Carbon market for climate smart agricultural practices

Why rigorous measurement, modeling, and scalability matter to farmers

Introduction

Climate-smart agricultural practices that improve soil health and sequester carbon can provide financial benefits to farmers while concurrently improving environmental conditions by increasing biodiversity, reducing GHG emissions from undisturbed land, minimizing the need for fertilizers and pesticides, and improving water quality and drought tolerance.[1] Farmers currently lack financial incentives to implement climate-smart management practices. Through a carbon credit program, farmers can increase their profitability and simultaneously implement farm management practices that enhance soils, improve environmental conditions, and mitigate climate change.[2] Generating high-quality carbon credits requires meticulous and transparent standards for GHG mitigation (for example, realistic baseline, additional, and permanent, etc.). Therefore, policy initiatives must focus on high-quality carbon credits underpinned by robust monitoring, reporting, and verification to ensure the long-term viability of a carbon crediting program. This provides financial resilience to farmers and ensures long term environmental benefits. The government can support these initiatives by providing market assurance via certification of acceptable soil carbon offset standards, and by providing technical assistance to encourage grower enrollment in the most robust programs. This document serves as a primer on the current state of the science that enables robust measurement, reporting, and verification.

Key Takeaways:

- A combined monitoring approach encompassing direct measurement, modeling and remote sensing technologies promotes an accessible and scalable program to farmers, helping to reduce their GHG emissions while securing their long-term financial resilience. See Table 1, which describes ways to improve the quantification of carbon credits in the future.
- The key to managing a complex, multi-field approach is very detailed tracking of field level reporting and verification activities so that the carbon program can be assured that there is no reporting overlap at the field level.
- Harmonization between government reporting and farm data systems could take several forms: collaboration between the USDA and carbon markets standard-setting bodies on what data are needed and how those requests are worded; development of a system for carbon project developers, verifiers, and/or registries to digitally access farmer data directly from the USDA, with safeguards for data privacy and security; and development of platforms by carbon market participants whereby carbon project data collection can be leveraged to generate government reports directly.
- By continually assessing which data are hard to obtain as well as which parameters are most important to GHG outcomes, we can simplify the inputs required (by sourcing default values) without sacrificing the collection of program critical data. If we align modeling and reporting with the types of data the farmers are generating, it reduces friction at the field level. Alignment along the chain from field to model to GHG reporting will reduce confusion, complexity, and conversions, and make it easier to implement software to increase automation and reduce effort and potential sources of error.

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[1] Popkin, G. 2020. March 31. *Can 'Carbon Smart' Farming Play a Key Role in the Climate Fight?* Yale Environment360. https://e360.yale.edu/features/can-carbon-smart-farming-play-a-key-role-in-the-climate-fight

[2] National Academies of Sciences, Engineering, and Medicine. 2019. Negative Emissions Technologies and Reliable Sequestration: A Research Agenda. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/25259.

- Research is needed to understand the drivers of carbon loss and the related indicators that can be monitored remotely.
- Software and digitization of farm data can reduce the complexity of a multi-field project, enable faster payments to growers, and lower the burden of data collection and increase the quality of data collected.
- It is critical that federal policies support and enhance farmers' ability to generate high-quality (i.e., credible and verifiable) carbon credits and avoid policies and programs that place unintentional and unnecessary roadblocks to farmer participation in carbon markets.

Monitoring, Reporting, and Verification

Monitoring

Past carbon credit methodologies rely either on the use of models or entirely on direct measurement. A scalable approach incorporates the best of both modeling and direct measurement, with rigorous guardrails to ensure both are done with scientific integrity. The newly released Soil Enrichment Protocol (Sept 2020) from the Climate Action Reserve and the Verra's Methodology for Improved Agricultural Land Management (Oct 2020) demonstrate a rigorous and flexible approach to carbon crediting on agricultural lands.

Considerations for a strong carbon crediting program

Permanence: Monitoring of performance and permanence must be required throughout and beyond the entire crediting period to effectively address the permanence of the credits. The internationally accepted standard for permanence of carbon offsets is 100 years from the year the emission reduction occurred. What remote monitoring technologies can help achieve this?

Leakage: Changes to agricultural management practices can potentially lead to changes outside of the project area. Most importantly, if the project leads to a decline in yield, some or all of that decline could be balanced by yield increases (and resultant emissions increases) elsewhere.

Additionality: There are multiple aspects to establishing additionality, including regulatory surplus, the timing of the activity in relation to the reporting and verification, the barriers faced by the farmer to implementation of new activities, and the question of whether the new practice(s) should be considered business as usual.
Source: Climate Action Reserve. 2020. Soil Enrichment Protocol v1.

Modeling

Validation and Multi-model approach

The use of biogeochemical computer models underpins the carbon crediting process by predicting GHG emissions and changes in soil carbon over time. Testing and validation of models must meet strict standards and pass an independent review process to ensure separation of training and test data, unbiased model performance, and accurate estimation of model uncertainty. Combining multiple biogeochemical models using ensemble approaches can further reinforce estimates of carbon credits and reduce uncertainties.

