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A synopsis of land use, land-use change and forestry (LULUCF) under the Kyoto Protocol and Marrakech Accords

B. Schlamadinger [a,*], N. Bird [a], T. Johns [a,k], S. Brown [b], J. Canadell [c], L. Ciccarese [d], M. Dutschke [e], J. Fiedler [f], A. Fischlin [g], P. Fearnside [h], C. Forner [i], A. Freibauer [j], P. Frumhoff [k], N. Hoehne [l], M.U.F. Kirschbaum [m], A. Labat [n], G. Marland [o], A. Michaelowa [p], L. Montanarella [B], P. Moutinho [q], D. Murdiyarso [r], N. Pena [s], K. Pingoud [t], Z. Rakonczay [u], E. Rametsteiner [v], J. Rock [w], M.J. Sanz [x], U.A. Schneider [y], A. Shvidenko [v], M. Skutsch [z], P. Smith [A], Z. Somogyi [B], E. Trines [C], M. Ward [D], Y. Yamagata [E]

[a] Joanneum Research, Elizabethstrasse 5/1, A-8010 Graz, Austria
[b] Winrock International, 1621 N Kent St., Suite 1200, Arlington, VA 22209, USA
[c] CSIRO Division of Atmospheric Research, G.P.O. Box 3023, Canberra, ACT, Australia
[d] Italian Agency for Environmental Protection and Technical Services, Via Curtatone 3, I-00185 Rome, Italy
[e] BioCarbon Consult, Badstr. 41, 77652 Offenburg, Germany
[f] Natural Resources Defense Council 1200 NY Avenue, #400, 20005 Washington, DC, USA
[g] Terrestrial Systems Ecology, ETH Zurich, CHN E35.1, CH-8092 Zurich, Switzerland
[h] Instituto Nacional de Pesquisas da Amazônia (INPA), Avenida Andre Araujo, 2936, C.P. 478, 69011-970 Manaus, Amazonas, Brazil
[i] Center for International Forestry Research, CIFOR Jalan CIFOR Situ Gede Bogor Barat 16680, Indonesia
[j] Max-Planck-Institut für Biogeochemie, Postfach 100164, D-07701 Jena, Germany
[k] Union of Concerned Scientists, 2 Brattle Square, Cambridge, MA 02238, USA
[l] Ecofys, Eupener Straße 59, 50933 Köln, Germany
[m] Environmental Biology Group, RSBS, The Australian National University, G.P.O. Box 475, Canberra, ACT 2601, Australia
[n] European Commission EUFO 1/1160 L-1555, Luxembourg
[o] Oak Ridge National Laboratory, Environmental Sciences Division, Oak Ridge, TN 37831-6335, USA
[p] Institute of Political Science–Political Economy and Development, University of Zurich, Mühlegasse 21, 8001 Zurich, Switzerland
[q] Instituto Pesquisa Ambiental da Amazônia (IPAM), SCLN 210 Bloco C, Sala 211, CEP 70862-530, DF, Brasília, Brazil
[r] Center for International Forestry Research, Jl. CIFOR, Situgede, Bogor 16680, Indonesia
[s] Pew Center on Global Climate Change, 2101 Wilson Blvd, Arlington, VA 22201, USA
[t] VTT Technical Research Centre of Finland, P.O. Box 1000, FI-02044 VTT, Finland
[u] European Commission, BU-9 4/65, B-1049, Brussels, Belgium
[v] International Institute for Applied Systems Analysis (IIASA), Schlossplatz 1, A-2361 Laxenburg, Austria
[w] Potsdam Institute for Climate Impact Research (PIK), Department of Global Change & Natural Systems, Telegrafenberg A 51, D-14473 Potsdam, Germany
[x] Fundación CEAM, Charles H. Darwin 14, S-46980 Paterna, Valencia, Spain
[y] Research Unit Sustainability and Global Change, Centre for Marine and Atmospheric Sciences (ZMAW), University of Hamburg, Bundesstr. 55, D-20146 Hamburg, Germany
[z] University of Twente, P.O. Box 217, 7500 AE Enschede, The Netherlands
[A] University of Aberdeen, School of Biological Sciences, Cruickshank Building, Aberdeen AB24 3UU, UK
[B] Joint Research Centre, Via Enrico Fermi 1, I-21020, Ispra, Italy, on Secondment from the Forest Research Institute, Frankel L.u. 42-44, H-1023 Budapest, Hungary
[C] Treeness Consult, Gramserweg 2, 3711 AW Austerlitz, The Netherlands

* Corresponding author. Tel.: +43 316 876 1340; fax: +43 316 876 91340.
E-mail address: bernhard.schlamadinger@joanneum.at (B. Schlamadinger).

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[D] Global Climate Change Consultancy (GtripleC), 14B Glenmore Street, Thorndon, Wellington, New Zealand
[E] National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki 305-8506, Japan

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ABSTRACT

The complexities inherent in land use, land-use change and forestry (LULUCF) activities have led to contentious and prolonged debates about the merits of their inclusion in the 2008–2012 first commitment period of the Kyoto Protocol. Yet the inclusion of these activities played a key role in agreement on the general framework of the Kyoto Protocol, and LULUCF will likely continue to play a substantial part in negotiations on national commitments post-2012. The Marrakech Accords dictate which LULUCF activities are to be included under the Kyoto Protocol and provide rules on how they are to be accounted in the first commitment period. However, these rules have limitations and drawbacks that may be avoided in the structure of future commitments beyond 2012. Through adherence to the objectives of the United Nations Framework Convention on Climate Change (UNFCCC), and the incorporation of several critical features, a future framework can more effectively address the mitigation challenges and opportunities of this sector.

1. Introduction

Achieving the ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC) of avoiding ''dangerous interference'' with the global climate system will require policies that ''cover all relevant sources, sinks and reservoirs of greenhouse gases'' (UNFCCC, 1992a)—including those from land use, land-use change and forestry (LULUCF).

Between 1989 and 1998 the net removal of carbon from the atmosphere by terrestrial ecosystems has been estimated to average 2.3 Gt C/year (IPCC, 2000) or nearly 30% of carbon emissions from all anthropogenic sources. At the same time, anthropogenic releases from the carbon pools of terrestrial ecosystems – primarily due to land-use change – amounted to 1.6 Gt C/year over the 1990s (IPCC, 2000) or about 20% of carbon emissions from all anthropogenic sources. The combined result of these natural and anthropogenic processes is a net removal of carbon from the atmosphere by terrestrial ecosystems. Given the significance of both the emissions and removals, and the potential to influence them with policy measures, it is important to continue to explore the inclusion of LULUCF in future international climate change agreements.

