AGRICULTURE & RURAL DEVELOPMENT
NOTES

Reduced Emissions and Enhanced Adaptation in Agricultural Landscapes

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This brief is based on the key messages of a conference held on January 23, 2009 at the World Bank to review the State of the Art on "Agriculture and Climate Change – Investing now for a Productive and Resilient Future."[1] It is not the formal position of any one academic institute or organization, but sets out the key issues on:

- Carbon as an integral part of sustainable land, water and biodiversity management in developing country agricultural landscapes and in any post-2012 framework and market mechanisms. Agricultural emissions reductions are already eligible under the Kyoto mechanisms for Annex I (industrialized) countries;
- Agricultural soil carbon measurement, modeling and monitoring capabilities;
- Challenges and opportunities in estimating soil carbon stocks and changes;
- A robust and integrated measurement and monitoring system; and
- Further action steps to ensure objective consideration of agricultural soil carbon in post-2012 climate change solutions.

CARBON IS INTEGRAL TO SUSTAINABLE LAND, WATER, AND BIODIVERSITY MANAGEMENT IN AGRICULTURAL LANDSCAPES

Seventy-five percent of the world's poor live in rural areas and most depend on agriculture for their livelihoods. Developing countries and especially the rural poor are concerned about adapting to climate change and enhancing the resilience of their agriculture-dependent livelihoods to climate change.

The adoption and scaling up of good agricultural practices and integrated natural resource management (NRM) can potentially address both mitigation and adaptation in production landscapes to climate change by:

Photo: Agriculture and Rural Development (ARD), The World Bank

- Protecting existing stocks of soil carbon in croplands, peatlands, and wetlands
- Replenishing soil and biomass carbon and improving productivity in degraded lands, and
- Reducing greenhouse gas (GHG) emissions from crop and grazing land.

Agriculture contributes to about 30 percent of GHG emissions, but has major potential to provide both mitigation and adaptation interventions to combat climate change and reduce poverty.

The limitations on the eligibility of agricultural carbon sequestration in the Clean Development Mechanism (CDM) of the Kyoto Protocol was a major missed opportunity to engage developing country farmers and rural poor in improved agricultural and NRM practices to mitigate climate change.

Proposals to also include agricultural offsets in post-2012 policies will need to design approaches to ensure that offsets are true reductions in GHGs. Carbon sink offsets need to be: (a) Measurable, (b) Reportable and (c) Verifiable, currently referred to as MRV.

The following issues are relevant for developing country agricultural soil carbon discussions:

1. Agriculture is a major GHG emitter and accounts for about 14 percent of global emissions. Furthermore, the continuing conversion of forests to agriculture is a major factor causing deforestation, which accounts for an additional 17 percent of global emissions. Thus combined, agriculture and land use change/deforestation contribute about 1/3 of current total anthropogenic greenhouse gas forcing.

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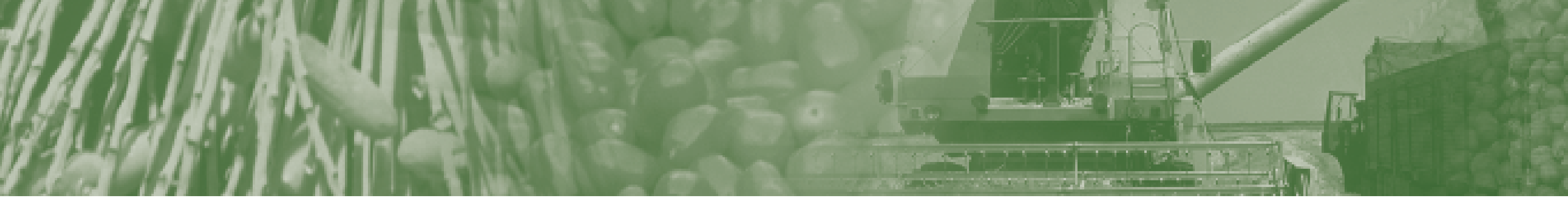

Most of agriculture's contribution comes from nitrogen dioxide (N_2O) and methane (CH_4) emissions, while the dominant gas for other land use is carbon dioxide (CO_2), associated from deforestation and biomass burning (IPCC-Working Group III, 2007).