Remote sensing

To ensure the high quality and scalable data are used in the carbon crediting process, whether to feed into a biogeochemical model or support a farmer's claim, remote sensing technology plays a critical role. It enables a massive scale-up across both space and time, helping to fill in historical data gaps and cover vast regions across the landscape.

Hybrid approach & scalability

While the quantification of carbon credits begins with direct measurements of soil carbon, the process is able to scale up efficiently and effectively only by leveraging the use of state-of-the-art biogeochemical models to simulate credits across millions of acres, and innovative sources of environmental data like remote sensing to meet the high data demands of the models. See table 1 for more information on how to improve future quantification.

Reporting

Defining reporting periods for agriculture

Many carbon offset projects, such as landfill gas destruction or improved forest management, allow for clearly-defined reporting periods that begin at the project start date and can easily be organized into 12 month blocks. This is especially true for projects which are single instances, not involving grouping or aggregation of multiple sites, fields, activities, etc. There are different “break points” in the annual cultivation cycle that could be chosen, but the key is to choose a break point that is both clearly definable and able to be consistently applied, as well as a logical point to extract outputs from a biogeochemical model. The reporting period (or cultivation cycle) should cover all activities from harvest to harvest each year.

Defining reporting periods for an aggregated carbon credit project can be complex. Every individual field is likely to have a different annual cultivation cycle, with harvest dates varying between fields based on weather, crop type, geography, management practices, etc. This means that, while each individual field will have a very clear reporting period, stretching harvest to harvest, and encompassing roughly one year, when these fields are grouped together into a single project there will be no fixed reporting period for the project itself. While this may seem unusual at first, based on past precedent in the carbon market, there is no conceptual or scientific reason why it should be problematic.

Leveraging and harmonizing government reporting

The majority of farmers are experts in farming, not in data collection and reporting. Every additional question asked or piece of evidence they need to provide chips away at their willingness to continue participating in a carbon project, or even to get involved at all. In some cases, information reported to government programs, such as annual crop insurance and for EQIP payments, overlaps with the information needed for crediting under a carbon project (e.g., crop type, planting dates, management activities, yield, etc.). This presents an opportunity for harmonization to reduce the burden of data collection on the farmer.

Simplifying and/or standardizing the process of reporting on use of custom software and complex models

One driver for the data collection burden on farmers is the complex needs of the quantification methodologies and biogeochemical models. Work can be done to research the sensitivity of models to certain inputs, and potentially develop more detailed collections of default input values to support gap filling in a credible manner. In this way, model developers can work to simplify the model inputs and outputs to simplify data collection and reporting. Project developers can reduce friction by building their systems to align the farm data with required model inputs and then smoothly align model outputs with quantification methodology equations. Registries and methodology developers can reduce friction by continually seeking feedback from project developers regarding ways in which protocol requirements can be streamlined and simplified.

Reporting and verification of permanence after crediting is complete – the role of remote monitoring

In order to issue offset credits related to stored soil carbon with a level of integrity that supports corporate carbon neutrality claims, a project developer and registry must work together to ensure carbon storage on a 100-year timeframe. 100-year contracts are not feasible for private project developers and farmers. However, achieving 100 years of permanence is possible through reliance on automated, remote monitoring of field-level activities, aggregated to the project level, to detect and estimate the magnitude of reversals during the permanence period (the period of time following the crediting period, during which no new credits are generated). Such a system can then be paired with financial mechanisms, such as a private buffer pool or an insurance product, to compensate the registry system for reversals which may occur far into the future. Further work is needed to define the actual approaches that will work for the market and the registries.

Verification

Market confidence and credit integrity require that project design, implementation, and performance must be regularly subjected to transparent auditing by independent experts. In the carbon market this audit process is known as verification and is guided by long-established international standards (e.g., ISO 14065), programmatic guidance (e.g., Climate Action Reserve Verification Program Manual), and accreditation programs (e.g., American National Standards Institute).

The challenge with setting a high bar for integrity and transparency through independent verification is that it can place a significant cost and time burden on farmers and project developers to connect agricultural management practices with credit generation and execute farmer payments, accordingly. In order to make agricultural carbon projects feasible, new methodologies recognize that projects must aggregate many different fields and farmers together, reaping benefits through economies of scale and by employing sample-based approaches. However, aggregation adds complexity, especially when applied to agriculture, where there can be significant variability between different fields. Data entry software can standardize the process of collection, cleaning, and using farm management data for credit quantification. By using software, the verifier can assess the underlying logic and engineering of the automated processes, thus gaining comfort with a large amount of data with a smaller amount of work. In addition, digitization at the farm level can significantly lower the burden of data collection, while simultaneously increasing the quality of the data being collected. If farmers can access solutions such as cloud-connected farm equipment, it will not only increase the likelihood of their participation (by reducing effort) but will also likely increase their potential carbon revenues (by increasing data coverage and quality, reducing the need to rely on default values). Digitization of USDA data supports this aim, as well.

