Quantification Options for Agriculture Projects

September 30, 2010

Introduction

Quantifying greenhouse gas (GHG) reductions associated with an offset project requires having accurate data on the changes in emissions, sequestration[1] or carbon storage caused by the project at relevant sources, sinks, and reservoirs (SSRs). The nature of agricultural GHG sources, sinks, and reservoirs, however, makes quantification relatively challenging. In contrast to industrial sources of GHGs, for example, which tend to be discrete and easily monitored, agricultural GHG sources and sinks are relatively small, dispersed over diverse landscapes, and sensitive to biophysical and climate conditions. These characteristics make it challenging to detect changes in emission and sequestration rates, and can cause rates to vary considerably over space and time. Forest projects face similar challenges in that they involve complex and diverse biological systems. However, low-tech field methods for measuring forest carbon stocks are readily available and verifiable, as individual trees can be observed and re-measured by a third party.

Background on Reserve Standards

The Climate Action Reserve's general policy is to require estimation methods that provide 95% confidence that actual GHG emissions (or carbon stocks) are within +/- 5% of measured or calculated values. Required levels of accuracy can vary depending on the specific sources or sinks being measured, the magnitudes involved, and their materiality with respect to overall GHG reductions. When a high degree of confidence is not practically achievable, the Reserve may choose to require conservative[2] estimates.

In Reserve protocols, GHG emissions or carbon stocks are quantified using standardized methodologies that incorporate actual measurements of project activity performance (to determine project emissions) or estimates of performance in the absence of the project (to determine baseline emissions). GHG emissions or carbon stocks for each SSR may be measured directly or calculated from measurements of parameters from which GHG emissions or carbon stocks can be derived. For SSRs where direct or indirect measurements are too costly or infeasible, GHG emissions or carbon stocks may be estimated using standard assumptions or models.

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[1] Sequestration is a measure of the change in carbon stocks over time, positive sequestration corresponds to removing carbon dioxide from the atmosphere.

[2] "Conservative" means that emission reductions will tend to be underestimated rather than overestimated. Conservative estimates will be those based on assumptions that tend to underestimate baseline emissions and overestimate project emissions. (Or, for carbon sequestration, overestimate baseline sequestration and underestimate project sequestration).

Choice of Quantification Methods for Agriculture Projects

The Reserve, in consultation with stakeholder workgroups, will need to develop practical and conservative approaches to quantifying GHG reductions at agricultural SSRs, building from the best available methodologies and tools. A number of approaches have been developed for quantifying agriculture GHG emissions, carbon stocks, and/or carbon sequestration, many of which were derived originally to support research but have been broadly adapted for use in GHG accounting methodologies. The approaches range in complexity, accuracy, and cost.

Field Measurement

Field measurement refers either to taking periodic soil samples to estimate soil carbon stocks over time, or directly measuring emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) gases in the field (e.g., using gas chambers that capture and analyze gas samples or gas sensors mounted above the terrain in flux towers or on aircraft). Field sampling methodologies array plots or instruments across a relevant area and collect a specified number of samples. Average values from collected measurements are used to estimate overall project GHG emissions or sequestration. Sample accuracy and field sampling design determine the overall accuracy of GHG estimates.

Field Measurement of Soil Carbon

When applied correctly, with sufficient sample replication, field measurements of soil carbon stocks have the potential to achieve a high degree of accuracy. However, there are significant costs associated with field measurements, especially when high accuracy is required. This is because soils vary considerably in inherent characteristics over small spatial scales, and it is difficult to detect incremental annual changes in carbon stocks because such changes are small compared to the total size of the soil carbon pool. While the cost of rigorous sampling can be very high, cost must be considered relative to the extent of the area the measurements represent. Sampling costs per acre, for example, will tend to decrease when estimating carbon stocks over larger areas because sampling efficiencies improve (i.e., fewer samples per acre are required to achieve the desired confidence level over the entire area being measured).

Field Measurement of GHG Emissions

Direct measurement of GHG emissions using gas chambers, even with well-designed sampling schemes, may not be able to achieve high accuracy due to the high variability in emissions over small spatial scales, making it difficult to generalize sample results. Moreover, gas sensors mounted on towers or aircraft are generally too specialized and expensive to be affordable for widespread application. Field measurement is therefore unlikely to be a feasible method for quantifying GHG emissions from agriculture projects.

Modeling Predictions

In recent years much work has been done to develop empirical and biogeochemical process models from experimental or observational field measurements. These models can predict GHG emissions based on data inputs collected at various scales (e.g., field level, county or region). Remote sensing applications may also provide inputs to these types of models. The quantification accuracy of models depends on the accuracy of measured inputs and how well model assumptions reflect actual circumstances. Accuracy can be improved by ensuring models are calibrated to a specific application.

