CLIMATE CHANGE

SCIENTIFIC ASSESSMENT AND POLICY ANALYSIS

Integrating agriculture, forestry and other land use in future climate regimes

Methodological issues and policy options

Report
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Wetenschappelijke Assessment en Beleidsanalyse (WAB) Klimaatverandering

Het programma Wetenschappelijke Assessment en Beleidsanalyse Klimaatverandering in opdracht van het ministerie van VROM heeft tot doel:

- Het bijeenbrengen en evalueren van relevante wetenschappelijke informatie ten behoeve van beleidsontwikkeling en besluitvorming op het terrein van klimaatverandering;
- Het analyseren van voornemens en besluiten in het kader van de internationale klimaatonderhandelingen op hun consequenties.

De analyses en assessments beogen een gebalanceerde beoordeling te geven van de stand van de kennis ten behoeve van de onderbouwing van beleidsmatige keuzes. De activiteiten hebben een looptijd van enkele maanden tot maximaal ca. een jaar, afhankelijk van de complexiteit en de urgentie van de beleidsvraag. Per onderwerp wordt een assessment team samengesteld bestaande uit de beste Nederlandse en zonodig buitenlandse experts. Het gaat om incidenteel en additioneel gefinancierde werkzaamheden, te onderscheiden van de reguliere, structureel gefinancierde activiteiten van de deelnemers van het consortium op het gebied van klimaatonderzoek. Er dient steeds te worden uitgegaan van de actuele stand der wetenschap. Doelgroep zijn met name de NMP-departementen, met VROM in een coördinerende rol, maar tevens maatschappelijke groeperingen die een belangrijke rol spelen bij de besluitvorming over en uitvoering van het klimaatbeleid.
De verantwoordelijkheid voor de uitvoering berust bij een consortium bestaande uit MNP, KNMI, CCB Wageningen-UR, ECN, Vrije Universiteit/CCVUA, UM/ICIS en UU/Copernicus Instituut. Het MNP is hoofdaannemer en fungeert als voorzitter van de Stuurgroep.

Scientific Assessment and Policy Analysis (WAB) Climate Change

The Netherlands Programme on Scientific Assessment and Policy Analysis Climate Change has the following objectives:

- Collection and evaluation of relevant scientific information for policy development and decision–making in the field of climate change;
- Analysis of resolutions and decisions in the framework of international climate negotiations and their implications.

We are concerned here with analyses and assessments intended for a balanced evaluation of the state of the art for underpinning policy choices. These analyses and assessment activities are carried out in periods of several months to a maximum of one year, depending on the complexity and the urgency of the policy issue. Assessment teams organised to handle the various topics consist of the best Dutch experts in their fields. Teams work on incidental and additionally financed activities, as opposed to the regular, structurally financed activities of the climate research consortium. The work should reflect the current state of science on the relevant topic. The main commissioning bodies are the National Environmental Policy Plan departments, with the Ministry of Housing, Spatial Planning and the Environment assuming a coordinating role. Work is also commissioned by organisations in society playing an important role in the decision-making process concerned with and the implementation of the climate policy. A consortium consisting of the Netherlands Environmental Assessment Agency, the Royal Dutch Meteorological Institute, the Climate Change and Biosphere Research Centre (CCB) of the Wageningen University and Research Centre (WUR), the Netherlands Energy Research Foundation (ECN), the Netherlands Research Programme on Climate Change Centre of the Vrije Universiteit in Amsterdam (CCVUA), the International Centre for Integrative Studies of the University of Maastricht (UM/ICIS) and the Copernicus Institute of the Utrecht University (UU) is responsible for the implementation. The Netherlands Environmental Assessment Agency as main contracting body is chairing the steering committee.

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Preface

This report was commissioned by the Netherlands Programme on Scientific Assessment and Policy Analysis (WAB) Climate Change. The report was reviewed by Gertjan van den Born, Bart Strengers, Leo Meyer (MNP, Bilthoven, the Netherlands) and Omar Masera (Instituto de Ecologica, UNAM, Mexico.

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Abstract

The current agreement under the UNFCCC and its Kyoto Protocol takes a fragmented approach to emissions and removals from Agriculture, Forestry and Other Land Use (AFOLU): not all activities, not all gases and not all lands are included. Overmore, net removals can be used to offset emissions from other sectors as the sector “Land-Use Change and Forestry” (LUCF) is not an integral part of the “quantified emission limitations or reduction commitments” or targets to which Parties included in Annex I to the UNFCCC have committed themselves.

The emissions in the AFOLU sector are significant and are predominantly located in non-Annex I countries. Having a large amount of emissions means there is also a significant mitigation potential in those countries. On the other side of the equation, if nations want to keep the option open to achieve the ultimate objective of the UNFCCC within a reasonable timeframe, the cut in emissions required under a possible post 2012 climate change mitigation regime needs to be significantly deeper compared to what has been agreed for the first commitment period under the Kyoto Protocol. Adding up these two aspects means that AFOLU needs to be brought into the equation. This could only ever be acceptable to non-Annex I Parties if this would not hinder their development but would rather propel it. Therefore, it should not lead to commitments for non-Annex I countries but be a tempting opportunity to improve national circumstances and to access (economic) benefits that result from an engagement in such an agreement.

This report presents five policy options that can be employed by non-Annex I Parties on a voluntary basis, at a moment of their choice, that will lead to a broader and deeper participation under a possible post 2012 climate regime without hindering but rather promoting their development, whilst at the same time enabling Annex I parties to take on commitments that lead to deeper cuts in emissions.

Samenvatting

Het Klimaatsverdrag van de Verenigde Naties (UNFCCC) en het bijbehorende Kyoto Protocol benaderen de sectoren landgebruik, bosbouw en ander landgebruik (*Agriculture, Forestry and other Land Use: AFOLU)* op een fragmentarische manier: niet alle activiteiten, niet alle gassen en niet alle land is onder het verdrag gebracht. Bovendien mag netto koolstofopname in deze sectoren gebruikt worden om uitstoot van broeikasgassen in andere sectoren te compenseren, aangezien de sector *"Land-Use Change and Forestry"* (LUCF) geen intergraal onderdeel is van de kwantitatieve emissie reductie doelstellingen zoals die zijn afgesproken voor de eerste budgetperiode onder het Kyoto Protocol voor de landen die zijn opgenomen in annex I van het klimaatsverdrag.

De hoeveelheid uitstoot van broeikasgassen in de AFOLU sector is significant en de meeste emissies vinden plaats in niet-annex I landen: landen zonder een emissie reductie doelstelling. Echter het feit dat er veel uitstoot plaatsvindt, betekent ook dat er een aanzienlijk mitigatie potentieel is in die landen. De andere kant van de medaille is dat als landen de mogelijkheid willen behouden om de hoofddoelstelling van de UNFCCC te behalen binnen een redelijk tijdsbestek, de emissie reducties onder een toekomstige klimaatsovereenkomst voor de periode na 2012 aanzienlijk groter moeten zijn dan er nu is afgesproken voor de eerste budgetperiode. Deze twee zaken tezamen maken duidelijk dat de AFOLU sector onder het toekomstige klimaatsregime gebracht zou moeten worden. Dit zal echter alleen acceptabel zijn voor niet-annex I landen als dat hun (economische) ontwikkeling niet in de weg staat maar het juist stimuleert. Het moet dan ook niet leiden tot verplichtingen voor niet-annex I landen; het moet eerder een uitnodigende kans zijn om de (economische) situatie in dergelijke landen te verbeteren en om (financiële) profijt te ondervinden van het aangaan van een dergelijke betrokkenheid.

