# RECOMMENDATIONS FOR MITIGATING U.S. AGRICULTURAL EMISSIONS

(Tim Searchinger, School of Public & International Affairs,
Princeton University tsearchi@princeton.edu)

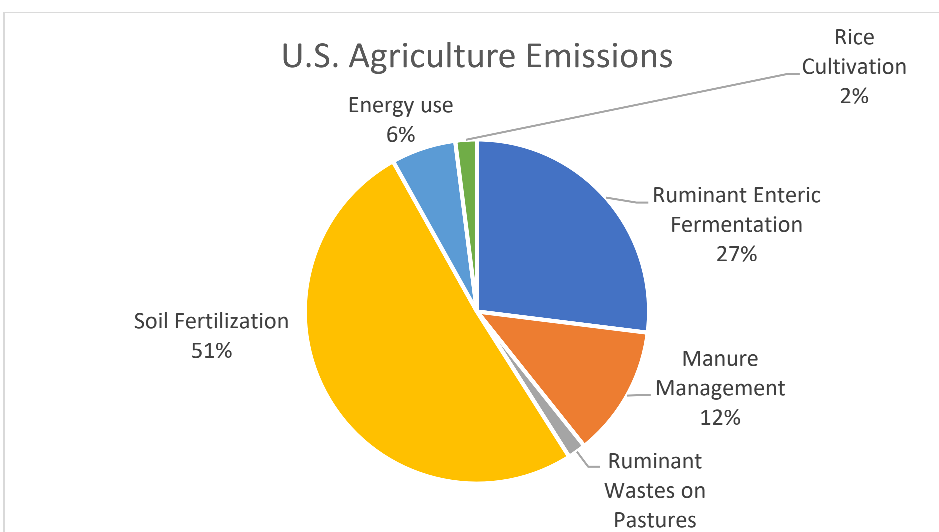
*Based on analysis in the reports: **Creating a Sustainable Food Future** (WRI, World Bank, UNDP, UNEP 2019), and **A Strategy to Make Danish Agriculture Carbon Neutral** (WRI 2021, forthcoming).*

**Summary:** U.S. agriculture is simultaneously climate-efficient and also generates agricultural emissions per person that are among the highest in the world. Agricultural mitigation is equivalent to the energy sector 25 years ago when solar, wind and battery technologies were promising but had yet to demonstrate cost-effectiveness. To reduce both U.S. and global agricultural emissions, the core need is to fund promising innovations through joint projects of farmers and researchers.

**The Challenge**: Emissions associated with U.S. agricultural production in 2018 were officially 670 million tons $CO_2e$, or 10% of U.S. emissions that year. This meaningful percentage still fails to convey the full importance of improvements needed to address climate change.

- The percentage is relatively low because overall U.S. emissions are so high. The same emissions per capita would be 24% of an average European's total emissions and roughly all per capita emissions in sub-Saharan Africa.
- Agricultural production emissions rise to around 12% of U.S. emissions when including emissions from energy used in U.S. agriculture and 14% when also including emissions from land use change related to conversion of native grasslands.
- Vast increases in output of food per agricultural acre are necessary even in the U.S. to meet global increases in food needs without large emissions from deforestation.

**Sources of U.S. Emissions**: The three major categories of U.S. agricultural emissions are (1) "soil management," overwhelmingly nitrous oxide emissions from the various sources of nitrogen in soils, (2) methane from enteric fermentation (mainly cattle digestion), and (3) manure management.



**Importance of Global Leadership**: Emissions from agriculture and associated land use change account for one quarter of global emissions. Because of rising food demands due to global population and income growth, emissions are on a course to grow to 15 gigatons $CO2_e$ by 2050, which would make avoiding dangerous climate change impossible. The world likely needs to increase annual food production from 2020 to 2050 by more than 40% even as it reduces agricultural emissions by two thirds and avoids clearing more land. U.S. leadership is necessary to develop cost-effective innovations to do so.

**Need to Increase Crop Yields and Livestock Feeding Efficiencies and Links to Protection of Forests and Grasslands:** Agriculture occupies half of the world's vegetated land, and this occupation has transferred vast quantities of carbon from native vegetation and soils to the air. Global strategies at a minimum require not expanding this agricultural footprint, and most require reducing agricultural land area so land can be reforested or otherwise help to remove carbon from the air. To avoid expanding land, the likely 40% or increase in food production requires at least a corresponding 40% increase in food production per acre. Food output per acre can increase either through higher crop yields or by reducing the feed required for meat and milk. Improvements in low yield countries are critical but continuing to boost land use efficiencies in high-yield countries like the U.S. is also necessary and requires innovations.

Although increasing yields spares land globally, it can actually encourage conversion locally. Even in the U.S., improvements in some crop varieties have encouraged conversion of native grazing lands to cropland with large releases of carbon. Policies to produce more food therefore also need to be coupled to policies to protect against land conversion.

**Reflecting land use efficiency in climate planning**: How greenhouse gas emissions are counted must reflect the need to increase output per acre. If not, policies may reward changes that reduce emissions by reducing food production and therefore cause more emissions overall through expansion of agricultural land to replace the food. Accounting systems must recognize that using more land to produce the same food also has greenhouse gas costs and using less land has benefits. They must factor in a "carbon opportunity cost of land" in some way so that they reward measures that increase output per acre and do not credit changes that offshore land use or just shift cropland from one part of the U.S. to another.

**Technical Options:** Although some technical options to mitigate U.S. agricultural emissions exist today, the most vital need is to push technological innovations that can mitigate more and at reduced cost. Below are some promising innovations to do so.

