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ORIGINAL ARTICLE

Land-based carbon storage and the European union emissions trading scheme: the science underlying the policy

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Abstract Climate change is occurring with greater speed and intensity that previously anticipated. All effective environmentally and socially sound mitigation efforts need to be employed to effectively address this global crisis. Land Use, Land Use Change and Forestry (LULUCF) projects can provide significant climate change mitigation benefits as well as poverty alleviation and biodiversity conservation benefits. The policies of the European Union Emissions Trading Scheme (EU-ETS), the world's largest carbon market exclude LULUCF. Scientific support for this exclusion was presented in a briefing paper published by the Climate Action Network—Europe (CAN) that puts forward the proposition that land based storage of carbon is ineffective. A careful review of the scientific papers cited in support of CAN's position indicates that, while the papers themselves are scientifically sound, they do not support the continued exclusion of LULUCF projects from the EU-ETS. At the same time some important recent research papers that describe the carbon storage and social benefit potential of such projects are not included in the analysis. An in-depth consideration of the scientific evidence is necessary in evaluating this policy option. Based on this evidence a case can be made for the inclusion of LULUCF projects in the EU-ETS.

Keywords Climate change · Carbon market · Land use land-use change and forestry · European Union Emissions Trading Scheme · Environmental and social benefits

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1 Introduction

It is now apparent that climate change is happening and with a speed and intensity that are a cause for grave concern (IPCC 2001; Meier et al. 2005; Emanuel 2005; Webster et al. 2005). Recent public announcements by leading scientists have sought to underscore the finding that the rate and severity of climate change is superseding earlier estimates (Lempinen 2009; Richardson et al. 2009). It now seems likely that even with concerted efforts by the international community it will be very difficult to constrain the concentration of CO_2 in the atmosphere (the principle greenhouse gas) below 450 ppm (Anderson and Bows 2009). Thus it will be correspondingly difficult to keep the increase in global temperature to no more than 2.0°C above pre-industrial surface temperatures (Ramanathan and Feng 2008). By recent estimates land use activities account for approximately 31% of global emissions of carbon dioxide equivalents (Scherr and Sthapit 2009). At the same time sequestration in terrestrial ecosystems could contribute as much as 20% to critical early climate mitigation efforts (Thomson et al. 2008). Given that the climate situation is more dire, intractable and dangerous than previously understood, Land Use, Land-use Change and Forestry (LULUCF) has been discussed as part of a coherent strategy to contribute to mitigation. Sequestration through land use is currently the only demonstrated, economically viable way to remove carbon from the atmosphere and potentially reduce carbon dioxide concentrations (Scherr and Sthapit 2009). Thus to achieve the stated United Nations Framework Convention on Climate Change (UNFCCC) goal of to achieve "...stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system..." (UNFCCC 1992, p. 4) it will be essential to use all viable, environmentally and socially beneficial methods to mitigate anthropogenic climate change and to recognize the critical potential role of the terrestrial biosphere in these efforts.

In addition to this unique and essential potential in the realm of climate change mitigation, many of the land use efforts to sequester carbon on the landscape such as increasing soil organic matter and adding appropriate tree species to smallholder farms also have potential important climate change adaptation benefits (FAO 2007). In addition to being effective as a strategy to store carbon, LULUCF provides an avenue for participation in the carbon market for the poorest developing countries that have been largely excluded from the market, at the same time potentially providing significant poverty alleviation and biodiversity conservation benefits. For all these reasons terrestrial bio-carbon is an important component of the analysis of climate change responses.

Indeed the importance of terrestrial ecosystem process for global carbon cycling and corresponding climate change impacts has been underscored in the work of Nemani et al. (2003) who demonstrated that global net primary productivity had increased significantly in recent years. A change in such a fundamental component of the carbon cycle can have massive repercussions in the climate system. The Nemani et al. (2003) study showed significant growth stimulation in both the northern high latitude ecosystems and in the tropics. This is a fundamental shift and has global implications. This work is underscored by that of McGuire et al. (2006) that indicated that in arctic ecosystems the feedback between climate change, plant and microbial physiological response and land use is a key process in determining whether and how these systems function as a greenhouse gas source or sink. All this underscores the fact that land use and the related behavior of terrestrial ecosystems are essential to the global response to climate change.

