SOIL CONSERVATION AND ENVIRONMENTAL MANAGEMENT: LESSONS FROM THE KYOTO PROTOCOL

Julian Dumanski,
Consultant in Sustainable Land Management, Ottawa, Canada

Abstract
The increasing emphasis on environmental quality creates a window of opportunity for soil conservation and for the world's farmers. Carbon (C) sequestration is the permanent and semi-permanent C locked up in soil or plant materials. Current estimates are that C sequestration can mitigate about 10 - 20% of global atmospheric greenhouse gas (GHG) accumulation. Countries that have ratified the Kyoto Protocol have already assumed obligations to reduce their contribution of GHGs to the atmosphere, including C, and many more will have to do so in the future. It is unlikely that these obligations can be met without the benefit of soil C sequestration. Currently, the UN Framework Convention on Climate Change (UNFCC) and the Kyoto Protocol are the only international environmental conventions which potentially provide financial benefits to farmers for environmental services, but many of the lessons learned in the evolution of the UNFCCC can also be usefully applied in the Convention on Biodiversity, the Convention to Combat Desertification, and the various agreements on international waters.

Additional Key Words: carbon sequestration, soil conservation, environmental conventions

Introduction
There is increasing evidence (World Bank, 1997) that under improved systems of land management, involving soil conservation and related technologies, agriculture can be both economically rewarding and provide environmental benefits to society, i.e. agriculture could be a major partner in the environmental solution. Well designed, farmer-centered, sustainable land management (SLM) interventions have distinct advantages as vehicles for pursuit of joint agriculture-environment objectives. The pillars of SLM are the application of agroecological principles to farming; an emphasis on human resource development and knowledge based management techniques; a participatory and decentralized approach; the value placed on natural and social capital enhancements in addition to economic efficiency gains, and the role of strong and self reliant rural institutions.

Land management decisions by individual farmers have implications for many environmental goods and services, such as impacting on *habitats* for fauna and flora, on a variety of *ecological services*, and on *amenity* or aesthetic values. The impacts may arise directly on land managed for agriculture and livestock, or indirectly as a consequence of fragmentation and degradation of natural (less managed) habitats such as forests and wetlands.

However, capturing agricultural and environmental benefits is difficult under current economic systems, which are designed primarily for trading in commodities as private goods, and which are increasingly influenced by negotiations involving globalization and trade. Unfortunately, these negotiations make only marginal (effective) reference to environmental concerns and other public goods and services. Therefore, some new financial protocols are required that better internalize environmental costs with economic benefits. Currently this is being explored using a market based approach, but this is a new and unexplored area for environmental management, and it often requires deeper blending of science and business management than has been the case to now. This requires the development of new financial instruments, such as environmental credits, the exploration of how to value the environmental outcomes, development of procedures for monitoring with acceptable transaction costs, and the evolution of national and international trading institutions, which in most cases, can be put into place only through cooperation among local, national, hemispheric, and global institutions..

The evolution of such market based incentive mechanisms is taking place under negotiations for the United Nations Framework Convention for Climate Change (UNFCCC) and the Kyoto protocol. These negotiations, as well as those under other international environmental conventions, open opportunities to better promote soil conservation. However, this requires that the soil conservation community become better informed, more proactive, and more actively involved in the discussions involving the negotiations. This paper identifies some evolving opportunities under the Kyoto Protocol, and it is argued that similar opportunities will become available under the other conventions in the future.

Opportunities to Promote Soil Conservation – Examples From The Climate Change Convention

Although all environmental international conventions deal with land management in some way or other, it's only the UNFCCC which currently provides direct opportunities and financing mechanisms from which farmers can draw benefits, and which can promote soil conservation. This is being explored through the flexibility mechanisms, e.g Joint Implementation (JI), Clean Development Mechanism (CDM, being negotiated under the Kyoto protocol, and the evolution of the international market to promote trading of carbon credits.

