Cornell University
Cooperative Extension

Agronomy Fact Sheet Series Fact Sheet #119

Farm Greenhouse Gas (GHG) Inventory

Introduction

Greenhouse gases (GHGs) contribute to warming of the earth's atmosphere and can be released from both natural and anthropogenic (human) activities. Because GHGs accumulate in the atmosphere, they contribute to rising temperatures and more frequent occurrence of extreme weather events. This factsheet describes the main sources of GHGs from dairy farm activities, carbon sequestration as a way to reduce emissions, and the role of software tools for GHG inventory assessments for dairy.

Greenhouse Gases and CO_2e

The three main GHGs from dairy farms are: carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). To account for differences in potency to warm the atmosphere, each GHG is assigned a global warming potential (GWP). Inventories can differ in what is used as GWP. New York law has chosen to use the "20-year GWP", established by the Intergovernmental Panel on Climate Change (IPCC), where CH_4 is 84 times more potent than CO_2 and N_2O is 264 times more potent than CO_2 (which has a value of 1). The GWP of each GHG is expressed as "carbon dioxide equivalent" or CO_2e, because the other gases are compared to CO_2. To convert from a ton of CH_4 to ton of CO_2e, simply multiply by 84.

Major Emissions sources from Dairy Farms

Dairy farms are a large source of CH_4, mostly from enteric emissions from the cows themselves, and from manure management (Figure 1). Therefore, these areas are the primary target for reducing CH_4 emissions with milk production efficiency and manure management.

Carbon Sequestration

Carbon can be captured from the atmosphere and added to soil or trees in a process called carbon sequestration. When this process is not easily reversible, it can reduce carbon in the atmosphere and hence reduce the farm's GHG footprint. A good example of more permanent carbon sequestration is carbon stored in a tree for 100 years which is then used as building material for another 200 years. Improving soil carbon storage through soil health practices is less permanent but important too as it can increase soil fertility, improve water storage during drought, as well as increase infiltration and reduce erosion during extreme precipitation events. Soil health activities that help farms adapt to extreme weather include reduced tillage and planting cover crops to increase soil organic matter, or having woody habitats such as hedgerows, riparian buffers or forest surrounding production fields.

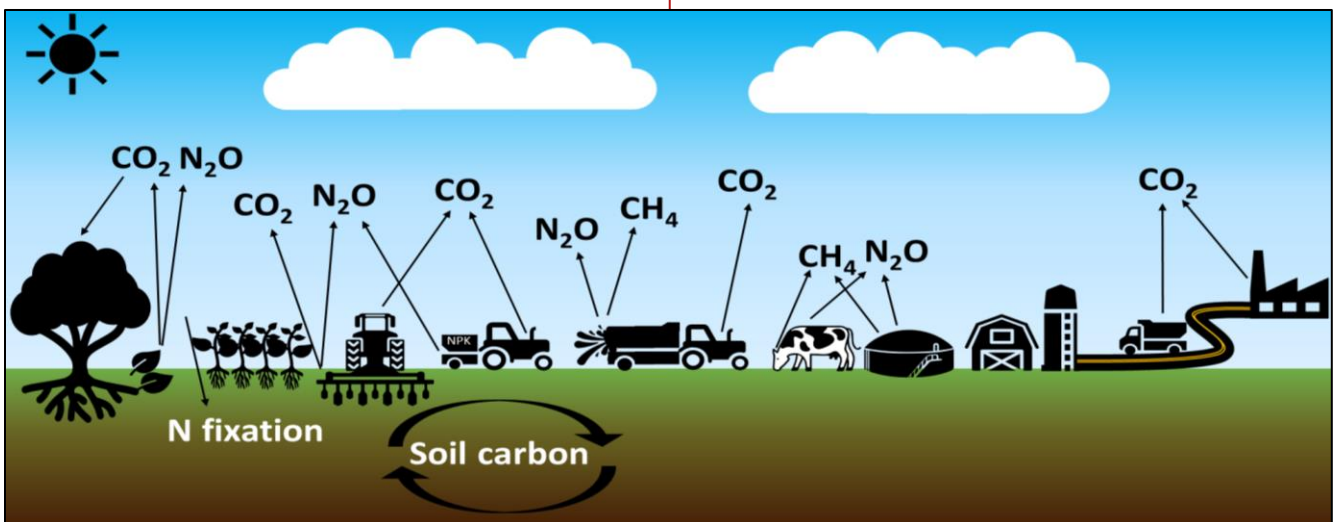

Figure 1: The main sources and potential sinks of greenhouse gases (GHGs) used to calculate the carbon footprint on a dairy farm. These include carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

