Greenhouse Gas Emissions Offsets from Agriculture: Opportunities and Challenges

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As the scientific evidence of global climate change continues to accumulate (IPCC, 2007) and the predicted impacts of a warming planet become more widely known, national policies and international agreements designed to mitigate global warming have sought to strike a balance between environmental sustainability and economic achievement. Under the 1997 Kyoto Accord (hereafter "Kyoto") a global framework for reducing greenhouse gas (GHG) emissions to pre-1990 levels was developed that established binding emissions reduction targets and timetables for industrialized countries, and included flexibility provisions intended to reduce the overall cost of emissions reductions. Countries subject to emissions limits were free to decide how to reduce emissions to meet the established targets over the period 2008–2012. Countries could design their own domestic policies to meet their targets. Kyoto's flexibility provisions allowed cooperation between industrialized countries to achieve emissions reductions through Joint Implementation and included the Clean Development Mechanism (CDM) to facilitate cooperation with developing nations that were not subject to binding emissions reductions. Despite the fact that not all countries ratified the 1997 agreement, many countries, provinces, and states have, in the time since Kyoto, enacted policies individually or in cooperation to reduce GHG emissions. In addition to binding regulatory approaches taken by governments there has also been at least one similar voluntary initiative undertaken by the private sector in the form of the Chicago Climate Exchange.

Cap and Trade

Economists have taken a strong interest in helping governments to evaluate various policy instruments to achieve emissions reductions. On the basis of the success of the United States' sulfur dioxide (SO_2) emissions trading program and a large body of scientific research on regulatory standards, emissions taxes, and tradable pollution permits (Hanley *et al.*, 2007), policy designs that establish enforceable property rights to verifiable quantities of emissions, which are transferable between parties, have been pursued most frequently and are the focus of the majority of ongoing national and international policy debates. This type of policy design is commonly referred to as "cap and trade" because the government establishes a "cap" on total emissions, allocates permits that constitute individual property rights to emit an allowable quantity of a pollutant, and allows firms to trade these "allowances." An allowance typically entitles its owner to one metric ton (tonne) of carbon dioxide equivalent (tCO_2e) emissions. The total emissions cap is expressed in terms of millions of tCO_2e ($MtCO_2e$) and the sum of all individual allowances equals the emissions cap or target.

Each firm subject to the emissions cap must have allowances to cover their total level of emissions or they are subject to fines or other penalties enforced by the government. To achieve required emissions reductions, a firm must either reduce its emissions or acquire allowances to cover its total emissions. Firms can reduce their own emissions by reducing output, operating more efficiently, and/or by investing in less C-intensive technologies. These options can become very expensive for anything more than modest reductions in emissions. Because different firms operating in many sectors of the economy use different technologies, they have different GHG abatement costs and there are potentially significant gains from trade if regulated firms are allowed to exchange emissions allowances in a market. By allowing firms to trade allowances, those with the lowest abatement costs can abate more pollution than required and sell excess allowances to firms with higher abatement costs. This allows society to achieve the desired environmental objective at a lower total cost than if all firms were only allowed to generate emissions equal to the amount of allowances they hold (whether grandfathered or auctioned to them) and no trade of allowances were allowed.

All else equal, a more stringent emissions cap will place greater pressure on all firms operating under the cap and is expected to result in greater demand in the market for allowances; this will have the effect of driving up the market price of allowances and, thus, firm compliance costs. Many factors in cap-and-trade program design can influence the overall cost to society.[1] Including mechanisms that give firms time to develop and transition to less C-intensive technologies and energy sources reduces the overall cost while increasing the political feasibility of a cap-and-trade policy. Typical mechanisms that achieve this include phasing-in a cap through gradual reductions over several years,

[1]One of the most notable factors that determines the overall cost of a cap and trade program is whether allowances are freely allocated or auctioned to firms (Burtraw *et al.*, 2001). This topic is outside the scope of the current paper.

allowing firms to "bank" low-cost emissions reductions achieved in early years to be used to meet more stringent reduction requirements in the future, and allowing regulated firms to pay for GHG emissions reductions by unregulated sources that have the effect of offsetting emissions released by the regulated firm. The third of these mechanisms is called an emissions offset, and is the focus of the remainder of this paper.

Agriculture and forestry are two of the most commonly considered sources of offsets in an emissions trading market because these sectors of the economy are not directly regulated and have the potential to adjust management practices in ways that sequester additional C or otherwise reduce emissions of the GHGs methane (CH_4) and nitrous oxide (N_2O) (IPCC, 2007; EPA, 2005). Discussion of forestry offsets is left to other authors and agricultural offsets are the focus of what follows. The remainder of this paper discusses potential sources of GHG-emissions offsets that represent *opportunities* for agriculture under policies that seek to limit global warming and the scientific and policy *challenges* that must be addressed in order for agricultural offsets to be an effective tool in mitigating human impacts on climate.

