JRC Scientific and Technical Reports

Monitoring, Reporting and Verification systems for Carbon in Soils and Vegetation in African, Caribbean and Pacific countries

Edited by

Delphine de Brogniez
Philippe Mayaux
Luca Montanarella

EUR 24932 EN - 2011

JRC
EUROPEAN COMMISSION

ies
Institute for Environment and Sustainability

The mission of the JRC-IES is to provide scientific-technical support to the European Union's policies for the protection and sustainable development of the European and global environment.

European Commission
Joint Research Centre
Institute for Environment and Sustainability

Contact information

Philippe Mayaux or Luca Montanarella
Address: Via E. Fermi, 2749 I-21027 Ispra (VA), Italy
E-mail: *philippe.mayaux@jrc.ec.europa.eu, luca.montanarella@jrc.ec.europa.eu*
Tel.: +39-0332-789706 or +39-0332-785349
Fax: +39-0332-789960 or +39-0332-786394
http://ies.jrc.ec.europa.eu/ http://www.jrc.ec.europa.eu/

Legal Notice

JRC 66514

EUR 24932 EN
ISBN 978-92-79-21136-2 (print)
ISBN 978-92-79-21137-9 (pdf)

ISSN 1018-5593 (print)
ISSN 1831-9424 (online)

doi: 10.2788/63356

Luxembourg: Publications Office of the European Union

Cover page pictures: provided by Grégoire Dubois and Philippe Mayaux

Printed in Italy

Monitoring, Reporting and Verification systems for Carbon in Soils and Vegetation in African, Caribbean and Pacific countries

Edited by

Delphine de Brogniez
Philippe Mayaux
Luca Montanarella

Crediting soil carbon sequestration in smallholder agricultural systems: what fits and what will fly?

Leslie Lipper[1], *Andreas Wilkes*[2] *and Nancy McCarthy*[3]

Increasing the organic carbon content in soils is beneficial for agricultural production and is also a means of capturing and storing atmospheric CO_2 in soils and mitigating climate change. A global effort to improve soil quality on farms has the potential to generate significant increases in both food security and climate change mitigation, given the potential number of poor farmers and land areas that could benefit. Improving farmer's management of soils for improving agricultural productivity has long been an objective of agricultural development strategies. Soil carbon sequestration has been identified by the IPCC as the largest potential source of climate change mitigation from the agricultural sector, and its inclusion in climate change policy frameworks has been debated for some time. Recognition of the potential for linking mitigation and food security objectives in policy and financing frameworks has recently been highlighted. Yet despite this enduring and multi-faceted policy interest, there has been only limited success attained in actually improving on farm soil quality, and even less in linking climate change mitigation finance to soil carbon sequestration. This paper seeks to explore the reasons for these failures, and suggest ways in which the joint food security and mitigation benefits from a global effort to improve soil quality may be captured.

The importance of improving soil quality for food security

Agricultural production is the main source of food and income for the majority of the world's poor. Most of these people are located in Sub-Saharan Africa and South Asia, where food insecurity rates are already quite high (FAO, 2009a). They are also the areas with the highest projected population growth rates for the next 50 years. Increasing the productivity and value of the farming systems of the poor is the most effective way to support their transition to food security (World Bank, 2007). Increasing the agricultural incomes of smallholder farmers allows them to make investments leading to long term improvements in livelihoods. Improving the returns to smallholder agriculture is both an efficient and equitable strategy for achieving economic growth and poverty reduction in countries with highly agricultural based economies – as in South Asia and Sub-Saharan Africa (World Bank, 2007; Thirtle et al., 2003).

---

[1] Agricultural Development Economics Division, Food and Agriculture Organization of the UN, *leslie.lipper@fao.org*
[2] World Agroforestry Centre, China & East Asia Node, *a.wilkes@cgiar.org*
[3] Lead Analytics, Inc. *nmccarthy@leadanalyticsinc.com*

Poor soil quality is one of the main constraints to improving agricultural productivity for many smallholder farmers in developing countries (Stocking, 2003; Lal, 2004). Poor land management practices – such as continuous cropping with no fallowing or fertilizer inputs, or cropping on sloping lands generating high rates of erosion – have depleted natural soil fertility and degraded soil quality (Lal, 2004; Cassman, 1999). The impact is declining productivity and increased vulnerability to natural hazards such as drought, floods or pests and diseases. Depleted soils have little capacity to store water or house beneficial organisms – which are important mechanisms for coping with drought and building resistance to pests and diseases.