Deze studie presenteert vijf beleidsopties die gebruikt kunnen worden door niet-annex I landen op een vrijwillige basis, op een voor het land gunstig moment; opties die zullen leiden tot een bredere en diepere betrokkenheid van ontwikkelingslanden in een post-2012 klimaatsverdrag, zonder dat deze betrokkenheid de algemene ontwikkeling van die landen in de weg staat, en wel tegelijkertijd de annex I landen in de mogelijkheid stelt om hogere emissie reductie doelstellingen aan te gaan.

Abbreviations

AFOLU	Agriculture, Forestry and other Land Use
AAU	Assigned Amount Unit
ARD	Afforestation, Reforestation and Deforestation
AWG	Ad Hoc Working Group
BAU	Business as Usual
CCM	Climate Change Mitigation
CDM	Clean Development Mechanism
CER	Certified Emission Reduction (generated through the CDM)
COP	Conference of the Parties (Parties to the UNFCCC)
COP/MOP	Conference of the Parties serving as the meeting of the Parties to the KP
ERU	Emission Reduction Unit (generated through JI)
FCCC	Framework Convention on Climate Change under the United Nations
GHG	Greenhouse gases
JI	Joint Implementation
KP	Kyoto Protocol
LUCF	Land-Use Change and Forestry
LULUCF	Land Use, Land-Use Change and Forestry
NC	National Communication
NGO	Non-Governmental Organisation
P&M	Policies and Measures
REDD	Reducing Emissions from (forest) degradation and deforestation
RMG	Rules, Modalities and Guidelines
SBI	Subsidiary Body on Implementation
SBSTA	Subsidiary Body on Scientific and Technological Advice
UNFCCC	United Nations Framework Convention on Climate Change

Units and Conversions

1 Gg	1 Gigagramme = 10^9 gramme
1 Gt	1 Gigatonne = 10^9 tonnes = 1 Pg = 10^{15} gramme
1 Gt	1000 Mt
1 Pg	Petagramme = 1 Gt
1 Mt	1 Megatonne = 1 million tonnes = 1 Tg = 10^{12} gramme
tC	Tonne carbon
1 tCO_2	0.27 tC
1 tC	3.67 tCO_2

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Executive summary

Parties to the United Nations Framework Convention on Climate Change (UNFCCC), in pursuit of the ultimate objective of the UNFCCC[1], have recently embarked on a new round of considerations regarding future action and commitments beyond 2012. This has opened a window to also reconsider the role of Agriculture, Forestry and Other Land Use (AFOLU). The IPCC Special Report on Land Use, Land-Use Change and Forestry (IPCC, 2000) already stated that emissions from land-use change (predominantly deforestation in the tropics) were 1.7 Gt carbon ($\pm$0.8 Gt C yr^{-1}) in the period 1980 to 1989. Continuing to exclude these and other AFOLU emissions from the international policy framework, and in particular the associated options for climate change mitigation, increases the risk that the possibility for nations to meet the ultimate objective of the UNFCCC will be lost.

This report presents policy options for the inclusion of AFOLU in a future climate change mitigation regime that are robust and effective and that:

- support countries that currently do not belong to Annex I of the Kyoto Protocol but that wish to increase their level of participation in a future climate regime by undertaking activities in the AFOLU sector;
- take into consideration country-specific circumstances and the willingness and ability/capacity of countries to engage in a future climate regime by undertaking activities in the AFOLU sector; and,
- include AFOLU activities more broadly under a future climate change mitigation regimes, providing the possibility for Annex I countries to commit to higher overall quantified emission limitation or reduction commitments post 2012.

To formulate these policy options this study reviewed: 1) what lessons can be learned from the current agreement and accords to identify weaknesses that can prohibit or impinge on the achievement of the three objectives outlined above, so as to learn from it; 2) what the mitigation potential of the AFOLU sector is and what the barriers are that limit the realisation of that potential; 3) what general policy options are being discussed for climate change mitigation regimes in general in order to dovetail proposals for the AFOLU sector; and 4) what criteria a future regime should meet to achieve the objectives outlined above. As a result five policy options were identified that together can facilitate the achievement of the three objectives above.

In addition to this, many aspects associated with the biggest mitigation potential in forestry (Reducing Emissions from Deforestation) have been reviewed so as to identify ways how a large proportion of this potential could be realised in a future climate regime.

This summary presents the results of the study and the recommendations.

Lessons from the past

Although the UNFCCC calls for a comprehensive approach addressing all GHGs, their sources and sinks, the treatment of emissions and removals from land use, land-use change and forestry (LULUCF) under the Kyoto Protocol (KP) and its implementing rules, the Marrakech Accords, is rather fragmented and sometimes considered flawed. One of the main causes for this is the fact that the land-use change and forestry (LUCF) sector is not included in Annex A of the KP that lists the sectors and gases that can be used by Parties listed in Annex I of the UNFCCC to achieve the emission limitation or reduction commitments listed in Annex B of the KP. This means that net emission reductions achieved in the LUCF sector offsets emissions in other sectors: it does not lead to higher overall net emission reductions and deflects attention

[1] "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".

away from fossil fuel emission reductions. On top of that, rules governing the use of LUCF and additional activities that were still to be decided after the KP was agreed, were designed after the targets for Annex I Parties were set; rules that impacted on the scale on which these activities could contribute to achieving the targets. Baseline construction, non-permanence, uncertainties and leakage were other areas of concern, some of which were solved by developing new methodologies or accounting rules, whilst others were solved politically. Separating direct human-induced impacts on net GHG emissions and removals from other impacts (natural and indirect human-induced impacts, and impacts from past management practices), the so-called “factoring out” of these effects, for instance, was addressed by introducing a cap on the use of forest management (based on a 85% reductions of the estimated removals).

In future regimes, many weaknesses of the current accords can be remedied, for instance: a base year could be replaced by a base period capturing some of the inter-annual variability of carbon fluxes, or gross-net accounting could level off variation in age-class distribution due to past management practices (the so-called “legacy effect”). One the other hand not all solutions match with each other, for instance one solution to the ‘factoring out’ issue calls for net-net accounting of forest management, whilst the elimination of the legacy effect would call for gross-net accounting. Hence, some challenges remain to be faced and this study presents some solutions.

The lessons learned from the past that have been identified in this report include:
- it is recommendable to agree to the rules governing the use of AFOLU before setting targets;
- targets should ideally be based on realistic projections of the AFOLU mitigation potential that can be realised in future. Country-specific data and information are required to determine such projections;
- country-specific circumstances do matter, must be taken into account and countries’ sovereignty must be respected;
- dealing with uncertainty has improved due to the IPCC Good Practice Guidance (IPCC, 2003) and the new IPCC Inventory Guidelines (IPCC, 2006), but some level of uncertainty will remain. This can to a large extend be solved by pragmatic political solutions or accounting rules;
- choosing a base period or reference level against which net emission reductions are calculated determines the scope for improvement in the future. As historic emission profiles differ from country to country, no single formula exists to determine a reference emissions level that will be acceptable to all countries;
- Inter-annual variability may be significant and may not always be detected by inventories. If land is included continuously under an accounting regime, positive and negative biases will both be accounted for;
- Age-class distribution due to past management practices of forests (legacy effect) differ from country to country and cannot be solved in one commitment period, except if gross-net accounting is applied. This however, opens the possibility to generate unintended windfall credits. On the other side, to deal with “factoring out”, net-net accounting would be the preferred option. Accounting rules must therefore, be designed carefully so as to avoid undesirable outcomes; and,
- Land-based and activity-based accounting can be mixed to provide even greater flexibility to countries while not jeopardizing the environmental integrity of the system.
- The need for default emission factors at disaggregated levels is still urgent. On average activity data can be collected by the countries themselves.