The international effort to address climate change implemented as the United Nations Framework Convention on Climate Change (UNFCCC) includes carbon emissions and removals from terrestrial ecosystems through the Land Use, Land-Use Change and Forestry (LULUCF) category. The convention recognizes aspect of LULUCF such as saturation (the limit of potential biological storage), non-permanence (the potential for re-emission of stored carbon) and human control (the distinction between changes in carbon dynamics due to natural processes such as changes in rainfall versus those due to human activity such as tree planting) (Schlamadinger et al. 2007). The UNFCCC agreements for the current 2008–2012 commitment period set out the inclusion of changes in terrestrial biocarbon resulting from afforestation, reforestation, deforestation, forest management, cropland management, grazingland management and revegetation for Annex B (developed) countries. Developing countries that do not have specific emission reduction commitments under the UNFCCC can participate in the process through projects initiated under the Clean Development Mechanism (CDM) that provide a way for Annex B countries to meet their commitments. However in the context of the CDM, afforestation and reforestation projects are the only terrestrial biocarbon vehicles. The restrictions on the inclusion of terrestrial biocarbon were implemented in the treaty in part due to concerns over the difficulty in measuring biocarbon, the potential for activities in one location being undermined at another location, such as when forest protection in one region simply displaces deforestation to another location, and the concern that biocarbon credits would be available in very large quantities (Schlamadinger et al. 2007).

In order to facilitate compliance with the requirements of the Kyoto protocol the European Union initiated the European Union Emissions Trading Scheme (EU ETS). Currently carbon credits generated by LULUCF are excluded from the EU ETS, by far the world's largest market for greenhouse gas emissions trading. This has the effect of limiting the range of climate change mitigation actions that European Union Member States can support at a time when current evidence suggests that much greater efforts on climate change are need than those that are in place. Many of the European Union Member States have not achieved the emissions reductions required by the Kyoto Protocol and recent estimates indicate that even with additional domestic action this target will prove impossible without the use of Kyoto mechanisms such as LULUCF (European Environment Agency 2005). The exclusion of LULUCF thus creates the potential for a lost opportunity to further mitigate climate change rather than a substitution of an offset for a domestic mitigation action.

In this situation excluding LULUCF amounts to excluding an action path that could help the situation. Forests and agroforestry systems can be very long-lived (on the order of centuries). If a particular piece of ground is converted from a low-productivity, low-carbon system to a high-productivity high-carbon system that provides real livelihood benefits to the people living on it, that system is likely to persist, storing carbon for the long-term. Although the amount stored in the carbon stocks on the this landscape may fluctuate, overall the carbon stocks remain substantial over time, compared to the original low-carbon system and the benefits to the people are arguably the strongest guarantee of permanence.

The exclusion of LULUCF from the EU ETS is based on political opposition mobilized in part by non-governmental organizations such as Climate Action Network—Europe (CAN-Europe 2009). These organizations have lobbied to keep land use carbon credits out of the EU ETS and to the present time they have been successful.

This paper seeks to examine some of the science underlying this opposition in the context of a broad scientific evaluation. The CAN Europe Briefing Paper "No Sinks in the EU ETS" opposes the inclusion of LULUCF in the EU ETS on the basis of a number of scientific studies, yet on closer examination these studies, while entirely valid scientifically, do not actually support this opposition. At the same time the Briefing Paper fails to mention recent, peer—reviewed research that underlines the potential of LULUCF to store significant amounts of carbon over the long-term while providing important poverty alleviation and biodiversity enhancement benefits.

2 Discussion

The first study cited in the CAN Europe Briefing Paper is by Korner et al. (2005) with the finding that mature trees of four species failed to show enhanced growth under elevated CO_2 levels. This research is not definitive, as other experiments (DeLucia et al. 2005; Norby et al. 2005) including the study by Heath et al. (2005) cited later in the Briefing Paper, do show such an enhancement effect. However the issue itself is irrelevant to the LULUCF issue because it does not call into question the ability to store carbon using land use change, only the rate at which this storage will occur. Reforesting an eroded, degraded, low-carbon landscape will store carbon as it accumulates in the trees and soil as the forest matures, with or without a CO_2 fertilization effect, a benefit that would only be avoided if the trees failed to grow altogether. From the perspective of a carbon trading system, if the trees do indeed grow at a lower rate, this will simply lead to issuance of a smaller amount of carbon credits.

The study by Heath et al. (2005) indicates that despite possible reductions in the rate of carbon storage as CO_2 levels rise, there is a substantial carbon storage benefit in the soil. Even if the reductions they observed occur on the landscape, at CO_2 levels that will not occur for decades, the carbon storage is still substantial. Heath et al. (2005) found significant carbon storage in the soil, a result that is consistent with a study by Silver et al. (2004) that found tropical rates of soil carbon storage under afforestation of just over a half a metric ton per hectare per year.

