USDA GLOBAL CHANGE FACT SHEET

Greenhouse Gas Emissions and Agriculture and Forestry

The global concentration of greenhouse gases in the atmosphere has increased measurably over the past 250 years, partly due to land use activities such as agriculture and forestry. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions have increased by roughly 31%, 131%, and 17%, respectively, since 1750. Agriculture and forestry practices have contributed to trends in emissions of these greenhouse gases through fuel consumption, land use conversions, cultivation and fertilization of soils, production of ruminant livestock, and management of livestock manure. Land management activities have also helped to offset greenhouse gas emissions by promoting the biological uptake of carbon dioxide through the incorporation of carbon into plant biomass and soils.

Global Sources of Greenhouse Gases from Agriculture and Forestry

The majority of the observed increase in carbon dioxide emissions is a result of fossil fuel combustion. The contribution of agriculture and forestry to fossil fuel combustion is minimal. However, agriculture and forestry play an important role in land use conversions, which is the second largest cause of increased carbon dioxide emissions. Land clearing (deforestation or removal of native vegetation) and forest burning are the primary land use conversions that contribute to global carbon dioxide losses. Often these practices take place to clear land for cultivation or for grazing. The result is the decomposition and combustion of biomass, causing carbon dioxide to be released to the atmosphere, and cultivation of cleared lands, causing in increased rates of decomposition of organic carbon in soils. The net effect is carbon losses from both biomass and soils.

Over half of global annual methane emissions and roughly a third of global nitrous oxide emissions are believed to derive from human sources. Agricultural practices contribute to these human-induced emissions in a number of ways. Agricultural soil management is a primary source of human-induced nitrous oxide emissions. While losses of nitrous oxide to the atmosphere occur naturally as a result of the soil nitrogen cycle, the application of additional nitrogen to amend soil fertility can increase the rate of emissions. The rate is amplified when more nitrogen is applied than can be used by the plants, which is often the case. Nitrogen is added to soils through the addition of mineral fertilizers, application of manure, cultivation of nitrogen-fixing crops (e.g., legumes), and retention of crop residues.

Additional agricultural practices involving crop cultivation and livestock production result in greenhouse gas emissions. For example, rice cultivation requires periodic flooding of rice paddies, which promotes anaerobic decomposition of carbon and results in methane emissions. Burning of residues in agricultural fields produces methane and nitrous oxide as by-products of combustion. Ruminant livestock such as cattle, sheep, goats, buffalo, and camels emit methane as a byproduct of their digestive processes (called “enteric fermentation”). Livestock manure

can also contribute to both methane and nitrous oxide emissions through the biological breakdown of organic carbon and nitrogen contained in manure; the magnitude of emissions depends on manure management practices.

Global Sinks of Carbon Dioxide through Land Management

While agricultural practices result in greenhouse gas emissions, land management can promote the up-take of carbon in plant biomass and soils. The net flux of carbon dioxide between the land and the atmosphere is a balance between carbon losses from land use conversion and regrowth of trees on abandoned agricultural lands as well as carbon sequestration in soils. Forest management practices such as manual thinning promote tree growth and result in additional carbon accumulation in biomass. In addition, wood products harvested from forests can serve as long-term carbon storage pools, at least until the wood material decomposes. Agricultural practices such as conservation tillage and rangeland practices such as rotational grazing can reduce carbon losses as well.

U.S. Emissions and Sinks in Agriculture and Forestry

National greenhouse gas emissions estimates are prepared each year by the U.S. EPA and submitted to the United Nations Framework Convention on Climate Change. Total U.S. greenhouse gas emissions for 2000, were estimated at roughly 7,000 teragrams of CO_2 equivalants ($TgCO_2$ eq.), representing an increase of 14% since 1990. Greenhouse gas emissions from agriculture and carbon fluxes from land-use change and forestry are estimated each year in the report. In 2000, agricultural practices, excluding fuel consumption, were responsible for about 7% of all greenhouse gas emissions in the U.S. (485 $TgCO_2$ eq.). However, land use and forestry practices offset total U.S. emissions by 12%, sequestering roughly 838 $TgCO_2$ eq. in forest biomass and soils, harvested wood products, and agricultural soils. Urban trees were estimated to sequester an additional 59 $TgCO_2$ eq..

Emissions and sequestration by agriculture and forestry sources and sinks are summarized in Tables 1 and 2. The relative contribution of different agricultural sources to total agricultural emissions is shown in Figure 1. The primary agricultural source of greenhouse gas emissions is nitrous oxide from agricultural soil management (e.g., fertilizer inputs, nitrogen-fixing crops, and crop residues). The relative contribution of agriculture and forestry sinks to carbon dioxide offsets is shown in Figure 2. Forest management contributes by far the most to carbon sequestration.

Agricultural machinery contributes a small proportion of overall U.S. emissions from fossil fuels. In 2000, less than two percent of total U.S. emissions from transportation-related fossil fuel combustion were attributed to farm vehicles. Diesel was the primary fuel consumed by agricultural vehicles resulting in emissions of 25 $TgCO_2$ eq., while emissions from motor fuel use in farm vehicles were estimated at 6 $TgCO_2$ eq.. Total transportation-related carbon dioxide emissions were about 1,790 $TgCO_2$ eq.. Emissions of methane and nitrous oxide emissions from on-farm consumption of fossil fuels were negligible.