The mitigation potential, options and barriers of the AFOLU sector

The potential

The total biophysical potential in agriculture is 5500-6000 Mt CO_2-eq yr^{-1} (Smith et al., 2006a). The projections of the overall economic potential in the forestry sector span a broader range: 2000 – 4000 Mt CO_2 y^{-1} by 2030 to 10.000-15.000 Mt CO_2 y^{-1} by 2030, the latter derived from top-down global models (Benitez et al. 2006, Strengers et al., submitted for publication). Of the global mitigation potential, a large proportion is located in non-Annex I countries or economies in transition, with 80% of the global total agricultural mitigation potential found in non-Annex I countries.

The options
The largest mitigation potentials in agriculture are: restoration of cultivated organic soils (1) and degraded lands (2), and rice management (3). These options are predominantly applicable to Asia (1, 2 and 3), the Russian Federation (1 and 2), South America (2) and Europe (1 and 2). The most important mitigation options in forestry are: reducing deforestation (by far!) and forest management. Reducing deforestation is predominantly applicable in Central and South America, Africa and Asia and forest management in OECD North America. In general, options with the highest potential in forestry can be found in tropical regions. Degradation of forests is probably another major source of emissions, but data on the exact magnitude are almost non-existent.

From the bio-energy perspective, it is clear that a future approach to AFOLU should be more integrated with policies that promote the use of bio-energy. If countries were given more flexibility in the way how they implement AFOLU in national accounting (e.g. activity-based accounting), they could better balance the objectives of productive uses versus carbon sequestration. A broader inclusion of AFOLU (on a voluntary basis) in non-Annex I countries may also help to provide greater incentives for energy-sector activities related to traditional biomass uses, such as efficiency enhancement and fuel switching.

It is clear that although the majority of the greenhouse gas emissions occur in Annex I countries, the largest mitigation potential is located in non-Annex I countries.

The barriers
Despite low costs and many positive side effects, not much of the mitigation potential in agriculture and forestry has been realised to date due to barriers. Barriers are categorised as economic; risk-related; political/bureaucratic; logistical; and educational and most mitigation options are hindered by more then one barrier, some of which are interrelated. The list of barriers is longest in tropical regions and most barriers are related to non-climate issues, such as: poverty and/or the lack of capacity or political will (the latter barrier also occurring in industrialised countries). If these barriers persist no significant mitigation will be achieved, even if good policy options are available. Political will, however, may relate to fears in non-Annex I countries that economic growth will be hindered when land-use change is halted; solutions are needed which provide economic opportunities as well as promote carbon conservation.

It is important that forestry and agricultural land management options are considered within the same framework to optimise mitigation solutions. Costs of verification and monitoring can be reduced by applying clear guidelines on how to measure, report and verify GHG emissions. Transaction costs, on the other hand, are more difficult to address: given the large number of small-holders in many non-Annex I countries, these are likely to be higher even than in Annex I countries, as transaction costs increase with the number of stakeholders involved. Organisations such as farmers'/foresters' collectives may help to reduce this significant barrier and consortia of interested fore-front players could be set-up by such collectives. In order for these collectives to work however, regimes need to be in place already and it is essential that the credits are actually paid to the local owner or land manager that realise emission reductions.

The most significant barriers to implementation of mitigation measures in non-Annex I countries (and for some economies in transition) are economic, mostly driven by poverty, food security and child malnutrition, which in some areas may be exacerbated by a growing population. In that context climate change mitigation is necessarily a low priority.

To begin to overcome these barriers, global sharing of innovative technologies for efficient use of land resources, to eliminate poverty and malnutrition, will significantly help to remove barriers (e.g. Smith et al., 2006b), which requires capacity building and education. More broadly, macro-economic policies to reduce debt and to alleviate poverty in non-Annex I countries, through encouraging sustainable economic growth and sustainable development, are desperately needed; farmers can only be expected to consider climate change mitigation when the threat of poverty and hunger are removed. Therefore, ideally policies associated with fair trade, subsidies for agriculture in Annex I countries and interest rates on loans and foreign debt would all need to be reconsidered with the intend to foster sustainable development.

The lack of political will to encourage mitigation is a significant factor in all economic regions. Most mitigation that currently occurs is a co-benefit of non-climate policy, often via other environmental policies put in place to promote e.g. water quality, air quality, soil fertility, conservation benefits etc. Also in Annex I countries (the European Union), little of agriculture's mitigation potential is projected to be realised by 2010 due to lack of incentives to encourage mitigation practices (Smith et al., 2005).

Policy options to include AFOLU in a post-2012 Climate Regime

This report presents a review of the options for future climate regimes that are currently being discussed amongst general climate specialists. The options include: legally binding quantified emission limitation and reduction commitments (QELRC); dynamic targets; dual targets, a target range or target corridor; "no lose", "non-binding" or one way target; a sectoral CDM or sectoral crediting mechanism; sustainable development policies and measures; trans-national sectoral agreements; and, technology research and development. Some of these are promising for climate regimes that include AFOLU. These have been elaborated to fit the specific requirements of the AFOLU sector and a set of five policy options was distilled. The options are summarised below.

Option 1: Capacity building, technology research and development

The capacity in setting-up a national system to inventory and monitor emissions and removals from AFOLU is an essential condition for controlling emissions in this sector. Therefore, those countries with a limited capacity to inventory, monitor and control emissions and removals from AFOLU should be assisted, if they so wish, in building their capacity in this area. In a second step, cooperation and assistance in technology research and development (e.g. low emission management practices, remote sensing, etc.) are important elements in the further process of monitoring and controlling emissions in the AFOLU sector. ODA, bilateral and multilateral agreements, public-private partnerships and other mechanism could provide the necessary funding. This option will be especially relevant to the least developed countries and those countries with relatively low technical and institutional capacity to inventory, monitor and control emissions.

Option 2: Sustainable Policies and Measures (sustainable P&Ms)

Countries could commit to policies aimed at sustainably reducing emissions and enhancing removals in the AFOLU sector. Options range from fully voluntary to fully mandatory and anything in between. Furthermore, commitments can be quantitative (effect on emissions is quantified, but not necessarily resulting in tradable emission permits) or qualitative. As options become more prescriptive, the need for a serious compliance and reward system increases. Sustainable P&Ms are probably required in combination with most other policy options, as action is normally not undertaken without some form of coercion.

In general, all countries could take on sustainable P&Ms, although some minimum technical and institutional capacity to inventory, monitor and control emissions and removals from AFOLU would be necessary. The more developed the institutional capacity of the country, the more prescriptive the sustainable P&Ms could be. Sustainable P&Ms could e.g. serve as a testing ground for countries without having to commit itself to quantitative AFOLU targets at the international level. This could be financed through funding made available independently from market-driven mechanisms.

Option 3: Extended list of eligible AFOLU CDM project activities

Currently, eligible activities under the Clean Development Mechanism (CDM) are limited to afforestation and reforestation, and reduction of non-CO_2 gases in agriculture. One possibility under a future regime could be to extend this list of eligible activities (e.g. by including reducing

deforestation or reducing CO_2 emissions in agriculture). In combination with other options (e.g. capacity building, sustainable P&Ms), it would offer an opportunity for countries to familiarise themselves with offset-type projects in the AFOLU sector.
Countries that can benefit most from this option will in general be those favoured by the private sector for safe investments. Countries with poor governance records or that are politically unstable will not be on the top of that list. So far, CDM projects are not equally distributed over the different continents and non-Annex I countries. An extended list of eligible AFOLU activities is likely to improve this situation.