For a future climate change agreement to more effectively include LULUCF, it is important to address the considerations raised in the present special issue concerning the options for, and the design of, the accounting system for LULUCF activities. This will help to assure that the climatic benefits of LULUCF actions are real, their crediting is fair, and their social and environmental effects are beneficial. In this light, it is important to take a step back and assess the way in which LULUCF was included in the Kyoto Protocol's 2008–2012 first commitment period, to understand the advantages and disadvantages of this approach, and to appreciate the reasons that certain paths were taken in the decision-making process.

The original provisions for inclusion of LULUCF were agreed to at the Third Conference of the Parties (COP3) to the UNFCCC in Kyoto, in 1997—under time pressure and without the support of a fully considered scientific basis. Furthermore, the text of the Kyoto Protocol did not set specific rules as to how LULUCF emissions and removals would be incorporated into the accounting system. The task of establishing specific rules was mandated to the Subsidiary Body for Scientific and Technological Advice (SBSTA) of the UNFCCC. In 1998, SBSTA invited the Intergovernmental Panel on Climate Change (IPCC) to produce a Special Report on LULUCF to support SBSTA's development of these rules. This Special Report provided options for definitions of terms, for the inclusion of additional activities under Article 3.4, and for accounting rules for LULUCF activities. It also discussed the implications of choices among definitions and accounting rules (IPCC, 2000).

The current framework for implementation, which was finally accepted at COP7 in Marrakech in 2001, is a negotiated solution produced by an evolving political process that had to deal with considerable scientific uncertainty. It has the great advantage of having been agreed to, thus allowing the negotiations to turn to other pressing issues. Nevertheless, there are deficiencies with the current framework: monitoring and reporting are complex and expensive; and the main source of LULUCF emissions, deforestation in developing countries, is not covered. Few would dispute the desirability of simpler or more cost effective ways to support the ultimate objective of the Convention. Upcoming negotiations on a post-2012 agreement provide an opportunity to reassess, to extend the list of eligible LULUCF activities, and possibly to simplify the manner in which LULUCF activities are included in the international climate change regime.

The fact that the contribution of LULUCF was agreed after the establishment of Kyoto targets constituted a major

problem for reaching agreement on the rules for inclusion of LULUCF, primarily because LULUCF was seen as a way to offset emissions. For some Parties, accounting for additional activities meant a renegotiation of targets as additional removals would have decreased the efforts needed to meet the targets set by Annex B of the Kyoto Protocol.

The papers in this special issue assume that a future international climate agreement, applicable to the period after 2012, will be developed under the UNFCCC and that it will specifically refer not only to *emissions by sources* but also to *removals by sinks*. We also assume that coverage of LULUCF activities will continue to include agriculture, forestry, and other land uses.[1] While the collection of papers in this special issue outlines options by which LULUCF emissions and removals might be included in an international climate agreement beyond 2012, it does not focus on ways of allocating emission targets to countries. The issue of long-term stabilisation of atmospheric greenhouse gas (GHG) concentrations – the ultimate aim of the UNFCCC – is not treated explicitly. The intent is to develop rules that effectively contribute to such stabilization and can be applied to LULUCF activities in the long term. This special issue focuses on carbon, because many of the controversial LULUCF discussions have focused on carbon stock changes. Non-CO_2 gases in agriculture are accounted for in other inventory categories, and the same could be done for non-CO_2 gases from forest lands.

This paper is structured as follows: Sections 2 and 3 review the special climate policy challenges presented by LULUCF, and how these challenges are addressed in the first commitment period. Section 4 presents objectives for including LULUCF activities post-2012, and discusses practical considerations that may be important for success. These objectives and considerations are presented as criteria for evaluating the options presented in the accompanying papers. Section 5 discusses an overall framework for future commitments and Section 6 draws some conclusions. Our goal is to examine options in a policy-relevant fashion without being overly prescriptive regarding any single approach.

2. How is LULUCF different from other sectors?

The UNFCCC deals with five economic sectors that are the sources of anthropogenic greenhouse gases (GHG) in the atmosphere. These sectors are energy, industrial processes, agriculture, LULUCF and waste. As the sectors are defined, GHG removals from the atmosphere occur only in LULUCF, because of biomass growth. This results in specific accounting characteristics which make the LULUCF sector distinct from the rest.

The LULUCF sector uniquely presents no less than *five*[2] avenues to reduce net GHG emissions, namely:

- provision of renewable energy;
- substitution for more fossil carbon-intensive products;
- reduction of emissions of non-CO_2 gases (e.g., from agriculture);
- sequestration of carbon through enhancement of terrestrial C stocks; and
- conservation of existing C stocks (e.g., through reduced deforestation, devegetation, forest degradation, and land degradation).

Terrestrial ecosystems also provide food, fuel, and shelter; preserve biodiversity; and supply other services and environmental benefits. Balance among the many terrestrial ecosystem services, including GHG mitigation opportunities, must be addressed if the LULUCF sector is to provide maximum contribution to the goals of the UNFCCC. This need for balance presents a multi-dimensional challenge to land management.

There are three unique characteristics of the LULUCF sector that require consideration in the context of greenhouse gas mitigation, namely *saturation* (which limits biological sequestration potential but not necessarily provision of renewable energy or wood products), *non-permanence*, and the *degree of human control*.

2.1. *Saturation*

Saturation refers to a limit on the potential for biological carbon storage. The limit occurs because carbon sequestration is limited by the amount of available land and by the activity-specific and location-specific amount of carbon that can be stored or protected on a unit of land. There are differences in the magnitude and timing of changes in carbon pools that depend on the nature of the respective pools (e.g., vegetation, dead wood, soil) as well as on climate, topography, soil type and past management practices. For example, carbon in tree biomass can continue to accumulate for up to several centuries, as shown in examples of old-growth forests. Stores of carbon in dead wood will continue to increase even after the carbon stocks in live trees have stabilized because these trees will eventually die and contribute to this pool, and dead wood can persist for very long time periods. Accumulation of carbon in some soils may continue even longer. The saturation limits of the overall sector can be extended if carbon in long-lived harvested wood products is increased. However, this may also be constrained by limited demand, for example, in housing by the maximum fraction of wooden houses at any given time, and the amount of wood per house.

Saturation is a critical issue in determining the degree to which particular land management activities can contribute to meeting specific CO_2 stabilization targets. The term ''saturation'' is used very loosely to indicate that, in the absence of some major disturbances that will reduce carbon stocks at large scales, it appears that the sink size of the terrestrial biosphere will approach a steady state, i.e., net primary production (input) will be balanced by heterotrophic respiration (outputs) at some point, if averaged over sufficiently large temporal and spatial scales.