The importance of soil carbon for climate change mitigation

According to the IPCC 4th assessment report (Smith et al., 2007) the technical mitigation potential of agriculture from 2005 to 2030 totals around 5500-6000 Mt CO_2eq. Of this, around 89%, or around 4895-5340 Mt CO_2eq, is from reduced soil emissions of CO_2, through improvements in grazing land management, cropland management, restoration of organic soils and degraded lands, bioenergy and water management (Smith et al., 2007). To put this in perspective, Chen et al (2011) estimate that emission reduction commitments made by Parties to the UNFCCC up to the end of negotiations in Cancun in December 2010 would leave the world with a shortfall of 10,000-14,000 Mt CO_2 eq compared to emission reductions required to limit global warming to 2 degrees Celsius by 2020. While the economic potential of agricultural mitigation to 2030 has been estimated to be only 28%, 46% and 74% of the total technical mitigation potential at $20, $50 and $100 per tonne CO_2 (Smith et al., 2007), the fact that agricultural practices which sequester soil carbon are technically mature and ready for deployment means that agriculture has a strong potential to play a non-marginal role in early action to change the global emissions path while other unproven and more costly mitigation technologies are being developed (Lal, 2004).

Among the agricultural mitigation practices assessed by the IPCC, a range of practices grouped under the category of cropland management have the highest technical potential for soil carbon sequestration, estimated to be more than 1400 Mt CO_2eq by 2030 (Smith et al., 2007). Cropland management includes improving agronomic practices, such as introducing improved crop varieties, use of improved fallows, green manuring and cover crops, which increase soil carbon stocks. Integrated nutrient management (improving fertilizer application and timing), introducing nitrogen fixing cover crops, water management (including soil and water conservation practices), tillage management (minimum soil disturbance and incorporation of residues), as well as agro-forestry practices are also included in the category of cropland management. The potential for sequestering carbon from adoption of these practices is global, with particularly high potential in East Africa and South and Southeast Asia (Smith et.al., 2007).

Improved grazing land management is another major group of practices that can generate globally significant levels of soil carbon sequestration, with an estimated technical mitigation potential similar to cropland management, i.e. >1400 Mt CO_2eq by 2030 (Smith et al, 2007) At around 3350 million ha (more than twice the global arable land area), grazing lands present a huge potential for sequestering carbon. According to Smith et al (2007), potential gains are particularly high in almost all regions of Africa and Asia, as well as South America. Increasing soil carbon in grasslands areas can be achieved through the introduction of improved grazing management, reducing or eliminating the occurrence of fires, and introducing improved fodder grasses or legumes. In addition, avoiding conversion of grasslands to croplands is a significant potential source of emission reductions.

Restoration of degraded lands refers to restoring soil organic carbon in areas which have been depleted. FAO (2007)'s analysis of the distribution of the soil carbon gap and of cropland suggests that 15% of total global croplands are located in areas with a medium to high potential for soil carbon sequestration. Measures to restore degraded lands include many of the same practices under improving cropland and grasslands management – essentially increasing organic inputs to the soil, reducing or eliminating tillage, increasing cover and residue incorporation, and the introduction of agroforestry and silvo-pastoral systems. In other cases the use of soil and water conservation practices, including terracing, bunds, and contour stripping are also used in restoration activities.

A fourth major potential source of soil carbon sequestration identified by the IPCC is restoration of organic soils, with an estimated technical potential of more than 1300 Mt CO_2eq by 2030 (Smith et al., 2007). These are peat or wetlands areas that have been drained and converted to agricultural production. Two major areas of importance for this type of activity include South East Asia and the Amazon Basin. The main method of reducing GHG emissions is avoiding conversion of such lands to agricultural production. Other practices to minimize emissions include avoiding row crops and tubers, avoiding deep ploughing, and maintaining a shallower water table (Freibauer et al., 2004).