Option 4: Sectoral targets
The **sectoral CDM** as well as the **sectoral "no-lose" target** allow nations to sell excess emission allowances that are generated when the target is met. The main difference between the two is that the sectoral CDM would in theory be administered and decided through the CDM Executive Board and the no-lose target through the COP or COP/MOP. In the case of the no-lose target, no compensation of emissions will be required; hence, the no-lose.
Both options require a national baseline which leads to a number of decisions that need to be made, for instance regarding base period or benchmarks, distribution of benefits to land managers, etc. Emissions reductions below a national AFOLU baseline (or enhanced removals above a national AFOLU baseline), would generate tradable emission permits for the respective country which can be sold on the international market.
The technical and institutional requirements regarding inventorying, monitoring and predicting AFOLU emissions are relatively high. Although, non-Annex I countries could only profit from the use of this policy option e.g. by taking on a no-lose target, political concerns to commit to quantitative targets may still outweigh potential economic benefits.

Option 5: Quantified Emission Limitation and Reduction Commitments (QELRCs)
The most far reaching option being proposed is the one whereby countries take on binding quantitative targets for the AFOLU sector. This could either be the AFOLU sector as a whole, or it could be a subset of the sector, e.g. cropland management, or forest degradation and deforestation. If a country cannot fulfil its target, it will have to compensate this through the acquisition of emission reductions elsewhere or by buying permits on the spot market.
When an initial commitment would involve a QELRC for selected AFOLU activities only, the country could gradually increase its level of participation by initially gaining experience with the inclusion of a subset only, and extending that by increasing the coverage of AFOLU under the binding commitment.

Which country can benefit from what options?

The policy options are not mutually exclusive and do not necessarily follow one after the other: a country could well choose to deploy a range of options simultaneously. Option 1 will be beneficial for many non-Annex I countries and quite some of them already successfully seek such assistance and benefit from it. The Least Developed Countries (LDCs) may find securing assistance more complicated due to the lack of institutional capacity, even though they may need the assistance most. In general LDCs can use options 1, 2 and 3 whereby CDM activities in the AFOLU sector could lead to many (co-)benefits for many land owners. The sooner LDCs and in general non-Annex I countries employ options 1 and 2, the sooner the economic benefits from option 3, 4 and 5 will come within reach. Countries that already have a relatively high level of technical and institutional capacity to monitor, inventory and control AFOLU emissions and removals, could consider to employ options 3, 4 and 5 in a post 2012 climate change mitigation regime, unless as stated political concerns related to taking on targets outweighs potential benefits.

Assessing the options against predetermined criteria

A set of assessment criteria was determined on the basis of extensive literature, for the evaluation of the policy options that are proposed. These criteria are divided into four groups:

- environmental criteria,
- economic criteria,
- distributional/equity criteria
- technical/institutional criteria

Assuring that future rules safeguard the fulfilment of the ultimate objective of the Convention would be an environmental criterion, while the cost-effectiveness of the approach falls in the category of economic criteria. Distributional/equity criteria are related to different aspects of fairness and equity as for example the guarantee that a country will be given the opportunity to satisfy its basic development needs. Technical and Institutional criteria judge the efficiency of the respective approach with regard to political and technical issues.

Scoring the options against the predetermined assessment criteria assists to systematically find the optimal approach which will satisfy as many criteria as possible, and may thus have the greatest chances of being successfully implemented. It is inherent to the approach that such an evaluation is bound to be subjective; other views and evaluations may be possible.

Based on this assessment, binding, quantitative targets (QELRCs) seem to be complying best with the criteria. Their drawback is however, the lower scores with regard to technical and institutional criteria. The next best option would be the no-lose target which does not reach the level of environmental effectiveness of QELRCs, but is to some extent superior to the latter regarding the technical and institutional criteria (e.g. by enhancing the level of participation across nations). Options involving only the (sectoral) CDM do not lead to net emission reductions beyond those of the combined QELRCs of a regime, thus scoring lower than sectoral no-lose targets on the environmental criteria. Furthermore, the negative score regarding equity is due to the disadvantages for less developed countries which will not be ready to engage in this market yet.

Sustainable P&Ms would follow. Their advantage lies in a relatively good fulfilment of the technical and institutional criteria, while having no significant disadvantages with regard to environment, economic and equity issues. The exact scoring will however, depend on the respective P&M chosen.

Option 1 would fulfil especially technical and institutional criteria. The scoring of this option, as well as of P&Ms, should however not diminish the importance of their role in a future climate regime. As mentioned, options are not mutually exclusive, and the options 1 and 2 have thus a very important complementary role in preparing countries for taking over quantitative commitments at later stages, if they so wish. The table below summarizes the findings whereby 'n.a.' means 'not applicable'; '+' means the criterion is satisfied; '0' means an uneven or possible varying score; and, '-' means the criterion is not satisfied.

Criteria	Capacity Building and Techn. R&D	Sust. P&M	Ext. list of CDM activitie s	Sectoral targets		QELRC	
				Sect. CDM	Sect. no-lose target	With limited AFOLU activity list	With full AFOLU sector
Environmental	n.a.	-/0	-/0	-/0	0	+	+
Economic	n.a.	0	+	+	+	+	+
Distributional and equity	-	0	-	-	+	+	+
Technical and institutional	+	+	-	0	0	-	-

Reducing emissions from deforestation: he biggest mitigation option in forestry

The report pays considerable attention to the biggest mitigation option in forestry (reducing emissions from deforestation) by elaborating: the proposals that have been made recently regarding the inclusion of this option under a future climate change mitigation regime; the current understanding as regards drivers of deforestation; the importance of stakeholder involvement and their possible role in this option; the various instruments for controlling deforestation (and forest degradation); and, the abilities and limitations of Remote Sensing (RS) in quantifying land cover change and changes in carbon stocks.

The figure below illustrates what the basic idea is behind the proposals that are currently being discussed: the compensated reduction (CR) approach and the proposal made by the Joint Research Centre in Italy.

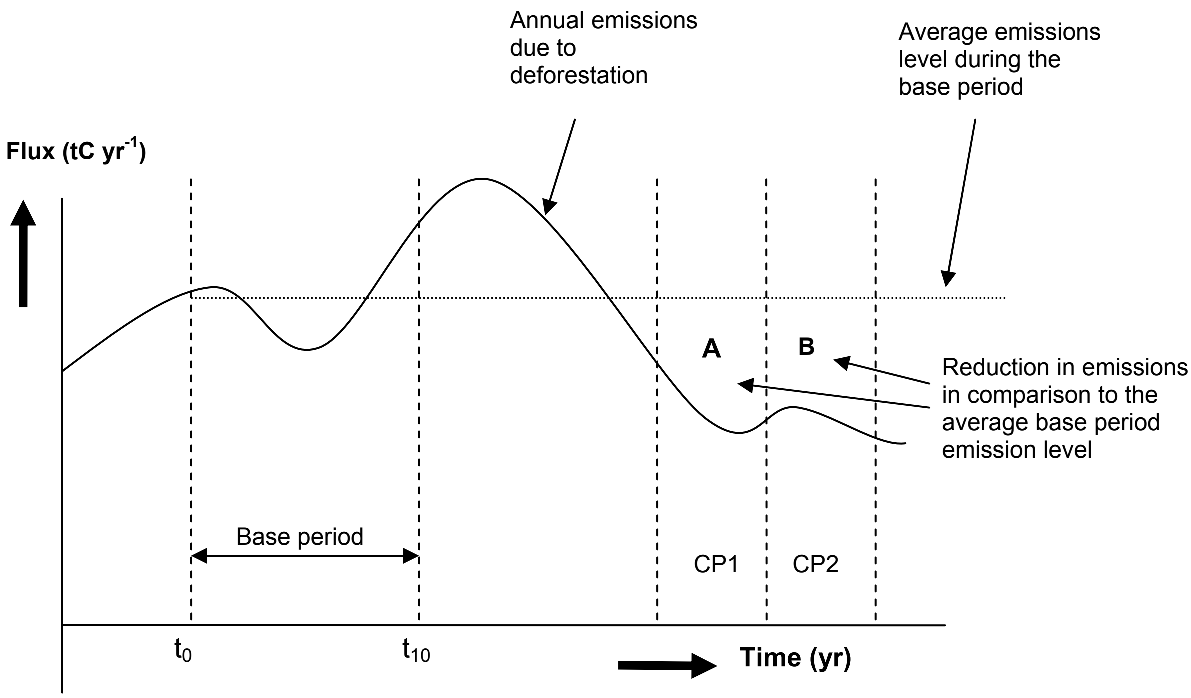

Figure: The solid line indicates annual emission levels due to deforestation. The dotted horizontal line is the average emissions level during the base period. Area A is the reduction in emissions during the 1st commitment period below the base period's emission level. Area B is the same but in the 2nd commitment period, if there was to be one.

