

methane emission rate of forage-based diets. Edible oils can increase feed efficiency with less methane output. Ionophores reduce the number of bacteria that produce methane in the rumen.

- ◆ **Improve the reproductive performance** of cows and decrease calf mortality rates.
- ◆ **Select genetics** that maximize feed efficiency, increase fertility, and improve overall herd health.
- ◆ **Properly store and handle manure** by using covered lagoons that prevent methane and other gases from escaping into the atmosphere. These gases can then be used for power generation on the farm.
- ◆ **Use on-farm energy generation** from biogas and anaerobic digestion technologies.
- ◆ **Improve on-farm energy efficiency** in barns, engines, pumps, and tractors.

How does US agriculture compare to other countries in regard to GHGs?

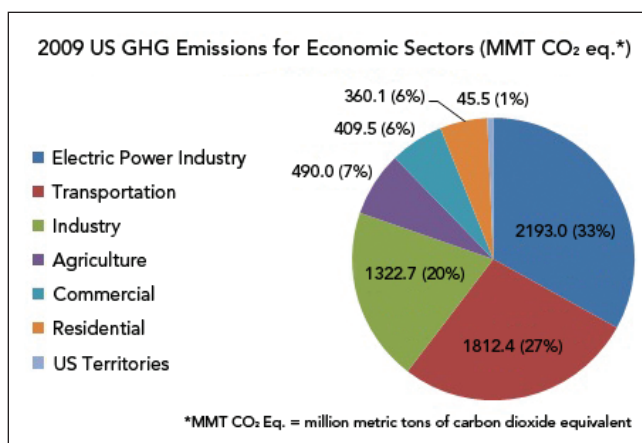
Emissions caused by human activity are called **anthropogenic** emissions. According to the Intergovernmental Panel on Climate Change, agricultural practices in all countries account for 18 percent of the total anthropogenic GHG emissions. This estimate includes the loss of carbon dioxide from deforestation and land use changes in developing countries.

How does agriculture compare to other US economic sectors?

In the United States, agriculture emits about 7 percent of the total anthropogenic US GHG emissions (or the equivalent of 490 million metric tons of carbon dioxide). Electric power, transportation, and industry account for 33 percent, 27 percent, and 20 percent, respectively. Since 1990, agricultural GHG concentrations have increased about 9 percent.

What portion of agricultural GHG emissions originates from animal operations?

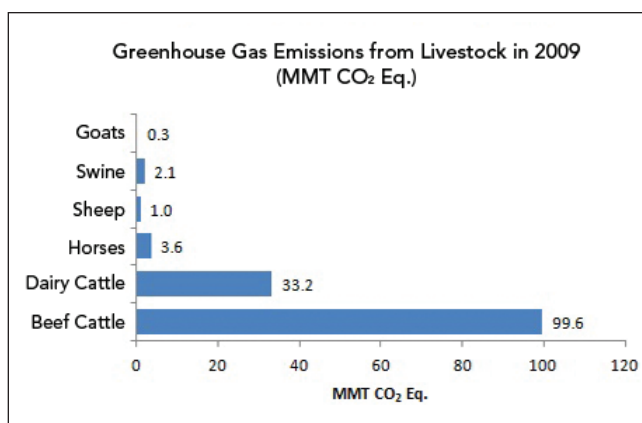
The total agricultural GHG emission includes emissions from both crop and animal production activities, including land management. Environmen-



tal Protection Agency (EPA) data indicate that **only about 3 percent of agricultural GHG emissions in the US are caused by animal agriculture**. However, because crop and animal production systems are closely integrated and dependent upon one another, it is difficult to attribute GHG emissions with certainty.

There are also significant differences in GHG emissions between livestock production systems. The following graph shows that, in 2009, beef cattle led all livestock production sectors in GHG emissions with nearly 100 million metric tons (MMT) of carbon dioxide equivalent (3 times that of dairy cattle, the next highest livestock sector).

GHG emissions also vary significantly within species. For example, beef cattle production varies in degree and density from open range to confined animal operations. And, manure storage, handling, and disposal practices vary among species, within species, and within regions. This makes it particularly difficult to estimate GHG emissions for livestock operations in the US.



What are the most important GHGs from animal agriculture? Where do they come from?

The most important GHGs from animal agriculture are methane and nitrous oxide. These are among the more potent GHGs: one molecule of methane will trap 21 times more heat than carbon dioxide, while one molecule of nitrous oxide will trap 310 times more heat than carbon dioxide.

No two agriculture operations are the same. However, most GHG emissions result from animal digestion and waste as well as land fertilization. The diversity of farms and ranches makes it difficult to accurately attribute GHG emissions to specific practices.

