Policy Briefs 7

Roadmap for Terrestrial Carbon Science

Research Needs for Carbon Management in Agriculture, Forestry and Other Land Uses

Discussion Draft
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The Terrestrial Carbon Group Project

In partnership with UN-REDD agencies, the World Bank, and CGIAR institutions, the Terrestrial Carbon Group is assessing the scientific and technical advancements needed, globally and in specific regions, to maximize terrestrial carbon mitigation and to document and reward outcomes. Implementation of terrestrial carbon emission reduction and sequestration activities can and does occur across a wide range of geographic scales and land classes. This requires a coherent, integrated information base for effective land management practices that produce real increases in sequestration together with real reductions in GHG emissions from terrestrial sources, and, transparent, consistent, and comparable quantification of changes in carbon stocks.

1 Introduction

Improved management of the world's terrestrial carbon in Agriculture, Forestry, and Other Land Use sectors (AFOLU) is a necessary part of the global effort to avoid dangerous climate change. There are a wide range of strategies for avoiding emissions and increasing sequestration of terrestrial carbon in forests, croplands, grasslands and drylands, and wetlands and peatlands. Many of these strategies can also increase ecological productivity, resilience, and biodiversity among other co-benefits.

It is expected that governments will agree in Copenhagen in the near future to incentives for improved management of some forms of terrestrial carbon in developing countries, including maintaining existing carbon (eg, avoiding deforestation and forest degradation) and creating new carbon (eg, afforestation). Efforts in both the public and private sectors are building the foundation for incentives for improved carbon management under agriculture, forestry, and other land uses.

As new incentives for protecting and sequestering terrestrial carbon are agreed in international negotiations and created in both voluntary and compliance markets, a robust technical and scientific information base is needed to translate policy frameworks and financial incentives into improved land management. In aggregate, implementation of many types of terrestrial carbon mitigation projects in many regions and land classes around the world will achieve substantial net increase in the land sink for atmospheric carbon. It is envisaged that successful implementation through public and private sector action will:

Maximize terrestrial carbon sequestration under agriculture, forestry and other land uses. Land owners and carbon mitigation project developers will be able to quickly and easily estimate the carbon

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The objective of the Terrestrial Carbon Group is for terrestrial carbon (including trees, soil, and peat) to be effectively included in the international response to climate change.

The Terrestrial Carbon Group Project is publishing a series of Policy Briefs to inform the United Nations negotiations on how to include terrestrial carbon in developing nations in the overall climate change solution. We welcome your comments.

mitigation potential and socio-economic feasibility associated with alternative management practices and implement these practices, resulting in a net increase in carbon stored.

Document terrestrial carbon outcomes. Implementers of terrestrial carbon emission reduction and sequestration activities will have tools and methods readily available to measure baseline carbon stocks and monitor changes in carbon over time. Governments will have established and have in operation national monitoring, reporting, and verification (MRV) systems that use tools, methods, and statistical designs appropriate to country circumstances to produce national carbon accounts that can be aggregated into global accounting systems.

Reward improved terrestrial carbon management. Implementers of terrestrial carbon emission reduction and sequestration activities are able to estimate reference levels to demonstrate additionality and account for leakage, and periodically report carbon outcomes to auditors and, if applicable, to offset credit purchasers. Auditors can in turn verify compliance of carbon mitigation activities to the agreed standards using approved methodologies and international guidance and recommended registration and, if applicable, offset credit insurance. Registries effectively track the performance of activities, including ownership of any economic incentives associated with meeting performance targets. This aggregated information is also available to be used to supplement national and international-scale estimates to assess the aggregate effect of activities in meeting national and / or international commitments.

2 What Types of Technical and Scientific Information are Needed?

Maximizing terrestrial carbon sequestration while minimizing emissions, then documenting and rewarding outcomes requires the ability to deliver the following functions:

- Estimate the total biophysical and feasible carbon mitigation potential (through avoided emissions and sequestration) for all lands
- Measure and monitor terrestrial carbon (area and carbon density) for different land classes at multiple scales
- Set reference emission and sequestration levels and comply with standards

2.1 Estimate the total biophysical and feasible carbon mitigation potential for all lands

All terrestrial carbon pools (and fluxes of all greenhouse gases from the terrestrial system) that interact with the atmosphere at timescales less than centuries, and all land classes, have an essential role to play in climate change mitigation. Land management practices can reduce the loss of carbon and other GHGs from ecosystems to the atmosphere and sequester atmospheric carbon in the land sink).

