

Introduction

The agricultural sector has a pivotal role to play in addressing, mitigating, and helping to adapt to climate change. Despite this, the opportunities for engaging this sector in climate change mitigation have been the subject of extensive debate. There are several reasons for this debate, largely stemming from the underlying importance of agriculture to climate mitigation and the challenge of integrating it into policy approaches.

First, agriculture depends on many diverse biological processes and a great number of equally diverse actors across a variety of managed landscapes. This means that properly addressing agriculture requires a complex and interlinked framework of programs and activities to reduce, sequester, or avoid greenhouse gas (GHG) emissions in a quantifiable manner. Second, programs and activities in the agricultural sector must deal with the issue that biological sequestration of carbon in soils and biomass is at risk of reversal. Third, both GHG emissions and emissions reductions or increased sequestration from agricultural activities are dispersed across large and variable landscapes and can be difficult to measure. Thus, careful consideration must be given in designing appropriate federal, state, and regional climate policies for agriculture to address these complexities while creating a program that both secures broad sectoral participation and maintains environmental integrity. Finally, it is imperative that considerations of GHG emission abatement activities be integrated with other nutrient management issues associated with agricultural resource management. It is increasingly clear that we must deal with these issues in an integrated manner that looks at the

range of activities and their nutrient impacts rather than considering them in a nutrient-specific or activity-specific manner. Conversely, incentives to achieve optimal environmental outcomes should consider and reward the many impacts of management activities or practices that have multiple beneficial outcomes.

The agricultural sector has significant potential to remove carbon dioxide (CO₂) from the atmosphere and store (or sequester) carbon while at the same time reducing its GHG emissions—in many cases at relatively low cost. With proper policies, the agricultural sector—which currently emits an estimated 6% of annual U.S. GHG emissionsⁱ—can play a significant role in meeting the U.S. goal of achieving an 80% reduction in GHG emissions by 2050. In doing so, agricultural climate policy can both make an important contribution to the sustainable incomes of farming communities and provide a host of ancillary environmental benefits.

The Basic Science of Agriculture and Greenhouse Gases

Agricultural emissions and sequestration affect three GHGs: carbon dioxide, nitrous oxide (N₂O), and methane (CH₄) (Figure 1). The basic atoms of these GHGs are carbon and nitrogen. These atoms are also the main building blocks of plants and organic matter. Carbon and nitrogen molecules cycle dynamically between the landscape and the atmosphere through what is known as the carbon and nitrogen cycles. This section provides a brief overview of the main mechanisms related to carbon and nitrogen cycles in order to elucidate the basic GHG-related opportunities within the agricultural sector