The IPCC Third Assessment report (Kauppi and Sedjo, 2001) estimated that 12–15% of fossil-fuel emissions until approximately 2050 could be offset by improved management of

[1] This is consistent with the IPCC 2006 inventory guidelines, now in final form, which merge the categories Agriculture and Land-use Change and Forestry to create one sector (Agriculture, Forestry and Other Land Use or AFOLU).

[2] In addition to the five opportunities listed, LULUCF acts to remove CH_4 from the atmosphere and impacts local and regional climate, either aggravating or providing opportunities to mitigate the effects of climate change.

terrestrial ecosystems globally (Sathaye and Bouille, 2001). This estimate is a measure of the technical potential and it does not take account of opportunity costs and other barriers to implementation. The economic potential is likely to be much smaller (e.g., McCarl and Schneider, 2001), and will depend on the incentives offered to landowners. The estimate by Sathaye and Bouille does not include the current so-called "residual carbon uptake"[3] in terrestrial systems, estimated at about 2.3 Gt C/year (Prentice et al., 2001). This residual carbon uptake is generally assumed to be the result of factors such as N and CO_2 fertilization, changes in climate, recovery from prior and more intensive management of lands, and other recent management decisions not influenced by C sequestration. Human management activities specifically designed to enhance or protect carbon stocks will provide climate benefits independently of whether the residual carbon uptake increases or declines.

2.2. *Non-permanence*

Non-permanence[4] refers to the reversibility of carbon sequestration in the biosphere. Management changes can increase the carbon stocks on a given area of land, but these increases can be reversed either by natural causes (fires started by lightning, disease, etc.) or through land-use decisions. The reverse is also true—a release (e.g., through a fire) can be followed by regrowth of the trees. There is no real parallel to this potential reversibility in emissions from fossil-fuel use.[5]

The combustion of fossil fuels, unless the resultant carbon dioxide is captured and sequestered in geological formations, always leads to CO_2 emissions to the atmosphere. Combustion releases carbon from the large, geologically stable, pool of fossil fuel resources. Human actions control the rate at which fossil fuels are utilised, but any release cannot generally be reversed. If fossil-fuel use is curtailed or reduced, this reduction in emissions is not lost, even if the emission-saving project is terminated at some time. Any reduction, once achieved, remains permanent.

For Parties with emission limitation commitments (countries specifically listed in Annex B), the Kyoto Protocol accounts for the non-permanence of carbon stocks on lands subject to its Articles 3.3 and 3.4 through the annual reporting of greenhouse gas inventories. These inventories ensure that any emission of CO_2 will be reported and, hence, will be accounted for in the balance of emissions and removals. Non-permanence became a specific issue in the context of the Clean Development Mechanism (CDM), a mechanism introduced in the Kyoto Protocol to encourage emission reductions and removals in developing countries. These countries do not have emission limitation commitments. As a consequence they are not required to account for any re-emission of carbon to the atmosphere, even if, as the rules permit, an increase in carbon stocks in their country has been used by an Annex B Party to meet its commitment. To address this asymmetry, carbon credits from CDM projects are temporary. Either upon termination of a CDM LULUCF project or upon release of the sequestered carbon back to the atmosphere, the Annex B Party that used the credits must replace them with other credits equivalent to the amount of carbon deemed to have been re-emitted, or Annex B Parties can use temporary certified emission reductions with a validity of 5 years that need to be replaced in any case after 5 years, irrespective of what happens with the project where the credits were generated (UNFCCC, 2005a).

Although the reporting requirements ensure that losses of carbon stocks will be accounted for, non-permanence can expose countries with commitments that include LULUCF to considerable risk. The relatively limited scope of LULUCF activities agreed to under the Kyoto Protocol and the Marrakech Accords means that the non-permanence risk associated with LULUCF activities is generally fairly small for the first commitment period. However, it may be an issue for Parties that elect to account for forest management under Article 3.4 and have ecosystems frequently affected by fire or subject to El Niño cycles.

Some suggest that the biosphere might become an overall net source of carbon to the atmosphere within 50–100 years, when the effect of climate change on terrestrial ecosystems is taken into account (Cox et al., 2000; Fung et al., 2005). For example, the warmer the planet gets, the greater the chance that certain carbon pools will become unstable and emit large quantities of CO_2, e.g., from soils (particularly frozen soils), peat lands, or more frequent fires.

If the global community were to adopt *full carbon accounting*,[6] as opposed to the more limited approach adopted for the Kyoto Protocol first commitment period, then the risk associated with non-permanence could significantly impact countries' ability to meet commitments. On the other hand, the integrity of the atmosphere would be better preserved.

2.3. *The influence of natural effects and control by humans*

The *influence of natural effects and control by humans* refers to the fact that many natural phenomena have an impact on increases and decreases in carbon stocks; consequently human efforts to influence terrestrial carbon sequestration are constrained by phenomena over which they have only limited control. For example, an area might be planted with trees (a human action), but the subsequent growth rate of those trees will be affected by droughts; storms; diseases; insect attacks; and changes in

[3] It is called the residual sink because it is calculated as a residual from the difference between the sum of known carbon sources and sinks, and the rate of carbon accumulation in the atmosphere.

[4] "Non-permanence" is not about the fact that individual trees in a forest stand die and decompose, or that a forest stand within a forested landscape can be harvested—such events do not necessarily mean a loss of carbon stocks in the entire forest which can consist of many stands. Rather, "non-permanence" is about the possible net loss of carbon at the project, landscape, regional, or national levels. Such a loss can be, for example, due to human decisions to convert the land to another land use, or due to large-scale disturbances such as fires, pests, insects or storms. The difference is that whereas the life of individual trees is limited, the carbon stored in forest landscapes is not necessarily non-permanent. Non-permanence is thus not a certainty, only a possibility.

[5] Geological sequestration of fossil fuel emissions is potentially reversible, although the risk of loss per unit time from a well-designed geological reservoir is likely to be very low.

[6] In the context of this paper, full carbon accounting is the inclusion of emissions and removals on all managed lands, in all pools, and of all relevant greenhouse-gases, without temporal interruption.

temperature, rainfall, CO_2 concentration, and atmospheric nitrogen deposition. These factors are largely beyond the control of land managers, although their effects on tree growth can be modified by management decisions such as choice of species, planting density, thinning regime, pest and fire control, or fertiliser addition. In essence, natural factors are the framework within which the additional human measures operate, and the natural factors define a baseline against which carbon management efforts should be measured.