GHG Inventory of Dairy Farms

A farm's GHG inventory (also referred to as footprint) is determined by adding all GHGs emitted from the farm (on a CO_2e basis) and subtracting the carbon sequestered by systems that store carbon for a long time such as forests.

A first step in calculating GHG emissions is to set the boundary of the assessment. A dairy inventory includes emissions and sequestration resulting from all activities on the farm, including crop production, grazing of animals, feeding of animals, manure storage and treatment, and energy and fuel use associated with these activities, and may or may not include the "upstream emissions" which come from the production and transport of products such as feed and fertilizer imported onto the farm. Once a product (such as milk or a crop) leaves the farm, the emissions are the responsibility of the next stakeholder in the supply chain.

Looking at on-farm GHG emissions from agriculture in the United States (which is estimated at 10% of the total emissions), 58% are from N_2O, 41% from CH_4 and 1% from CO_2 (Figure 2).

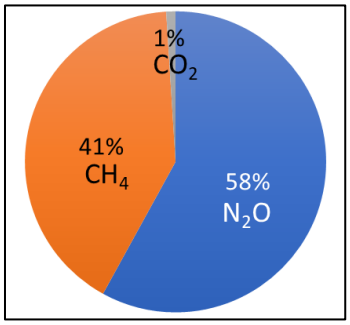

Figure 2: U.S. Agricultural greenhouse gas emissions according to the U.S. Annual Greenhouse Gas Inventory for 2019 (USEPA 2021). This does not include farm energy use.

Feed production, manure management and enteric fermentation from cows are the major sources of CH_4 and N_2O on a dairy. Farms can improve their inventory by improving milk production efficiency, reducing methane from manure storage and improving nitrogen use efficiency. Additionally, carbon sequestration by improved management of woodlands can lower the inventory.

Inventories can be reported per unit of fat and protein corrected milk (FPCM; volume basis), per animal, per unit of land area for crops, and per farm. For the overall GHG inventory of the dairy industry, total emissions need to be taken into account.

GHG Inventory Assessment Tools

Modeling tools are needed to estimate a farm's GHG emissions and monitor impact of management changes and progress made over time. Various tools exist, ranging in scope and complexity. For dairy farms, a whole farm tool should capture both field and animal processes and on-farm management practices. Simpler models that aim to do this apply a multiplication factor to each of the practices on the farm to estimate whole farm GHG emissions and carbon sequestration. These models, called emission factor or empirical models, capture conditions for a farm and allow for running of simple scenarios to guide management decisions. However, these models do not typically account for external influences such as weather and they do not allow for use of more detailed dietary or field management information. Process or simulation models are more complex and require greater data input. Although process models are often impractical for farms to run, they are useful research tools that can guide development of beneficial management practices for the farm. All tools will need to be evaluated prior to adoption, to ensure that input data are relevant to local farming practices and output is consistent with local emission data.

In Summary

The three main greenhouse gases from dairy farms are CO_2, N_2O, and CH_4. Estimating GHG inventories for farms can help identify opportunities for reducing emissions.

Additional Resources

- Intergovernmental Panel on Climate Change (IPCC). https://www.ipcc.ch/.
- Natural and Working Lands. https://blogs.cornell.edu/workinglands/
- USEPA (2021). U.S. Annual Greenhouse Gas Inventory for 2019. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

Disclaimer

This fact sheet reflects the current authors' best effort to interpret a complex body of scientific research, and to translate this into practical management options. Following the guidance provided in this fact sheet does not assure compliance with any applicable law, rule, regulation or standard, or the achievement of discharge levels from agricultural land.

For more information

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