The Kyoto Protocol and Soil Conservation: The objective of the Kyoto Protocol is to stabilize and reduce GHG emissions, mitigate climate change, and promote sustainable development. The Protocol is historic in that it is the first attempt to achieve international agreements to mitigate global climate change through reduction in GHGs, and the first to employ the flexibility of the global market for global environmental management. The Kyoto Protocol recognizes the overwhelming importance of controlling and reducing GHG emissions (sources), primarily from industrial and transportation sources, but it also recognizes the corresponding opportunities to be gained through better management of carbon reservoirs and enhancement of carbon sinks (sequestration) in forestry and agriculture. The latter are achieved through soil conservation, improved local land management practices, such as crop rotations and zero tillage, and management of land use change (conversions). Through these mechanisms, the Kyoto Protocol is emerging as an important and effective opportunity for promoting soil conservation. Experience has shown that structuring the international agreements such that global emitters can pay for some of the accrued environmental benefits, as is done for SO_2 emission reductions under the Great Lakes environmental agreement, is an important mechanism for both delivery and sustainability of the actions.

The Kyoto protocol emerged first as a framework agreement, but through international negotiations it is progressing into sets of legal articles. These impose obligations on all signatories, but they also identify opportunities for improved environmental land management at local, national and international levels. This is particularly true for soil conservation, where the sequestration of carbon above and below ground increases soil organic matter, enhances soil fertility, and improves production, while concomitantly reducing atmospheric CO_2. The Protocol provides us with an opportunity to promote local, national and global soil conservation, and develop networks and partnerships for this purpose. It is a classic "win-win" situation.

Global Potentials for Carbon Sequestration: Soil C sequestration and soil conservation are important mechanisms in mitigation of climate change through reduction of atmospheric CO_2. Atmospheric concentrations of GHGs have increased significantly since the beginning of the industrial revolution. To the middle of the 20th century, land conversions from grasslands and forests to agriculture, and poor land management practices, have been the major contributors. Since then, burning fossil fuels (industry and transportation) and cement manufacturing have become the main causes. However, agriculture and land use change still contribute about 20% of the anthropogenic emissions (IPCC, 2001). Also, tropical deforestation continues to contribute about 1.1 – 2.1 Gt C yr^{-1} to the atmosphere (IPCC, 2000), and the process is accentuated by soil erosion and other degradation processes.

The global potential for C sequestration is considerable. For example, the potential for US cropland is approximately 75 – 208 Mt C yr^{-1}, China is approximately 105 – 198 Mt C yr^{-1}, the EU is approximately about 45 Mt C yr^{-1}, Canada is approximately 24 Mt C yr^{-1}, and India is 39 – 49 Mt C yr^{-1}. This is about 8 % of annual emissions due to fossil fuel burning in the US and up to about 45 % of fossil fuel emissions in India (Lal *et al*., 1998; Lal, 2003; Smith, 2003; CFI, 2002).

In addition, recent evidence from the humid tropics indicates that tropical regions have considerable potential for C sequestration. For example, C accumulation rates in tropical agroforestry systems range from 4 - 9 t C ha^{-1} yr^{-1}, and over a normal rotation of 20 – 25 years, above ground C accumulations in plant biomass can be as high as 50 t C ha^{-1}, and C accumulations in the soil can be as high as 5 – 15 t C ha^{-1} (Palm *et al*., 2000). Studies on the potential under irrigation indicate that if irrigated agriculture could be expanded 10%, and an equivalent amount of rain-fed land was converted to native grassland, approximately 6 % of the total C emitted in the next 30 years could potentially be sequestered (Entry *et al*., 2002). In most cases and considering the collective impacts of improved land management, about 10 – 20 % of emissions reduction commitments under the Kyoto protocol could be achieved through C sequestration.