In contrast, fossil-fuel use is influenced less by natural effects, although changes in weather and climate can impact those portions of fossil-fuel use devoted to space heating and cooling and to irrigation; and they can impact the availability of resources like wind, solar radiation, and water. Also, humans have greater control over the use of fossil fuels, at least in the longer term, as decisions can be made to increase the use of carbon-free or carbon-neutral energy sources.

During the negotiations on the Kyoto Protocol and Marrakech Accords, concerns emerged that unless reporting and accounting for LULUCF were restricted to the direct results of human activities, a significant part of the residual carbon uptake might be counted as part of the actions undertaken to meet commitments. The size of the residual carbon uptake (2.3 Gt C/year), as compared to mitigation efforts sought in other sectors, had an important influence on LULUCF negotiations. The difficulty of dealing with the interplay between natural phenomena and human efforts in LULUCF remains one of the most difficult issues under discussion. This is particularly the case since the IPCC, on preliminary inspection, sees no prospect of comprehensive methodological advice for factoring out indirect and natural effects (which can be both positive and negative) on carbon stock changes from the direct effects of human actions, at least in the short or medium term (IPCC, 2003). This special issue includes a paper that revisits the ''factoring out'' issue (Canadell et al., 2007).

3. LULUCF in the 2008–2012 commitment period

3.1. *Main features of current agreements*

The main features of the agreements as negotiated from Kyoto to Marrakech (1997–2001) are that the carbon accumulations and losses from LULUCF in the following areas must be included in the commitments of Annex B countries:

- Carbon stock changes and non-CO_2 emissions between 2008 and 2012 on new forest areas (afforestation and reforestation (AR) created since 1990 or deforested (D) since 1990;

Countries may also elect to include any of the following activities to meet commitments:

- Carbon stock changes and non-CO_2 emissions between 2008 and 2012 on areas subject to forest management, up to a cap that is, in most cases, a fraction of the anticipated uptake; and
- Carbon stock changes and non-CO_2 emissions between 2008 and 2012 on areas subject to cropland management, grazing land management and revegetation relative to carbon stock changes and associated greenhouse gas emissions from these activities in 1990.

Table 1 – Summary of LULUCF activities in the first Commitment Period of the Kyoto Protocol

Initial land use	Final land use		
	Forest	Cropland	Grazing land
Forest	FM	D	D
Cropland	*AR*	CM	GM
Grazing land	*AR*	CM	GM

The activities shown in italics in the table are also eligible as CDM projects, undertaken in developing countries. For reasons discussed below, the most significant omission in the CDM is the ineligibility of a reduction in deforestation, which could be quantitatively more important than the activities that are eligible.

- Afforestation and reforestation projects in non-Annex B countries agreed under the terms of the Clean Development Mechanism (CDM), up to a limit of 1% of the Annex B country's total emissions in 1990.

The afforestation, reforestation and deforestation (ARD) activities are conceptually long-term changes from non-forest to forest or vice versa, such as the conversion of croplands or grasslands into forests. Wood harvesting is not considered to constitute deforestation unless it is followed by a change in land use. Emissions caused by deforestation are considered to occur in the year of the disturbance for accounting purposes; however carbon removals from the atmosphere (stock increases in the biosphere) resulting from afforestation and reforestation occur over an extended period of time. Consequently, the restriction on what can be used to meet commitments – carbon stock changes resulting from activities undertaken since 1990 – causes a bias towards emissions from deforestation, particularly in the first commitment period[7]. This accounting imbalance resulted in a peculiar situation for some countries: even though their forest areas and carbon stocks may be increasing, they may nonetheless incur a net debit due to inclusion of deforestation that occurs within the commitment period but exclusion of atmospheric removals that result from pre-1990 AR. This situation eventually required special treatment in the negotiations.

Under Article 3.4 of the Kyoto Protocol and the Marrakesh Accords, countries may choose to account for carbon stock changes due to forest management (FM), cropland management (CM), grazing land management (GM) or revegetation (RV). If a country has elected to account for any of these activities, it must account for carbon stock changes on all lands subject to these activities.

Table 1 gives a broad summary of the main land-use activities included in the Kyoto Protocol's first commitment period. The matrix only refers to managed lands, since unmanaged lands are not included in UNFCCC inventories

[7] Deforestation before 1990 will hardly have any effect on GHG emissions and removals in the commitment period, because deforestation activities only have short-term effects on carbon stocks. Thus, the exclusion of pre-1990 deforestation activities has no major impact. In contrast to deforestation, afforestation or reforestation prior to 1990 can have a large impact on removals for many decades because of the slow growth of trees. Therefore, exclusion of AR before 1990 has a significant impact on GHG emissions and removals reported in the commitment period.

and Kyoto Protocol accounting. Revegetation is not shown in the table because it is not associated with a specific land use category. Revegetation can occur in croplands and grazing lands, and also in other land such as urban or conservation land, but not on forest land.

3.2. *Addressing the special characteristics of LULUCF in the current Kyoto Protocol rules*

3.2.1. *The residual carbon uptake and limitation to results of direct human actions*

Emissions from industrial processes and use of fossil fuels can be estimated or measured with reasonable confidence, particularly in countries with accurate data on energy supply and demand (i.e., most Annex B countries under the Kyoto Protocol). However, even after inclusion of known biosphere sources and sinks, reconciliation of observed increases in atmospheric CO_2 concentrations with known fossil-fuel emissions and observations of oceanic uptake of CO_2 implies that there must be an additional very large residual carbon uptake (2.3 Gt C/year) in the terrestrial biosphere. This residual carbon sink is very large compared to the mitigation efforts required for countries to meet their commitments under the Kyoto Protocol. This information had an important influence on LULUCF negotiations. It was (and still is) not known how much of this residual carbon uptake might be occurring in Annex B countries. In particular, there was concern that some Annex B countries might be able to meet their Kyoto commitments solely or largely through claiming a significant portion of this residual carbon uptake within their national boundaries. This would relieve them of the need to make serious efforts to reduce emissions from fossil fuel use. One of the ways in which this concern was addressed was by limiting the use of LULUCF activities to "direct human-induced" effects on carbon stocks. The limitation to direct human-induced effects also served as part of a compromise between Parties that wanted the Kyoto Protocol to focus on emissions from fossil fuel sources and those that felt that LULUCF activities should be included.