The CR approach addresses many of the issues that had plagued efforts to address deforestation through project-based crediting. For example, under a project-based approach, it is difficult to address leakage, while CR avoids intra-country leakage, and provides a better basis for addressing other types of leakage. Similarly, under a project-based approach, projections of future deforestation rates are essential for calculating the offsets but by calculating base periods from historical data, as done in the CR approach, this problem is avoided.

Measures to reduce emissions from deforestation

At the national level, any such effort is likely to be operationalised through a package of activities, some of which may take the shape of "traditional" projects. The suite of activities that a country may (need to) employ to get a handle on deforestation can include:

1. improved land-use planning and integrated conservation and development programmes;
2. a revision of the forest law;

3. building an increased monitoring and data base capacity in the forestry department and increasing staffing levels in local forest offices;
4. develop market-oriented instruments, including Payment for Environmental Services (PES) and offset projects (e.g. CDM);
5. introduce improved farming techniques through which less new agricultural land is required removing pressure from forest;
6. shift from traditional forestry practices to Sustainable Forest Management (SFM);
7. transfer responsibility for open-access forest to community authorities;
8. allow for projects financed by NGOs, bilateral assistance, multi-lateral donor funds;
9. establish an environmental trust funds at national or regional level to channel financial resources from different origins, share risks, and decentralise financial resources to the local level; and,
10. implement and execute taxation schemes and public awareness campaigns.

Understanding the processes of Governed and Ungoverned Deforestation and Degradation

Although the debate in the context of the UNFCCC and its KP is concentrating on deforestation, it is reasonable to assume that forest degradation is a significant source of emissions as well, both in Annex I as well as non-Annex I countries. Therefore, this report, where possible also reviews the issue of forest degradation. It distinguishes governed and ungoverned deforestation and forest degradation as each has different drivers. Understanding the underlying drivers helps to identify instruments to halt these processes as comprehensive reviews indicate that although some well-known factors – such as roads, higher agricultural prices and shortage of off-farm employment opportunities – tend to be correlated with forest clearance, many other factors – which are popularly thought to be causes, particularly poverty – are not consistently related in any way. Several studies have shown clearly that although there is a tendency for poorer people to live in the vicinity of forests, most forest clearance for agriculture is done by better off individuals or companies who have at least the small amount of capital necessary to clear the land.

For each of these three categories the main stakeholders are identified, the specific measures that can be taken to curb them, the effectiveness and the cost efficiency of the measures, the practicability and acceptability of the measures, the poverty and equity dimensions of the measures and the general enabling requirements for the measures.

Remote Sensing: abilities and limitations

Remote Sensing (RS) will be essential for the cost-efficient monitoring of land-cover change (deforestation). Costs of imagery have come down substantially over recent years and are relatively low compared to conducting expensive field inventories as large areas can be represented within a single image. It must be clear that land cover change is a threshold approach and not a sliding scale: an area is either forest or not.

Estimates of changes in biomass or carbon stocks (a 3 dimensional issue) based on remote sensing need extensive field surveys and are site-specific. This also implies that results cannot be extrapolated to other areas as results cannot be generalised and relationships cannot be predicted across geographically and ecologically different places using RS. Collecting ground survey data, essential to develop and ground-truth remotely sensed predictions of biomass (3D), as against area estimates (2D), therefore makes estimating forest degradation far more expensive. The application of RS for both the monitoring and quantification of land-cover change (2-dimensional) as well as changes in carbon stock (3-dimensional) are reviewed in the report. The table below summarises the nested approach that is required to monitor land-cover changes and related changes in carbon stocks, integrating different techniques and data sources.

	Technique or type of sensor	Output
Global observations		
Detection of major hotspots of land cover change	Medium resolution sensors (250-1000 m), e.g. MODIS/MERIS	Hotspots of land cover change: large fire and deforestation events (> 10 ha) Near real-time
Regional /national observations		
Stratification into homogeneous regions	- High resolution sensors (10-60 m), e.g. Landsat, SPOT, CBERS - Existing (digital) maps	Eco-regions, climatic regions Per decade or more
Wall-to-wall mapping	- High resolution sensors (10-60 m), e.g. Landsat, SPOT, CBERS - Ancillary data, field verification	Medium scale maps, areas of directly human-induced land cover change (5-10 ha) (Inter-)annually and construction of a historic baseline
Sampling hotspots of land cover change	- Aerial photography	Fine scale maps, areas of directly human-induced land cover change, including forest degradation (<0.5-1 ha)
Forest degradation mapping	- Digital/visual interpretation of high resolution images - Very high resolution sensors (< 5 m), e.g. IKONOS, Quickbird Radar (SAR) and/or LiDAR	Remote sensing derived estimates of carbon stocks
Plot-based observations		
In-situ estimation of changes in carbon stocks	- Plot based sampling - Forest inventories, FAO statistics - Existing standard data IPCC (2003)	Quantified (averted) emissions and removals of carbon in relation to directly human-induced land cover change

Further conclusions include:

AFOLU needs to be included more comprehensively in a future climate regime if nations want to keep the option open to reach the ultimate objective of the Convention in a timely manner. This will require more and new policy options. Such options need and can be designed in such a way that ‘mistakes’ from the past are not repeated. Furthermore, the options need to promote a broader and increasing level of participation amongst Parties; respect country-specific circumstances and sovereignty; be practical and comprehensive; not impinge on country’s development; and reward the rightful stakeholders. To what extend the formulated policy options can be successful will depend on the further rules that will govern them.

Climate policy that depends on government subsidies will not be sufficient to tap into the large mitigation potential held by the AFOLU sector; policies that integrate emission reductions/uptake into carbon markets hold more promise.

To better understand the potential contribution of AFOLU in a future climate change mitigation regime, ideally more country-specific data and information should become available.

Targets in the future, that include emission reductions and removals in the AFOLU sector, must be reasonable tough but achievable. This will result in fair carbon prices that will invite the appropriate levels of investment. To allow market mechanisms to function properly, besides the already mentioned barriers, macro-economic barriers should also be minimised in order to realise the largest possible proportion of the full mitigation potential.