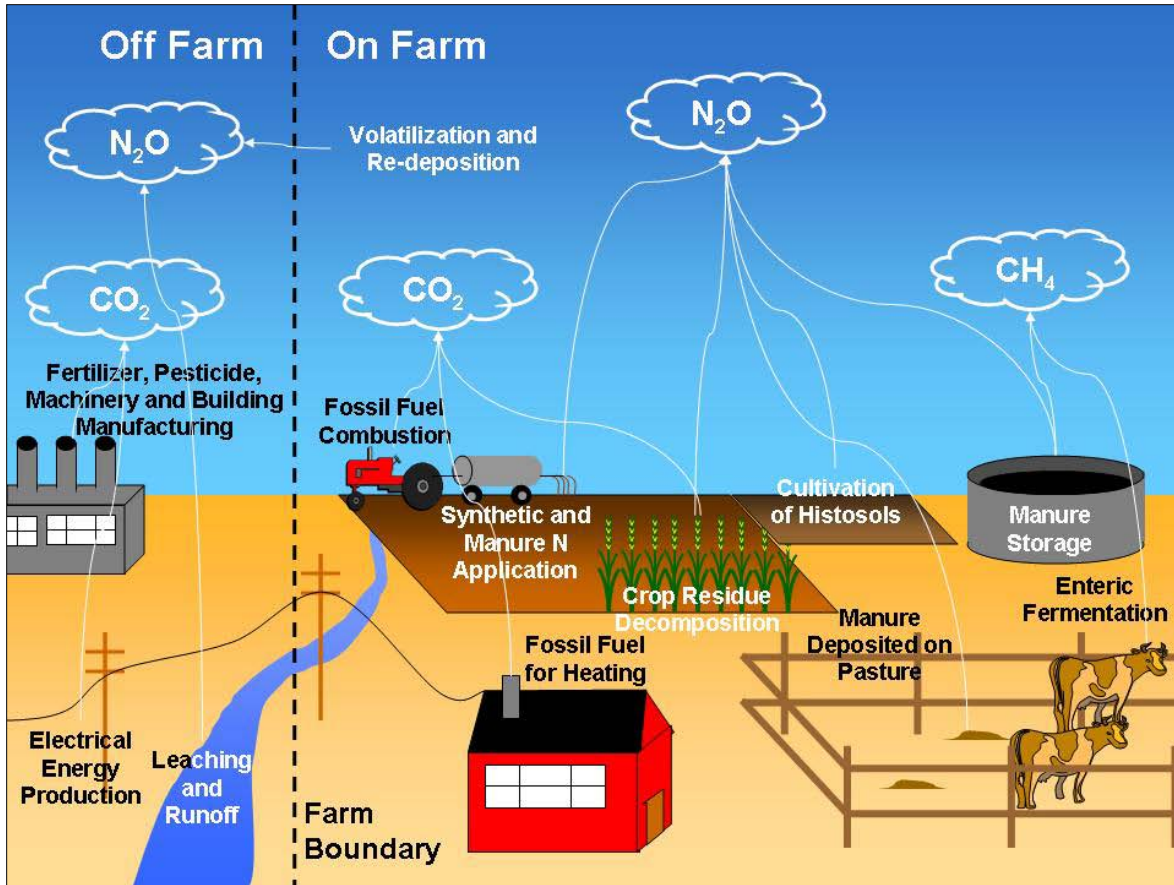


Figure 1. On-farm and Off-farm Emissions of GHGsⁱⁱ

Through photosynthesis, atmospheric CO₂ is converted into simple sugars that are further structured into starch and other plant tissues and biomass. When a plant dies, its biomass is partially decomposed and released again to the atmosphere as CO₂ and partially converted into soil organic carbon (or humus)—a process known as soil carbon sequestration—by soil microbes and fungi. Historically, large amounts of CO₂ have been released from disturbed and deteriorating soils due to burning forests, plowing grasslands, draining wetlands, converting land to annual cropping, and other land use and land use change practices. The loss of soil carbon has decreased soil's structural stability and its crop production potential and has increased soil erosion.

Good agricultural practices can rebuild the carbon stored in the soil that was lost in earlier years by removing CO₂ from the air today.

Farmers can sequester soil carbon by reducing soil disturbance through minimal or low-till practices, by producing more biomass by for example planting winter cover crops or adding composts and manures to soils, and by managing crop residues. Every ton of carbon stored in soil directly correlates with a reduction in atmospheric CO₂. This carbon sequestration process is seen by many countries, including the United States, as a critical means to reduce atmospheric GHG levels and future emissions of GHGs. Much research has focused on agriculture's role as both a source and a sink—or absorber—of GHGs.

Nitrogen is an essential nutrient for plant growth, but soils that contain an excess of certain forms of nitrogen or receive nitrogen when the plant is not ready to take it up can emit large amounts of N₂O through the action of soil microbes. Excess nitrogen in the soil most often occurs through the

inappropriate application (e.g., overapplication or application at the wrong time) of inorganic fertilizers and/or excessive manures. Particularly under moist conditions, microorganisms in the soil convert excess mineral nitrogen (in its nitrate form) into N₂O. By synchronizing the amounts and timing of nitrogen fertilizer added to soils with a growing plant's nitrogen demands, and by supplying this nitrogen in slow-release forms, preferably in narrow seed-placed bands, an excess of "free" nitrogen can be avoided, so that N₂O emissions and releases of reactive nitrogen from soils can be minimized.