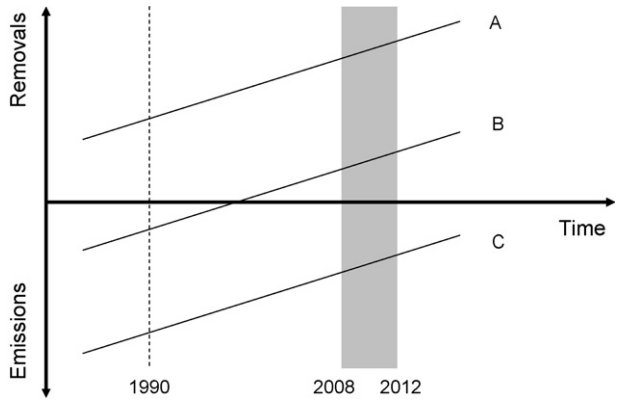

Fig. 1 – Net-net accounting on croplands and grazing lands. Three scenarios of emissions or removals of carbon in cropland and grazing land management are illustrated with the trend lines A, B, and C. Net credits are calculated as the removals or emissions in the commitment period (2008–2012) minus the removals or emissions in 1990. Any of the three trend lines above, showing three scenarios of the time path of carbon emissions and removals, would lead to net credits under Article 3.4 "cropland management" or "grazing land management". If the lines had a negative slope, this would lead to a debit under net-net accounting. The vertical axis in this figure represents the rate of change in carbon stocks over time and the horizontal axis represents time.

3.2.2. *Net-net accounting*

Under the Kyoto Protocol emissions and removals during the first commitment period from cropland management, grazing land management, and revegetation are compared with emissions and removals from these activities during a previous period (base year or base period). This is called net-net accounting. When net-net accounting is used, any long-term trend in carbon fluxes due to increased temperatures, CO_2 levels, or nitrogen deposition will tend to cancel out between these periods. Consequently, net-net accounting (see Fig. 1) reduces the likelihood of removals from indirect and natural effects entering the accounting. If emissions to the atmosphere are reduced over time (Fig. 1, line C), if removals from the atmosphere can be increased over time (Fig. 1, line A), or if emissions are replaced by removals (Fig. 1, line B), such "improvements" to a Party's overall emissions profile will assist it in meeting its commitment.[8]

Most croplands and grazing lands are subject to human activity every year. Further, it is possible to significantly influence the rate of emissions or atmospheric removals on croplands and grazing lands within the time frame of a commitment period or two. Croplands are thought to be a current source of emissions in many countries (Janssens et al., 2003) and even in countries where croplands are now a sink for greenhouse gases there are opportunities to increase the sink strength. Since changing the management of a cropland site can change a source of CO_2 into a sink or increase sink strength relatively quickly, there is a short-term opportunity to reduce this source of CO_2 and to create or enhance a sink. In short, because most countries could improve their emission profile on crop and grazing lands in the near-term, the majority of Annex B parties to the UNFCCC found net-net accounting acceptable for croplands and grazing lands although it was not acceptable on forest lands (see Issue 1 box below).

Issue 1: Net-net accounting and saturation:

Net-net accounting implies that once the mitigation benefits of a LULUCF activity decline, e.g., if the emissions increase or sequestration decreases (e.g., the lines in Fig. 1 would have a negative slope); the increase in emissions or reduction in removals will have to be compensated by other measures. For example, consider net-net accounting for a country containing forests with a non-uniform age–class distribution. As the dominant age class approaches maturity, the rate of sequestration by the forests will decrease. As a result, the country may have a debit under net-net accounting, caused by the

[8] An emission is a negative change in a terrestrial carbon stock, and a removal is a positive change (increase) in a terrestrial carbon stock.

natural consequence of the existing age–class distribution, which would have to be met through reduction in emissions from other sectors.
In many Annex B countries, reforestation policies were initiated decades ago, and many forests could be reaching maturity and carbon saturation. In this situation net-net accounting would cause debits even without a country having taken any adverse land-use decisions. Therefore, gross-net accounting was adopted for forest management for the first commitment period under the Kyoto Protocol.

3.2.3. *Gross-net accounting*

Gross-net accounting considers emissions and removals during the commitment period only, without comparison to the emissions and removals of a previous time period. If a LULUCF activity leads to net emissions in the target (commitment) period, these emissions must be added to emissions from fossil fuels and other sources in determining total emissions. If the LULUCF activity leads to net removals from the atmosphere in the target period, these removals can be subtracted from emissions from other sources in determining compliance with targets.

For a country that is sequestering carbon gross-net accounting will therefore assist in meeting targets even where LULUCF removals from an activity are diminishing over time. On the other hand, even if LULUCF emissions are being reduced over time, the Party may have debits under gross-net accounting.

The Kyoto Protocol uses gross-net accounting to measure the impacts of forest management activities in the first commitment period.[9]

Issue 2: Gross-net accounting and natural and indirect effects:

Gross-net accounting raises more concerns about the impacts of indirect and natural effects, and effects of past management practices, than does net-net accounting. Since gross-net accounting does not compare rates of emissions or sequestration, there is no cancellation effect between a base period and the commitment period. Natural and indirect effects, such as CO_2 fertilization, responses to other aspects of climate change, or changes in carbon stocks resulting simply from the existing age–class distribution, can result in carbon sequestration in the commitment period without any action on the part of land managers. Such increases are considered ''unearned'' increases and result in ''windfall credits''. Windfall credits have been particularly problematic because, if allowed to count toward commitments, such LULUCF removals could be large compared to Annex B countries' emission reduction commitments in the first commitment period. To address this problem, given that gross-net accounting was to be used for forest management under the Marrakech Accords, there was a simultaneous agreement to exclude indirect and natural effects on carbon stocks. This understanding was expressed in the guiding principles statement that ''accounting excludes removals resulting from: (i) elevated carbon dioxide concentrations above their pre-industrial level; (ii) indirect nitrogen deposition; and (iii) the dynamic effects of age structure resulting from activities and practices before the reference year[10]'' (UNFCCC, 2005b).
In the case of forest management, the Kyoto Protocol limits the extent to which removals can be used to meet commitments, as a proxy means to factor out indirect and natural effects.[11] For afforestation and reforestation, it can be argued that in the absence of these activities no or little carbon stock increase would result from indirect and natural effects, or from pre-1990 age–class effects. Therefore, no further ''factoring out'' measures were deemed necessary.

To summarize, net-net accounting is used for the accounting of Article 3.4 activities cropland management, grazing land management, and revegetation. Gross-net accounting is to be used for afforestation, reforestation and deforestation activities under Article 3.3[12] and for forest management activities under Article 3.4 (Table 2). If the LULUCF sector was a net source of emissions in 1990, then deforestation is also accounted on a net-net basis.