Whether under a regulated or voluntary offset market, much of the activity that will deliver terrestrial carbon mitigation will occur at scales smaller than the national level (referred to here as "projects"). These projects can range from very small areas parcelled together to large contiguous areas encompassing entire regions within a country. In order for project-scale activities to cumulatively generate carbon emissions reduction and sequestration at levels that make a meaningful contribution to global climate change

mitigation, national landscape-scale planning is needed to design and optimize domestic policy incentives and to deliver supporting infrastructure.

National governments, multi-lateral institutions, international donors, private investors, and others that work to identify the most significant land-based carbon mitigation opportunities at sub-national and national scales need to know the magnitude, location, and type of biophysical carbon mitigation potential associated with major land classes. This requires process-level understanding of the controlling factors for carbon and GHG emissions and sequestration – including the effects of geographic and temporal variability, biophysical limits, and natural disturbances – as well as estimates of historical and current emission and sequestration patterns.

In addition to biophysical potential, there are other important technical and socio-economic factors that control the actual, or feasible, mitigation potential for any land area. Technical capacity for implementing alternative land management practices requires knowledge and access to suitable methods to estimate the mitigation potential, over time, of alternative management options in a project area and to assess the practicality of implementing new management practices.

2.2 Measure and monitor terrestrial carbon for different land classes at multiple scales (including national MRV)

Under a global agreement on incentives for terrestrial carbon maintenance and sequestration, carbon accounting systems will be required at multiple scales:

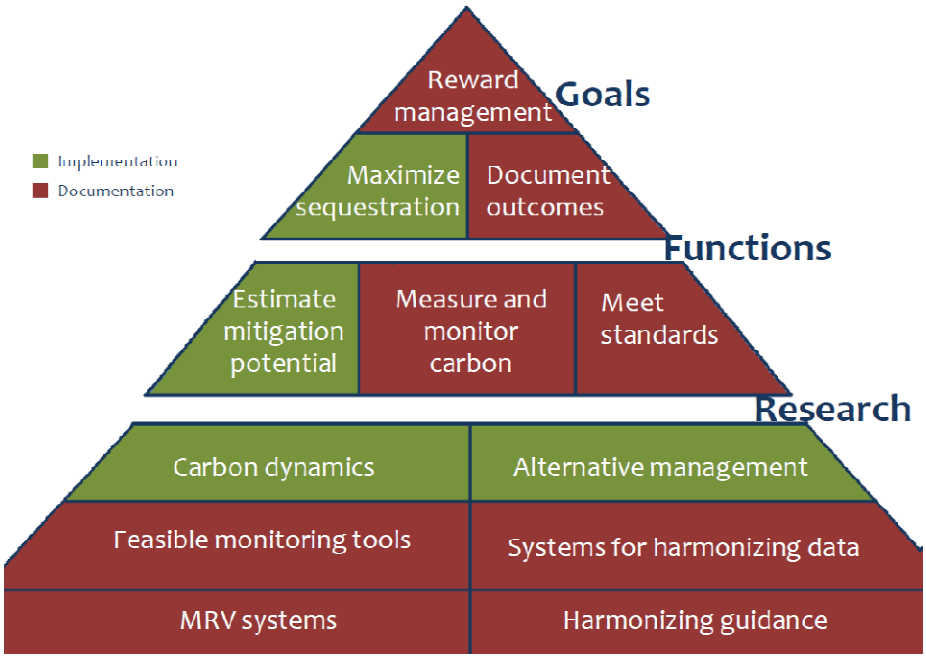
- At the national level to demonstrate fulfilment of voluntary or compulsory national commitments. National-level MRV systems will be expected to produce and report information that is verifiable, comparable with information from other nations, and consistent over time.
- At sub-national or project scales where much of the activity that will deliver carbon benefit will occur. For project-scale implementation of terrestrial carbon management (whether under international agreements or voluntary carbon markets), detailed and location-specific information must be collected to predict, measure, and document the carbon outcomes of changes in land management.
- At the global scale, an integrated information framework is needed for ensuring that project- and national-scale accounting can be aggregated to produce estimates of impact on atmospheric GHG concentrations (ie, determine global net emissions / sequestration for terrestrial systems). In order to cross-check the accuracy of aggregated national data, global-scale projections of carbon emissions reduction and sequestration potential are needed.

Data requirements and selection of measurement methods will reflect the scale, scope, and stage of implementation of each carbon accounting system. At any scale, data collection and carbon estimation must use a consistent framework and comply with relevant standards and criteria.