2. There is significant biological/technical potential for GHG mitigation within agriculture through both emissions reductions (mainly of N_2O and CH_4) and removals of CO_2 (with increasing storage of carbon (C) in soils and biomass on agriculture land), on the order of 5.5 to 6 Pg CO_2 equivalents yr^{-1}, over a 10-30 year time horizon (IPCC-Working Group III, 2007). The dominant component (about 80 percent) of this potential is associated with soil carbon sequestration in cropland and grazing lands and restoration of degraded lands in developing countries (IPCC-Working Group III, 2007).
3. There is strong consensus based on robust empirical datasets that enhancing soil organic carbon contents of soils can improve land, water, and crop productivity, as well as, enhance the adaptive capacity of the land against climate-related shocks—the mitigation-adaptation double divided.

SOIL CARBON MEASUREMENT CAPABILITIES

However, soil carbon sinks have not received much consideration in current GHG reduction policies, in part due to the lack of understanding by many policy makers and others about the capabilities of measuring soil carbon. Thus it is worth stating some key facts regarding the general scientific capabilities to measure soil carbon:

- The carbon content of a soil sample can be measured with a high degree of accuracy and precision. Instrument error associated with modern dry combustion auto-analyzers are less than 0.1 percent and the overall lab measurement error using proper protocols is in the neighborhood of 1-2 percent.
- Equipment and protocols for soil sampling are well documented and have been applied throughout the world, for decades.
- The general response of soil carbon stocks to environmental variables and management practices are relatively well known. There are hundreds of long-term field experiments globally which provide information on management-climate-soil interactions on soil carbon dynamics.
- Sophisticated models of soil carbon dynamics have existed for over 20 years and are increasingly deployed for research, management, and policy applications.

CHALLENGES AND OPPORTUNITIES IN ESTIMATING SOIL CARBON STOCKS AND CHANGES

There are challenges involved in estimating soil carbon contents and carbon stock changes at the field scale due to the fact that:

1. Soil carbon contents are often highly variable within an individual field.
2. Annual changes are usually small, relative to existing carbon stocks. For example, typical carbon stocks in the top layer (20 cm or so) of many agricultural soils are on the order of 20-80 tons/hectare whereas typical rates of carbon changes might be on the order of 0.1-1 tons/hectare/year; therefore, there is a low 'signal to noise ratio' over short time scales.
3. Multiple factors (for example, soil type, climate, and previous land use) influence soil responses at a specific location.
4. While there are many existing field experiments that document soil carbon changes, at the global scale, experimental measurements are lacking for many if not most crop, soil, climate, and management combinations.
5. There are virtually no 'inventory' measurement systems for soil carbon (for example, in comparison to forest biomass inventories).

Thus the fundamental problem with respect to direct measurement of soil carbon stocks and stock changes is not so much an issue of measurement capabilities, but rather a question of applying efficient sampling designs and rigorous protocols. Various measures, such as the use of benchmark sampling locations that can be precisely relocated (to reduce the influence of spatial variability) and re-measured over multi-year intervals, can contribute to an efficient design to quantify soil carbon stock changes.

A ROBUST AND INTEGRATED MEASUREMENT AND MONITORING SYSTEM

Measurement and monitoring systems involve tradeoffs with respect to the time, effort, confidence, and cost invested in the estimates. Generally, two alternatives exist, but an optimal system will integrate direct measurements with modeling and other data sources such as remote sensing. The existing alternatives include:

a. **Direct Field Measurements**: At one end of the spectrum, direct field measurements of soil carbon stock change could be required for every participant and/or field involved in an offset project. Monitoring and certification of offset credits generated would be strictly determined from the field measurements.

b. **Model-based Approaches**: At the other end of the spectrum, a practice-based approach could be applied in which participants are given a fixed credit for adopting a particular practice, where the presumed soil carbon change is based on average estimates for a large region, based on existing data sources. Monitoring and certification of offset credits generated would be on the basis of the participant applying a specified practice.

