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Advances in Agricultural GHG Measurement and Monitoring: Implications for Policy Makers

Agricultural landscapes support rural livelihoods, produce food, fiber and energy, and deliver a wide array of ecosystem services. Agricultural practices, including expansion into forest lands, are a major source of greenhouse gas (GHG) emissions. Yet, agriculture can also mitigate GHG emissions through the reduction of nitrous oxide and methane emissions, as well as through carbon sequestration, particularly in the developing world. Despite significant mitigation potential of a range of agricultural practices, limited awareness and low confidence in monitoring of agricultural interventions has inhibited inclusion of agriculture in climate change policy and emissions offset markets. Some examples include the UNFCCC process and domestic cap-and-trade legislation. Sub-national systems, such as the California Action Registry, offer further opportunities for gaining experience with agricultural GHG offsets.

There are a range of applications for agricultural mitigation including not only offset projects, but also large landscape-scale projects, regional initiatives such as Nationally Appropriate Mitigation Actions (NAMAs), and supply chain projects in which agribusiness companies aim to reduce their climate footprint. Across all of these applications, there is a need for robust and credible monitoring, reporting and verification (MRV) capabilities to demonstrate that shifts in agricultural practices produce real changes in net GHG emissions. In many cases, agricultural GHG MRV will be called upon to use a landscape-scale approach in which management decisions and incentive systems can recognize the mosaic of land use types (including forested land) and incorporate the full set of impacts within agricultural landscapes.

Climate-friendly agricultural practices include enriching soil carbon through integrated soil fertility management (such as residue management and reduced tillage); increasing living biomass with perennial crops and trees and conserving natural vegetation; reducing fossil energy use through improved fertilizer management; and minimizing emissions from livestock through better feeding practices and manure management

This brief is an effort by a group of leading practitioners and academics in agricultural GHG measurement, monitoring, policy and research to communicate the status of agricultural GHG MRV capabilities. It considers the importance of robust agricultural methodologies, the barriers that have impeded their development and the current status of MRV for climate-friendly agricultural interventions. Finally, it recommends policy actions to support the development of methodologies to strengthen the emissions reductions achievable by agriculture in a future international climate agreement and in national policies.

Agriculture in the Emissions Offset Markets

To participate effectively in emissions offset markets, agricultural mitigation projects need to demonstrate real and additional emissions reductions or carbon sequestration by complying with established methodologies. Until recently, little activity has been directed toward developing robust methodologies for quantifying agricultural mitigation practices. As the pool of approved methodologies and supporting infrastructure grows, land managers will have expanded opportunities to seek financial rewards for climate-friendly practices.

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Photo credit : *P. Casier, CGIAR*

Terrestrial mitigation projects are not well integrated into regulated carbon markets. In 2007, the Clean Development Mechanism (CDM) Executive Board approved the first land-based carbon methodologies for af forestation and reforestation (A/R) projects. The CDM now recognizes 17 different A/R methodologies and six agriculture methodologies (including methane reduction). However, most of these are not in wide use, and they do not address agricultural soil carbon. Out of over 5,000 projects in the CDM pipeline, only 57 are A/R projects and one is an agricultural irrigation project. There are, however, agriculture related projects within other CDM classifications, including 335 manure, 59 composting, and 375 various agriculture residue to energy projects.

Agricultural mitigation is emerging in the voluntary markets. In 2009, livestock, agricultural soil and agroforestry represented 4%, 3% and 1%, respectively, of voluntary market volume, typically drawing low prices. Before its mid-2010 collapse, the Chicago Climate Exchange (CCX) was the main venue for agricultural soil projects, however, standards for measurement were not considered sufficiently rigorous. The Voluntary Carbon Standard (VCS) has managed to reinvigorate the options for agricultural land management projects, and their 2008 Agriculture, Forestry and Other Land Uses (AFOLU) guidance has sparked recent methodology development. Under California's cap-and-trade program, offsets from livestock manure digesters and forests have been approved by the state-founded offset verifier, Climate Action Reserve.