3.2.4. *Bioenergy*

The use of biomass for energy is not mentioned as a land-use activity in the Kyoto Protocol and Marrakech Accords, but it is recognized through the reduction in fossil fuel emissions, e.g., when biomass fuels are substituted for fossil fuels in the energy sector. Even if land use were not directly included in climate change mitigation policies, renewable bioenergy options could benefit from policies targeting the energy sector (Schneider and McCarl, 2005). The same holds true for substitution of GHG-intensive materials by wood or other renewable materials.

Issue 3: Bioenergy in the CDM:

Under CDM procedures, credits for emissions reductions are issued based on reducing emissions compared to a baseline scenario. The current CDM rules state that only emissions from source categories listed in Annex A of the

[9] For Article 3.3 AR activities, a ''quasi gross-net accounting'' was achieved by using the *since* 1990 restriction.

[10] Note that this principle was deemed to be met in the first commitment period by the ''since 1990'' restriction on afforestation and reforestation (Article 3.3) and a cap placed on credits from forest management under Article 3.4.

[11] In the agreement reached at the resumed session of COP6 in Bonn in June 2001, in order to avoid windfall gains from indirect, natural and pre-1990 effects, gross-net accounting for forest management under Article 3.4 was subjected to a cap equal to 15% of projected removals, or 3% of base year emissions, whichever was less (Fig. 2, line A). There are negotiated exceptions to this rule, but the aim was to reduce the likelihood that the residual carbon uptake would enter the accounting system. In terms of overall magnitude, this was seen as successful.

[12] Countries for which land-use change was a net source in 1990 account for deforestation on a net-net basis.

Table 2 – GHG accounting approaches under the Kyoto Protocol

Article 3.3 (ARD)	Article 3.4 (FM)	Article 3.4 (CM, GM, RV)	Non-LULUCF sectors
Gross-net	Gross-net	Net-net	Net-net

Note: ARD, Afforestation, reforestation and deforestation; FM, forest management; CM, crop management; GM, grazing land management; and RV, revegetation.

Kyoto Protocol (energy, industrial processes, solvent and other product use, non-CO_2 gases in agriculture, and waste) can be factored into the baseline scenario. As a result of this restriction, net emissions from forests and woodlands where biomass fuels are produced unsustainably (i.e., with a depletion of carbon stocks) are not included in the baseline scenario. This means that activities that reduce emissions from forests and woodlands by improving the efficiency of biomass energy systems in non-Annex B countries, or by replacing unsustainable biomass use with other renewable energy sources, will not generate credits. This is problematic because projects that reduce emissions from forests by improving the efficiency of biomass use may present one of the most significant opportunities to use the CDM for countries that rely on biomass rather than on fossil fuels, such as many countries in Africa. However, these activities would generate credits if avoided forest degradation were an eligible activity under CDM rules.

In addition to opportunities to reduce emissions from the land base, increasing the efficiency of biomass use can contribute to the sustainable development of project areas and of the host countries in general. For example, increased efficiency of biomass use can: improve health by reducing local and indoor air pollution; reduce the unsustainable exploitation of natural resources; decrease the amount of time spent on gathering fuelwood; assist in reducing erosion; and reduce water quality and supply problems resulting from deforestation (Schlamadinger and Jürgens, 2004). It should be noted that projects that substitute bioenergy for fossil fuels do generate credits under the CDM because they result in reduced emissions from fossil fuels.

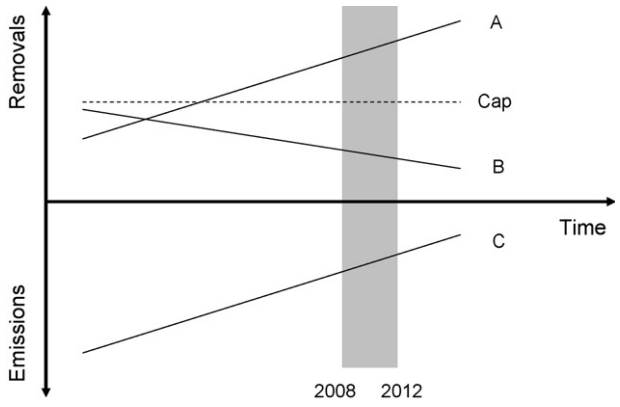

Fig. 2 – Gross-net accounting on forest management lands. Actual removals of carbon (in tonnes C/year) in forest management, illustrating the effect of a cap on credits that a country can use for compliance. If forest management results in an emission (i.e., line C), then debits occur. However, it is likely that a country would not elect forest management, unless a net removal by managed forests is expected (lines A or B). In case A the credits are limited to the cap. In case B, the cap is not exceeded, so the credits will depend on the actual amount of removals during the commitment period.

3.2.5. *Avoided deforestation*

For the first commitment period; the role of non-Annex B countries in LULUCF mitigation options has been limited to afforestation and reforestation (AR). AR projects under the CDM are restricted to areas that were not forested in 1990 and, like all CDM projects, to those projects that would not have occurred without the CDM financing. Unlike other CDM projects, AR projects receive credits that have pre-defined expiration dates (*temporary CERs* and *long-term CERs*). Use of AR CDM credits by Annex B Parties is limited to 1% of their base-year emissions per year.

Avoiding deforestation was not accepted as an eligible CDM activity in the Marrakech Accords because it was thought that the leakage[13] from projects that avoided deforestation could be very significant and difficult to estimate and monitor. The possibility that the scale of carbon credits could be quite large also played a role in the decision to exclude avoided deforestation from CDM projects.

Nevertheless, deforestation in developing countries accounts for roughly one-quarter of global greenhouse gas emissions. A post-2012 international agreement should include some method for addressing deforestation in non-Annex B countries (or their future equivalent). This has lately been called for by several countries and organizations (Aisi, 2005), and the use of national baselines, which could help alleviate concerns about leakage, has been proposed.

Issue 4: Avoiding deforestation:

Several deforestation avoidance projects have been initiated over the past decade outside of the Kyoto Protocol/CDM. These have been designed and implemented with an integral component that includes a community programme and landowner involvement to avoid carbon leakage. These projects demonstrate that it is possible to

[13] "Leakage" of carbon emissions refers to a reduction of emissions within an accounted project while simultaneously another source, which is not accounted for under LULUCF reporting, is emitting more carbon. As an example, leakage occurs if forests are protected in one area (under Kyoto reporting) and the deforestation formerly scheduled to take place there is then simply transferred to areas not subject to LULUCF reporting.

reduce emissions from deforestation if a project is designed properly (Brown et al., 2000; Aukland et al., 2003; Trines, 2004). However, modalities will need to be developed to ensure that the impacts on deforestation are appropriately taken into account. For example, the choice of the baseline can have a major impact on the integrity of credits generated. While project baselines can be more accurate than national or regional baselines, leakage could be more problematic at the project than at the national level.

