Carbon Footprint of Livestock Production

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Livestock production is being held accountable

Concerns about the climate impact of livestock production and meat consumption produce significant debate among producers, consumers, and scientists. The Food and Agriculture Organization of the United Nations (FAO) announced that 18 percent of human-induced greenhouse gases emissions come from livestock (FAO, 2006). Other research (Pitesky et al., 2009) discredits the FAO estimation and claims the value is based on inappropriate or inaccurate scaling of predictions and does not apply to U.S. production systems. One argument suggests that the FAO report attempts a life-cycle assessment for livestock production but does not use an equally holistic approach for other sectors such as transportation. So, is U.S. livestock production eco-friendly? Producers who value sustainability need to understand current research and gather data about carbon footprint of livestock production and be able to discuss the question.

Greenhouse gas emission trends based on recent EPA and USDA report

Greenhouse gases emitted from livestock production mainly include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The greenhouse gases in the atmosphere can delay heat on the Earth's surface from being lost to space, similar to the effect of the glass walls of a greenhouse ("greenhouse" effect), and contribute to global climate change. Each greenhouse gas (CO_2, CH_4, and N_2O) has a different global warming potential (GWP). The 100-year GWP of CH_4 is 21 times that of CO_2, and the GWP of N_2O is 310 times that of CO_2 (EPA, 2014). It is common practice to combine the total effects of all greenhouse gases using CO_2 equivalent unit (CO_2e). The CO_2 generated by animal breathing is considered to be biogenic in nature, or "carbon neutral" (as contrasted to CO_2 from fossil-fuel combustion, which adds new carbon to the atmospheric-biospheric circulation system), and therefore is often excluded or deferred in accounting for total greenhouse gas emissions.

The U.S. Environmental Protection Agency (EPA) estimated that agriculture was responsible for 8.1 percent of total U.S. greenhouse gas emissions, in which agricultural soil management (N_2O), enteric fermentation (CH_4), and manure management (N_2O+CH_4) represented 4.7 percent, 2.2 percent, and 1.1 percent respectively (Figure 1, data from EPA, 2014). Enteric fermentation and manure management can be directly linked to livestock production. Agricultural soil management activities involve cropping practices and fertilizer application. Crop production and soil management practices may use commercial and manure fertilizer. It is difficult to separate the portion of agricultural soil greenhouse gas

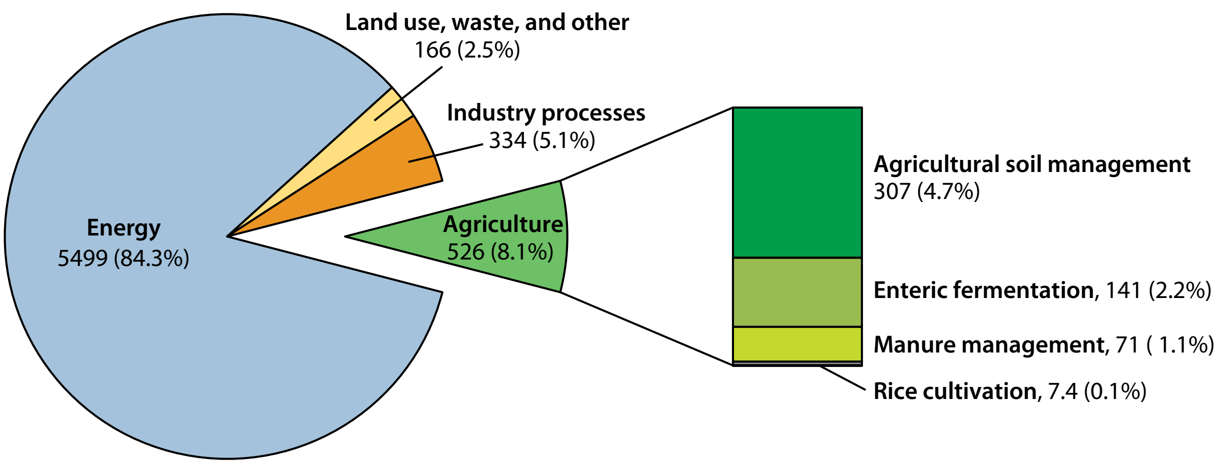

Figure 1. 2012 U.S. GHG emissions in million metric tons CO_2e by sectors (Data from EPA, 2014).

Table 1. Greenhouse gas emission factors for livestock production

	Greenhouse gas emission factors (kg CO_2e/head/year)			
	Enteric fermentation[1]	Manure management[2]		Total
	CH_4	CH_4	N_2O	
Dairy Cattle	2457	1962	435	4854
Beef Cattle	1575	33	97	1705
Horses	378	57	35	470
Sheep	168	12	64	244
Goats	105	7	10	122
Swine	32	302	30	364
Poultry	-	1.3	0.8	2.1

[1] Dairy and beef cattle emission factors were calculated based on net energy estimates, feed characteristics and the CH_4 conversion factor for 2012 from EPA (2014); others are default emission factors from IPCC (2006). [2] Calculated from total U.S. emissions and livestock population for 2012 from EPA (2014).

emissions that can be attributed to livestock production when manure is applied to soil.