Offsets as Opportunities for Agriculture

The three main GHGs that can be mitigated through agricultural activities are CO_2, CH_4 and N_2O. Agricultural management practices can be altered or changed in many ways to reduce emissions from existing practices, to enhance the removal of CO_2 from the atmosphere (C sequestration), or to displace emissions from fossil fuels by using crops or residues as sources of energy (IPCC, 2007). Displaced fossil fuel emissions from bioenergy crops represent an important opportunity for agriculture and remain a fertile topic for research as governments continue to rely on renewable fuel standards as an important component of energy and climate change policies. Fossil fuel emissions displaced are not treated as a source of offsets under cap-and-trade policies and we turn our attention to the biophysical and economic potential of reduced emissions from current practices and sequestration.

Reduced or more precise application of nitrogen (N) fertilizer or livestock manure can reduce N_2O emissions if greater N-use efficiency can be achieved. Methane emissions from livestock can be reduced by improving feeding and manure management practices (*e.g.* by covering lagoons or capturing CH_4 through use of anaerobic digesters). Increased feeding efficiency can be achieved through the use of dietary additives that suppress methanogenesis or improved forages, and opportunities for manure management, treatment and storage that reduce CH_4 emissions both represent mitigation options in livestock management (IPCC, 2007; Smith *et al.*, 2008). Atmospheric C can be sequestered in the soil and in vegetation. Soil management practices that increase sequestration include conservation tillage (*e.g.* mulch till, ridge till and no till) and crop residue management (Lal *et al.*, 1998). Vegetative C storage can be enhanced through perennial grass plantings and grazing management (Follett *et al.*, 2000). Although existing agricultural practices already play a role in mitigating the global warming effect of some fossil fuel emissions that result from fertilizer production and fuel use, there is considerable potential to expand and improve upon existing practices. This potential for wider use of mitigating practices is what creates the *opportunity* for farmers to sell emissions offsets in a market for CO_2-equivalent emissions.

An important aspect to keep in mind when evaluating different mitigation options is the distinction between the technical potential and the economic potential that individual agricultural practices represent (McCarl and Schneider, 2001; Smith *et al.*, 2008). Technical potential refers to the biophysical ability of various management practices to reduce emissions, but does not take into account the cost-effectiveness of the same practices. In moving from the science of C sequestration and CH_4 capture to thinking about the adoption of new cropping or manure management systems, it is necessary to take into account whether there are adequate incentives for farmers to adopt mitigating practices. We can expect farmers to adopt these practices only if the costs of implementation are covered by the benefits received.

Under a cap-and-trade program, farmers can sell offsets to regulated emissions sources to cover the cost of these practices, but economic analysis of cap-and-trade policies to date suggests that, even at the highest prices per tCO_2e considered, only a subset of the mitigation options that have technical potential are economically feasible (McCarl and Schneider, 2001; EPA, 2005; Smith *et al.*, 2008). The global technical mitigation potential by agriculture in 2030 has been estimated to be as high as ~5,500 to 6,000 $MtCO_2e$/year; this is in contrast to the global economic potential, which has been estimated for the same year to be as low as 1,500 $MtCO_2e$/year for a carbon price of US\$20/tCO_2e and as high as 4,300 $MtCO_2e$/year for a price of US\$100/tCO_2e (Smith *et al.*, 2007).

It is also important to consider non-agricultural sources of offsets like forestry and landfill gas when assessing the potential role of agricultural offsets. The economic analysis done by the US Environmental Protection Agency (EPA) (2005) to assess the domestic C-sequestration potential of forestry and agriculture found that for market prices over US$30/tCO2e, the economic incentives are such that crop and pasture lands are expected to be converted to forests because the sequestration potential of forest exceeds soil-C sequestration and high prices cover the cost of land-use conversion. Over the higher range of prices considered, agricultural soil C has lower relative economic potential than afforestation. This is one illustration of why agriculture should not be analyzed in isolation from other sectors that can supply offsets. It is also important to consider both domestic and international sources of offsets (if available) because the demand side of the market is seeking to minimize its cost of compliance and it stands to reason that if country "A" can supply the offsets needed for compliance at a lower cost than country "B," the lowest-cost source of abatement will be exhausted before firms consider paying for higher-cost alternatives.