Model predictions are generally considered less accurate than field measurements on relatively small scales, like a farm or field. However, model accuracy tends to improve when estimates are made over larger areas, like a county or region. In addition, while modeling estimates of *absolute* GHG emissions or carbon stocks may be relatively uncertain, models are often capable of accurately predicting *changes* in emissions or sequestration due to specific interventions, which is the key to quantifying GHG reductions associated with offset projects.

Some models explicitly incorporate the effects of different management practices. These models are potentially useful for estimating baseline emissions for offset projects, because baseline management practices can be specified and their effects modeled using actual climate and economic data measured over the course of the project. This kind of approach will often provide better estimates of baseline emissions or sequestration than simply using historic or proxy field measurements.

Use of Standard Factors or Coefficients

In some cases, general coefficients can be derived that estimate GHG emissions, carbon stocks or sequestration per unit of area (or other relevant denominators, such as activity levels). To estimate GHG emissions, the factors are multiplied by the size of the project area or by measured activity data, such as the amount of fertilizer applied to a field. Standard factors and coefficients are typically derived from field measurements or models and their accuracy depends on how well the data used in their derivation represents the conditions of the specific project. When field measurements from a specific site are used to derive site-specific emission factors, these will be more accurate than using regional or national emission factors to estimate emissions from that site.

Standard factors and coefficients are simple and transparent to use, and can streamline the application of a protocol. However, because such factors are generalized representations, they tend to be the least accurate tool for estimating GHG emissions or sequestration in agriculture. As a general rule, Reserve protocols use standard factors to conservatively estimate GHG emissions or sequestration at relatively minor sources and sinks.

Integrated Approaches

The general quantification methods listed above are not mutually exclusive. In many cases, it may be possible to combine them in ways that balance accuracy and practicality. For example, requiring field measurements of key model inputs (e.g., daily climate, soil characteristics, cropping history, and current cropping system) at a project location could improve the accuracy of modeled soil carbon estimates for that particular site. In addition, model predictions could be verified by periodically testing them against field measurements at the project site.

Alternatively, standard factors and coefficients could be derived for specific circumstances (e.g., for specific regions, management histories or cropping systems) using models calibrated with representative input data or actual field data. This would enable the use of tailored emission or sequestration factors, improving accuracy and simplifying quantification procedures.

Relying on Aggregation

Since achieving required levels of quantification accuracy may be costly or difficult for individual projects in the agriculture sector, the Reserve has begun to consider ways to achieve accuracy requirements across a group of projects, i.e., projects that are part of an “aggregate.” Accuracy requirements for aggregated projects can be achieved more cheaply and easily because of improved sampling efficiency: fewer samples per acre would be required to achieve the same level of accuracy. The economies of scale that are possible through aggregation may help to make rigorous quantification methods more affordable. The Reserve has developed aggregation guidelines for its Forest Project Protocol based on these principles and sees aggregation as a potentially critical component of agriculture offset quantification methodologies.

Developing Climate Action Reserve Agriculture Offset Protocols

Table 1 summarizes the agriculture SSR quantification methods that the Reserve is aware of to date. The Reserve, in consultation with protocol workgroups, will consider these methods, as well as others that may be available, during each protocol development process. Specifically, the Reserve will examine how to achieve its target standard for accuracy while balancing practical and cost-effective implementation of quantification approaches. In addition, the Reserve anticipates that the most appropriate methods may vary geographically based on cropping systems, management history, and available data.

Table 1. Summary of Existing GHG Estimation Methods for Agriculture SSRs

Category of Method	Specific Method	Agriculture SSR Estimated	Cropland management	Grassland conservation	Grazing land management	Nutrient management	Rice Cultivation
Field sampling	Soil cores to measure organic carbon content	Measures soil carbon reservoir (used to derive CO_2 sequestration)	x	x	x		
	In-situ laser or light spectroscopy	Measures soil carbon reservoir (used to derive CO_2 sequestration)	x	x	x		
	Flux towers and aerial gas measurements	Measures CO_2, CH_4 or N_2O gas exchange from the ecosystem	x	x	x	x	x
	Gas chamber techniques	CO_2, CH_4, and N_2O gas exchange from soils	x	x	x	x	x
Biogeochemical process models	CENTURY model	Predicts carbon sequestration rates in soils	x	x	x		
	DNDC model	Predicts carbon sequestration, CH_4, and N_2O	x	x	x	x	x
	Daycent model	N_2O emissions from soils				x	
Empirical models	Bauwman et al.	N_2O emissions from soils				x	
Emission factors	IPCC N_2O	N_2O emissions from soils				x	
	IPCC CH_4	CH_4 from flooded rice					x
	U.S.-specific rice emissions (EPA Inventory)	CH_4 from flooded rice					x
	Midwest N_2O emission factor (Millar et al.)	N_2O emissions from soils				x	
	CCX no-till	Carbon sequestration in soils	x				
	CCX conversion to grassland	Carbon sequestration in soils		x			
	CCX grazing land	Carbon sequestration in soils			x		