The CAN cited study of soil carbon loss in England (Bellamy et al. 2005 cited in New Scientist 7 September 2005) is relevant to the calculation of the global carbon budget, but is only peripheral to the discussion of LULUCF. Soil carbon tends toward a stable level under a given set of climate and management circumstances. In the soils studied the management was generally unchanged but the climate warmed, leading to increased decomposition and soil carbon loss. This is fundamentally different from a land use change in which management of a low-carbon system is changed in order increase the carbon content of the soil. The implication of this work is that some soils in temperate regions may achieve a somewhat lower stable level than they otherwise might have without a concomitant temperature increase. However because most Clean Development Mechanism (CDM) lands are in the tropics that are already subject to high temperatures that favor rapid soil decomposition, and because the greatest predicted warming is likely to occur at high latitudes, the increase in decomposition is likely to be low in these CDM locations. Soils in LULUCF projects can be expected to continue to accumulate carbon for long periods as the system moves toward a new high-carbon state and while this may occur more slowly at warmer temperatures, it is very unlikely to result in net losses of soil carbon. The conditions that favor faster rates of decomposition also favor faster rates of plant production, resulting in relatively high stocks of soil carbon. In any case, any potential decrease of soil carbon due to temperature changes would affect both the baseline (without project) and the project cases, thus the marginal (net) benefit of the project would still be similar to that without a temperature change, so the effect on net carbon storage is likely to be minimal.

The CarboEurope study (New Scientist 2005; Ciais et al. 2005; Janssens et al. 2003) showing carbon losses from European ecosystems during a drought needs to be seen in the context of the system's long-term trajectory. In fact, the same study states that in non-drought years these systems are a net sink for 7–12% of European emissions. Again as with the English soil study, these are not land areas, mostly in the tropics, being managed specifically to go from a low-carbon to a high-carbon state and again, any drought is likely to affect both baseline and project cases. Yet with the correct selection of plants and management, tree biomass carbon and soil carbon can be increased, even in very dry climates such as Niger (Rinaudo 2005; Magha 2005), while providing substantial poverty alleviation and biodiversity benefits.

The Canadian study (Biocap Canada Foundation 2006) showing large carbon losses during the early stages of forest re-growth examines moments in time in a forest growth cycle. The authors see landscape carbon storage as a viable mitigation strategy, stating that, "...Canada is in an ideal position to use its forests as carbon sinks to help fight climate change" (Biocap Canada Foundation 2006, p. 1). The authors stress that their carbon emission and uptake data are part of the landscape's carbon cycle and make no statement about whether the system over the whole cycle is a carbon source, sink or essentially neutral. Taking one stage of forest development, at the stand level, cannot represent the carbon budget of an entire forest, including an ensemble of all age classes present. Moreover this is a study of management of an existing forest and such management is not currently creditable under the CDM and thus is irrelevant to the current discussion of LULUCF inclusion in the EU ETS.

The final study cited by the CAN (Fung et al. 2005) is a simulation of the global carbon cycle that partitions carbon between the atmosphere, the land, and the ocean. The authors performed a number of simulations using scenarios including historical simulations for 19th and 20th century emissions and projections for the 21st century derived from the Special Report on Emissions Scenarios (SRES) (Houghton et al. 2001; Nakicenovic et al. 2000). The authors did find that under some scenarios the fraction of carbon in the land and oceans decreased with increasing CO2 levels. However the results were not unambiguous, for example under the A1B "balanced energy sources" the fraction in the land sink stabilized when atmospheric CO_2 reached approximately 450 ppm and in one scenario the fraction increased slightly thereafter, while under the A2B "business as usual" scenario the land fraction continued to decline as atmospheric CO_2 concentration increased. Models that partition global carbon between land, ocean and atmosphere produce highly variable results, as the authors note, depending to a great extent on model parameters and assumptions. The model used in the Fung et al. (2005) study essentially shows that high emission levels can outpace the land and ocean ability to absorb the excess carbon emissions globally, as would be expected in order for carbon dioxide to increase in the atmosphere. However this result says nothing about the viability of land-based carbon storage as part of an integrated mitigation strategy. Where a low-carbon degraded landscape is managed to increase carbon stocks the additional tons stored are stored regardless of the emission levels and to that degree help to mitigate atmospheric carbon levels.

While none of the studies cited in the CAN Europe Briefing Paper indicate that LULUCF is not a viable part of an integrated mitigation strategy, the Briefing Paper fails to include significant recent research showing the potential for LULUCF carbon storage and attendant poverty alleviation and biodiversity enhancement benefits.