How can this Potential be Realized: When soils are cultivated, about 20 – 30 % of the soil C is released to the atmosphere within the first 20 years in temperate regions, and 50 – 75% in the tropics due to cultivation, erosion and other degradation processes (Lal, 2000). The majority of this lost C can be replaced with good land management. The best options involve using technologies of soil conservation, such as less intensive cultivation, including zero tillage, diversifying crop rotations and using legumes, and good soil fertility and nutrient management. The potential from these practices is considerable. For example, the IPCC (2000) guidelines suggest a climate mitigation efficiency of 10 – 15 % for conversion from conventional to zero tillage, and this can be realized over a period of at least 20 years (IPCC, 2000). Other estimates show that average global C sequestration rates for reconverting agricultural land to forests and grassland (permanent cover) are about 300 kg C $ha^{-1}yr^{-1}$ for the first 20 years, and about 400 kg C $ha^{-1}yr^{-1}$ thereafter for the next 80 years (Lal, 2000). West and Post (2002) estimated that converting from conventional to zero tillage and improving crop rotations and soil fertility management can result in C sequestration from about 250 - 750 kg C $ha^{-1}yr^{-1}$ for a minimum of 25 – 30 years. The main benefits come through a combination of zero tillage coupled with crop rotations and soil nutrient management. Minimal benefits are observed with reduced tillage. The potential for C sequestration through restoration of degraded lands is about 500 - 1000 kg C $ha^{-1}yr^{-1}$ (Lal, 2000).

Adoption of zero tillage is currently about 30% of cultivated land in Canada and the US, approximately 20% in Australia, and just over 50% in Brazil. Much of the increased adoption is occurring in regions where zero till is evolving from an “input” technology to a “process” technology. Experience in Argentina and Brazil shows that rates of return are higher when zero till is combined with compatible technologies such as improved water management, more complete rotations including forages and legumes, nutrient cycling, crop residue management and interactions with soil microbiology and rhizoecological principles, integrated pest management, predator-parasite interactions, etc.

Production and Environmental Co-Benefits of Carbon Sequestration and Soil Conservation: Lands in agriculture and forestry are important pools in the global C cycle, and the management practices used can determine whether these lands are sources or sinks of C. For example:

- Sequestration of C in the soil requires technologies that increase organic matter inputs to the soil and decrease decomposition and oxidation of soil organic C. Such practices include reducing tillage intensity, decreasing the (bare, cultivated) fallow periods, using a winter cover crop, increasing rotation cropping, particularly with legumes, ensuring balanced soil fertility and nutrient management, restoration and preservation of wetlands, and restoration and maintenance of marginal lands in pasture or forests, etc.
- On the other hand, soil erosion and desertification, burning of crop residues, grassland degradation, wetland reclamation for agriculture, low water use efficiencies, organic matter and fertility loss, excessive tillage particularly with the moldboard plow and disk harrow, etc. are sources of C emissions.

Increasing the level of soil C and organic matter can provide considerable environmental and production co-benefits:

- Increased organic matter improves soil aggregation, which in turn improves soil aeration, soil water storage, reduces soil erosion, improves infiltration, and generally improves surface and groundwater quality.
- Increasing the SOC content of soil through sequestration improves nutrient cycling by stimulating soil biology and biodiversity. This stimulates the decomposition rate, enhances the nutrient supplying power of the soil, and reduces the need for external inputs such as fertilizers.
- In addition, the increased water storage capacity and improved soil fertility provides some degree of mitigation against droughts and crop failure in dry years.
- The amount and quality of SOM is an important indicator of soil quality and ecosystem health, and healthy ecosystems are essential for improved human health.

The advantages of promoting C sequestration is that it can be achieved in the short term using technologies that are readily available, such as soil conservation, and there are considerable production and environmental co-benefits.

Costs and Values of Sequestered Carbon: Carbon sequestration must be economically beneficial (feasible) to farmers if the gains made under soil conservation are to be permanent. Generally some changes in land management and increased investments are necessary to effect improved C sequestration, and once capitalized at the farm level, these practices will be maintained as long as economic returns are adequate. However, if economic returns become negative and lands under conservation tillage are returned to conventional cultivation, then the gains in SOC and SOM may be lost.

