innovative policy solutions TO GLOBAL CLIMATE CHANGE
In Brief, Number 2

Agriculture's Role in Addressing Climate Change

Agriculture can make an important contribution to climate change mitigation while providing benefits to both farmers and the general public. Agriculture can reduce the net greenhouse gas (GHG) emissions that cause climate change by:

- **Storing carbon in soils and plants;**
- **Producing fuels and electricity to replace fossil fuels; and**
- **Reducing emissions from livestock operations and agricultural lands.**

Options for encouraging these activities include:

- **Legislation that simplifies, broadens and harmonizes farm programs and promotes environmentally friendly practices;**
- **Policies that stimulate the use of biofuels and bioenergy; and**
- **GHG emissions trading.**

Agricultural practices that reduce or offset GHG emissions can also improve soil productivity, water quality, and wildlife habitat.

Introduction

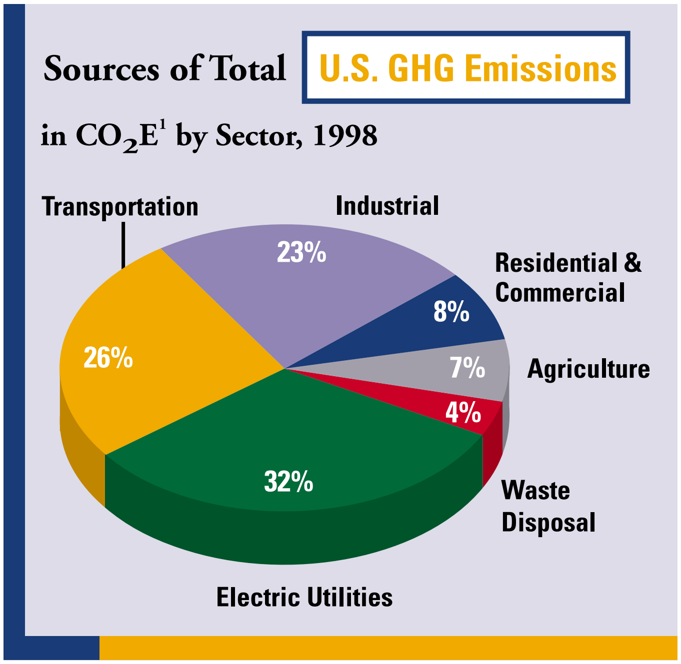
Human activities are increasing atmospheric greenhouse gas (GHG) concentrations. Evidence is growing that higher global temperatures, higher sea levels, and increased climatic variability, including changes in precipitation patterns and magnitudes, will result. These changes will affect agriculture by making some crop and animal production operations difficult or infeasible in their current locations. Slowing the rate of increase of atmospheric GHG concentrations will require efforts in every sector of the economy. Agriculture can make important contributions to these efforts, and can benefit by doing so. Agricultural practices that reduce or offset GHG emissions can increase farmer income, improve soil productivity and water quality, and enhance wildlife habitat.

Agriculture contributes approximately 7 percent of total U.S. GHG emissions, with nitrous oxide (N_2O) accounting for 66 percent and methane (CH_4) 34 percent of agricultural emissions.[1] In addition to reducing these emissions, agriculture has opportunities to assist in offsetting emissions from other sectors. The agricultural sector can:

- Store carbon in soils and plants;
- Produce fuels and energy from biomass and animal waste to replace fossil fuels; and
- Reduce CH_4 and N_2O emissions from livestock operations and agricultural lands.

This paper describes how the U.S. agricultural sector could take advantage of these opportunities.[2]

Figure 1



Source: U.S. EPA. Inventory of Greenhouse Gas Emissions and Sinks: 1990-1999.

Note: Emissions from electricity produced by industries but sold to the grid are included in the "Industrial" category. Emissions due to other industrial, residential and commercial use of electricity are included under "Electric Utilities." Excludes emissions from U.S. territories.

[1]CO_2E means carbon dioxide equivalents.