The various concerns and lessons mentioned above, associated with existing non-Kyoto projects for deforestation avoidance, will also affect any projects or activities that might be included in a post-2012 agreement. For example, a recent proposal by Brazilian non-governmental organizations would create a provision through which carbon credits could be generated by deforestation avoidance in non-Annex B countries (Santilli et al., 2005).

Reducing emissions from deforestation may have significant potential as a mitigation strategy because it can yield large benefits within a relatively short time. However, there are associated risks that must be considered when proposing to include this activity in a possible future agreement. This is discussed in a separate paper in this special issue (Skutsch et al., 2006).

4. Objectives of including LULUCF activities in a climate mitigation agreement, and features of successful strategies for reaching these objectives

To assess options for a post-2012 agreement, consistent criteria that balance the overall objectives with practical solutions are needed. In the following section, we present our interpretation of the climate-related objectives of including LULUCF activities in a climate mitigation regime. In addition, we discuss strategies to meet these objectives.

4.1. *Climate-related objectives of including LULUCF activities*

The ultimate objective of the UNFCCC and all related agreements is to:

> ... achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner (UNFCCC, 1992a).

Other articles of the Kyoto Protocol provide additional objectives:

> ... To achieve this, such policies and measures should take into account different socio-economic contexts, be comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation, and comprise all economic sectors ... (UNFCCC, 1992b).
>
> Promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol, including biomass, forests and oceans as well as other terrestrial, coastal and marine ecosystems ...(UNFCCC, 1992c).

With this in mind, as far as LULUCF options are concerned, a post-2012 agreement should aim to create and promote incentives that:

A. Reduce major sources of emissions from LULUCF (reduce deforestation, forest degradation, unsustainable logging, etc.).
B. Enhance and expand major carbon reservoirs.
C. Promote the sustainable use of biomass in materials and for energy generation.
D. Link emission reduction and sink enhancement activities with adaptation strategies.

4.2. *Necessary features of strategies to meet the climate objectives*

This section lists the practical considerations that will be important in making progress toward the objectives listed in Section 4.1. These considerations are more operational in nature but they are nevertheless important to the success and acceptability of certain LULUCF options in meeting the objectives of a post-2012 climate agreement. Necessary features of options for considering LULUCF post-2012 are:

1. Promotion of participation by:
   - mobilizing investment for LULUCF activities;
   - providing a consistent and predictable economic environment for investment in LULUCF activities;
   - improving the simplicity and practicality of monitoring and accounting systems;
   - acknowledging countries' land-use sovereignty;
   - promoting sustainable development;
   - contributing toward achieving global equity;
   - recognizing differentiation, i.e., taking account of countries' differing circumstances.[14]

[14] LULUCF options for the post-2012 period must be cognizant of individual countries' rights and objectives. Non-climate objectives may be of more immediate interest to local communities, land managers and other stakeholders than combating climate change itself. Individual countries may also be interested in synergies with other UN conventions in achieving of climate mitigation objectives at local and national levels. Non-climate objectives may include: increasing food and/or energy security; improving agricultural/forestry productivity; alleviating poverty or stimulating economic development; reducing desertification and soil erosion; reducing loss of, or enhancing, biodiversity; improving water quality and quantity. It must be noted that LULUCF activities can also have adverse impacts in some of these areas, and individual countries will have to balance these positive and negative effects when designing land-use strategies. Climate-objectives will be just one among many drivers of land use.

The ultimate purpose of any greenhouse gas mitigation treaty is to modify human behaviour to limit the build-up of greenhouse gases in the atmosphere. If rules are too cumbersome, or if other factors prevent effective implementation of LULUCF projects, then no effective mitigation will be achieved. It is therefore important to assess whether any particular way of implementing LULUCF activities is more straightforward, or if certain aspects hinder effective mitigation.

It is also important to assess whether rules make sense in a wider context, whether they are cognizant of other constraints (such as countries' sovereignty over their land area), and whether LULUCF activities undertaken for climate change mitigation are compatible with other international goals (such as national security, sustainable development and global equity). Finally, the UNFCCC and Kyoto Protocol call for countries to take on common but differentiated commitments. It is important that rules ensure that this principle can also be implemented in the LULUCF sector.

2. Completeness over time and space by:
   - complete geographical coverage and inclusion of all significant sources and sinks;
   - avoiding leakage (space);
   - covering non-permanence (time);
   - avoiding cherry picking (space).

A criticism of the rules of the current Kyoto Protocol is that it allows Parties to engage in ''cherry picking'', or selecting only those activities through which they expect to gain credits and ignoring other activities through which they would incur debits. This is the case through countries' rights to freely select their activities under Article 3.4 and also under the CDM. Under the CDM Annex B countries can select projects with favourable carbon balances while they and potential host countries can ignore all activities that may lead to adverse greenhouse gas implications. If the aim of a climate treaty is to protect the global atmosphere for future generations, it is important that accounting be comprehensive over time and space.

3. Incentives for improvements within countries by:
   - avoiding windfall credits; and
   - closing emission loopholes.

Closing loopholes in order to avoid windfall credits is related to the points discussed in the preceding section. It is important that loopholes are closed so that Parties have to meet their mitigation commitments through genuine emission reductions in either the fossil fuel or LULUCF sectors. If commitments can be met without countries taking any genuine action, the ultimate goal of climate change mitigation is undermined.

4. Practicality and political acceptance through:
   - consistency with inventory guidelines;
   - compatibility with the current accounting system;
   - fairness, transparency and consistency with the long-term goal of climate-change mitigation; and
   - consistency with internal methodologies (avoiding double counting, etc.).

Regardless of the accounting options accepted in future international agreements, the rules should be transparent, fair, internally consistent, and predictable; and they must contribute to the ultimate goal of climate change mitigation. Consistency with internationally agreed inventory guidelines and provision for an easy transition from the current accounting system would also be desirable features.

Criteria 1 through 4 described in this section, plus criteria C and D of the previous section, are used in the subsequent papers of this special issue to evaluate the different options for accounting for LULUCF activities. Criteria A and B above are not explicitly included since fulfilling criteria 1 through 4 automatically ensures that criteria A and B are also fulfilled.

In addition to being assessed against the above criteria, any option for LULUCF accounting will have to address the following topics as part of its design:

- definitions for inclusion of land and activities;
- eligibility of activities;
- estimation methods; and
- accounting rules.