Federal government role

Creating flexible and science-based policies surrounding carbon credits will lead to financial resiliency for farmers and environmental improvements. Decisionmakers should carefully draft policies, incentives, and programs to ensure that they do not hinder, undermine, or prevent farmers from participating in a carbon credit program. For example, current crop insurance program requirements disincentivize growers from covering their soils, especially after late planting periods of prevented crops. Amended, properly structured crop insurance rates would incentivize, or at minimum not inhibit, climate smart agriculture practice adoption and accelerate the pace of soil carbon sequestration, while increasing the resilience of US agriculture.

Further, carbon credit policies and programs should require participants to adhere to the highest standards of carbon offset quality. This means that carbon credit programs should: draw on research that documents benefits of climate smart approaches and avoid policies that reinforce approaches that lack scientific rigor. For example, a Carbon Bank run by the USDA would implement flexible standards and leverage the current design of carbon credit programs[3].

In addition, enhancing federal datasets would enable access to more robust datasets that could be leveraged by carbon credit programs. By expanding the quality, coverage, and ease of access to government data, carbon credit programs could further boost the scientific methodology behind crediting programs. For example, increasing the quality and resolution of government soil data layers (e.g., SSURGO) and allowing digital access to individual farmer data, without compromising privacy or security, would increase scientific rigor of carbon credit methodologies and reduce the reporting burden on farmers.

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[3] For in depth assessment of Carbon Bank opportunities, refer to the "Policy Opportunities for Climate Smart Agriculture" policy brief released April 22, 2021.

Improving quantification of carbon credits in the future

Advances in science and technology have critical roles to play in improving the ability of both growers and project developers to implement climatically impactful practices at scale by 1) reducing the accounting burden on growers to generate high-quality credits, and 2) reducing the cost to quantify net GHG emissions on agricultural soils. Table 1 provides a short overview of specific ideas that could address each barrier and links to any relevant ongoing work or research.

Table 1. Areas where innovation can improve quantification of carbon credits

Challenge Area	Approach	How it addresses challenge	Examples of Ongoing Work
Burden of data entry	Improved quality and resolution of soil datasets (e.g., SSURGO)	Reduces grower data entry burden and burden on carbon project developer to enter soil analysis results	
	Data standards for practice documentation that meet registry requirements	Enables direct data capture from FMIS to verify practices and run models	OpenTEAM
	Remote sensing to identify management practices	Fills in historical gaps, reduces burden of monitoring	Indigo Atlas Satellite Technology, Gao et al.[4,5]
	Test assumptions of number of years of historical data required for accurate baselines	Reductions in number of years of historical data required would enable more land to be put towards creditable changes	
Cost of quantification	Low-cost trace gas emission detection	Enables greater data capture on new practices to calibrate and validate models	
	In-lab spectroscopic methods for soil analysis	Multiple parameters estimated from single measurement, increases throughput	MIR technology development[6,7,8,9]
	In-field spectroscopic methods for soil analysis	Reduces operational costs/logistics of soil sampling	SHI DeepC system[10]

[4] Gao, Feng; Anderson, Martha C.; Hively, W. D. 2020. "Detecting Cover Crop End-Of-Season Using VENµS and Sentinel-2 Satellite Imagery" Remote Sens. 12, no. 21: 3524. https://doi.org/10.3390/rs12213524

[5] Gao, Feng Nmn, Feng Gao, Martha Anderson, Craig Daughtry, Arnon Karnieli, Dean Hively, and William Kustas. "A within-season approach for detecting early growth stages in corn and soybean using high temporal and spatial resolution imagery" Remote sensing of environment 242, (2020): 111752. doi: 10.1016/j.rse.2020.111752

[6] Leonardo Deiss, Andrew J. Margenot, Steve W. Culman, M. Scott Demyan. 2020. Tuning support vector machines regression models improves prediction accuracy of soil properties in MIR spectroscopy. Geoderma, Volume 365, 114227, ISSN 0016-7061, https://doi.org/10.1016/j.geoderma.2020.114227.

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[8] Wijewardane, N.K., Ge, Y., Wills, S. and Libohova, Z. (2018), Predicting Physical and Chemical Properties of US Soils with a Mid-Infrared Reflectance Spectral Library. Soil Science Society of America Journal, 82: 722-731. https://doi.org/10.2136/sssaj2017.10.0361

[9] Dangal, Shree R.S.; Sanderman, Jonathan; Wills, Skye; Ramirez-Lopez, Leonardo. 2019. "Accurate and Precise Prediction of Soil Properties from a Large Mid-Infrared Spectral Library" Soil Syst. 3, no. 1: 11. https://doi.org/10.3390/soilsystems3010011

[10] Ag Daily. Nov 2020. Soil Health Institute to develop soil carbon monitoring system.https://www.agdaily.com/crops/shi-develop-soil-carbon-monitoring/

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