Beef and dairy cattle remain the major contributors of CH_4 emissions from enteric fermentation, accounting for 71 percent and 25 percent respectively, in 2012; the remaining emissions were from horses, sheep, swine, goats, American bison, mules, and asses (EPA, 2014). Emissions from enteric fermentation generally follow trends in cattle population, while emission factors per unit of product are going down.

From 1990 to 2012, beef cattle emissions increased only 0.6 percent while beef production increased 14 percent; dairy emissions increased only 6 percent while milk production increased 36 percent (USDA, 2013).

For greenhouse gas emissions from manure management, dairy cattle are considered the largest contributor (46.7 percent), followed by swine (31.2 percent), beef cattle (15 percent), and poultry (6.1 percent) (EPA, 2014). The shift toward larger facilities in both dairy and swine industries has resulted in an increased use of liquid manure systems, which have higher potential CH_4 emissions than dry systems (EPA, 2014).

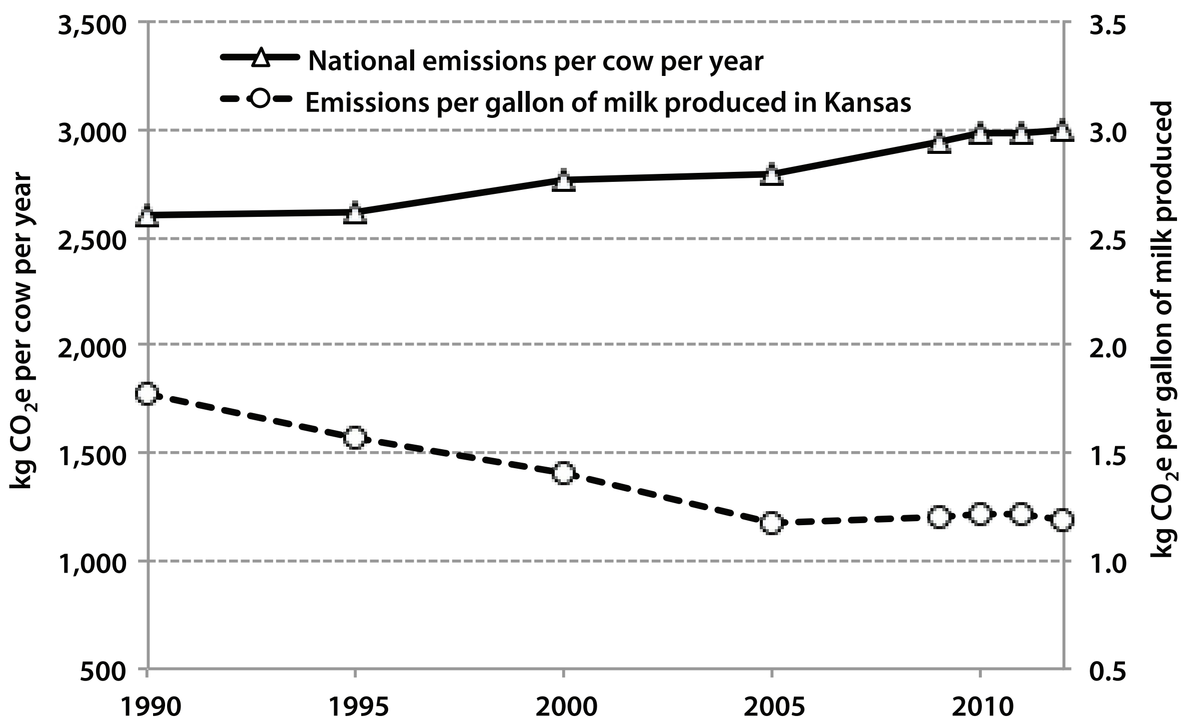

Figure 2. Greenhouse gas emission factors for dairy cow enteric fermentation in Kansas from 1990 to 2012 (Data is adapted from EPA, 2014 and USDA, 2013).

Table 2. Comparison of carbon footprints of various activities

Activities	Carbon footprint	Reference
Consuming 1 gallon of milk	8 kg (17.6 lb) CO_2e	Thoma et al., 2013
Driving a car and consuming 1 gallon of gasoline	9 kg (20 lb) CO_2e	Walser, 2013
Consuming 1 kWh electricity generated from coal	0.9 kg (2 lb) CO_2e	WNA, 2011

Emission factors

Emission factors that measure greenhouse gas emissions per head of animal per year can be used to develop emission inventories and to compare emissions from different categories (Table 1). Emission factors for enteric fermentation are based on average annual conditions on net energy estimates and feed characteristics, while emission factors for manure management are mainly dependent on how the manure is managed or the manure distribution among different waste management systems. The CH_4 conversion factors for liquid manure systems are much larger than that for dry manure system (e.g. 50 to 80 percent for anaerobic lagoon vs. 2 to 5 percent for dry manure, solid storage, IPCC, 2006).