Aside from these potential sources of soil carbon sequestration assessed by the IPCC, there is also considerable soil carbon sequestration potential that may be captured by reducing emissions from deforestation and forest degradation as well as the conservation, sustainable management of forests and enhancement of forest carbon stocks (e.g. REDD+). Although the major source of emissions reduction benefits in the REDD+ category come from the above-ground carbon sequestered in trees, the potential soil carbon benefit from avoided conversion of forest to agricultural lands is large, accounting for around 10-30% of total carbon emissions from tropical deforestation (Don et al., 2011). Since agricultural expansion is a major driver of deforestation, increasing the intensity of agricultural production – including by adoption of many of the sustainable land management practices listed in the preceding paragraphs – has potential to reduce agricultural emissions while also creating supportive conditions for forest carbon sequestration (Angelsen, 2010).

Synergies between agricultural, food security and mitigation from improving soil quality

The list of practices under the various categories of soil carbon sequestering activities above is remarkably similar to those identified as necessary for sustainable land management to improve agricultural production (Lal, 2004; FAO, 2009b; FAO, 2010). The major exceptions are avoided conversion of organic soils and avoided deforestation and forest degradation, which have negative impacts on agricultural production by reducing areas for crop and livestock production. However even these activities could have synergies for agricultural development and food security if structured to include intensification on existing agricultural lands (Angelsen, 2010).

In looking for synergies between agriculture, food security and mitigation, it is necessary to have an understanding of the benefits of improvements to soil quality for each objective under varying circumstances, as well as the costs of making such improvements. The analysis also requires some consideration of prioritization of objectives between agricultural growth, food security, and climate change mitigation. For low income, agriculture- dependent developing countries, agricultural growth for food security is a key priority, increasingly recognized in national development strategies and plans as well as agricultural sector strategies (Future Agriculture Consortium, 2011). Mitigation from the agricultural sector is not likely to be a top policy priority per se, although achieving lower emissions growth patterns is important, particularly since it may be linked to financing for mitigation, as well as conditions on development assistance.

Identifying locations, farming systems and farming groups where increasing soil quality is likely to have the greatest impacts on agricultural productivity is a first step in identifying potential synergies. The main benefits to smallholder farmers of adopting soil improving sustainable land management practices include increases in yields per hectare, increases in yield stability over time due to greater resilience, and reduction in production costs (FAO, 2009b; FAO, 2010). The degree to which any one of these three types of benefits can be obtained by individual farmers adopting sustainable land management practices is quite variable, depending on the specific agro-ecological conditions they are operating under, the past history of land use, the socio-economic environment (including input and output markets, and policies affecting access to land and other inputs), as well as specific household characteristics.

Nevertheless, we can identify some general conditions where agricultural benefits to soil improvements are likely to be highest. Key issues to consider are climate, soil type, and current use and quality of the land. For example, a recent summary of the literature (Branca et al., forthcoming) on the impacts of improved cropland management on agricultural yields indicates that higher average yield gains are obtained from adopting sustainable land management practices in dry areas – in both cool and warm climates – compared with moist areas. One of the benefits of increasing soil organic carbon is increasing the capacity of the soil to absorb and store water. This creates greater capacity to withstand drought, and also reduces flooding and soil erosion since runoff is reduced. These impacts on water availability, together with associated fertility impacts, generate significant increases in yields moving from conventional to sustainable land management practices. In humid areas, positive yield effects are also gained, but at lower rates of increase compared to yields in conventional systems. Soil types and level of degradation are also key determinants. Sequestration rates are generally higher on heavier clay soils compared with sandy soils, and moderately to lightly degraded soils generally have higher sequestration rates with the adoption of sustainable land management, at least in initial phases (Lal, 2004).

Grazing intensity is one of the main factors affecting soil carbon stocks in grazing lands outside hyper-arid and arid areas. Compared to heavy grazing, moderate grazing has generally been found to increase organic matter inputs to soils and therefore increase soil carbon stocks (Conant and Paustian, 2002). Moderate grazing is also often associated with higher biomass productivity and richer biodiversity in grasslands, though this depends also on the site-specific grazing history, vegetation types and climate variables (Milchunas and Lauenroth, 1993). These benefits may translate into increased livestock health and productivity (Kemp and Michalk, 2007), though the short-term economic optimum for livestock keepers often involves grazing at levels that deplete above- and below ground resources, since total animal weight gain per unit area is often higher at higher stocking densities (Jones and Sandland, 1974).