Specific recommendations

Policy options and mitigation potentials:

1. Policies must be developed that consider all land uses (forestry, agriculture and wetlands) together;
2. Mitigation policies should ideally be developed within the wider framework of sustainable development;
3. To achieve mitigation through the AFOLU sector, removing macro-economic barriers (e.g. related to fair trade, agricultural subsidies in Annex I countries and interests on loans and foreign debt) is a prerequisite;
4. To achieve a broader and deeper participation of countries in a future climate change mitigation regime, options must be available that fit the individual countries and their development objectives;
5. A particular focus on reducing emissions from deforestation and restoration of cultivated organic soils and degraded lands is justified, amongst other things, due to the exceptional high potentials to contribute to the achievement of Article 2 of the UNFCCC;
6. For the post 2012 era, AFOLU net emission reductions and removals should be an integral part of the overall greenhouse gas emission reduction target (ideally after the rules governing the use of AFOLU are determined). That target can be more stringent, *ceteris paribus*, to optimally foster action and optimise the use of market-based mechanisms; and,
7. A design of a future climate change mitigation regime for AFOLU must try to avoid mistakes made in the past and many rules, modalities and guidelines can be improved on the basis of lessons learned.

Science and Technology:

1. To set an overall AFOLU target, projections are urgently needed. One way of accomplishing that is to request more detailed country-specific data and information provided by countries in their national communications; and,
2. To be able to compare estimates and projections on the basis of country-specific data and information, a harmonised approach in terms of terminology and methods is required.

In relation to reducing emission from deforestation:

1. Such strategies should distinguish between local processes of governed and ungoverned deforestation (and degradation (see also chapter 8)), and should incorporate different measures to address them as they have different drivers and stakeholders;
2. Domestic activities will (in part) be undertaken locally, nested within an overall national programme or strategy which may also include broader measures (law enforcement, training, etc);
3. Anti-deforestation measures may best be directed to companies/organizations and individuals;
4. Fighting forest degradation may work best if measures are directed to communities and integrated into programmes of devolution of control of forests to communities (community-based forest management);
5. To distribute economic returns to the rightful stakeholders, successful Payment for Environmental Services (PES) systems need to be designed; and,
6. In order to build experience a number of pilot projects should be launched in the shortest possible timeframe. In addition, consideration should be given to rewarding “an early start” in this policy area, comparable to that used for the CDM in the past.

1 Introduction

1.1 Background

In pursuit of the ultimate objective of the United Nations Framework Convention on Climate Change (UNFCCC), namely, "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system", the UNFCCC Parties in December 1997 adopted the Kyoto Protocol (KP). The KP commits industrialised nations and several economies in transition – together known as "Parties included in Annex I" of the UNFCCC (or Annex I Parties) to reduce their aggregate emissions of six greenhouse gases (GHGs) by at least 5% below 1990 levels between 2008 and 2012, with the levels of the legally binding targets varying from country to country. Subsequently most Parties to the UNFCCC signed the Kyoto Protocol but not all ratified. Some even turned away from earlier commitments, but following the ratification of the KP by the Russian Federation in September 2004, the Protocol entered into force on 16 February 2005. The Protocol now has 155 Parties, including 35 Parties that account for 61.6% of Annex I Parties' 1990 carbon dioxide emissions (ENB, 2005; Trines, 2006) while the UNFCCC has 189 Parties. (www.unfccc.int)

Article 3.9 of the Kyoto Protocol requires the KP Parties to initiate, not later than 2005, a process to consider future action and commitments beyond 2012. As some Parties to the UNFCCC have not ratified the KP, a process on long-term action under the Convention also remains important. But in both cases Parties are starting to look ahead. In November 2005, at their meetings in Montreal, Canada, Parties launched **three processes** relevant to this report.

One: The Conference of the Parties serving as the first Meeting of the Parties to the Kyoto Protocol (COP/MOP1) established an **Ad Hoc Working Group** (AWG) on Further Commitments for Annex I Parties under the Kyoto Protocol (UNFCCC, 2006; Decision 1/CMP.1). The AWG shall report to each session of the COP/MOP on the status of the process, and shall aim to complete its work and have its results adopted by the COP/MOP as early as possible and in time to ensure that there is "no gap" between the 1st and subsequent commitment periods. The AWG met for the 1st time in May 2006 (UNFCCC, 2006).

Two: The Eleventh Conference of the Parties to the UNFCCC (COP11) initiated a **Dialogue** on long-term cooperative action to address climate change by enhancing implementation of the Convention. The purpose of the Dialogue - initiated without prejudice to any future negotiations, commitments, process, framework or mandate under the Convention – is to exchange experiences and analyse strategic approaches for long-term cooperative action to address climate change and includes, *inter alia*:
- Advancing development goals in a sustainable way
- Addressing action on adaptation
- Realizing the full potential of technology
- Realizing the full potential of market-based opportunities.

The Dialogue takes the form of an open-ended and non-binding exchange of views, information and ideas in support of enhanced implementation of the Convention and is conducted under the guidance of the COP. (UNFCCC, 2006)

Three: Reducing Emissions from Deforestation in Developing Countries. In response to a request by Papua New Guinea and Costa Rica, supported by several other Parties, COP11 included an agenda item on "Reducing emissions from deforestation in developing countries: approaches to stimulate action". Subsequently, the COP invited Parties and accredited observers to submit their views on issues relating to reducing emissions from deforestation in developing countries, focusing on relevant scientific, technical and methodological issues, and the exchange of relevant information and experiences, including policy approaches and positive incentives and recommendations on any further process to consider these issues. The COP further requested the secretariat to organize a workshop before the twenty-fifth session of the Subsidiary Body on Scientific and Technological Advice (SBSTA) in November 2006, and directed the SBSTA, after considering the submissions and the workshop, to report at its twenty-seventh session (December 2007) on the issues referred to it, including any recommendations. (ENB, 2005; FCCC/CP/2005/L.2, 2005)

Together these three processes have opened a window to (re)consider how Agriculture, Forestry and other Land Use (AFOLU) can contribute to achieving the ultimate objective of the UNFCCC.

The acronym AFOLU originates from the elaboration of the new IPCC Inventory Guidelines (2006) which includes a volume "Agriculture, Forestry and other Land Use", truncated as AFOLU. The 2006 IPCC AFOLU inventory guidelines include the full GHG balance and therefore, allow for a comprehensive approach of the sectors that are included. In the past emissions and removals from AFOLU were grouped differently by the IPCC with a separate chapter on Agriculture and a chapter on Land-Use Change and Forestry (LUCF). Under the Convention process a similar agenda item did exist that also included land use, changing LUCF into Land Use, Land-Use Change and Forestry: LULUCF. In this report AFOLU is used where possible to refer to all emissions and removals from Agriculture, Forestry and other Land Use. Sometimes LULUCF is used because reference is made to a less then 100% comprehensive approach taken in the past, or LUCF when reference is made to the inventory sector.

Although the UNFCCC calls for a comprehensive approach addressing all GHGs, their sources and sinks, the treatment of emissions and removals from LULUCF under the KP and its implementing rules, the Marrakesh Accords, is rather fragmented and sometimes considered flawed. The fragmentation arises from the fact that Parties' quantified emission targets, listed in Annex B of the Protocol, were agreed in 1997 prior to detailed consideration of how these Parties might quantify AFOLU emissions and removals in meeting these targets. The result was a set of complex Rules, Modalities and Guidelines (RMGs) for quantifying these emissions and removals, various caps and limitations on the use of LULUCF, and subsequent inefficient and costly monitoring and reporting obligations. It is the wish of most Parties to address at least some of these shortcomings in a practical way, also tapping into the creativity and innovation of the AFOLU sectors enabling them to contribute significantly to reducing emissions and increasing removals of GHGs in the critical time window for realizing the UNFCCC objective. This report aims to assist Parties in achieving that goal.

This report was requested by the Ministry of Agriculture, Nature and Food Quality (LNV) and the Ministry of Housing, Spatial Planning and the Environment (VROM) of the Netherlands in support of the negotiations process. It has been prepared with the financial assistance of the Netherlands Research Programme on Climate Change (NRP-CC).