Opportunities for U.S. Agriculture

Storage of Carbon in Plants and Agricultural Soils. Photosynthesis removes carbon dioxide (CO_2) from the atmosphere and stores the carbon in plant materials and soils. U.S. cropland soils currently sequester 20 million metric tons of carbon per year (MMTC/yr), and have an estimated biophysical potential to sequester 60-150 MMTC/yr more; grazing lands could sequester up to another 50 MMTC/yr.[3] To put this in context, 60-200 MMTC is about 12–40 percent of the reduction that would be needed to return expected 2010 U.S. GHG emissions to their 1990 level.

Carbon sequestration can be accomplished through the following measures:

Management Practice	Farming Type/Location	Additional Benefits
Conservation tillage/no-till	Row crops	Improved soil fertility & productivity; Reduced soil erosion; Improved water quality; Improved wildlife habitat
Reduce summer fallow	Wheat growers	
Increase winter cover crops	Southeast	
Improve water & nutrient use	Grazing & row crops	
Rotational grazing/ Improve grazing crops	Grazing lands	
Conversion of cropland to grassland, forests or wetlands	Marginal lands	

Soils have natural carbon-carrying capacities, and it may be difficult or impossible to increase their carbon content beyond these limits. Most soil carbon gains from conservation tillage are achieved within approximately 20 years, and the carbon stored can be released later—for example, if farmers revert to traditional farming practices. Reversion to traditional practices will result in most of the carbon being released back into the atmosphere within a few years. However, temporary storage of carbon may offer significant benefits by reducing the rate of increase of atmospheric CO_2 until more permanent solutions are found.

Production of Fuels and Electricity. Fossil fuel combustion is the major source of U.S. GHG emissions. The agricultural sector can help reduce reliance on fossil fuels in several ways. Agricultural lands can be used as sites for generation of electricity via wind power, reducing the need to generate electricity from fossil fuels. In addition, use of plant materials and animal waste as an energy source can help reduce reliance on fossil fuels. Plant materials can be used either to generate electricity or to produce transportation fuels. Unlike the release of CO_2 from fossil fuel combustion, CO_2 released during combustion of plant materials and animal wastes is counterbalanced by the CO_2 that plants remove from the atmosphere during photosynthesis. However, the overall net GHG benefits of ethanol are uncertain due to GHG emissions from the farming, transportation, and conversion methods currently used in the U.S.

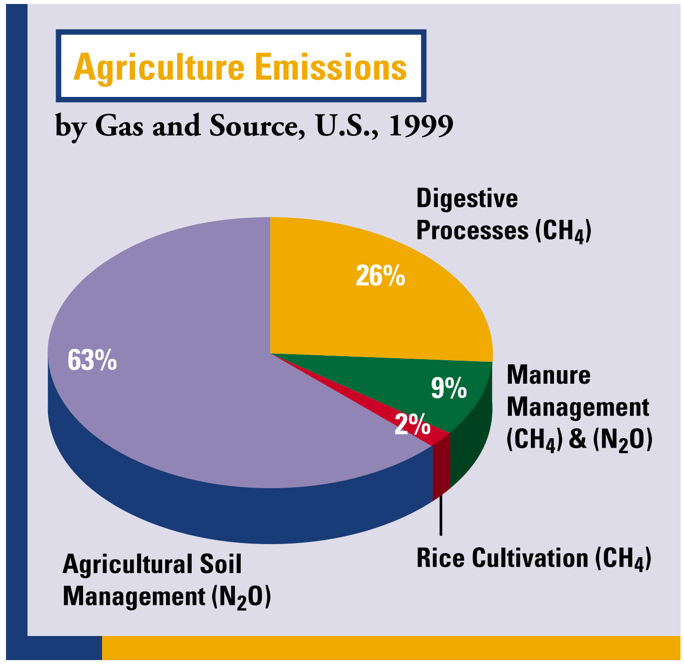
Where large amounts of animal wastes are available in a concentrated location, as in large confined animal feeding operations (CAFOs), CH_4 can be captured and used to generate electricity. The most significant constraints to utilization of animal wastes for power generation are: the rates offered by utilities to medium-scale independent power producers; lack of access to capital; lack of appropriate farm-scale technologies; lack of standardized connection requirements; and lack of "net metering" requirements.[4]