Essentially this analysis suggests that synergies between mitigation and agricultural growth for food security are likely to be the rule with adoption of sustainable land management. However the degree to which soil improvements generate food security versus sequestration benefits varies. Sustainable land management practices in drylands are key to food security, with relatively smaller sequestration benefits per hectare. Figure 1 below summarizes some examples of activities and their relative contribution to mitigation and food security (defined as agricultural productivity increases in this context).

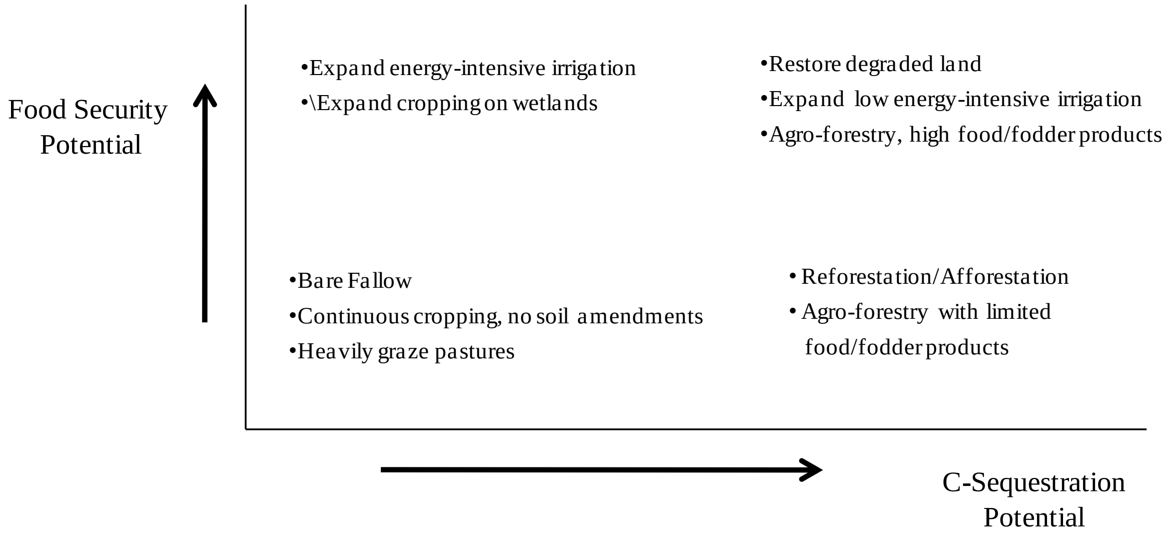

Figure 1. Examples of Potential Synergies and Trade-Offs (Source: FAO, 2009b)

Barriers to adopting practices that improve soil quality

Despite the agricultural benefits that farmers may obtain from adopting sustainable land management practices and fairly extensive campaigns to support their dissemination, the adoption rate amongst small farmers has been quite low. A recent summary of the literature has highlighted key constraints (McCarthy et al., forthcoming).

Unsurprisingly, one of the main barriers to adoption is costs, including three major categories of costs: initial investment costs, annual operating costs, and opportunity costs of income foregone by undertaking the activities needed for improving soils (FAO, 2009b; FAO, 2010). A commonly reported major problem is financing the initial costs of adoption of a system that has net positive benefits but only over the long term. In some cases investment costs can be quite significant (e.g. soil and water conservation infrastructure) and also involve considerable labor inputs (FAO, 2009b; FAO, 2010).

Opportunity costs are probably the most important category of costs that have not been well understood or addressed, and are likely to be a major cause of low adoption rates. The issue is the amount of time it takes to obtain a higher return to agriculture than obtained under the conventional, or baseline practice. During the transition between systems, farm income can even be negative for some periods, particularly where the new system requires activities, such as reduced stocking levels or fallowing to restore degraded lands. These kinds of opportunity costs are likely to be highest where degradation is high and longer recovery periods required (FAO, 2009b; FAO, 2010).

Another major barrier to the adoption of sustainable land management activities is the lack of enabling institutions, such as extension services, machinery and input supply chains and ways of managing collective resources (FAO, 2010). Achieving the adoption of sustainable land management practices on a broad basis will require agricultural policies that provide incentives for effective input use and crop diversification which in many cases are lacking. While individual financing at the farm level is needed to support transitions to systems that generate higher soil quality, without government investments to create supporting conditions, adoption will still be quite constrained.