There are challenges related to both of these alternatives. While alternative (a) is arguably the most rigorous in terms of quantification, it is impractical, both operationally and in terms of cost, particularly for developing countries. The costs of measurement and monitoring would be prohibitive for the majority of projects. Alternative (b), while being a low cost option, arguably lacks sufficient rigor to address the skepticism about soil carbon sinks – are they really performing as advertised? Unfortunately, an adequate database of field measurements and understanding of soil carbon changes does not yet exist to permit the derivation of 'stock change factors' or other model-based estimates that would satisfy the demands for accuracy and precision in estimating soil carbon changes, at project scale, for the various practices, soil types, climate conditions and land use histories involved, particularly in developing countries.

Therefore, a robust compromise would be to integrate both direct field measurements and model-based approaches to leverage state of the art scientific understanding and existing data, as embodied in currently available dynamic models of soil carbon change, along with a coherent and expanding network of field based measurements, under 'on-farm' conditions. This can improve the performance of and determine the uncertainty of model-based estimates. Over time, the reliability and performance of such a hybrid system would improve such that monitoring and verification could increasingly be based on practice-based approaches including, remote sensing and rapid ground survey methods, and correspondingly less on direct measurement based verification.

THE NEED FOR AN ENVIRONMENTALLY STRONG AND EFFECTIVE POST-2012 FRAMEWORK

Fortunately, political momentum is building for an environmentally strong and effective post-2012 framework, fueled by the state-of-the-art science presented in the International Panel on Climate Change (IPCC) Fourth Assessment Report. The European Union's leaders are working on both a mid-term reduction target for 2020 and a long-term objective of avoiding 2°C of warming. The world's first GHG emissions cap-and-trade market, the European Union Emissions Trading Scheme (EU-ETS), topped US$24 billion in 2008, and is expected to grow significantly. In the U.S., legislation to place mandatory caps on GHG emissions and establish a GHG trading market has been proposed in both houses of Congress. Thirty leading U.S. companies have formed the U.S. Climate Action Partnership (US-CAP) to press for adoption of such legislation. States like California and the northeast states are moving ahead to implement their own cap-and-trade regulations. By end of 2009, New Carbon Finance expects to see the global carbon market on a level with 2008 at around US$121 billion, supported by higher trading activity but lower prices. If the US does introduce a federal cap and trade scheme in line with the latest proposals, the global carbon market could increase significantly in the post-2012 period, turning over of the order of US$2 trillion per year by 2020 (New Carbon Finance).

Photo: Agriculture and Rural Development (ARD), The World Bank

China recently released a national strategy on climate change and a group of major tropical nations, led by Papua New Guinea and Costa Rica, have signaled interest in reducing emissions from tropical deforestation, the source of roughly one-fifth of global GHG emissions. Negotiators seeking to develop the post-2012 international framework have an unparalleled opportunity to build on this momentum in a way that furthers the United Nations Framework Convention on Climate Change (UNFCCC) objective of stabilizing atmospheric GHG concentrations at a level and within a timeframe so as to avert dangerous climate consequences. There is growing awareness that such a framework must not only require deeper reductions from industrialized countries but also reform of the CDM.

- **A key issue for agriculture is which sinks will be recognized under any future ETS**. Sequestration in 3.3 sinks will almost certainly be recognized under the ETS. It is undecided whether sequestration in article 3.4 sinks will be recognized.
- **Developing country farmers will have a potentially powerful incentive to better manage soil and water resources** for improved food production AND carbon sequestration if the ETS allows article 3.4 sinks to be included.
- **Emissions can be offset by storing carbon in sinks**. Kyoto Protocol Article 3.3 sinks are defined as woody vegetation more than 2 meters tall, more than 20 percent crown cover, and greater than 0.2 ha in area. Kyoto Protocol Article 3.4 sinks include carbon in soil and vegetation, both above and below ground on crop and grazing land.
- **Early investigations suggest that soil has potential to store significant quantities of carbon**, but for article 3.4 sinks to be included there needs to be substantial investment in research and development of both emissions and sequestration on agricultural land.