Technical Challenges for Agricultural GHG MRV

Expanded implementation of agricultural GHG projects requires progress in estimating mitigation potential and monitoring capabilities to meet expectations in voluntary markets, and eventually for regulatory markets, NAMAs, supply chain and other applications. Key challenges include:

Baselines and additionality: Climate mitigation projects are based on the principle that emissions must be reduced over some baseline. Given the ecological, social and economic complexity of many agricultural landscapes, it is often difficult to determine precisely what this baseline is and the GHG mitigation relative to it over time (i.e., additionality).

Heterogeneity: In agricultural landscapes, land use and soil type varies, and each landscape component will respond differently to alternative management practices. Effective monitoring of agricultural management outcomes at the landscape-scale requires the capacity to measure carbon and other GHGs for multiple land classes under different management regimes.

Low signal-to-noise ratio: A particular challenge for soil carbon is that the magnitude of annual changes is usually small relative to the size of existing carbon stocks, i.e., a low 'signal-to-noise ratio'. To detect meaningful change in carbon stocks and credibly attribute change to shifts in management practices, it may be important to develop monitoring approaches that achieve greater measurement precision or apply estimation techniques over larger areas and time frames.

Permanence: The environmental integrity of any biocarbon mitigation effort requires mechanisms to address the risk of future events such as fire, disease, or human intervention causing a loss of carbon to the atmosphere. Accounting approaches deal with the problem of permanence with buffer reserves, contracts, easements, insurance policies and risk premiums discounting the carbon price, but permanence must still be addressed through effective long-term monitoring.

Site-specific information gaps: For potential agricultural GHG project areas, data on local ecology, land use history and local drivers of land use change are often incomplete. There are many possible combinations of crop and soil types, climate conditions and management practices, and experimental measurements needed to understand the net mitigation impacts. Information that does exist may be dispersed, and the available mix of government, academic, and private information sources may not be comparable or accurate.

Measuring N_2O and CH_4 agricultural emissions: Nitrous oxide (N_2O) and methane (CH_4) face a different set of monitoring issues than terrestrial carbon. They do not have to contend with 'signal-to-noise' and permanence challenges, although they do confront similar field measurement issues such as additionality and heterogeneity. Models for emissions on farms from fertilizers must also be made more precise and relevant to precision fertilizer management. For methane, more work is needed in measuring emissions from rice paddies and from enteric fermentation, as well as on optimal diets for livestock to reduce emissions.

Cost-effectiveness: Developing requirements that balance the need for precise and accurate information with realistic expectations for the effort and expense that can be dedicated to MRV is essential for incentivizing shifts in agricultural practices. It is widely believed that strict MRV requirements inhibited implementation of A/R projects under the CDM, while lax rules contributed to low prices under CCX.

Status of the Tools for Agricultural GHG MRV

The ability of agricultural GHG projects to meet all of these challenges, along with rising standards of credibility and rigor in the emissions offset markets, is being aided by developments in remote sensing, sampling techniques for field measurements and modeling tools. Remote sensing has been used to record land use and land cover change for several decades and can also be efficiently used to track changes in the relative distribution of land use classes over time (more on this below). Field measurements and remote sensing data can be integrated into models to produce estimates with varying levels of accuracy, depending on available data and local ecology. Typical inputs for models include information such as current and historic natural disturbance, management practices, land use change, climate, soil properties, growth rates, decomposition rates, biomass pools (above and below ground estimates), conversion equations and estimates of variability and error. In tropical regions, reliable input data for models remains a major obstacle.

This section characterizes the status of measurement and monitoring capability for a number of agricultural landscape interventions.

Annual crop soil management

Annual crop systems can sequester soil carbon by incorporating above-and below-ground biomass. Soil carbon in a given soil sample can be measured with a great deal of accuracy and precision, and models of soil carbon to assess baseline carbon stocks and flows have been available for decades (eg, Century, EPIC, RothC models). But the high spatial variability in soils, efforts needed to extract soil samples, the complexity of soil carbon flows, along with the relative lack of investment in estimation techniques – compared to models for above ground biomass – has made them less precise for monitoring than those for woody perennials. There is a particular need for validation of soil carbon models in under-researched tropical areas.