Methane is primarily produced under anaerobic (oxygen-free) settings such as in water-saturated soil conditions (e.g., rice agriculture) by methanogenic bacteria. In cattle and sheep, methanogenic bacteria also are part of the fermentation process in the rumen. Cattle and sheep thus form the largest source of methane from animal production systems. Conversely, some bacteria present in most (non-waterlogged) cropping systems will transform methane into CO₂, a process called methane oxidation.

Fortunately, much of agriculture is fundamentally about managing ecological landscapes and soils, in a way that "tightens up" the carbon and nitrogen cycles and retains more of these atoms in the production chain rather than releasing them to the atmosphere. Farmers can "grow" soil carbon at the same time that they grow crops and livestock. Practices such as switching from traditional tillage agriculture to a reduced-till or zero-till cropping system (where this year's crop is planted directly into last year's crop residue) not only returns more organic matter to the soil profile (thereby sequestering carbon) and builds soil quality, it also reduces the use of fossil fuels and costly supplemental fertilizer products. Policies that support both GHG reduction benefits (more soil carbon, less CO₂ and N₂O emissions) while supporting traditional farm products will create tangible and globally beneficial results and outcomes. Further, capturing the GHG benefits as a marketable commodity, a carbon offset or credit (see Box 1), will allow the agriculture sector to leverage the broader carbon markets and related pools of investment.

Box 1. Notes on Terminology

Offsets and Carbon Credits

Throughout this document we use the terms "offsets" and "carbon credits" interchangeably. Both terms are used to characterize the GHG emissions reduction benefits from project-based activities. Under a variety of voluntary or regulatory regimes, these units can be used to meet voluntary or compliance-based objectives as a supplement or alternative to reducing emissions yourself.

Carbon Dioxide Equivalent and Global Warming Potential

Each carbon credit or offset is defined in the units of 1 ton of CO₂ equivalent (t CO₂e). Calculation of CO₂e reflects the global warming potential (GWP) of greenhouse gases in which carbon dioxide is used as the reference gas against which other GHGs are measured. For example, one N₂O molecule has the same global warming effect as 298 CO₂ molecules, while one CH₄ molecule has the same global warming impact as 25 CO₂ molecules. This concept makes it possible to compare and rank the impact of agricultural practices on GHGs and global warming and, thus, the mitigation potential of certain activities or changes in practices.

Quality in Agricultural Carbon

In our increasingly hyper-connected world, no issue has become as central to the production of both agricultural and manufactured goods as quality. Quality is what distinguishes products from their competitors, what helps determine both price and access to markets. In a world where money flows instantly from one corner of the planet to another, and where customers have easy access to pricing information at the click of a browser button, quality is the big differentiator.

Even for commodity markets, where quality would seem to be a minor issue, standardized levels of quality are needed to ensure that traders know what they are bidding on and that buyers get what they expect. That is why futures markets define their contracts using terms like yellow corn #1, red winter wheat #1, west Texas Sweet crude, or Brent crude. And just as it is on the Chicago Board of Trade, so too it is for carbon. Because whether we are talking about coffee, corn, or carbon, it is important that commodities be measured, monitored, and standardized. Basic levels of quality are needed if markets are to function. Buyers need to have some assurances that they will get what they pay for.

Every farmer is familiar with the practice of pulling a “test sample” from a bin of stored grain that is ready for market. These tests essentially judge the “quality” of the commodity based on factors such as test weight (the number of pounds per bushel), percent of protein, percent of dockage or foreign material, color, and damage due to disease, frost, or other factors. The market, backed by the U.S. Department of Agriculture (USDA) Grain Inspection Service, has set standardized quality criteria against which all farm products are judged. When it comes to carbon, judging the quality of a carbon credit is both more difficult and more important than it is with standard commodities. It is more difficult because emissions reductions—unlike corn or oil—cannot be seen, touched, and tested. At the same time, it is more important precisely because a carbon credit cannot be physically touched. It needs to be verified and to meet a pre-defined set

of quality criteria. A carbon credit is only as good as the standards against which it is verified and measured.