Methane—Enteric fermentation produces methane as a natural part of digestion in ruminant animals. It accounts for 33 percent of the total GHG emissions in agriculture and 71 percent of all agricultural sources of methane. Activities related to the **storage and land application of manure** release 12 percent of the total agricultural methane emissions, and represent 25 percent of all agricultural sources of methane. Other significant sources on farms and ranches include rice cultivation and the burning of agricultural residues.

Nitrous Oxide—Soil management activities are the greatest source of nitrous oxide emissions in agriculture. Nitrous oxide is released in soils after the application of synthetic and organic fertilizers (in-

cluding manure) and emitted from manure in bedded packs (a mixture of wood shavings or kiln-dried sawdust and manure on the pen floor that provides a comfortable surface for cows to lie on) and lots. Nearly 53 percent of agricultural GHG emissions are from nitrous oxide. Ninety-two percent of nitrous oxide is from agricultural soil management. Other significant sources include manure management and the burning of agricultural residues.

Table 1 gives the total amount of agricultural GHG emissions expressed as carbon dioxide equivalents in million metric tons. Overall, methane emissions from enteric fermentation fluctuated from 1990 to 2009, primarily as a function of beef and dairy cattle populations and feed digestibility. During this same period, total GHG emissions from manure management increased 46 percent (a 56 percent increase for methane and a 23 percent increase for nitrous oxide). The majority of this increase is due to the increased use of liquid manure management systems, which tend to produce more methane emissions in swine and dairy operations.

The degree to which human activities, including animal agriculture production, contributes to climate change is largely unknown. However, efforts are underway to identify all major sources of GHGs to determine strategies aimed at reducing these emissions. While animal agriculture contributes only a small amount (about 3 percent) of all GHG emissions, producers should know the issues and consider alternatives to reduce their overall carbon footprint.

Table 1. Emissions from Agriculture (MMT CO₂ Eq.)¹

GHG and Source	1990	2000	2005	2006	2007	2008	2009	% Increase
Methane (CH₄)	171.2	186.7	190.1	191.7	198.2	197.5	196.8	15.0
Enteric fermentation	132.1	136.5	136.5	138.8	141.0	140.6	139.8	5.8
Manure management	31.7	42.4	46.6	46.7	50.7	49.4	49.5	56.2
Rice cultivation	7.1	7.5	6.8	5.9	6.2	7.2	7.3	2.8
Field burning of agricultural residues	0.3	0.3	0.2	0.2	0.2	0.3	0.2	-33.3
Nitrous Oxide (N₂O)	212.4	224.0	228.7	227.1	227.6	228.8	222.5	4.8
Agricultural soil management	197.8	206.8	211.3	208.9	209.4	210.7	204.6	3.4
Manure management	14.5	17.1	17.3	18.0	18.1	17.9	17.9	23.4
Field burning of agricultural residues	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Totals:	383.6	410.6	418.8	418.8	425.8	426.3	419.3	9.3

¹MMT CO₂ Eq. = million metric tons of carbon dioxide equivalent
Source: EPA

Key terms

Anaerobic digestion—A series of processes in which microorganisms break down biodegradable material (such as animal waste) in the absence of oxygen. On the farm, this process can produce heat for animal facilities or energy to power engines.

Anthropogenic—Relating to or influenced by human activity.

Biogas—A gas produced by the anaerobic digestion or fermentation of biodegradable materials such as animal manure, plant material, and crops comprised primarily of methane and carbon dioxide. The burning of biogas can be done on-farm as an alternative energy source.

Carbon footprint—The total amount of greenhouse gases emitted in terms of carbon dioxide equivalents (or CO₂ Eq).

Enteric fermentation—A digestive process that occurs in ruminant animals (such as cows, sheep, and goats) where methane is produced as a natural by-product of microbial fermentation.

Greenhouse effect—The process whereby certain gases in the atmosphere absorb heat radiated from the Earth, thus moderating atmospheric temperature. Without the greenhouse effect, the average temperature on Earth would be about 0°F and life as we know it would not exist.

Greenhouse gas—A gas (including water vapor, carbon dioxide, methane, and nitrous oxide) that absorbs heat in the atmosphere, causing the “greenhouse effect.”

Methane (CH₄)—A relatively potent GHG, methane absorbs 21 times as much heat as carbon dioxide. Methane is among the most abundant organic compounds on Earth.

Nitrous oxide (N₂O)—A major greenhouse gas and air pollutant, nitrous oxide absorbs 310 times as much heat as carbon dioxide. The livestock sector (primarily chickens, cows, and pigs) produces 65 percent of anthropogenic nitrous oxide emissions.

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