Opportunities for using mitigation finance to support transitions to sustainable land management in smallholder agricultural systems

The mitigation value of activities that reduce emissions may be rewarded through the emerging regulatory and voluntary frameworks being established. Carbon markets established under cap and trade regimes, such as the Clean Development Mechanisms (CDM) under the Kyoto Protocol, are one potential source of such financing. In the context of developing country agriculture, emission reductions provided through carbon sequestration could potentially be credited to offset emission reductions in other sectors. However soil carbon sequestration from agricultural sources is not an allowable source of emissions reductions under the CDM at present. Sequestration from afforestation and reforestation is allowed, however even these have been restricted to a maximum of 11 Mt CO_2eq in the first commitment period (Larson et al., 2011). Agricultural, including soil carbon, offsets are eligible in some sub-national regulatory schemes (e.g. Alberta offset credit system), but at present the scale of these schemes is relatively limited, and at this stage such sub-national systems tend not to accept offset credits generated in developing countries. Because of restrictions on eligibility under the CDM and other compliance schemes, agricultural offsets are mostly restricted to the voluntary market, where they account for a small proportion of total credits generated (Hamilton et al., 2010). The voluntary market in turn is very small compared to global compliance markets (Kossoy and Ambrosi, 2010; FAO, 2009) and to the scale of emission reductions required globally. Thus, regardless of the future developments in global, national and sub-national offset markets, this form of mitigation finance is unlikely to become a major channel of new funds for smallholder agriculture soil carbon sequestration in the near term.

Some lessons from early pilot activities indicate that pilots to develop new classes of project are expensive, although the returns for project participants may potentially be high. Soil carbon accrues slowly over time, while upfront investment costs are often high, making such projects unattractive compared to many other investment options. Looking beyond small-scale pilots, payments for carbon sequestration to smallholder farmers achieved on any large scale will need to be embedded in government programs. On the one hand, this is because a significant proportion of investment costs in agricultural carbon projects occur upfront, while private buyers of carbon projects are often unwilling to bear the risks of upfront investment. On the other hand, government-funded agricultural extension systems provide an institutional basis for upscaling adoption of agricultural activities.

In this regard, one of the more interesting possible future developments for mitigation financing for developing country agriculture is through the nationally appropriate mitigation actions (NAMAs) that are currently under discussion in the UNFCCC process. The NAMA concept is still evolving and to date covers a wide range of financing and crediting proposals, from offset trading markets to public sector payment programs. At a general level, it has been suggested that NAMAs could provide an over-arching structure for 3 different types of action differentiated by source of funding: (i) unilateral actions undertaken by developing countries without support from developed countries; (ii) actions supported by developed countries; and (iii) actions that generate tradable carbon credits.[4]

Thus NAMAs could essentially be structured to be a public sector investment into building long term capacity for accessing a new source of finance for agriculture, be it through carbon markets or public sector incentives for mitigation (including international public sector sources such as the Cancun Fund). Since NAMAs are to be proposed by Parties to the UNFCCC, they can consider agricultural and land use sector development priorities, and integrate with national agricultural programmes. In fact, of the NAMAs submitted by non-Annex 1 countries to the UNFCCC in 2010 *(http://unfccc.int/meetings/cop_15/copenhagen_accord/items/5265.php)* 32 relate to agriculture, indicating strong developing country interest in accessing support for agricultural development through NAMA implementation mechanisms.

Nevertheless, despite interest in the potentials of the voluntary market, the possibility of a reformed CDM in which soil carbon is eligible, and the potential of NAMAs, it is important to bear in mind that total estimated mitigation finance is only a small share of the overall investments required by developing country agriculture as a whole (FAO, 2009b). Market and non-market mechanisms that link with other sources of public and private finance will be needed to generate the funding required.