Options for **Biofuels and Bioenergy** — i.e., use of plant materials and animals wastes to produce energy — include:

Fuel/Energy	Farm Product Used	Additional Benefits
Ethanol	Corn, Sugar, Rice straw	Reduced dependence on oil imports
Biodiesel	Soybeans	
Electric power generation	Animal wastes or grasses and trees grown in shelterbelts or on marginal & abandoned cropland	Improved wildlife habitat; Reduced soil erosion; Improved water quality

Reducing CH_4 and N_2O Emissions from Agricultural Lands and Livestock Operations. As shown in Figure 2, N_2O from agriculture soils constitutes the bulk of agricultural GHG emissions. Agricultural lands contribute to N_2O emissions through the breakdown of nitrogen fertilizers, manure decomposition in soils, and releases from legumes. Emissions can be reduced by increasing efficiency of fertilizer use, including more precise fertilizer placement and timing, immediate incorporation of fertilizers into soils, and improved matching of manure application rates to crop utilization rates. Efficient fertilizer management will also improve water quality by reducing nutrient runoff into waters.

Figure 2



Source: U.S. EPA. Inventory of Greenhouse Gas Emissions and Sinks: 1990-1999.

Whereas most N_2O emissions come from cropland, over 95 percent of CH_4 emissions are due to livestock,[5] both from the digestion process and from manure. Digestive processes of beef cattle account for 40 percent of these emissions. Further reduction of these emissions through more efficient feed rations is somewhat limited given the large feed efficiency gains over the last 20 years. However, digestive process CH_4 emissions can be further reduced through improvements in grazing-plant quality. Improved herd management — particularly improved nutrition and increasing the percent of cows producing calves — can reduce CH_4 emissions per unit of beef produced. It is estimated that widespread adoption of these measures could reduce CH_4 emissions from beef cattle by 20 percent.[6]

Manure management options to reduce CH_4 emissions include:

Treatment Option	GHG Pros & Cons	Additional Benefits
Anaerobic digesters	CH_4 can be used to produce energy	Odor reduction; Enhanced fertilizer
Low rate aeration	Requires energy input	Odor Reduction
Aeration	CH_4 reduction offset by high energy use; Possible N_2O emissions	Odor Reduction; Nitrogen is converted to plant-available nitrates
Aeration and sludge removal, followed by anaerobic digestion	CH_4 and N_2O emission reductions; High energy use	Odor reduction; Reduced nitrogen loading on land
Covered manure storage	CH_4 reductions	Can be used as fertilizer

Tradeoffs and Complementarities. Agricultural practices may affect more than one greenhouse gas as well as other environmental goods and services. Consequently, optimizing the net GHG or environmental effects of an agricultural practice requires a comprehensive evaluation of a complex set of environmental interactions. For example, while irrigation can increase soil carbon, the increased CO_2 emissions due to energy used in pumping and the increased N_2O emissions due to increased fertilizer use may negate much of the gain.

U.S. Policy Options – The Farm Bill

Reducing net U.S. GHG emissions through changes in agricultural practices and land uses will require new agricultural policies. It is useful to classify such policies as those that could be adopted as part of the conservation title of the Farm Bill and those that go beyond the Farm Bill.