Global, national, and regional C markets are evolving in the US, Europe, and Asia. However, the prices being offered for a certified C credit (one t CO_2 equivalent) are highly variable, indicating that the market is still very immature. Although governments have major roles in developing the market by regulating policy and directly and indirectly setting the price through incentive payments and other interventions, the current action of governments in the evolution of these markets is not clear. Thus, it remains difficult to judge whether current market prices will be sufficient to entice many farmers to make the necessary changes in land management to ensure sufficient sequestration to meet Kyoto requirements.

Regardless of the uncertainty, there is a good deal of interest in participating in the potential global C trading market. For example, twenty five companies from energy, industry, farm and forestry sectors are cooperating to establish the Chicago Climate Exchange for trading credits in GHGs. In Europe, the UK and Denmark have legislated trading systems, and the EU has set up a GHG allowance trading system, the first pilot transaction of which took place in February, 2003. In Canada, a consortium of energy and pipeline companies has been exploring C trading contracts with farmers in Canada and the US, but no trades have been effected thus far. Other corporations such as BP, Plc, and Royal Dutch Shell launched their own cap and trade programs in 1998 to cut emissions.

Although the interest in C trading is considerable, the prices per tonne are highly variable. Monitoring of the rudimentary C market in the US and Europe indicates trades often coming in as low as US$0.85 - 3.00 per t CO_2 equivalent ($3.15 – 11.10 per t C). The Prototype Carbon Fund, developed by the World Bank for purchase of emission reductions (ERUs) from industry, has priced one t of emission reductions at US$3 per t CO_2 equivalent. Currently, the same price range is being considered by the proposed BioCarbon Fund for purchase of credits (CERs) from C conservation and sequestration activities in forestry and agriculture (Benoit Boesquet, personal communication).

The value of C sequestration in agriculture can also be examined as the cost to create one tonne of C credit. A study was recently completed in Saskatchewan, Canada, based on implementation costs of various government sponsored land management programs and the amount of C sequestered as a consequence. These costs ranged from US$ 6.30 – 18.70 per t C ($1.70 – 5.05 per t CO_2 equivalent)(Canadian Fertilizer Institute, 2002). Similarly, Tokyo Electrical Power recently invested US $5 M in reforestation in Tasmania, at an equivalent cost to US$38 per t C ($10.27 CO_2 equivalent). Although the combined agricultural and environmental value of sequestered C (identified as external costs or opportunity costs) has been calculated for Europe at US$ 115 to 277 per t C, the C trading price being set by the market is generally in the range of US$ 4 - 15 per t C ($1.08 – 4.05 per t CO_2 equivalent) (Pretty *et al*., 2002).

Current prices on the C market are still marginal compared to the production benefits gained from carbon sequestration and soil conservation. For example, the potential addition to gross farm income in the US from C sequestration has been calculated at between US $100 M to 4 B. In Europe, this estimate is between US $27 M to 223 M. The estimated annual value of C to agriculture is calculated to be in excess of $50 per tonne. Some analysts suggest that C could increase net farm income by about 10% (Pretty *et al*., 2002).

The initial signals from the market are that current prices are about 50% of what they should be. In spite of this, some trading is already taking place on an experimental basis. Current prices may be somewhat attractive to farmers who have already capitalized on sequestration technologies, but they are not likely to stimulate large scale changes in land management, particularly for high value systems. However, the market is still very young, and initial prices may simply reflect opportunistic buying, i.e collecting the low lying fruit.

Capturing the Opportunities of the Market: Mobilizing the hundreds of millions large and small scale farmers in the world to adopt soil conservation technologies and sequester C for the benefit of society will be a major undertaking. It will require global partnerships involving business, farmer associations, NGOs and governments working collectively toward common, beneficial goals. A fair, equitable, and accountable global market place, and a C price that at least equals the costs of sequestration, will be central to the system.

