into the atmosphere when manure is collected in uncovered lagoons and can use the captured CH_4 as an energy source. Anaerobic digesters installed to manage manure and capture and use CH_4 are often part of nonfederal voluntary and compliance carbon offset programs.

Scientific research continues to investigate agricultural practices that may increase sinks and reduce emissions. Voluntary and state programs have applied and illustrated potential GHG emission reductions. Current research topics related to sinks include improving estimates of (1) carbon storage in soils and (2) the effects of different management practices on carbon sequestration. Topics related to reducing sources include improving manure management technology and livestock genetics and feed efficiency. (Note: This In Focus was originally authored by Genevieve K. Croft, former CRS Specialist in Agricultural Policy.)

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