National- and project-scale accounting will likely have different data requirements. Commonly, project accounting will be focussed on smaller areas and emphasize finer geographic scale of measurement and higher frequency of monitoring, while national accounting will be focussed on coarser geographic scale of measurement (but be comprehensive for major land cover types) and lower frequency of monitoring. National terrestrial carbon accounting systems require appropriately scaled-up technical tools and infrastructure for documenting changes in carbon over space and time. Resulting data systems must align with existing and evolving international guidance, as well as country circumstances, and be capable of integrating project-scale data.

Estimating terrestrial carbon stocks relies on measurement of the areal extent and carbon density of different land classes in an area of interest. Once base measurements are in hand, on-going monitoring generates estimates of change in carbon stocks. Efficient monitoring of terrestrial carbon to produce information relevant to project implementation, landscape-scale planning, and national and international accounting will require valid statistical designs for estimating area, biomass, and carbon as well as conversions to other land cover and uses.

Figure 1. Goals, required functions, and priority research areas for implementing and documenting improved management of the world's terrestrial carbon.



2.3 Set reference emission and sequestration levels and comply with standards

In order for terrestrial carbon management to be rewarded under incentives, carbon accounting systems need to document actual change from reference emission levels and reference sequestration levels (ie, additionality).[1] For example, a business-as-usual approach to setting a reference emission level assesses carbon at risk of emission and rewards management that protects at-risk carbon.

When carbon emissions shift to another location, within or beyond national borders, as a result of carbon project activity, the carbon benefit of the project is diminished. Appropriately developed reference emission levels at project and national scales are important to address domestic leakage.

The scale, type, and quality of information required to develop reference levels will depend on the standard-setting body under which a project seeks to be rewarded, as well as any specific criteria set by the organisation providing the funding for the activity (eg, governments or private carbon credit purchasers) and / or the government of the country in which the project takes place. General information needs

[1] See Terrestrial Carbon Group Project Policy Brief Numbers 2 and 3.

include land cover, local environmental conditions (eg, soil types, climate, hydrology, fire regime), biological conditions (eg, species composition, growth rates), historical and current land use, and socio-economic factors for the region (eg, population, food and fuel demand, infrastructure, commodity prices, governance). These data can be integrated using modelling tools to project future emissions or sequestration in the absence of an incentivized change in land management.

To be rewarded for carbon projects in the regulated or voluntary market, compliance is required with approved standards and methodologies. Standard-setting bodies specify methodologies and technical information requirements for different types of projects and independent auditors verify that project implementation meets methodology criteria before recommending registration and credit issuance.

3 What are the Major Research Needs?

As incentive systems for improved terrestrial carbon management evolve through international negotiations and voluntary markets, there are significant opportunities to advance the scientific and technical foundation for estimating mitigation potential, multi-scale monitoring, and achieving high-quality reporting and verification. While much is known and considerable capacity and expertise is available, knowledge and technology gaps remain that must be addressed, globally and in specific regions. The following six categories encompass the major areas for advancement:

1. Process-level understanding of carbon dynamics and sequestration potential
2. Scientific research base for alternative management practices
3. Feasible accounting tools for all lands and carbon pools (including all GHGs)
4. Systems for harmonizing terrestrial carbon data across global to project scales
5. Pathways to establishing national MRV systems that reflect country circumstances
6. Harmonization of reporting guidance across scales, sectors and markets

3.1 What's In Place

Forest carbon dynamics and management options are well-understood in many parts of the world –more effective tracking of changes is needed in some regions. Many types of croplands are well-studied, but some types and regions require more attention – several initiatives are pursuing convergence on robust monitoring methods. Grasslands and drylands have received significant research attention, but require additional research synthesis and adaptation of monitoring methods and models is needed. Technical work in wetlands and peatlands has been robust in some regions, but additional process-level knowledge is needed to enhance estimation of sequestration potential. Current efforts to develop widely accepted monitoring methods need additional resources. Progress will enable projection of mitigation potential (total biophysical and under alternative management), in specific regions, and documentation of actual change in terrestrial carbon.

While the international policy framework for expanding incentives for improved terrestrial carbon management is still undecided, the technical and scientific basis for implementing terrestrial carbon management techniques and quantifying resulting changes is significant and growing and there is considerable experience around the globe. Widely-accepted guidance for measurement, reporting and

verification of terrestrial carbon is available through the IPCC and other organizations. A variety of land management techniques have been demonstrated to effectively maintain and sequester carbon. A range of countries have successfully combined field measurements, remote sensing and models to quantify changes in terrestrial carbon, particularly in above-ground biomass. Existing data produced through public and private data-gathering programs can provide a useful foundation of experience and infrastructure for expanded measurement and monitoring systems.