*Increasing Crop Yields and Livestock Feeding Efficiencies*: Innovative technical options to increase agricultural yields include several potential crop breeding breakthroughs. Possibilities include improved hybrid wheat, efficiency gains in photosynthesis across multiple crops, innovative crop rotations, and crop varieties and management that achieve and take advantage of a higher share of ammonium in soil nitrogen. Improved grazing systems and breeding livestock to reduce "residual feed intake" can increase feed conversion efficiencies.

*Alternative proteins:* Growing demands for proteins both for animal feed and direct human consumption drive much growth in emissions and land use. More climate-efficient animal feeds include both tree-based oilseeds and novel uses of perennial grasses to generate both quality fodder and protein concentrates. Growing opportunities exist for agriculture to contribute to meat substitutes.

*Reducing Enteric Methane Emissions*: Methane from enteric fermentation (mostly cow burps) account for more than 25% of all GHG emissions from U.S. agricultural production, with nearly ¾ from beef production and ¼ from dairy. Two promising feed additives show potential for sustained reductions in these emissions and may improve overall feed efficiency.

*Improving Manure Management*: Managed manure generates 12% of agricultural production emissions, of which half is from dairy and a third is from swine. Most attention to reducing these emissions has focused on deploying methane digesters, which is an excellent option for some manure systems, but can be too expensive for others. If digesters leak or add crops to the manure to boost gas output, digesters can also increase emissions. Promising additional options include ways of acidifying manure, efficient systems for separating solid and liquid manure fractions and longer run options to turn manure into valuable end products.

*Reducing Nitrogen Emissions*: Roughly half of U.S. agricultural production emissions, and 20% globally, relate to use of nitrogen in fields. Most such emissions are from nitrous oxide, a potent greenhouse gas, and occur both from application of synthetic fertilizer and manure and from recycling of nitrogen within farm fields. To reduce nitrous oxide emissions, strategies must achieve both more efficient application of nitrogen and less conversion of nitrogen to nitrous oxide in soils. In the shorter run, the best options include cover crops, creative uses of "nitrification inhibitors," and precision agricultural methods used to alter the timing and quantity of fertilizer application. Microbes that fix nitrogen and replace some fertilizer show promise. Longer term solutions include biological nitrification inhibition through plant breeding.

*Reducing Agricultural Energy Emissions*: Around 6% of agricultural production emissions in the U.S. result from on-farm fuel consumption. In addition to various conservation strategies, the major opportunity to reduce energy emissions in agricultural production requires non-fossil fuel sources: renewable hydrogen or even more innovative ideas for producing low-carbon nitrogen fertilizer, and alternative fuel sources for tractors and other heavy machinery. Because tractors and fertilizer factories operate for decades once built, transitions need to start soon.

*Stabilizing and Building Soil Carbon*: While agriculture in the U.S. — as elsewhere — is a net source of GHG emissions, farms and pastures also store carbon in vegetation and soils. Carbon stores have decreased throughout modern times. The greatest and most technically certain potential to save soil carbon in the U.S. comes from avoiding the conversion of grasslands to cropland (roughly 140 million tons $CO_2$ per year). Cover crops are the most promising option for building soil carbon. Although somewhat uncertain scientifically, carbon sequestration might reach 80-100 million tons of $CO_2$ per year for many years if used on all physically possible croplands. Roughly 4 percent of U.S. cropland uses cover crops but has reached 40% in Maryland with government support. Programs to advance cover crops should encourage innovations to reduce costs, including improvements in cover crop seeds, planting technology, and economic uses. Improved data collection is also key for all soil carbon efforts.

**Energy production**: U.S. farms offer massive potential to generate wind and solar energy. By one estimate, they could generate $200 billion in lease payments, rural taxes and wages for rural America from 2020 to 2030. Wind and solar will typically produce at least 100 times more useable energy per acre than bioenergy.

**Policy Recommendations**: The guiding principle for climate mitigation should be the advancement of innovative technologies that have the potential to become profitable or cost-effective enough to be widely adopted in the future both in the U.S. and globally.

*Establish goals to reduce the greenhouse gas intensity of different types of agricultural emissions:* Quantitative goals should guide investments. Using intensity targets, such as reduced manure emissions per ton of milk, recognizes the need to produce more food.

*Fund coordinated, innovative projects:* New funding should primarily be directed toward projects that work with multiple farmers, adjust management based on what works, and have the participation of farmers, agronomists and researchers. (Conservation innovation grants provide one model.) Goals should include demonstrating and improving promising technologies. Projects directed at alternative proteins, and innovative measures to boost output per acre should also be eligible

*Establish technical teams*: USDA and EPA should establish technical committees to guide selection of research priorities and coordinated projects. Teams should identify the most promising technical options to reduce each type of emissions, establish and revise technology development plans, improve emission estimates, and monitor progress.

*Expand on-farm renewable energy infrastructure*: As part of its infrastructure initiative, including improved electricity transmission lines, the Administration should identify promising farm locations for wind and solar power, contact local farm groups, and provide grants for coordination of wind and solar power development in target regions.

*Strengthen Sodsaver*: Farm conservation provisions prohibit farm subsidies, including crop insurance, for farming drained wetlands, but they still allow subsidies to flow eventually to those who convert grasslands. Farm subsidies should be denied on any cropland converted in the future from unbroken grasslands or forests, both to reduce emissions in the United States and to be consistent with policies to discourage deforestation in tropical countries.

*Expand funding for AgARPA with a climate direction:* The U.S. should increase funding to $1.5 billion per year for additional research into ways of reducing agricultural greenhouse gas emissions and increasing output per acre.

*Enhance GHG accounting*: The U.S. should adopt accounting methods to guide U.S. decision-making that reflect the carbon opportunity cost of land as well as agricultural production emissions, so mitigation efforts reflect the need to increase output per acre.