Afforestation/reforestation (A/R)

When carried out as tree-planting in blocks of single or multiple species trees, models developed and validated by forest researchers can reliably predict quantities of carbon taken up by a growing stand of trees from sample plots in the project. These models, based on mapping of tree stands and allometric models using tree diameter or height, allow for relatively inexpensive estimation of sequestered carbon. Certainty is higher for the tree species used in pulp and timber plantations such as pine, eucalyptus or well-researched forests such as temperate hardwoods. Some uncertainties remain about the contributions to soil carbon or the quantity of carbon stored below ground in trees as roots, although generally accepted root-shoot ratios are common practice. Improved validation and adjustments to models are needed for under-researched tree species and biomes.

Avoided deforestation

For a large-scale mitigation project in a heterogeneous agriculture landscape that includes a sizeable area of standing forest, a component of avoided deforestation emissions reductions may be included. Many of the same principles and methods cited for A/R above apply to avoided deforestation. Models for forest biomass are relatively robust, but soils are often 'conservatively excluded' from these methodologies to simplify them. Natural forests are more frequently multi-age mixes of species, which may reduce precision compared to planted stands of trees. Literature

Photo credit : *Ganame Adama, farmer, explains the importance of protecting the trees on his farm to conserve soil and water nutrients. P. Casier, CGIAR*

Major Agricultural Mitigation Initiatives

As awareness of the importance of agricultural mitigation increases, a number of initiatives have been launched to synthesize and share knowledge and test mitigation practices and monitoring tools. Some examples include:

- The Technical Working Group on Agricultural Greenhouse Gases (T-AGG) is assembling the scientific and analytical foundation to support the implementation of high-quality agricultural GHG mitigation activities, beginning with a focus on US production agricultural and grazing lands. Key reports have been produced summarizing literature and evaluating implementation strategies.
- The World Agroforestry Centre is leading a global initiative on Reducing Emissions from All Land Uses (REALU) which is identifying how shifting cultivation system can evolve into carbon-storing agroforests and diverse tree crop production systems, supporting "high carbon stock rural development pathways."
- The Consultative Group on International Agricultural Research (CGIAR) is developing a challenge program on Climate Change, Agriculture and Food Security (CCAFS) to provide technical, institutional and policy support for agricultural management strategies that boost climate resilience and improve rural livelihoods.
- The UN Food and Agriculture Organization has initiated the Mitigation of Climate Change in Agriculture (MICCA) project in support of efforts to mitigate climate change through smallholder agriculture in developing countries with a focus on improving data on greenhouse gas (GHG) emissions and testing mitigation potential through pilot projects.
- Through the GEF-funded Carbon Benefits Project, a consortium of research institutions, in collaboration with local communities, is developing standardized protocols for data collection and an integrated system employing remote sensing and carbon and GHG models to estimate project baselines and changes over time, for a range of project types.
- The Global Research Alliance on Agricultural Greenhouse Gases (GRA) has been mandated by participating governments to address gaps in research on agricultural greenhouse gases, coordinate research and technical advancements internationally, and serve as a platform for information-sharing and technical convergence.
- Through the Global Agriculture Climate Assessment, a consortium of multinational food companies and NGOs is assessing agricultural mitigation potential within supply chains using the Cool Farm Tool, an open-source globally- relevant GHG farm-level calculator, and developing a multi-sectoral learning platform allowing this work to be done in a coordinated fashion across regions, crops and industries.

These initiatives will be most useful for supporting agricultural mitigation if they direct attention to both specific technical advancements and complex landscape-level management strategies (eg, restoring degraded lands across entire regions) and share findings through structured frameworks that bring together research institutions, private companies, and national and international agencies.

estimates of natural forest biomass may be used to constrain and validate model estimates.