Table 1. Major Research Needs

	Carbon dyamics	Alternative Management	Accounting Tools	Data Systems	MRV Systems	Guidance
Forests	Globally harmonized estimates of emissions & sequestration	Heterogeneous systems.	Monitoring degradation; Regionally-relevant models	Data sharing across sectors and scales.	Establish in all countries. Capacity for monitoring degradation.	Harmonize definitions and standards across scales and sectors.
Croplands	Partitioning to soil carbon pools. Variability with depth.	Integrated cropping, agroforestry, and other alternative practices	Regionally-relevant field data and models.	Data sharing across sectors and scales.	Regional conversion equations. Field data.	Methodology development / approval.
Grasslands / Drylands	Soil carbon dynamics and sequestration rates. Fire events and	Effects of grazing and fire management.	Regionally-relevant field data and models.	Data sharing across sectors and scales.	Regional conversion equations. Field data.	Methodology development / approval.
Wetlands / Peatlands	Depth, density, decomposition maturity. Controlling factors for GHG emissions. Peatland subsidence.	Effect of rehabilitation efforts (eg, rewetting).	Tools / methods to accurately inventory area and fluxes.	Integration of reasearch data .	Regional conversion equations. Field data.	Methodology development / approval.

Robust knowledge base -incremental work needed

Existing Knowledge base - additional coordinated research required

Growing knowledge base - more comprehensive research needed

Emerging knowledge base - significant research investment needed

3.2 What Are the Gaps?

A number of challenges remain. Research and information synthesis for carbon management techniques have not been equally distributed across carbon pools, land use types and regions of the world. Richer process-level understanding is needed across all land use types for historical, current and potential emissions and sequestration as well as for drivers of land use conversion and degradation. There is a relative scarcity of information for drylands, wetlands and peatlands and non-biomass carbon pools (eg, soil organic matter).

There are significant differences in guidance for reporting emissions and sequestration at the project and national levels and streamlined processes are needed for approving consistent definitions, standards and methodologies. There is considerable variety among countries in their ability to measure and monitor all types of terrestrial carbon. In general, non-Annex I countries have limited data-gathering capacity and access to reliable existing datasets and conversion equations. While there are some remote sensing data products that are commonly used to monitor changes in land cover, there are concerns about continuity and interpretation capability for these data streams. Overall, there is inadequate consistency in data-gathering methods (and resulting datasets) across scales and sectors.

3.3 How Can We Fill Gaps?

The international community can help to stimulate greater project-level activity and landscape-scale planning and creation of integrated MRV systems by enhancing and harmonizing guidance for terrestrial carbon accounting across regulated and voluntary markets. Increased clarity and consistency for definitions, land cover and land use classification, standards, methodologies and technologies can facilitate production and delivery of transparent, comparable, consistent information. At the national-level, creation of terrestrial carbon accounting systems can commence with the surveying of existing data systems (eg, national or sub-national surveys, commercial or research-scale data-gathering) and designing inventory and monitoring strategies that are relevant to country circumstances (eg, biophysical and socio-economic conditions).

The research community can contribute to enhanced terrestrial carbon management and quantification in the full range of land use types and geographic regions by:

- Enhancing measurement and monitoring capacity. For example, developing relevant new technologies for carbon quantification (e.g., more rapid in situ measurement tools) and establishing networks of permanent benchmark monitoring sites.
- Synthesizing and integrating data systems. For example, building common archives for biomass and carbon studies and projects, remote sensing data and conversion factors.
- Improving access. For example, sharing and adapting existing models and ensuring continued access and expanding interpretation capacity for the most commonly used remote sensing datasets.

There are many different organizations already working on various aspects of terrestrial carbon management and quantification. Integration and expansion of investment in research and development and technology transfer as well as greater information sharing and coordination is needed across the public and private sectors, across scientific disciplines and across geographic scales.

4 Where Do We Go From Here?

In Spring 2010, working with the research community, civil society, intergovernmental organizations, and foundations around the world, this initiative will convene a strategic implementation symposium. This symposium will bring together public and private sector experts to set in motion collaborative activities to support detailed negotiations and ensure successful REDD / AFOLU implementation. Symposium discussions will be informed by work over the coming months to enrich the scientific foundation for gap-filling activities and to "map" the spectrum of agencies and institutions working, at scales from local to global, on scientific initiatives that support implementation of RED / AFOLU.

Notes