1.2 Objective & Scope

The objective of the report is to propose a suite of policy options for the inclusion of AFOLU in future climate change mitigation regimes that is robust and effective, and that encourages a broad(er) participation of Parties to the Convention through the AFOLU sector.

This study accordingly assesses the options in terms of their potential to increase such levels of participation in Climate Change Mitigation (CCM) regimes, whilst taking into account on one hand a more complete and coherent approach to all emissions and removals in AFOLU, and on the other hand country-specific circumstances.

The scope includes all major mitigation options in agriculture and forestry, all Parties to the UNFCCC, and all technological options.

1.3 Report structure

The introductory chapter outlines the objective, scope and structure of the report, as well as the methodology used to formulate the policy options; policy options that in the view of the authors will facilitate the inclusion of AFOLU in future climate change mitigation regimes in a way that is robust and effective, and that encourages a broad(er) participation of Parties to the Convention. Chapter 2 elaborates on some of the technical, methodological and scientific issues that have helped or hindered the debate on the land-use sector or the implementation of activities in the land-use sector in the past. The elaboration of these issues assists with improving the design of a future climate change mitigation regime.

Obviously the potentials of various mitigation options in the land-use sector are relevant, in particular in combination with policy options. Chapter 3 estimates what mitigation potential may be tapped into and where, indicating where particular mitigation options can be found, what the barriers are, and makes suggestions how barriers can possibly be addressed to optimise the use of the mitigation potential.

Chapter 4 lists a set of criteria, drawn in part from published literature, that the policy options must meet in order to encourage the broadest participation of Parties, as well as to refine the environmental; economic; distributional and equity; and, technical and institutional characteristics of the policy options. This list is used towards the end of the report to evaluate the policy options in the AFOLU sector being proposed.

Chapter 5 reviews the general literature on architectures for future climate change mitigation regimes, to illustrate how proposals for the AFOLU component of such regimes (chapter 6) can dovetail with the AWG and the Dialogue. Chapter 6 elaborates how elements of such regimes can work for the AFOLU sector and how the broadest participation of Parties to the UNFCCC can be realised. Chapter 7 reviews how the options score against the criteria identified in chapter 4.

Chapter 8 has a specific focus on implementation and monitoring issues related to emissions from deforestation and forest degradation. But it also devotes significant attention to Remote Sensing (RS) specifically because it will become a technology of increasing importance, especially in the area of the establishment of national baselines, monitoring, and verification: it is important to understand its current and future capabilities and limitations. Stakeholder involvement is another subject that is discussed at some length as the use of land and natural resources is all about people: people who own the land, use it (exploit or overexploit), consume the products, and depend on it for their lives and livelihoods. Systems to pay for environmental services provided by the land have been reviewed and situations, in which they may successfully be applied, identified and presented.

Chapter 9 presents the main conclusions and recommendations.

1.4 Methodology

As stated, the objectives of this study are to design policy options that aim to:

- support countries that currently do not belong to Annex I of the Kyoto Protocol but that wish to increase their level of participation in a future climate regime by undertaking activities in the AFOLU sector;
- take into consideration country-specific circumstances and the ability / capacity of countries to engage in a future climate regime by undertaking activities in the AFOLU sector; and,
- to include AFOLU activities more broadly under a future climate change mitigation regimes leading to higher overall quantified emission limitation or reduction commitments.

To achieve those objectives a methodology was chosen which is reflected in figure 1.

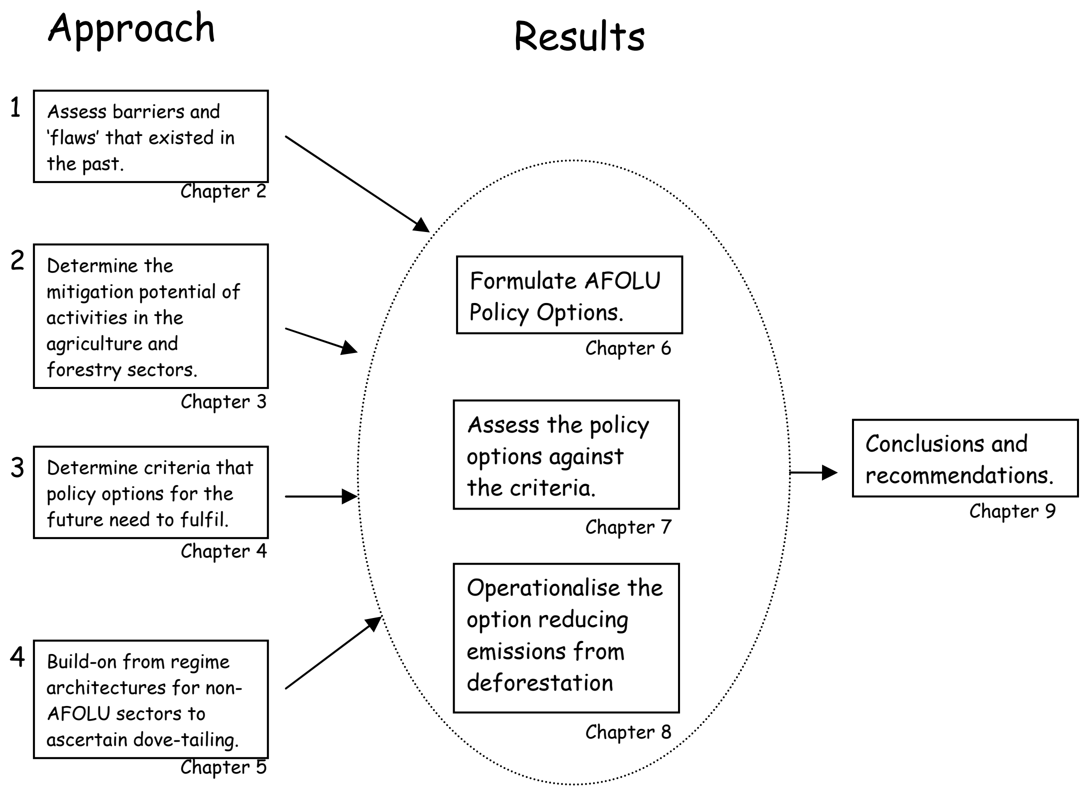

Figure 1: Illustration of the methodology

The general idea is that the treatment of LULUCF needs to improve in comparison to the current rules, modalities and guidelines and that it needs to tie in better with the rest of the climate change mitigation regime. Therefore, the shortcomings are reviewed to assess what went wrong in the past and the barriers that may have caused this. In addition, the options that are currently circulating for overall climate change mitigation regimes are reviewed to determine to what extent they can be applied to or deal with the AFOLU sector, which has a broader coverage in comparison to LULUCF.

The other two aspects that are reviewed are: 1) what the potential is for the different AFOLU activities and practices and what the barriers are to the realisation of the potentials; and 2) what criteria should be met by a solid climate change mitigation regime.

All of this together led to the formulation of a number of policy options that can be employed by different groups of countries, depending on their ambitions and the country-specific circumstances. The options are assessed against the criteria that were determined previously to see how the policy options score in a number of relevant areas.

2 Looking Back to Move Forward

Technical, Methodological and Scientific Issues (including some Reporting and Accounting Issues)

Before starting any design work on a future climate change mitigation regime, it is worth assessing what we can learn from the current regime. This chapter provides that assessment.

2.1 Main reasons that led to the current regime structure and rules governing LULUCF

If the issues surrounding LULUCF weren't so plentiful and complicated, it would have been a lot easier to reach consensus at the time of Kyoto and in the run up to the Bonn agreements (COP6^{bis}, 2001) and we might have ended up with a different set of rules that govern the use of LULUCF. But what were the reasons that led to the current set of rules? (see box 1 for a rough description of the rules). This section reviews the most important 'reasons why' and what the 'lesson learned' for the future is.