Of direct relevance to the carbon storage potential of CDM LULUCF projects is the work by Silver et al. (2004) in which the carbon gains from reforestation in a tropical location were tracked. Silver et al. found that over the study's 55 year period there had been a net gain of 33 metric tons per hectare in soil carbon and 80 metric tons per hectare in above ground biomass carbon. This was in a warm moist tropical situation in which soil carbon storage would have to overcome significant rates of decomposition. This carbon storage occurred when unimproved pasture was reforested. This is a direct, conservative model of what is possible via carbon storage through reforestation under circumstances similar to many potential CDM locations.

There is also strong evidence that land-based carbon storage can be combined with important poverty alleviation and development benefits. Roshetko et al. (2002, 2006) has shown that smallholder forest gardens established on deforested, degraded lands in Indonesia can store 80 metric tons of carbon per hectare while providing food, income, spices, medicine, oils and resins to significantly improve the lives and livelihoods of the rural poor.

The assertion that land use change projects provide no biodiversity benefits rests on characterizing such projects as large monoculture commercial tree plantations and then arguing that such plantations have lower biodiversity than the forests they replace. This is incorrect as such plantations are inherently economically viable and are thus generally excluded from the CDM under additionality rules. Development projects involving many poor smallholders however are not excluded in this way. These development projects that reforest an area with a mix of native multi-purpose species provide direct biodiversity benefits through the trees and the habitat they provide, as well as taking use-pressure off of remaining stands of native forest. This conversion is not from a high biodiversity natural forest into the new monoculture forest, but often starts from degraded, deforested land, with very low biodiversity, then creating a trajectory toward a diverse multi-species landscape.

The biodiversity benefits of LULUCF carbon sequestration projects are well known for many locations around the world including such biodiversity hotspots as the Noel Kempff carbon project in Bolivia (Brown et al. 2000). Documented methods for achieving this benefit include reducing the fragmentation of degraded landscapes and creating critical habitat for both flora and fauna (FAO/RWEDP 1998/99). Biodiversity conservation and enhancement is thus an integral part of the benefits that can be realized by LULUCF projects.

Finally the key issues that the CAN Europe paper raises in relation LULUCF are:

- Permanence—Development of LULUCF projects can increase the productivity of land through high yield agroforestry systems and these reduce the need to clear new land. Further, viable production systems that benefit local people can persist and be maintained for long periods of time. Despite the fact that much of the carbon stored through land use is likely to remain stored away from the atmosphere for the foreseeable future, the credits themselves are temporary, so that those that are replaced despite their persistence represent a net gain in mitigation. In addition, under the UNFCCC compliance regime it is possible to quantify and evaluate the persistence of carbon sequestered on the landscape using an integrated spatio-temporal approach, that is particularly effective when performed in the context of the creation of a Full Greenhouse Gas Account (FGGA). Such an integrated approach is being implemented in the Russian boreal forests as part of the effort to include them in the quantification of sources and sinks in the country's national accounts under the UNFCCC schema (Stewart et al., 2008). This transparency in the context of the international framework serves to further incentivize policies that enhance permanence as well as mechanisms such as areal buffers to address permanence risk.
- Additionality—Establishing "what would have happened" is a problem for any CDM project, including those in the energy sector. The same level of rigorous examination applies to all CDM project types, including the use of standard additionality tools approved by the CDM Executive Board.