Key issues to overcome in promoting agricultural mitigation actions

In the negotiations over inclusion of land use offsets in the CDM, it became clear that land use offsets were perceived as less credible than other sources of offset supply. Two main issues with soil carbon sequestration were (a) the risk that soil carbon is not sequestered permanently, so the impacts of mitigation actions on atmospheric concentration of CO_2 would not be permanent, and (b) the perceived high uncertainty associated with measuring agricultural GHGs. Thus, no matter whether agriculture is to be supported through tradable credits or public mitigation finance, agricultural

[4] http://unfccc.int/files/meetings/ad_hoc_working_groups/lca/application/pdf/mitigation1bii140808_1030.pdf (page 4 referring to negotiation text page 94: alternatives to paragraph 75, alternative 2)

mitigation actions have to ensure a high level of credibility through quality standards in order to be accepted. Land use based agricultural credits are still in their very early stages. Recently, uncertainty in international and national regulatory contexts has contributed to a low value for many voluntary credits, and for land use credits in particular, possibly due to concerns with credibility (Conte and Kotchen, 2009). Achieving a significant level of financing for agricultural mitigation will require national and international stakeholders to cooperate in developing widely accepted protocols that ensure the credibility of agricultural emission reductions while also reducing the barriers to smallholder participation.

Regarding the risk of non-permanence, the solution adopted under the CDM was to create a special class of emission reduction certificates, known as temporary CERs, or tCERs, while other industrial emission reductions generate lCERs (long-term CERs). In addition, the EU ETS, one of the largest trading systems, excluded tCERs outright, deeming them incomparable with lCERs. The effect of these decisions was to segment the market, placing land use projects in a market segment for which there was limited compliance demand, and thus tCER prices are lower than for lCERs. An alternative solution to the risk of non-permanence has been developed in and embraced by the voluntary market. The Voluntary Carbon Standard (subsequently renamed Verified Carbon Standard - VCS) pioneered the use of a risk buffer fund. Each project is assessed against risks of non-permanence and a corresponding proportion of the credits are placed in an untradable risk buffer fund. Since different projects face different levels of risk, overall risk of non-permanence is managed by hedging the risks of different projects against each other. This mechanism has subsequently been adopted by some other voluntary standards.

Regarding the credibility of emission reduction estimates from agricultural land use projects, early experimentation through voluntary markets has provided some indication of possible options to address issues of credibility. There are several sources of uncertainty associated with soil carbon sequestration activities that MRV systems for GHG accounting must explicitly or implicitly address: (i) uncertainty over whether or not an activity is implemented and an accurate accounting of the land area involved; (ii) uncertainty arising from emission factors attributed to mitigation actions, particularly in heterogeneous agricultural landscapes; (iii) uncertainty due to lack of scientific documentation of the impacts of management practices on non-CO_2 emissions associated with carbon sequestering processes.

One of the biggest constraints to building viable agricultural MRV systems in developing countries is the lack of research establishing a credible basis for associating changes in soil carbon sequestration with changes in agricultural activities. Some early agricultural mitigation programmes (e.g. under the Alberta offset system, VCS and Climate Action Reserve) give excellent examples of the protocols for estimating emission reductions that can be set up when a sufficient basis of research information is available.

In the absence of such information, however, there are several options for addressing the problem. One approach would be to conduct very intensive field measurements of soil carbon changes with changes in land practices and to issue credits based on actual measured changes. This approach is not likely to be widely applied, mainly because extensive direct measurements are quite expensive to conduct. Another option is combine detailed activity data with conservative (e.g. IPCC Tier 1) default values for crediting soil carbon sequestration. This would have the advantage of low measurement costs, but potentially low accuracy. Starting with a conservative, simple approach would allow for the development of methods via "learning by doing" and increasing the research basis alongside early mitigation actions. Prioritizing areas for soil carbon crediting by the ease with which changes in soil carbon can be detected - e.g. areas where a high "signal to noise" ratio between changes in soil carbon and existing stocks are found would be one way to improve accuracy with this method (McCarthy and Lipper, 2010). One potential objection to this approach is that a very conservative approach may not yield sufficient emission reduction credits to make agricultural sequestration feasible for crediting, since the reduction in the value of the emission reductions would be greater than the reduction in transactions costs. Furthermore, field measurements of soil carbon in a smallholder project setting would be subject to a large set of influencing factors and uncertainties, and would not necessarily be an effective way to reduce the uncertainty of soil carbon sequestration estimates.