The main economic motivation for including offsets as part of a cap-and-trade policy to reduce GHG emissions is to reduce the overall cost of achieving the emissions target or cap. Economic analysis of cap-and-trade legislation is perhaps the best place to look to see the estimated effect of including offsets on the cost of allowances, and thus the overall cost of achieving a GHG emissions target. Recent analysis of the draft American Clean Energy and Security Act of 2009 (H.R. 2454) by the United States Congressional

Budget Office found that the inclusion of both domestic and international offsets has "a significant effect on allowance prices" and decreases the market price 69% in 2012 to US$35 compared to when offsets are not a compliance option under the legislation (CBO, 2009, p. 16). The EPA's economic analysis of the same legislation similarly found that "offsets have a strong impact on cost containment" and that "without international offsets, the allowance price would increase 96%" to US$25–34 in 2015 (EPA, 2009a, p. 3). Both analyses of the most recent federal cap-and-trade legislation in the United States illustrate how incorporating offsets into a cap-and-trade program may influence the cost of climate change mitigation.

Scientific research has demonstrated many opportunities for agriculture to supply emissions offsets in a market for GHG emissions, but researchers and policymakers must always be mindful of the relative abatement cost of alternative sources of both domestic and international offsets when evaluating different policy designs. The market price of allowances will ultimately determine how big a role agricultural offsets will play in emerging markets.

Scientific and Policy Challenges to Offset Effectiveness

The fact that science has demonstrated the potential for agriculture to provide emissions offsets under a cap-and-trade program and that including offsets as part of policy design may significantly decrease the cost of such programs is not enough to ensure the environmental integrity of legislation or international agreements that aim to mitigate the effects of climate change. To focus readers' attention on some of the most substantive issues that must be addressed in order for agricultural offsets to be an effective component of a regulatory (non-voluntary) cap-and-trade program, I will address four principal dimensions of policy design:

- Verifiability,
- Enforceability,
- Additionality, and
- Permanence.

Verifiability

In order for agricultural offsets to be credible emissions reductions, they must be verifiable. There must be scientifically valid techniques or methods capable of quantifying the amount of actual emissions offset by every single individual management practice (*e.g.* no-till or livestock methane capture) that is allowed under the offset policy established by a cap-and-trade program. It must be possible to verify that practices have been installed on every single farm, and monitoring or auditing must occur to ensure that practices are implemented or maintained consistent with the protocol established for each practice. Verifiability encompasses the technical ability to verify the amount of emissions that have been offset by a given practice and specific protocols must be established at the outset so that market participants know how quantification of CO_2e will be performed.

Verification will necessarily involve a third party that is not involved in the farm operation and is in no way associated with any entity serving as an aggregator of offsets undertaken by many individuals. Because maintaining an offset registry could potentially entail working with many tens of thousands of individual farmers located in many states or countries, many of the details involved in commoditizing the sequestered C or captured CH_4 involve significant transaction costs that must be carefully managed in order for the operation of an offset registry to even be feasible. It is important to note that the cost of using third party services to audit management practices or coordinate large groups of farmers so that they can access the market must be borne by the parties involved and, when this cost is added to abatement cost for a specific practice, it increases the market price required to incentivize emissions offsetting practices.

Enforceability

In order for emissions reductions to be credible, they must be enforceable. This means that legal contracts between farmers and the offset registry or third party aggregator must be established to clearly spell out the responsibility of all parties involved and the duration of the contract. It is likely that multi-year contracts will be required to entice farmers to change tillage practices, plant perennial grasses or make capital investments in manure-handling or -treatment systems, and this is discussed further under the permanence dimension below. The consequences of violating the contract must also be clearly spelled out to ensure that emissions reduction obligations are fulfilled, otherwise the environmental integrity of the cap-and-trade program could be called into question.

Enforceability may be a particularly important consideration for dealing with the inclusion of international offsets in a domestic cap-and-trade program. This may limit the ability of countries with particularly poor property rights or legal systems to participate in an emissions market if it is not feasible to enforce the provisions of the required contract. To the extent that third parties can help to overcome this potential obstacle, greater cooperation between industrialized and developing countries like that envisioned by the CDM in the Kyoto Protocol will be possible. Because the marginal abatement costs for farmers in developing countries are considerably lower than for farmers in industrialized countries, international offsets typically play a disproportionately large role in reducing the overall cost of cap-and-trade programs, as detailed in analyses of the Waxman-Markey cap-and-trade bill being considered currently by the 111th US Congress (CBO, 2009; EPA, 2009a)

Additionality

All agricultural practices adopted that offset GHG emissions must be in addition to any practices the farmer would have adopted in the absence of cap-and-trade legislation that would pay them for emissions they offset. The point of reference is some baseline level of "business as usual" activity and the way that such baselines are established must be determined *ex ante*. Dealing with additionality is one of the most difficult issues in the design of offset programs because a large number of farmers have already undertaken these practices for a variety of reasons that may or may not have included the potential to be paid for soil-C sequestration in the future. The 2009 Waxman-Markey legislation allows offset projects that exceed the activity baseline established and that were undertaken after January 1, 2001, to be included if the offsets were registered under some other program recognized by the administrator of the EPA.