The Farm Bill. At present, there are a large number of narrowly focused conservation programs. Responsibility for implementing these programs is divided between the Natural Resources Conservation Service (NRCS) and the Farm Services Agency (FSA), both agencies of the U.S. Department of Agriculture (USDA). The large number of programs and the disparities in eligibility requirements are major barriers to farmer participation. Major conservation programs and the environmental benefits they now encourage are shown below:

	CRP[1]	CREP[1]	WHIP[2]	FPP[2]	EQIP[2]	SWP[2]	WRP[2]	CC[2]	CTA[2]
Soil Carbon Storage	X	X	X	X	X	X	X	X	X
CH_4 Reductions					X	X			X
N_2O Reductions	X	X	X		X	X			X
CO_2 Reductions	X	X	X		X	X	X	X	X
Water Quality Benefits	X	X	X		X	X	X	X	X

[1]*Implemented by the FSA*

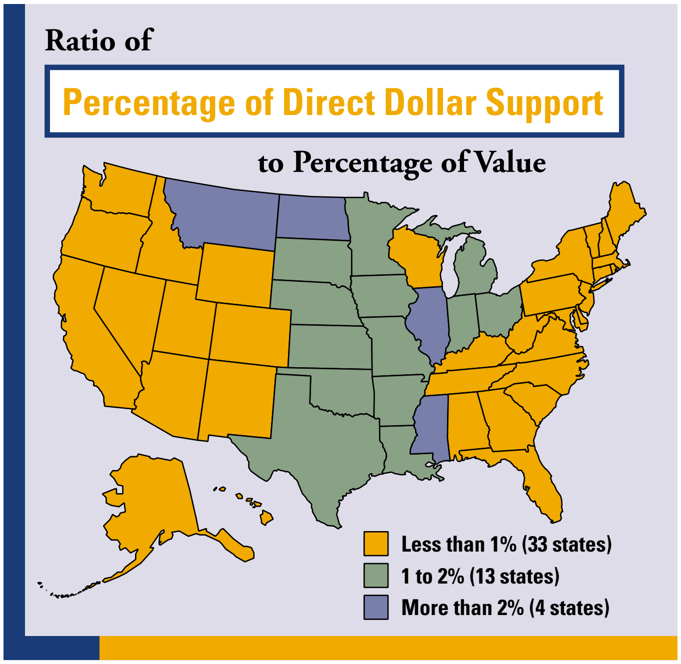
[2]*Implemented by the NRCS*

CRP: Conservation Reserve Program; CREP: Conservation Reserve Enhancement Program; WHIP: Wildlife Habitat Incentive Program; FPP: Farmland Protection Program; EQIP: Environmental Quality Incentive Program; SWP: Small Watershed Program; CC: Conservation Compliance; CTA: Conservation Technical Assistance.

Participation in environmental programs such as the CRP, WRP, and EQIP has been voluntary. These programs provide payments to farmers for taking environmentally friendly actions. The Conservation Compliance program required farmers who opted to receive government subsidies to control erosion and protect wetlands. In recent years, however, the trend has been to make fewer demands on farmers, and eligibility for crop insurance payments has been delinked from wetland (Swampbuster) and erosion control (Sodbuster) provisions.

Effectiveness of present programs in addressing environmental goals is also hampered by the restricted geographic spread (see Figure 3), limited sizes and types of farm operations participating, and limited funding. Thus conservation programs could be more effective if they were more fully funded, simplified, broadened, and harmonized.

Figure 3



Source: Center for Agricultural and Rural Development, Iowa State University, 2001.

Note: Ratio shown is the percent of total commodity payments received by a state divided by the state's share of total U.S. value of agricultural production.

New Approaches. Reform of farm programs is under consideration for a variety of reasons, including international trade rules that constrain production subsidies. Guaranteed commodity prices and crop insurance subsidies encourage more acreage under cultivation than would occur without the programs. Reforming these subsidies might be one of the most cost-effective means of reducing net GHG emissions from agriculture and providing other soil, water quality, and wildlife habitat benefits.

A number of proposed new conservation programs are intended to provide payments for a wide range of conservation practices and environmental services, including soil, water quality, wildlife habitat, and GHG benefits across a wider variety of land use and management categories. These programs would offer higher payments as more conservation practices are adopted or services provided.