To understand what constitutes quality in the carbon markets, it is useful to understand what constitutes a carbon credit. A GHG offset is derived from a decrease in GHG emissions or an increase in sequestration caused by a project that has met specific eligibility criteria. Over the years, carbon markets around the world have come to expect credible “carbon credits” to meet specific criteria that ensure that a purchased GHG offset actually represents a ton of greenhouse gas removed from the atmosphere. Because of the intangible nature of carbon credits, the criteria and methodologies for GHG reductions revolve around the transparency of accounting and the use of unambiguous standards. Most commonly, the application of these standards are verified by independent, third-party “verifiers.” This increases the marketplace’s confidence in the GHG offset issuance process and ensures that the quality of the goods being offered, bought, and sold meet the specified quality criteria. Examples of these criteria include:

- Assurances that reduced or sequestered GHGs provide an added benefit beyond regulatory and statutory requirements and are not likely to have happened in the absence of the incentive provided by the carbon market (i.e., emissions reductions result from additional action);
- Confidence that the reduction that occurs has a durable effect over a period of time that is meaningful from the perspective of addressing climate change (i.e., that it is effectively permanent or will remain stored and not be released for an agreed-upon time period and that it has a relevant “lifespan”);
- Assurances that the GHG credits accurately represent the quantity of emissions reduced or sequestered (i.e., that they are measurable and quantified to specified standards of accuracy using the best available scientific methods);

- Confidence that the processes and documents that produce, quantify, and track offset credits can be audited by independent third parties and provide additional evidence that the credits are sequestered, reduced, or avoided in a verifiable manner (i.e., sufficient evidence is collected and documented so that buyers and third parties without a conflict of interest can verify the volume of carbon credits issued); and
- Assurances that the outcome of a GHG-reducing activity is not being negated by GHG emissions shifting elsewhere (i.e., there is no leakage, which is typically defined as an increase or decrease in emissions outside an offset project's accounting boundaries as a result of the project that is not otherwise accounted for by the project).

Each of these criteria has over the years played an important role in the development of both regulated and voluntary carbon markets worldwide. These same criteria will have important implications for carbon credits developed through agricultural activities and processes. The difference lies in how agricultural carbon is measured and monitored.

While discussions of verification techniques, additionality, and leakage are necessary when discussing agricultural carbon, the application of these criteria do not differ much in agricultural projects from their application in other sectors. However, measurability and permanence issues become quite challenging with regards to biological systems, including agriculture.

Not only does farmland cover an enormous amount of varied terrain and climates, emissions are highly variable in both space and time. No one single technique has been deemed sufficient to develop a comprehensive GHG measurement or monitoring system for terrestrial ecosystems. This is equally true whether the system in question is an agricultural system or a forest system. At its simplest, this means that carbon sequestered or N₂O and CH₄ emissions avoided can either be measured directly using on-the-ground technologies, quantified indirectly through proxy variables or remote sensing techniques, or predicted using biogeochemical process modeling. Each approach and technology

has unique constraints related to costs, accuracy or precision, and sampling design requirements. Therefore scientists often use a variety of techniques across a range of scales to crosscheck the measurements from any one method in order to overcome these limitations and to improve the reliability of quantification procedures. Given the centrality of measurement to the development of programs to advance agricultural GHG emissions reductions, Chapter 2 explores the issue in more depth.

Likewise, addressing permanence in agricultural systems can be extremely complex. As molecules move through the nitrogen and carbon cycles, they do not stay in one place. They are in a state of near constant flux. If by permanent we mean "in one place, forever," we are trying to define the actors in a biological process by a measure that simply cannot be adequately applied to highly dynamic living systems. For this reason, the word permanence may be something of a misnomer when it comes to the biological sequestration of GHG. Perhaps a better word for this concept is "longevity" or "lifespan." In other words, we should not be asking ourselves: "Is this carbon permanent?" Rather, we should come to a better definition of the reasonable "lifespan" of a ton (or pool) of carbon reduced or sequestered. As addressing the issue of longevity is vital to moving forward with programs to advance agricultural GHG emissions reductions, Chapter 3 looks at this issue.

There are three additional issues that, while not a focus of this report, need to be at least mentioned here: the rapidly evolving nature of agricultural GHG science and technology, the need for transparency pertaining to all aspects of policy and project development for GHG issues, and the issue of "leakage."