Agroforestry

Agroforestry project activities are most often a mix of annual cropping and some variant of A/R, and the monitoring methods for agroforestry involve a mix of methodologies for these types of project activities. The potential spatial complexity of agroforestry presents a challenge to monitoring these systems, but there has been significant progress in sampling strategies. The CDM has an approved methodology for small-scale agroforestry based on A/R principles, but as currently written are problematic because national definitions of forest must be used, which characterize most agroforestry systems as forest, thus excluding annual cropping land.

Livestock management changes

Mitigation from livestock management involves reductions in methane emissions from gut fermentation of ruminants or changes in management of manure that lead to reduced emissions of methane. Monitoring is supported by a CDM standard on a per-farm basis for installation of improved manure management systems for methane capture, and by per-animal emission factors for animals from the IPCC.

Biochar incorporation into soil

Due to its high stability in soils, models have been developed to describe the long residence time of charcoal and its contribution to soil carbon stocks. In these models, roughly speaking, the application rate equals the sequestration rate, with a small loss of carbon over time due to slow degradation. The research around biochar is still very new, and the validity of these models is still being debated. However, the CDM is currently assessing the treatment of biochar, and a biochar methodology has been submitted to the VCS.

The components of agricultural methodologies discussed in this section have clearly reached varying levels of sophistication, but on the whole they are more advanced than many in the climate change community recognize. Additional research will improve them, but the key technological elements on which future methodologies will be built are currently available. The move from single component agricultural mitigation interventions to landscape-scale projects and programs will not require an additional layer of complexity, but the landscape methodologies can be based on the principle of modularity in which various components of the methodology can be added or subtracted depending the context of a particular landscape. As the quality of modeling improves, costs are likely to go down over time. There are also promising innovations in participatory data collection including the use of handheld GPS devices and cell phones.

Policy Actions to Improve Agricultural GHG MRV

This is a critical moment for investing in the development of agricultural MRV systems that are useful for the diverse public and private approaches for incentivizing agricultural mitigation currently being explored. The voluntary markets will likely continue to be the field of innovation for the short-term, but the growing profile of agriculture in the UNFCCC process as well as opportunities to build experience within subnational regulated markets will be important as well.

Project developers have addressed the monitoring challenges as they have emerged from implementation experiences. Credible agricultural MRV systems will also underlie NAMA programs and supply chain emission reduction projects.

If MRV systems are not convincing, then they will not provide the assurance of quality that markets demand, nor will agriculture be seen as a permanent mitigation option, fully fungible with others. Now is the time to lay the groundwork for the long-term development of these MRV systems. Policy makers can begin by implementing the following recommendations:

Include full range of agricultural mitigation options in the post-Kyoto framework

As a global climate treaty evolves, it should incorporate incentives for agricultural mitigation that encompass the full range of management practices that have been shown to reduce emissions and sequester carbon. Under the Kyoto Protocol, only carbon sinks in vegetation more than 2 m tall and 20% crown cover are included. As MRV tools continue to be developed, policy frameworks can allow for different types of incentives and financing for mitigation projects that achieve

Photo credit : *Solutions for smallholders, like this cattle farmer from Ninigui Village in Burkina Faso will be necessary for adapting to climate change. P. Casier, CGIAR*

different MRV tiers in order to encourage project implementers and countries to gain experience while building MRV capacity and infrastructure. Including agricultural soil carbon.

Support research programs for agricultural MRV Within the UNFCCC, a SBSTA work programme on agriculture can catalyze robust research on the technical challenges described above and link information to policy discussions regarding specific mechanisms and financing. This process could help establish a global assessment of agricultural soil carbon and create an extensive set of 'inventory' locations where direct measurements of terrestrial carbon would be collected along with pertinent soil, climate and land use management information. It might also support projects to advance agricultural MRV technologies including remote sensing.