Important program design considerations include:

- **Whether all who use a practice or only new adopters can participate;**
- **Potential loss of environmental benefits – e.g., buffer strips reverting to cropland; and**
- **Benefits being offset by other changes – e.g., conservation tillage offset by additional lands brought into production, or increased pesticide use that may accompany no-till.**

Some have formally expressed concern that "good actors" (i.e., those who adopted practices before program implementation) should not be excluded from program benefits. Including all who use an eligible practice addresses this concern, avoids problems of early adopters of desired practices reverting to detrimental ones in order to become eligible to participate, and would be easier to implement as it eliminates the need to differentiate between current adopters and farmers who adopt because of the program.

Research has shown that targeting programs to induce adoption of conservation tillage could cut program costs by more than 50 percent depending on the scale of the program. Approximately 36 percent of U.S. cropland was under some form of conservation tillage last year, and the effect of policies that encourage adoption of conservation tillage should be measured relative to this baseline adoption rate. Furthermore, the environmental benefits of many practices vary widely depending on soils, topology, climate, and location. Consequently, linking program criteria to the level of environmental benefits could help maximize environmental gains.

Programs that encourage environmentally friendly practices may be easier to implement if they do not require measurement, verification, or monitoring of specific environmental benefits. However, a policy that does include measuring, monitoring, and verification might generate more real environmental benefits, encourage innovation in measurement methods, and facilitate GHG emissions trading. Short of measuring specific GHG reductions, regional, practice-based benchmarks or baselines can be used. The approach of offering an incentive for adopting a practice could be coupled with additional incentives if measurement, monitoring, and verification are undertaken.

Pilot Programs. A pilot program would be a relatively low-cost way to demonstrate the feasibility of encouraging a large proportion of farmers to adopt climate-friendly practices. Pilot projects in a range of geographic areas, cropping and animal husbandry systems, and farm sizes could be selected to provide critical information on how many, and what types of, farmers will adopt practices at various subsidy levels, and whether demonstration sites, technical assistance, or other outreach efforts are effective. Pilot programs could also serve to test methods for measurement, monitoring, and verification.

Beyond the Farm Bill

Emissions Trading. Emissions trading has the potential to bring income into the agricultural sector from external sources. Electricity generators and other industries with relatively high marginal GHG emission reduction costs are already experimenting with purchasing GHG reductions from farmers who increase soil carbon or reduce animal waste emissions. Emissions trading could increase total income flowing into agriculture and decrease the need for government subsidies.

Emissions trading can be a cost-effective way to meet a national emission goal. The key to keeping costs low is to include in the market all potential sources of emission reductions, particularly those that can achieve reductions at low costs. Most evidence points to agriculture as being a low-cost provider of GHG reductions. The costs of sequestering soil carbon and reducing agricultural CH_4 and N_2O emissions are likely low relative to the costs of emission reductions from fossil fuel combustion.

Emissions trading would increase the need for more elaborate baseline information and measurement, monitoring, and verification systems because buyers of GHG reductions need to document, and be confident, that the reductions have taken place. Although there is substantial U.S. experience in point source emissions trading, there is very limited experience with trading programs that allow trades to take place between point and non-point source emitters, and most agricultural emission reduction options are non-point. In addition, in an emissions trading program that includes the agricultural sector, contracts would have to be designed: (a) to address possible post-contract losses in the case of stored carbon; and (b) to prevent current users of climate-friendly practices from abandoning these practices in a quest for reductions to sell. Trading arrangements limited to GHG reductions may be less effective than trading approaches that also include other environmental benefits such as water quality improvements.

Biofuels and Bioenergy Legislation. Policies that encourage biofuel and bioenergy research and use could improve their competitive position, provide environmental co-benefits, and enable these fuels to play a significant role in GHG mitigation. For example, to improve the net GHG benefits of ethanol, technological advances are needed in feedstock production and conversion processes. Biofuel use can be encouraged by equalizing the price of biofuels and fossil fuels. The current market for ethanol exists only because a gallon of ethanol is taxed at a lower rate than a gallon of gasoline at the federal level and in some states.