Sources

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Table 1: U.S. Greenhouse Gas Emissions from Agriculture ($TgCO_2$ eq.)

Gas/Source	1990	1995	1996	1997	1998	1999	2000
CH_4	**164.9**	**176.2**	**171.5**	**170.9**	**171.6**	**171.1**	**169.6**
Enteric fermentation	127.9	133.2	129.6	126.8	124.9	124.5	123.9
Manure management	29.2	34.8	34.2	35.8	38.0	3706	37.5
Rice cultivation	7.1	7.6	7.0	7.5	7.9	8.3	7.5
Residue burning	0.7	0.7	0.7	0.8	0.8	0.8	0.8
N_2O	**283.5**	**300.2**	**309.8**	**315.0**	**316.0**	**313.9**	**315.5**
Ag. soil management	267.1	283.4	292.6	297.5	298.4	296.3	297.6
Manure management	16.0	16.4	16.8	17.1	17.1	17.1	17.5
Residue burning	0.4	0.4	0.4	0.4	0.5	0.4	0.5
Total	**448.4**	**476.4**	**481.3**	**485.9**	**487.6**	**485.0**	**485.1**

Source: EPA 2001, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000

Table 2: U.S. Carbon Sinks in Agriculture and Forestry ($TgCO_2$ eq.)
(Parentheses indicate carbon sequestration)

Carbon Stock	1990	1995	1996	1997	1998	1999	2000
Forests	(773.7)	(773.7)	(773.7)	(546.3)	(546.3)	(546.3)	(546.3)
Harvested Wood	(209.0)	(205.3)	(205.3)	(212.7)	(205.3)	(216.3)	(223.7)
Urban Trees	(58.7)	(58.7)	(58.7)	(58.7)	(58.7)	(58.7)	(58.7)
Agricultural Soils	(37.3)	(60.2)	(60.2)	(60.4)	(67.2)	(67.7)	(67.4)
Total	**(1078.7)**	**(1097.9)**	**(1097.9)**	**(878.1)**	**(877.5)**	**(889.0)**	**(896.1)**

Source: EPA 2001, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000

Figure 1:
Relative Contribution of Agricultural Sources to Total U.S. Agricultural Emissions in 2000

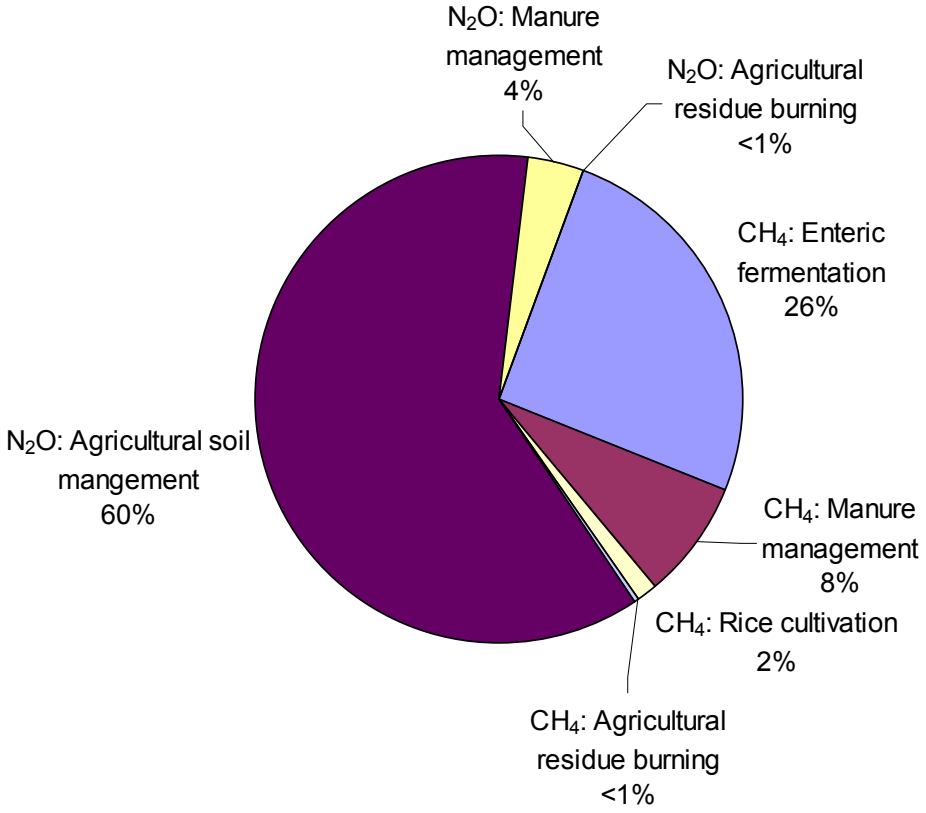

Figure 2:
Relative Contribution of Sinks to Total U.S. Agriculture and Forest Carbon Sequestration