C credits gained through sequestration are potentially non-permanent, and thus more complex than those gained from reducing emissions. There are several policy designs that can deal with this. One is to establish contracts with farmers for creation and long term maintenance of the C credit (*pay as you go*). This implies monitoring and enforcement in the sense that payment received for a credit would have to re-imbursed if the C (or the land management system under which payment was accepted) is not maintained. Another option is to recognize the non-permanent nature of sequestered C and establish *variable length contracts* whereby the contract holder would be paid a discounted rate depending on how long the C would be kept out of the atmosphere. A third option would be to establish *annuity accounts*. An individual contractor (farmer) could draw on the income of the account but not the principle. If C is "released" from the account through change in land management, the value would be removed from the principle (Pretty *et al*., 2002). In developing countries, these different options could be administered through community trusts or village trusts.

Carbon is normally treated as a commodity rather than a public good in the majority of discussions on biologically sequestered C from agriculture and forestry. However, this has considerable implications on the functioning of the C market and on transaction costs for C trades. Treating C as a commodity requires contracts based on a *per tonne payment mechanis*, with a potential for high monitoring costs in terms of precision of measurement, validation, and certification (monitoring costs of industrial C are simpler and normally cheaper than those for biological C). However, sequestered C also has value as a public good for mitigation of climate change, and although not yet certain, this may be greater than its value as a commodity. The implication, however, is that assessment of C as a public good can be achieved by monitoring change in land management technologies, i.e. *per hectare payment mechanism*, at much lower transaction costs. These two types of contracts are not exclusive and could operate concurrently in the same region. The first is more suitable for direct contracts with business or corporations which have mandated emission reduction requirements, whereas the latter are more suited to governments or NGOs who have interests to promote public services (Antle *et al*., 2002).

A great deal of analytical work is still required to fully define how the markets will work, the transaction costs, and the discounts due to factors such as uncertainty and non-permanence. Currently the scientific understanding of C sequestration is ahead of the economic analyses, and it remains an international challenge to combine science with good economic analysis to determine policies which will work for the environment and for the farmers implementing them.

Implications of Recent Negotiations (COP9), Milan, Italy, 1 – 12 December, 2003

Although the Kyoto protocol is still not in force, negotiations continue on how to assess, monitor and report on the required national emission reductions. These latest negotiations, sometimes called the "forest negotiations", were the first to officially adopt carbon sinks into the protocol, but these recognized only sinks created by aforestation and reforestation, with a cap of up to 1% of national reduction commitments. Further, the negotiations recognized temporary sinks (tCers) which must be reconfirmed after each reporting cycle, and long term sinks (lCers) which are considered more permanent. Sinks created in agricultural lands are still not recognized and cannot be counted against national emissions for the first reporting cycle. These negotiations continue to treat C as a commodity, which is acceptable for industrial emissions, but creates an accounting nightmare for biological sequestration in the CDM. Also, all countries still have to notify the IPCC on how they will treat soil management under the Protocol.

Thus, the first reporting period will not be important for soil sinks in conservation and agriculture. Therefore, preparations should begin for the second reporting period, in an effort to ensure soil sinks are included. Concurrently, however, research on sinks is increasing in many countries and emphasis is shifting from international to national fora. Thus, programs are emerging to encourage farmers to adopt conservation measures and to enhance soil carbon sequestration under national initiatives, but using procedures and criteria consistent with those developed under Kyoto (Environment Canada, 2004). These efforts are to ensure that soil sinks will ultimately be accepted and possibly traded as Certified Emission Reduction units (CERs) in the second reporting period. The refocusing of soil sinks on national programs also has the effect of treating C more as a public good, thereby favouring payment to farmers for provision of environmental services. The trend towards this is already taking place in Europe, under the revision negotiations for the Common Agricultural Policy (CAP).

Much remains to be done to operationalize the Kyoto protocol, not least of which is to rationalize and simplify the very complex accounting and reporting system. Also, efforts have to be made to overcome the mistrust between developed and developing countries concerning the implementation of projects involving carbon sinks. There are still considerable differences on carbon sinks, particularly in Brazil, China, and India, who insist that Annex 1 countries must first meet their emission reduction targets, and who do not favour having sinks projects implemented in their territories.

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