A third option – that is being used in the development of methodologies for several voluntary carbon standards – is to use a more sophisticated biogeochemical process model, such as Century, Roth-C or DNDC, which is combined with a limited set of field measurements used to parameterize and validate the model. The difficulty with the use of such models is that although it may be possible to validate the general outputs of the model, long-term experimental data with which to validate model predictions for specific management changes is lacking for most management practices in most agroecosystems worldwide. Discussion on early experiences with this approach has begun (e.g. Olander and Haugen-Kozyra, 2011), but as yet there are no agreed protocols to ensure transparency in the ways in which such models are manipulated in the process of operation. Further research is needed to validate models across varying agro-ecosystems and farming systems. This will require careful consideration of sampling design, rigorous implementation of study protocols and long term research sites. This is a prime example of where public funding can support the development of agricultural mitigation schemes. Ideally a set of coordinated long term research monitoring plots for soil carbon under transitioning farming systems could be established and maintained by public sector research institutions – including potentially FAO.

To date, most applications of modeling approaches have occurred in the farming systems of developed economies, where regulatory requirements ensure that farms maintain relatively comprehensive farm records which can provide the basis for activity monitoring data. In most developing countries, such regulatory requirements and other capacities required for accurate activity monitoring often do not exist. Insufficient attention has been given to the requirements for precise activity monitoring, although some smallholder pilot projects are developing early examples of monitoring procedures. Irrespective of whether financial support derives from carbon markets or public climate mitigation finance, credible activity monitoring systems are required. Activity monitoring for up-scaled adoption would further have to be based on existing agricultural M&E (monitoring and evaluation) systems. Analysis of an existing agricultural M&E system suggests that they may provide a credible basis for MRV of agricultural mitigation actions where (i) their procedures are encoded in explicit rules that are transparently communicated, (ii) they include provisions for quality control and quality assurance, and (iii) where they are based on institutional arrangements that provide accountability in ways appropriate to the national context (Wilkes et al, 2011). Developing country M&E systems are insufficiently documented to allow an assessment of the extent to which existing systems meet these criteria.

Conclusions: What fits and what will fly?

In thinking about the role of mitigation in agricultural production systems it is important to consider that projected increases in agricultural production are a necessity for reaching global food security and poverty reduction objectives, and these increases will entail an overall increase in agricultural emissions. This is born out in projections of agricultural related emissions from developing countries. Imposing a mitigation requirement on the development of livelihoods for the poorest people on the earth is neither feasible nor desirable. However working to identify and support development pathways that generate lower emissions than a “business as usual” high energy development pathway is quite desirable. The key role of mitigation finance in this context then, is to support the development of low emission development pathways, using mitigation finance to support transformations of smallholder agricultural production systems that generate more secure and profitable livelihoods that are adapted to climate change and contribute to the mitigation of climate change.

Allowing soil carbon sequestration emissions reductions in the CDM and building a program of work to support development of appropriate MRV systems is an issue being raised in the UNFCCC process. Agriculture is also on the agenda of the SBSTA (Subsidiary Body for Scientific and Technological Advice of the UNFCCC) meeting scheduled for June 2011 and these issues are likely to be addressed. However the uncertainty in the overall international system is a much more pressing issue, with significant implications for the future of any mitigation finance. It may be that a wider range of agricultural offsets (including soil carbon) are eligible for the CDM under a post-2012 global climate agreement. Alternatively, if no global agreement is achieved, various national or regional cap and trade systems may be established, expanded and possibly linked.

Early experiences with agricultural mitigation pilot projects in the voluntary market suggests that mitigation finance will only make a meaningful contribution to the achievement of agricultural development objectives in developing countries if it is linked to public finance, and embedded in existing programs for promotion and monitoring of adoption. In this respect, early small-scale pilot experiences are essential for working out feasible approaches to credible estimation of emission reductions. Mechanisms, such as NAMAs, which have potential to enable linking of mitigation action support with markets and non-market sources of climate finance have potential to contribute alongside upscaled public finance to meeting the multiple objectives of sustainable land management.