Finally, LULUCF activities implemented to mitigate climate change should be tested for their full impact on the climate system. Changes in the Earth's land surface affect the climate system, both locally and globally, through their effect on greenhouse gas emissions but also through their impact on the surface energy balance—that is, through their effect on reflected solar radiation, latent heat, and sensible heat. These factors may be of minimal importance for LULUCF activities that involve, for examples, efficient use of forest products or avoiding deforestation, but they deserve serious consideration for some types of projects, especially those that involve changes in surface vegetation at high latitude. We should be comfortable that activities undertaken to mitigate climate change do not have conflicting consequences.

5. Discussion—an overall framework of possible commitments

As the international community searches for acceptable, simple, cost-effective ways to include LULUCF activities in efforts to address greenhouse gas emissions, it is important to understand that the approach to LULUCF adopted for the first commitment period of the Kyoto Protocol is only one possible approach. In the first commitment period the Kyoto Protocol uses a single, quantitative target to set national objectives for limiting greenhouse gas emissions. This quantitative target (permissible tons of GHGs emitted) can be met through a combination of activities enhancing removals or reducing emissions by LULUCF and reducing emissions from non-LULUCF sources. In a sense this represents one approach within a range of possible approaches. A contrasting approach could utilize completely separate targets (a sectoral target approach) for different sectors—one for LULUCF and another

(or others) for non-LULUCF emissions. Exceeding a target in one sector need not be permitted to "count" toward meeting the target in another sector.

Equally distinct from the approach of the Kyoto Protocol would be an approach that does not require quantification of improvements in LULUCF, whether through reductions in emissions or increases in terrestrial carbon stocks. Such an approach might be entirely based on "policies and measures". The universe of approaches can be suggested by using the two-dimensional matrix shown in Fig. 3. Moving across the matrix horizontally, one moves from a single, integrated target, through separate but linked targets – where accomplishments in LULUCF and non-LULUCF could, to an extent specified in formal agreements, be used to meet either target – to targets that are completely independent of one another. As one moves vertically down the matrix, one moves from quantitative through quasi-quantitative to non-quantitative approaches. A quasi-quantitative approach might be one in which countries commit to certain levels of expenditures on improved land management without committing to any specific GHG result. A non-quantitative agreement could, for example, focus on implementation of policies and measures, such as the elimination of subsidies for conversion of lands to grazing or providing incentives for establishing plantations. For some countries this type of approach might be an effective, politically acceptable and cost-effective way to participate in an international agreement. On the other hand, non-quantitative approaches make it hard to evaluate success or transfer credits.

Prior to the Kyoto Protocol, the UNFCCC was based on voluntary commitments and these did not achieve the desired goal. The actual system for the first commitment period (Fig. 3) provides quantitative, integrated targets, but only for some Parties (those listed in Annex B of the Kyoto Protocol). These targets can be achieved by adopting internal policies and measures and through the use of several "flexible mechanisms" that enable Parties to incorporate non-domestic emission reductions and atmospheric removals to achieve their targets. However, the fact that developing countries – non-Annex B countries – did not commit to quantitative targets for the first commitment period has meant that LULUCF efforts in those countries are limited. By expanding the range of approaches to LULUCF activities within climate mitigation efforts, it may be possible to make greater use of the biosphere in achieving climate objectives.

The papers in this special issue present and assess alternative approaches to inclusion of LULUCF in a climate change agreement beyond 2012. Some papers propose options that recommend slight modifications to the current system, maintaining the concept of a single, integrated, quantitative target. Others move along the first row of Fig. 3, suggesting that LULUCF targets, although quantified, could be separated from non-LULUCF targets, to varying degrees. A discussion of options that envision targets based at least partially on policies and measures is also provided. Included in this latter group are proposals in which non-Annex B countries would progress from voluntary LULUCF mitigation activities to implementing specific policies and measures to achieve some reductions in emissions, while avoiding commitments to quantitative targets. An example of this approach would be for a country to undertake measures to reduce illegal logging and/or to reduce deforestation rates, without committing to a specific rate in a specified time period.

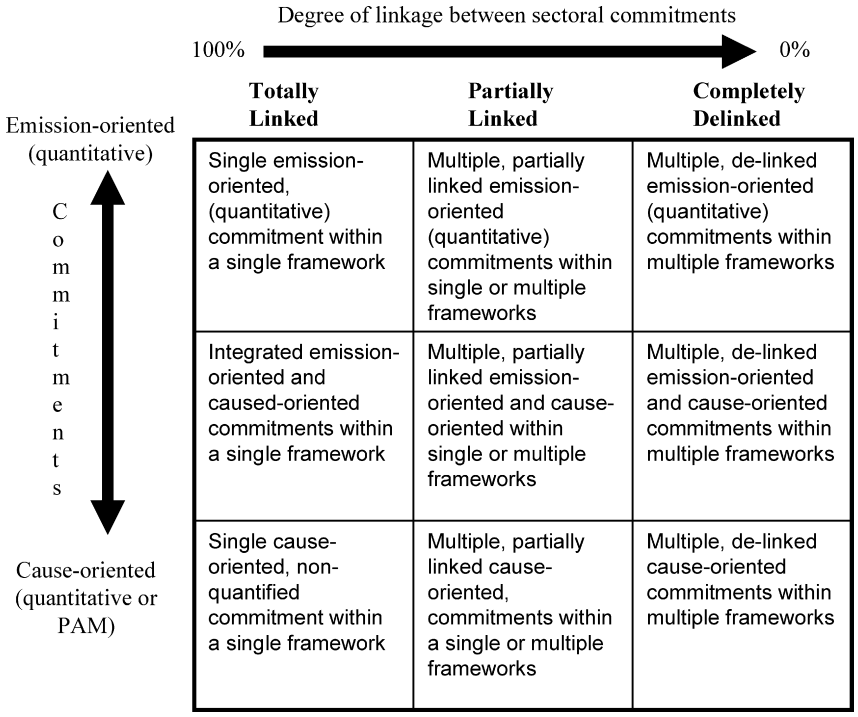

Fig. 3 – Matrix of generic commitment options and options for linking LULUCF commitments into a wider international climate arrangement.

6. Conclusions

The current system for including LULUCF activities in accounts of greenhouse gas mitigation efforts is not perfect. It was arrived at through a process of complex negotiations which initially focused on sectors other than LULUCF. Now, with a better understanding of the problems associated with LULUCF accounting, comes the opportunity to improve the mechanism by which LULUCF activities are included in a post-2012 climate agreement.

In this paper, we have presented a synopsis of LULUCF activities under the Kyoto Protocol and Marrakech Accords. We have drawn attention to the difficulties associated with the current agreement. We have also presented six criteria for assessing proposals for the inclusion of LULUCF in a future agreement. Other papers in this special issue describe and discuss options for treatment of LULUCF activities in the period following 2012.

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