Leakage is defined in the *Special Report on Land Use, Land-Use Change, and Forestry* from the Intergovernmental Panel on Climate Change (IPCC) as: "the unanticipated decrease or increase in greenhouse gas (GHG) benefits outside of the project's accounting boundary as a result of project activities."ⁱⁱⁱ Leakage is actually a displacement of emissions or emissions reductions from one area (the project area) to another (outside the project area) that is directly

attributable to the project's activities. In the development of forestry projects, leakage has been cited as being a major obstacle,^{iv} and there is also a potential for leakage in agricultural projects. All agricultural mitigation interventions must be designed so that there is minimal pressure on other areas. However, the mere occurrence of leakage does not necessarily negate the environmental integrity of agricultural projects. Only in cases where leakage is not quantified and deducted from the project's carbon offsets does leakage pose an insurmountable barrier.

A distinction is made between primary leakage (directly attributable to the actors) and secondary leakage (not directly attributable to the actors), depending on whether the increases in GHG emissions are directly attributable to the actors responsible for the agricultural mitigation activities.^v

Primary leakage occurs when the actors responsible for agricultural mitigation activities are engaged in new activities that increase GHG emissions outside of the project area due to the planned project activities. It can be further divided into two subtypes:

- **Activity shifting.** Emission reductions are not avoided but merely displaced in whole or in part to an area outside of the project area. This is most likely in cases where yields are reduced. One example is a project area where fertilizer management is implemented but results in lower yields. To compensate for the reduced yields, more fertilizer is used in another area under the same manager who was responsible for the mitigation activities in the project area.
- **Outsourcing.** This occurs when agricultural project activities lead to the purchase or contracting out of the services or commodities that were previously produced inside of the project area to compensate for the loss of revenue from reduced yields. For example, a company that was previously producing rice within the project area purchases rice from other operators to maintain an ongoing supply of rice to their distribution network. This differs from

market effects (see below), since outsourcing is undertaken by the original actors responsible for the agricultural mitigation activities and not by third parties.

Secondary leakage occurs when agricultural mitigation project activities create incentives for people other than the original actors responsible for those activities to increase GHG emissions elsewhere. Secondary leakage has market effects when agricultural project activities lead to shifts in supply or demand of the products and services affected by the project actions, which will in turn increase GHG emissions. For example, the reduction in stocking rates due to a rangeland management project leads to a rise in beef prices, which then increase the amount of land under grazing by third parties. However, the difficulty in identifying secondary leakage effects lies in proving the one project had an impact in raising beef prices over all other market and climatic impacts. These will need to be assessed on a case-by-case basis, taking all other drivers into account.

Structure of the Report

To further discourse on these issues, we have produced this document as a "discussion draft" or "Version 1.0," which will be further refined with additional inputs as it serves as a springboard to further discussion and as new science, evidence, and technologies evolve. The report is structured as follows:

- **Chapter 1. Principles:** A set of core principles that C-AGG proposes to guide discussion and policy and program development in the arena of agricultural GHGs.
- **Chapter 2. Carbon and Agriculture: Getting Measurable Results:** A discussion of the "state of the science" and the challenge of obtaining measurable results from projects generating offset credits in changing natural ecosystems.
- **Chapter 3. Permanence:** An examination of the concept of "permanence" and the various tools and mechanisms that have been used—and that could be effectively used—to manage the risk of carbon loss in biological systems.

- **Chapter 4. The Potential of Agricultural Projects and Practices to Reduce GHG Emissions and Promote Carbon Sequestration:** An overview of a sample of agricultural activities that have been identified as having the potential to generate offsets.
- **Chapter 5. C-AGG Policy Recommendations:** Recommendations for the incorporation of agricultural GHG emissions reductions activities into U.S. climate change policies and programs.

The participants of C-AGG believe agriculture has a vital role to play in addressing climate

change and helping the United States meet its GHG emissions reduction goals. Furthermore, we are confident that efforts to reduce agricultural GHG emissions and increase soil carbon sequestration can benefit farmers, landowners, and the environment if guided by science and undertaken transparently and with appropriate measurement, monitoring, and verification protocols. This report is intended to provide information useful to those designing policies and programs to realize agriculture's potential contribution to GHG mitigation.