- Leakage—As development of LULUCF projects can create a local resource where none currently exists by planting native species on denuded landscapes with the participation of local people, they are likely to result in non-creditable but nevertheless real, “positive leakage”. That is, people who, with the project in place, are now able to sustainably harvest firewood, building materials and craftwood from the project will no longer need to cut existing forests. Their use will be displaced from the existing forest to the project area with a corresponding reduction in deforestation. Existing CDM methodologies (http://cdm.unfccc.int/methodologies/ARmethodologies/index.html) address leakage by deducting it from the overall greenhouse gas accounting. Methods of addressing leakage are also included in the Voluntary Carbon Standard (Voluntary Carbon Standard 2008) and a practical approach to leakage has also been developed by the World Bank’s Biocarbon Fund (BioCarbon Fund 2008), indicating that viable ways of addressing leakage have been made available.
- Uncertainties—All CDM projects, indeed all climate mitigation projects, are subject to uncertainties, however a large, well-established literature and the many approved CDM baseline and monitoring methodologies for forestry projects, demonstrate that carbon stocks and stock changes can be accurately and precisely measured and monitored over time to within the needed specifications. In fact, many CDM methodologies suggest simplifications in places where the deviation is on the conservative side. For example, it is possible to omit some carbon pools, provided it can be demonstrated that they increase and benefit from the project. In addition the uncertainties can be addressed within such a project by selecting the lower bound of the uncertainty and only crediting the most conservative estimate of carbon sequestration. Where difficulties in quantifying the uncertainty itself arise it is valid to use the IPCC guidelines on default values for uncertainty in order to arrive at a sufficiently conservative and acceptable estimate. Uncertainty at larger scales is also a problem with very large uncertainties sometimes present in efforts at full carbon accounting at a national scale (Jonas et al. 2008; Nilsson et al. 2003). However, there is strong evidence that carbon stocks in LULUCF projects as opposed to large scale national accounting efforts, can be measured to precision levels of plus or minus 10% with a confidence interval of 95% and that this can be achieved without incurring exorbitant costs (IPCC 2003).
- Socio-Economic and Environmental Impacts—Multi-benefit development LULUCF CDM projects have numerous poverty alleviation and development benefits with the potential to enhance food and income security for poor rural people while providing fruit, medicine, firewood, building materials, natural insecticides, resins, craft materials, and forage. Biodiversity benefits can also be substantial. That these projects are consistent with the stated development goals of developing countries is evident in countries such as Ecuador in which the Designated National Authority, the Ministry of the Environment, provides guidance and leadership to CORDELIM, the organization tasked to promote and facilitate LULUCF projects.
- Technology transfer—LULUCF projects have the potential to provide such key technology transfer benefits as agroforestry techniques, improved germplasm and extension support to impoverished communities. These services and materials provide the foundation for an ongoing sustainable system that local people can then improve and adapt to their own particular circumstances.

The Briefing Paper’s concern that admission of LULUCF will compromise the adoption of sustainable energy projects is unfounded. LULUCF projects under the CDM are limited to 1% of industrialized countries’ 1990 emissions and thus are unable to flood the market with cheap credits that undermine the viability of renewable energy projects.[1] Thus LULUCF projects do not have the capacity to undercut the renewable energy sector. The real difficulty for renewable energy is that over 50% of the CDM portfolio has been in gas capture projects that are very inexpensive because of the point source nature of the production and the high greenhouse warming potential of nitrous oxide and various kinds of fluorocarbons. It is these projects that are undercutting wind and solar energy projects and making them less attractive in the marketplace. Keeping LULUCF out does nothing to rectify this problem but does have a major impact in keeping a large number of developing countries from participating in the lion's share of the carbon market and reaping poverty alleviation, development and biodiversity gains at the same time. In fact, keeping LULUCF out is bad for renewable energy, because a key benefit of reforestation projects is that it helps to build renewable biomass resources for the future. The restrictive inclusion of LULUCF in the CDM has already led to a negative impact on renewables: it has eliminated solar energy, biogas and other renewable energy projects as a replacement of traditional, non-renewable biomass (fuelwood and charcoal) from the CDM, and only lately (January 2008) these types of projects have been re-admitted to the CDM, and only as small-scale projects.

3 Conclusion

As a review of the cited scientific literature indicates, LULUCF projects do have climate mitigation advantages both in the aboveground biomass and in the soil. These projects offer a wide range of potential benefits to some of the poorest people on the planet as well as substantial biodiversity improvements. Excluding LULUCF from the EU ETS keeps poor countries and poor people from equitable participation in the carbon market because these countries do not have the infrastructure and fossil-fuel baseline to obtain credits in other ways. The CDM has failed to address improvements of the traditional biomass energy sources that, for example, most poor people in Africa rely on, and excluding LULUCF removes another possible revenue stream for poor communities. At the same time, revenues for mitigation are removed that would allow action that will otherwise not occur, especially as Kyoto signatories may fail to meet their reduction targets. Global sink strength is a critical question but not one that impinges on the use of LULUCF in the EU ETS, as at whatever strength the "background sinks" have, specific activities to improve carbon storage will contribute to climate change mitigation.

It is important to note that the LULUCF exclusion also sends a negative political signal to current non-Kyoto Protocol Annex I countries and to developing countries who would mainly benefit from these activities as they are too poor to afford an energy infrastructure that would allow them to participate in other types of Clean Development Mechanism projects. This has the effect of further dampening their interest in the protocols and undermines the treaty's viability and future prospects.

For all of these reasons it is important that the EU ETS be opened to LULUCF projects so that a real opportunity for climate change mitigation, poverty alleviation, and biodiversity conservation is not missed.

[1] The opposition to LULUCF projects has lead to a current limited application of LULUCF to 1% of 1990 emissions for Annex I countries.

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