References

Angelsen A. 2010. Policies for reduced deforestation and their impact on agricultural production. PNAS 107(46): 19639-19644

Branca G, McCarthy N, Lipper L and Jolejole M. forthcoming. Climate Smart Agriculture: a synthesis of empirical evidence of food security and mitigation benefits from improved cropland management. MICCA Working Paper, FAO, Rome

Cassman, K. 1999. Ecological intensification of cereal production systems: Yield potential, soil quality, and precision agriculture Proc Natl Acad Sci U S A. May 25; 96(11): 5952–5959

Chen C, Hare B, Hagemann M, Höhne N, Moltmann S and Schaeffer M. 2011. Cancun Climate Talks: keeping the options open to close the gap. Climate Action Tracker Briefing Paper, 10 January 2011. Accessed at *http://www.climateactiontracker.org/briefing_paper_cancun.pdf*, May 31, 2011

Conant R, Paustian K. 2002. Potential soil carbon sequestration in overgrazed grassland ecosystems. GLOBAL BIOGEOCHEMICAL CYCLES, VOL. 16, NO. 4, 1143.

Conte M, Kotchen M. 2009. Explaining the Price of Voluntary Carbon Offsets. Working Paper, Center for the Study of Energy Markets, University of California Energy Institute, UC Berkeley.

Don A, Schumacher J, Freibauer A. 2011. Impact of tropical land-use change on soil organic carbon stocks – a meta-analysis. Global Change Biology (2011) 17, 1658–1670

FAO, 2010, *Climate Smart Agriculture, Policies, Practices and Financing for Food Security, Adaptation and Mitigation*, URL: *http://www.fao.org/docrep/013/i1881e/i1881e00.htm*

FAO 2009a . The State of Food Insecurity in the World, FAO, Rome.

FAO, 2009b , *Food Security and Agricultural Mitigation in Developing Countries: Options for Capturing Synergies*; URL: *http://www.fao.org/docrep/012/i1318e/i1318e00.pdf*

FAO. 2001 “Soil Carbon Sequestration for Improved Land Management” World Soil Resources Report No. 96, Rome, Italy

Future Agriculture Consortium 2011. Policy into Use: Accelerating Agricultural Growth through CAADP. CAADP Policy Brief Overview March 2011 available at: *www.future-**agricultures**.org*

Hamilton K, Sjardin M, Peters-Stanley M, Marcello T. 2010. Building Bridges: State of the Voluntary Carbon Markets 2010. Ecosystem Marketplace & Bloomberg New Energy Finance.

Jones R.J. and Sandland R.L. 1974. The relation between animal gain and stocking rate: derivation of the relation from the results of grazing trials. Journal of Agricultural Science 83: 335–342

Kemp D, Michalk D. 2007. Towards sustainable grassland and livestock production. Journal of Agricultural Science, 145: 543-564

Kossoy A, Ambrosi P. 2010. State and Trend of the Carbon Market 2010. World Bank Environment Department, Washington D.C.

Lal R. 2004. “Soil carbon sequestration impacts on Global Climate change and food security *Science* 304: 1623-1626.

Larson D, Dinar A, Frisbie J. 2011. Agriculture and the Clean Development Mechanism. Policy Research Working Paper 5621, World Bank, Washington D.C.

McCarthy N, Lipper L, Branca G. forthcoming. Climate Smart Agriculture: smallholder adoption and implications for climate change mitigation and adaptation. MICCA working paper, FAO, Rome

McCarthy N and Lipper L. 2010. Capturing synergies between food security and mitigation in smallholder agriculture: The Role of Monitoring, Reporting and Verification Costs in Accessing Carbon Finance. 117th Seminar, European Association of Agricultural Economics. 25-27 November 2010 – University of Hohenheim.

Milchunas D and Lauenroth W. 1993. Quantitative effects of grazing on vegetation and soils over a global range of environments. Ecological Monographs 63(4): 328-366

Olander L and Haugen-Kozyra K. 2011. Using Biogeochemical Process Models to Quantify Greenhouse Gas Mitigation from Agricultural Management Projects. Technical working group on agricultural greenhouse gases (T-AGG) Supplemental report Nicholas Institute for Environmental Policy Solutions, Duke University, N Carolina.

Stocking, M.A. 2003 Tropical Soils and Food Security: The Next 50 Years Science 302, *www.sciencemag.org*

Thirtle C., Lin L. and Piesse J., 2003. The impact of research-led agricultural productivity growth on poverty reduction in Africa, Asia, and Latin America. World Development, 31 (12): 1959–1975

World Bank, 2007 World Development Report, Agriculture for Development, The World Bank,Washington D.C.