Additionality may ultimately lead to unintended consequences if the financial incentives of being paid for offsets are great enough. Consider that under the US EPA's revised [since EPA (2005)] baseline emissions scenario used to analyze the draft Waxman-Market bill there are already enough acres under conservation tillage that agricultural soil-C sequestration starts in 2010 as a net C sink of 77 MtCO_2e compared with being a net source of 32 MtCO_2e when estimated in 2005 (EPA, 2009b). This represents a nearly 100 MtCO_2e in emissions difference that is largely attributable to increased adoption of conservation-tillage practices. If these farmers were to plow up all of these acres after a cap-and-trade program is enacted, only to turn around the following year and re-establish their conservation tillage so that their practices are eligible to be compensated as offsets, this would release the vast majority of the sequestered C back into the atmosphere, thus negating any mitigation previously achieved. This seems like a potentially significant unintended consequence, but one that is altogether reasonable to expect if early adopters are not eligible to receive offset credits. This is related to the issue of permanence.

Permanence

Because some agricultural practices that offset GHG emissions are reversible, as is the case with soil-C sequestration, adoption may not represent permanent removal of the offset emissions as would be the case if a regulated source reduced its emissions by an equivalent amount. Permanence has been dealt with in many ways that include the provisions in the contract already described under the enforceability dimension that detail how reversion is handled. Among other things, this may rely on offset credits placed into a "reserve pool" when offsets are credited to farmers based on the GHG and practice adopted. This practice has been used by the Chicago Climate Exchange (www.theccx.com) and the government of Alberta (www.carbonoffsetsolutions.ca) in issuing the only such agricultural offset credits awarded through functioning emissions markets to date. Emissions offset by agricultural practices may be discounted so that the number of marketable credits generated is less than the estimated amount of sequestration that occurs to account for the frequency of reversion among certain practices. For example, 1 tCO_2e may be placed into the reserve pool for every 5 tCO_2e sequestered so that for every 5 metric tons removed from the atmosphere, farmers are eligible to sell 4 tCO_2e. This discounting or credit-issuance rate is done to address permanence and the reserve pool that can be drawn on to maintain the overall environmental performance of the emissions market.

Permanence is a key reason why agricultural offsets are often viewed as a tool to bridge the gap between the present and the time when new technologies and fuel sources can be developed that achieve emissions reductions that are not subject to the same challenges. By lowering the cost of reducing emissions in the near term, offsets can help reduce the overall cost to society of transitioning away from fossil fuels and developing new technologies.

References

Burtraw D *et al.* (2001) The effect of allowance allocation on the cost of carbon emission trading. Discussion Paper 01-30, August. Washington, DC: Resources for the Future.

Congressional Budget Office (CBO), Cost Estimate (2009) H.R. 2454 American Clean Energy and Security Act of 2009, http://www.cbo.gov/ftpdocs/102xx/doc10262/hr2454.pdf.

Environmental Protection Agency (EPA) (2005) Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture, EPA 430-R-05-006. Washington, DC: Environmental Protection Agency.

Environmental Protection Agency (EPA), Office of Atmospheric Programs (2009a) Preliminary Analysis of the Waxman-Markey Discussion Draft: The American Clean Energy and Security Act of 2009 in the 111th Congress, http://www.epa.gov/climatechange/economics/pdfs/WM-Analysis.pdf.

Environmental Protection Agency (EPA), Office of Atmospheric Programs (2009b) Updated Forestry and Agriculture Marginal Abatement Cost Curves, http://www.epa.gov/climatechange/economics/downloads/WM-EPAAnalysis-DataAnnex.zip.

Folett RF *et al.* (2000) The Potential of U.S. Grazing Lands to Sequester Carbon and Mitigate the Greenhouse Effect, First Edition. Boca Raton: CRC.

Hanley N *et al.* (2007) Environmental Economics: In Theory & Practice, Second Edition. London: Palgrave Macmillan.

Intergovernmental Panel on Climate Change (IPCC) (2007) Fourth Assessment Report, Working Group III Report, Mitigation of Climate Change. Geneva: IPCC.

Lal R *et al.* (1998) The Potential of U.S. Cropland to Sequester Carbon and Mitigate the Greenhouse Effect, First Edition. Boca Raton: CRC.

McCarl BA Schneider UA (2001) Climate change: Greenhouse gas mitigation in U.S. agriculture and forestry. Science 294 2481–2482.

Smith P *et al.* (2008) Greenhouse gas mitigation in agriculture. Philosophical Transactions of the Royal Society B: Biological Sciences 363, no. 1492 789–813.

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