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Greenhouse Gas Emissions and Sinks in U.S. Agriculture

Agriculture and land-use activities have played a central role in the broader debate on energy and climate policy options in the U.S. and abroad. Although most federal legislative proposals to reduce net U.S. greenhouse gas (GHG) emissions would not require reductions in the agriculture sector, some would incentivize voluntary actions. For example, legislation considered by a previous Congress would have established a separate carbon offset program, with tradeable credits, for domestic agriculture and forestry practices that reduce or *sequester* (store) carbon. Some proposed carbon tax legislation would finance activities in the agriculture sector that support these objectives with a portion of the new tax revenue.

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 sequester 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.

U.S. GHG Inventory

Since the early 1990s, the U.S. Environmental Protection Agency (EPA) has prepared an annual *Inventory of U.S. Greenhouse Gas Emissions and Sinks*. Federal agencies, including the U.S. Department of Agriculture (USDA), contribute data and analyses. The *Inventory* reports GHG estimates by sector, source, and GHG type.

The *Inventory* expresses GHG estimates in terms of CO_2-equivalents, aggregated to millions of metric tons ($MMTCO_2$-Eq.). 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.

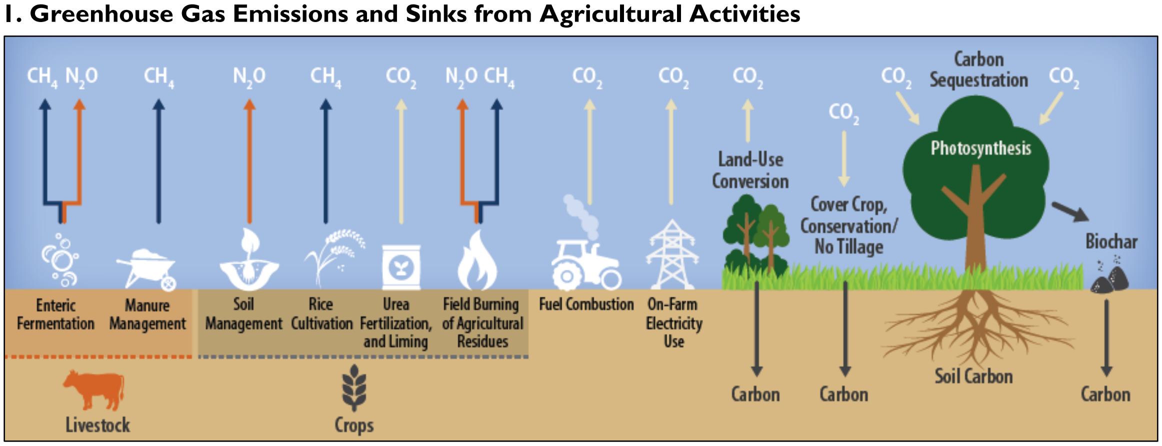
The *Inventory* presents GHG estimates for two types of sector classifications. One classification follows international standards. Every country preparing its national inventory considers the same GHG sources and sinks for the same standard sectors. These include an agriculture sector and a *land-use, land-use change and forestry* (LULUCF) sector. The *Inventory* also reports estimates for several EPA-defined economic sectors, including agriculture, transportation, electric power industry, industry, commercial, and residential. Under this format, the agriculture sector includes emissions from fuel-combustion by farm equipment (e.g., tractors) as well as the emission sources already accounted for in the international standard sector for agriculture. This document focuses on the emissions from the agriculture sector, as defined by EPA, and the most recent data available (from 2017).

Agricultural GHG Emissions

EPA reports that agriculture sector emissions totaled 582.1 $MMTCO_2$-Eq. in 2017 (**Table 1**), equal to 9.0% 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:

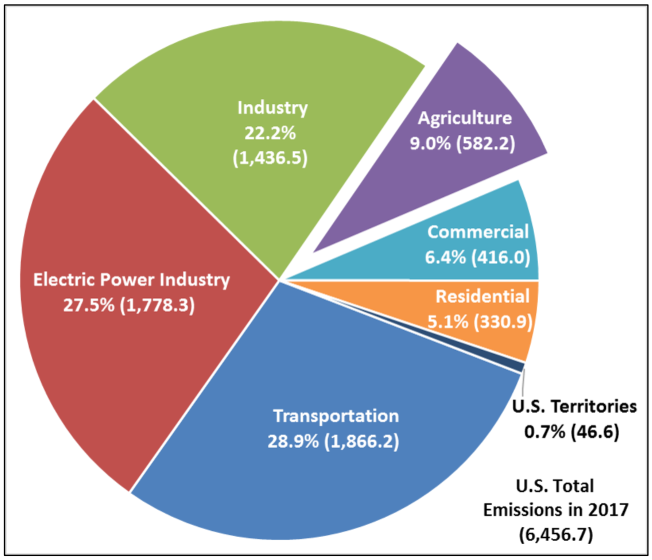
- Potentially offsetting agricultural sinks.
- Forestry activities, which are accounted for in LULUCF.
- Emissions from generating the electricity that farms use.
- Emissions from activities in the food system more broadly, such as production of agricultural inputs and post-harvest transportation and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

Figure 1. Greenhouse Gas Emissions and Sinks from Agricultural Activities



Source: CRS. **Note:** *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*, 2017 data.

Notes: Emissions, in $MMTCO_2$-Eq., are presented in parentheses.

In 2017, three activity types accounted for 90% of U.S. agriculture (economic sector) emissions:

1. **Soil management (46%, 266.4 $MMTCO_2$-Eq.)**. N_2O emissions from soils, associated with agricultural practices that disturb soils and increase oxidation, releasing emissions into the atmosphere. Associated with fertilization, irrigation, drainage, cultivation and tillage, shifts in land use, and application and/or deposition of livestock manure and other organic materials on cropland and other farmland soils.
2. **Enteric fermentation (30%, 175.4 $MMTCO_2$-Eq.)**. 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 (14%, 80.4 $MMTCO_2$-Eq.)**. 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, or pits).

Agricultural emissions were higher in 2017 compared with 1990 but were lower than in 2010 (**Table 1**).

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

Emissions by Gas (Activity)	1990	2000	2010	2017
Total, Ag. Econ. Sector	**534.9**	**550.4**	**593.7**	**582.2**
N_2O (soil and manure mgmt.)	265.7	264.5	292.4	285.2
CH_4 (enteric ferment., manure mgmt., rice cultivation)	217.4	237.8	245.7	248.7
CO_2 (urea fertilization, liming)	7.1	7.5	8.6	8.2
CO_2, CH_4, and N_2O (fuel use)	44.6	40.4	47.1	40.0
Total Ag. w/Electricity-Related	**569.9**	**592.3**	**634.3**	**620.9**
CO_2, N_2O, SF_6 (electric.-rel.)	35.1	41.9	40.6	38.7
Tot. Emissions, All Sectors	**6,371.0**	**7,232.0**	**6,938.6**	**6,456.7**

Source: CRS from *EPA Inventory* (emissions in $MMTCO_2$-Eq.).

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 biological 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). The *Inventory* accounts for U.S. GHG sinks in the LULUCF sector. LULUCF net sinks account for both emissions and sinks from land use and land-use change, thus reflecting net changes in stored carbon. 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 714.1 $MMTCO_2$-Eq. for 2017. The magnitude of this net sink is equivalent to about 11% 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 2017, "cropland remaining cropland" (10.3 $MMTCO_2$-Eq.) accounted for about 1.4% of LULUCF net sinks, a decrease from about 5.0% in 1990.

Practices That Counter GHG Emissions

Farming practices that sequester carbon or reduce GHG emissions could play a role in legislative proposals seeking to reduce U.S. GHG emissions. One approach could involve establishing a *carbon offset* or *carbon banking* program. Other options include regulations or tax incentives. In general, converting industrial land to agricultural use, or keeping land in agriculture, would sequester more carbon in the soil than would other types of industrial, commercial, or residential land uses. For existing agricultural land, practices to increase carbon sequestration may include retiring or restoring land, converting it to forested land, using conservation tillage and other practices that increase biomass retention in soils or reduce soil disturbance, and installing vegetative windbreaks.

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 also 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 for energy. Anaerobic digesters installed to manage manure and capture and use the CH_4 emissions are often part of non-federal voluntary and compliance carbon offset programs.

Scientific research continues to investigate agricultural practices to increase sinks and reduce emissions. Voluntary and state programs have applied and documented 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 livestock genetics and feed efficiency and manure management technology.

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