A positive measurement to evaluate livestock-related greenhouse gas emissions considers emission factors per unit of production (e.g. per gallon of milk produced) instead of per animal head. Because of improved productivity, the emission factors per gallon of milk produced from dairy cow enteric fermentation have declined in the last two decades, although the emission factors per cow had a tendency to increase. From 1990 to 2012, the dairy lactation rates in Kansas increased by 72 percent from 12,576 to 21,675 lb/year/cow (USDA, 2013). As a result, the emission factors per gallon of milk produced from dairy cow enteric fermentation in Kansas declined by 33 percent, from 1.8 to 1.2 kg CO_2e per gallon of milk produced (Figure 2).

The concept of carbon footprint

A carbon footprint is a measure of the impact of a product or activity on the environment, and in particular climate change. The carbon footprint considers the total greenhouse gas emissions caused directly and indirectly by the product or activity. The carbon footprint for livestock products should include not only direct emissions on the farm (i.e. enteric fermentation and manure management, which have been summarized above), but also indirect emissions for the whole lifecycle of livestock products in the crop production fields for livestock feeding; on the road to market; in the processing plant; through packaging, distribution, and retail of the products; all the way to the purchase and disposal of the package by the consumer. The dairy industry might be the most well-defined livestock production system to date. In 2010, the University of Arkansas Applied Sustainability Center completed the first national carbon footprint study of fluid milk through life cycle analysis (LCA). The study collected data from more than 536 farms and 50 processing plants, and analyzed more than 200,000 transportation trips from 2007 to 2008. According to the study, the carbon footprint of milk, from farm to table, is 8.0 kg (17.6 lb) CO_2e per gallon of milk consumed, which accounted for loss of 12 percent at retail and an additional 20 percent loss at consumption (Thoma et al., 2013). While the largest greenhouse gas contributors are feed production and milk production, there are opportunities to reduce carbon impacts throughout the supply chain (Figure 3).

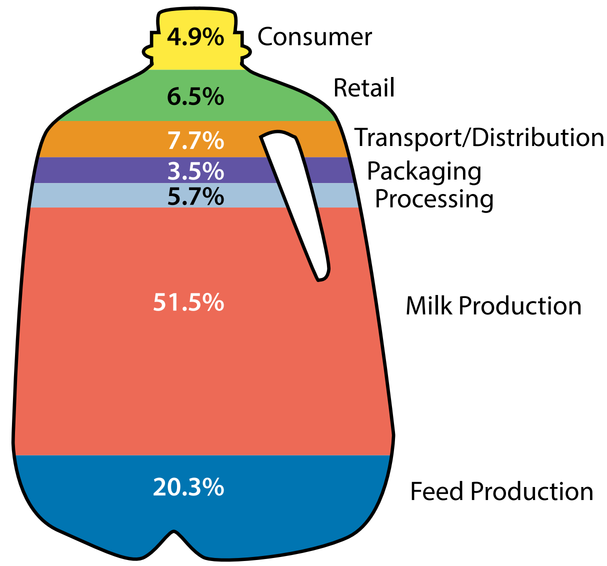

Figure 3. Carbon footprint of U.S. fluid milk: contribution by supply chain. Note that emissions from enteric fermentation and manure management are included in the milk production stage; emissions from fuels, fertilizer, and milling are included in the feed stage. (Source: Innovation Center for U.S. Dairy, 2013)

Carbon footprints of various activities are compared in Table 2. The table indicates that the carbon footprint of consuming 1 gallon of milk is comparable with that of burning 1 gallon of gasoline, or consuming 9 kWh electricity generated from coal.

What can livestock producers do to reduce carbon footprint?

Environmental stewardship is a critical responsibility of livestock production. Productivity is a contributing factor in reducing carbon footprint per unit of product. Practices and technologies that increase production efficiency conserve resources and improve environmental stewardship. While there is opportunity to reduce carbon impacts throughout the entire supply chain, livestock producers need to use energy efficiently and invest in environmental improvements to reduce their carbon footprint. The following on-farm carbon reduction strategies have been recommended, but improving feed efficiency and manure management represent the greatest opportunities.

- Improve cropping practices and technology.
  - Efficient use of cropland.
- Improve animal productivity.
  - Produce more meat, milk, and eggs, from less input.
  - Select genetics that improve overall herd health, increase fertility, and maximize feed efficiency; improve the reproductive performance and decrease mortality rates.
- Improve feed efficiency.
  - Use highly digestible feed, consider dietary supplements and additives to increase efficiency and reduce emissions.
  - Improve nutrition through ration balancing and feeding management.
- Improve manure management.
  - Properly store and handle manure, e.g. using covered lagoons or composting.
  - Reduce energy input and produce renewable energy by capturing biogases from manure through digesters.
  - Properly apply manure to agricultural land and replace chemical fertilizers.
- Improve on-farm energy efficiency.

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