Support the development of agricultural landscape scale methodologies

In addition to the acceptance of agricultural mitigation generally, methodologies are needed that can handle large, heterogeneous areas in the same project. There is growing agreement that a combination of models and on-the-ground measurements can yield robust MRV if applied at large enough scales (for example, through broad landowner participation within a given area). Relatively simple landscape methodologies can be developed with modular designs in which components of the meth-odology can be added or subtracted depending on context.

Support national capacity for agricultural monitoring

Over the next 5-10 years, as MRV methods progress, developing countries will require enhanced technical capacity (eg, infrastructure, regionally relevant MRV tools and methods, national planning, and pilot projects) so they are able to take full advantage of emerging incentives for agricultural mitigation. These countries will need improvements in data collection, remote sensing and modeling to create and manage national agricultural GHG inventories and to monitor GHGs on project and national levels.

Develop mechanisms to finance agricultural MRV

Early financing is needed from global donors to build capacity for MRV. As these investments are made and a critical mass of credible emission reductions is produced, private investments will be more likely to flow. Also, solutions are needed for the challenge of financing project setup and baselines when landowners may have to wait five years or more while carbon credits accrue.

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For Further Reading:

Carbon Gold. 2009. General methodology for quantifying the greenhouse gas emission reductions from the production and incorporation into soil of biochar in agricultural and forest management systems – under development. VCS Association. http://www.v-c-s.org/methodology_gmfqtgger.html.

Carbon Offset Solutions. Approved Alberta protocols. 2009. http://carbonoffsetsolutions. climatechangecentral. com/ offset-protocols/approved-albertaprotocols. Hamilton, K., M. Sjardin, M. Peters-Stanley, and T. Marcello. 2010. Building bridges: state of the voluntary carbon markets 2010. Bloomberg New Energy Finance and Ecosystem Marketplace.

CDM [Clean Development Mechanism] Executive Board. 2009. Simplified baseline and monitoring methodology for small-scale agroforestry - afforestation and reforestation project activities under the clean development mechanism-version 2. UNFCCC [United Nations Framework Convention on Climate Change].

EFDB [Emission Factor Database] - IPCC [Intergovernmental Panel on Climate Change] National Greenhouse Gas Inventories Project. http://www.ipccnggip.iges.or.jp/EFDB/ find_ef_s1.php. Hamilton, K., M. Sjardin, M. Peters-Stanley, and T. Marcello. 2010. Building bridges: state of the voluntary carbon markets 2010. Bloomberg New Energy Finance and Ecosystem Marketplace.

McIntyre, B.D., H.R. Herren, J. Wakhungu, and R.T. Watson, eds. 2009. Agriculture at a crossroads: synthesis report. International Assessment of Agricultural Knowledge Science and Technology for Development. Washington, DC: Island Press.

National Research Council. 2010. Verifying Greenhouse Gas Emissions: Methods to Support International Climate Agreements. Washington, DC: National Academies Press.

National Research Council. 2010. Verifying Greenhouse Gas Emissions: Methods to Support International Climate Agreements. Washington, DC: National Academies Press.

Regional Greenhouse Gas Initiative. Offset Categories. http:// rggi.org/market/offsets/categories. B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, and O. Sirotenko. 2007. In: Agriculture. In: B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer, eds.

Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, pp. 497 – 540.

UNFCCC [United Nations Framework Convention on Climate Change]. Approved SSC-A/R metho ologies. [http://cdm. unfccc.int/methodologiesSSCmethodologies/SSCAR/approved.html].

VCS [Voluntary Carbon Standard]. 2008. Guidance for agriculture, forestry, and other land use projects. VCS Association.

Vermeulen, S.J., P.K. Aggarwal, A. Ainslie, C. Angelone, B.M. Campbell, A.J. Challinor, J. Hansen, J.S.I Ingram, A. Jarvis, P. Kristjanson, C. Lau, P.K. Thornton, and E. Wollenberg. 2010. Agriculture, food security and climate change: outlook for knowledge, tools and action. CCAFS Report 3. Copenhagen, Denmark: CGIAR-ESSP Program on Climate Change, Agriculture and Food Security.

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