Increased use of fuels and energy from biomass could also be accomplished through new laws. For example, Minnesota mandates that only ethanol blends be sold instead of pure gasoline and is considering a similar mandate for biodiesel. In the Midwest, Environmental Protection Agency summer air pollution reduction mandates are achieved through use of ethanol. Vermont has explicitly included farming operations in its net metering rules, thus removing a key barrier to the use of biomass for generation of electricity. A number of states have established renewable portfolio standards, under which a set fraction of electricity must be generated using renewable resources, including biomass.

Water Quality Initiatives. Initiatives designed to meet water quality goals can induce changes in agricultural practices that also contribute to GHG reduction goals. For example, water quality can be improved by practices that increase carbon storage and reduce CH_4 and N_2O emissions. Such practices include conservation tillage, use of buffer strips, conversion of cropland into grass or forestland, efficient use of fertilizers, and improved management of animal wastes.

Benefits and Costs to U.S. Agriculture

Depending upon the form of the policy implemented, U.S. agricultural producers stand to gain financially from programs that effectively promote GHG reductions. For many farmers, climate-friendly practices and land use make good financial sense, independent of policies to promote them. Providing more and better information might lead more of these farmers to adopt such practices. Other farmers find that climate-friendly practices do not make financial sense for them, and would only increase their use of climate-friendly practices if financial inducements were available. These farmers would adopt new practices if the payments were large enough to cover all costs associated with switching practices, including:

- **Direct costs.** These include the cost of new equipment, lower crop yields, or loss in profits caused by crop-switching.
- **Indirect costs.** For example, experience indicates that six years may be needed to successfully switch from conventional tillage to no-till, a period during which farmers may experience increased risks and workloads.

Even though agriculture may be a low-cost provider of GHG emission reductions, a full cost analysis needs to include the costs of monitoring and verifying those reductions, regardless of who bears those costs.

Conclusions

Agriculture could play a significant role in addressing climate change. In doing so, agriculture may be able to tap additional revenue sources. Farmers will likely reap economic benefits, emitters could reduce their GHG reduction costs, and the public could receive greater environmental benefits from farm payments. The magnitude of environmental benefits will depend on what policy is adopted, the care with which trade-offs inherent in agricultural practice changes are weighed, and how the policy is implemented.

Agriculture could play a significant role in addressing climate change.

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[1] Source: U.S. EPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1999. Historically, agricultural practices caused losses of soil carbon resulting in carbon dioxide (CO_2) emissions. As of 1990 U.S. agricultural soils are estimated to be either losing or gaining small amounts of carbon (between a loss of 2 million metric tons carbon (MMTC)/yr to a gain of 10 MMTC/yr).

[2] This Brief describes major reduction opportunities. Other more limited and emerging opportunities will be examined in future Pew reports.

[3] This potential is a result of soils' capacity to regain the carbon lost due to previous management practices. Sources: Bruce, J.P., et al. Carbon Sequestration in Soils. Journal of Soil and Water Conservation. 54:382-389. Lal, R., et al. Managing U.S. Cropland to Sequester Carbon in Soil. *Journal of Soil and Water Conservation*. 54:374-381. Sperow, M, et al. Potential Soil C Sequestration on U.S. Agricultural Soils. Unpublished Paper.

[4] At least 18 states now allow customers with their own electric generating systems (such as rooftop solar photovoltaic panels) to sell unused electricity back to their local electric utility. To accomplish this, these states have established "net metering" to measure electricity sent into the power grid from customers as well as electricity drawn from the grid.

[5] Rice production contributes approximately 6% to U.S. agricultural CH_4 emissions. Improved water, residue and fertilizer management offer opportunities to reduce these emissions, as do changes in types or mixes of rice grown and fertilizers used.

[6] Source: U.S. EPA. Methane Emissions 1990-2020: Inventories, Projections and Opportunities for Reductions. EPA 430-R-99-013, September 1999.

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