ACTION STEPS TO ENSURE THE ADEQUATE INCLUSION OF AGRICULTURAL CARBON IN THE POST-2012 INTERNATIONAL RESPONSE TO CLIMATE CHANGE.

This note is focused on agricultural carbon, but is closely linked to the development and operationalization of a new paradigm for agricultural intensification—more food and fiber but with less land, more efficient water use, less fossil fuel inputs, significantly reduced land and water pollution, and reduced greenhouse gas emissions. In the context of this agricultural paradigm shift, the following action steps are important for protecting and enhancing agricultural carbon:

1. **Establish a global assessment of agricultural soil carbon, which includes:**

   i. A mechanism to finance a number of pilot projects, to establish an extensive set of re measurable 'inventory' locations—where direct measurements of terrestrial carbon would be collected—along with pertinent soil, climate, and land-use and management information. Account for increasingly variable or changing climate.

   ii. A set of rigorous field and lab protocols, and cross lab calibrations that would be applied across all the pilot projects.

   iii. A common data archive, in which all the information from the various projects participating—with appropriate safeguards for data confidentiality—would be available for use by a suite of open source models. These models could then be evaluated and improved, with the provision for independent data sets to be used in establishing measures of model uncertainty.

   iv. Pilot projects to develop and test remote sensing-based and ground survey-based methods for monitoring and verification of management practice implementation.

   v. Scaling up the testing and application of emerging technologies to enhance agricultural carbon sequestration and monitoring—such as biochar, biogas, digital soil maps, and soil-sensing spectral methods.

2. **Develop a mix of market and non-market mechanisms to encourage agricultural carbon sequestration and reduce carbon emissions, such as:**

   i. Payments for ecosystem services that can be accessed by communities for actions that enhance agricultural biomass and soil carbon, above- and below-ground biodiversity, and hydrological (environmental) flows.

   ii. Public support for agroecological zone and distributed hydrological modeling, alongside land-use planning approaches to optimize synergies and tradeoffs of land-and-water management options for improved productivity and agricultural carbon sequestration from local to national and even regional scales.

   iii. Voluntary funds from developed countries, philanthropic organizations, and the private sector to encourage desirable land-and-water management approaches that protect and enhance agricultural carbon sequestration.

3. **Better understand national sovereignty issues related to biodiversity, forests, and land-and-water management. Use the improved agricultural carbon assessments and modeling methodologies that have been highlighted to ensure rights to equitable ownership of carbon credits and to minimize or resolve conflicts.**

4. **Enhance the capacity of national institutions and professionals to ensure their effective participation in:**

   i. The negotiation process at national (across sectors), regional, and international levels leading up to, and during, a post-2012 climate change treaty.

   ii. Creating and managing national agricultural carbon inventories and the monitoring and verification of project and national-level outcomes.

   iii. Developing appropriate national mechanisms and overseeing the distribution of agricultural carbon payments to the rural communities engaged in protecting and sequestering agricultural carbon.

This ARD Note was prepared by Erick Fernandes and Dipti Thapa and edited by Sonia Madhvani of the World Bank. It is based on key messages from a 2009 Conference held on January 23, 2009 at the World Bank to review the State of the Art on *"Agriculture and Climate Change – Investing now for a Productive and Resilient Future."*

1 Participants from Civil Society Organizations, Philanthropic Foundations, Academia, and the World Bank contributed presentations and experiences: The World Bank, Kansas State University - Department of Agronomy, Woods Hole Research Center, Colorado State University, Cornell University, COMESA, World Wildlife Fund (WWF), Katoomba Group, Ecoagriculture Partners, Climate Focus, C-Quest Capital, B&M Gates Foundation Grantee - World Soil Information Center (ISRIC), International Development Research Centre (IDRC) -, The William J. Clinton Foundation, The H. John Heinz III Center for Science, International Development Research Centre (IDRC) Rural Poverty & Environment/Climate Change Adaptation, Rockefeller Foundation, International Biochar initiative (IBI), and ProNatura.