1. The target for non-LULUCF (see Annex B of the Kyoto Protocol) was set before agreement was reached whether, and if so, which and how LULUCF activities could be used by Annex I Parties to offset GHG emissions of other sectors. This meant that no action needs to be undertaken for any unit of GHG emissions in non-LULUCF sectors that can be compensated with a LULUCF unit. After the withdrawal of the USA from the Kyoto Protocol, the caps on forest management for Russia, Japan and Canada were set so as to make the agreement acceptable by providing these countries the opportunity to use AFOLU units generously. To avoid this in future the contribution of AFOLU needs to be an integral part of the agreed targets. This can lead to higher overall targets for all countries taken together but can remain with the same level of flexibility of how to reach the target.
2. Scale: When agreement needed to be reached on the extent to which LULUCF could contribute to mitigation commitments, it was unclear what the potential was of all the mitigation options in agriculture and forestry in the individual countries. This was mainly caused by a lack of reliable country data and consequently a lack of reliable projections of what part of that potential could be realised by individual countries during the commitment period if the use of LULUCF options was not limited.
3. Additionality/Baseline: if one wants to determine what the impact is of undertaking an activity, one needs to know what the Business As Usual (BAU) scenario is with which one compares the performance. The trajectory that describes this BAU scenario is referred to as the baseline. For energy, but especially for forestry, baselines are sometimes hard to determine, because they become counterfactual as soon as the project is implemented or is undertaken. This will be further discussed in section 2.2.2 and chapter 8.
4. Baseyear/base period: Building on from the previous point, if one wants to know how much better the emissions performance is of a project or a country during e.g. the commitment period, it needs to be compared to the performance at another moment in time: a base year or a base period, or more recently also referred to as "reference level". Because the inter-annual variability in the AFOLU sector can be high, a reference level determined over multiple years gives a better idea than a level determined on the basis of a single (base) year. This will also be further discussed in section 2.2.2.
5. Leakage: an activity undertaken on one location (e.g. avoid deforestation) may be negated by that same activity or another activity being undertaken elsewhere (in this example e.g. relocating the deforestation activity to the next possible location). Credits generated with the activity in such a case do not represent real overall emission reductions.
6. Uncertainty related to measuring and monitoring, baseline determination, projections of trends into the future, etc. were all causes for concern and made carbon crediting a risky business. Some sources of uncertainty have been addressed by the IPCC Good Practice Guidance on LULUCF (2003) and some by the new IPCC Inventory Guidelines (2006).

Some sources of uncertainty, for instance in relation to different remote sensing (RS) techniques, will be further discussed in chapter 8.

7. Reversal/non-permanence: comparing emission reductions from e.g. fossil fuel combustion with removals by sinks (a process that can be reversed at another point in time) may not be 100% correct. To deal with the possible temporary nature of net removals the concept of "temporary crediting" was introduced for the CDM. However, in the case of national accounting continuously over time temporary crediting may not be required in the same way as it isn't required for Annex I countries now.
8. Country-specific circumstances: different interest of different stakeholder groups and Parties was causing unconventional divides in the negotiations. For instance, a country that belongs to the Congo Basin has very different interest compared to for instance an arid or semi-arid country like Burkina Faso.
9. Sovereignty issues: Some countries were afraid that a situation might arise whereby a country would threaten to remove its forest if no funds would be made available to keep it. In addition, a risk was perceived that foreign entities would buy land in other countries with the objective to take it out of production in order to conserve the vegetation on it. This could be interpreted as interference with a country's sovereignty as it might conflict with the national development goals of the country itself. The latest proposals are more country-driven: the non-Annex I countries themselves being in the driver seat of what is acceptable and with what rules.
10. Complicated social and socio-economic aspects because emissions and/or removals are most often related to land use and not a "point source" as is the case in other sectors: if AFOLU activities are not undertaken by or for the local population they may be evicted from their lands, or the AFOLU activity may not be durable. Therefore, designing stakeholder participation systems or systems to reward the owners for the environmental services provided by their land, is of critical importance. This will be discussed in more detail in chapter 8.

***Box 1**: Key features of the LULUCF agreement as laid out in the Marrakech Accords*

At COP 7 (Marrakech, October/November 2001), Parties were able to take a decision on LULUCF and related issues. The rules for LULUCF activities, agreed as part of the Marrakech Accords, include three main elements:

1. A set of principles to govern LULUCF activities;
2. Definitions for Article 3.3 activities and agreed activities under Article 3.4; and
3. A four-tier capping system limiting the use of LULUCF activities to meet emission targets.

The principles in the Marrakech Accords respond to concerns that the use of LULUCF activities should not undermine the environmental integrity of the Protocol. These principles underscore, for example, the need for sound science and consistent methodologies, as well as the importance of conserving biodiversity. They also specify that naturally-occurring removals, including removals as a consequence of indirect anthropogenic effects, should be excluded from the system and that any re-release of greenhouse gases (e.g. through forest fires) must be promptly accounted for.

The extent, to which Parties can account for emissions and removals from specific LULUCF activities, for the first commitment period, is limited by the following four-tier capping system:

Tier 1: If a Party's afforestation, reforestation and deforestation activities result in more emissions than removals, then the Party may offset these emissions through forest management activities, up to a total level of 9 megatons of carbon per year for the five year commitment period.

Tier 2: The extent to which forest management activities can be accounted for to help meet emission targets beyond 9 megatons of carbon per year is subject to an individual cap for each Party, listed in the Marrakech Accords. This cap includes joint implementation projects involving forest management.

Tier 3: Emissions and removals from cropland management, grazing land management and revegetation can be accounted for to help meet emission targets on a net basis (e.g. changes in carbon stocks during 1990, times five, will be subtracted from the changes in carbon stocks during the first commitment period, in the lands where these activities will take place).

Tier 4: Only afforestation and reforestation projects are eligible under the clean development mechanism. Greenhouse gas removals from such projects may only be used to help meet emission targets up to 1% of a Party's baseline for each year of the commitment period. Definitions and modalities for the inclusion of afforestation and reforestation activities under the CDM will be developed by the SBSTA, with a view to recommending a decision to COP 9.

Source: http://unfccc.int/issues/lulucf.html

2.2 Scientific & Methodological Issues

Although there are many positive aspects associated with the AFOLU sector, this section only deals with a number of issues that were and may still be of concern.

2.2.1 Non-permanence

Mitigation strategies in sectors like energy, transport and/or industrial processes directly reduce emissions. Processes in the AFOLU sector on the other hand involve a two-way process: emissions and removals. On one hand CO_2 is removed from the atmosphere and stored in biomass but at the same time, in the same system, carbon is released due to the decay of biomass (e.g. dead leaves and (parts of) trees). The net balance may well be positive but it is always a combination of emissions and removals. This also means that the net balance may be negative at some point in time or that even all carbon benefits achieved by the project activity may be undone. This is where AFOLU differs from all other sectors: emission reductions may not be permanent. Some experts however, draw a parallel to the delay in emissions from the combustion of fossil fuels (not burning today but at a later date) and argue that emission reductions in other sectors are also rather a delay than a permanently emission avoided for ever and hence, similar to the delay in emissions in the AFOLU sector. But discussing this dichotomy is beyond the scope of this report.

Another aspect to bear in mind is scale: net removals may be reversed locally, but on a landscape level the overall carbon balance may still be positive. Differences in net emissions or removals between small areas are levelled off if the total area covered is larger.

The possible non-permanent character of carbon sequestration is not an issue when land on which the carbon is sequestered is always taken into consideration when emissions and removals are estimated, and possible debits are compensated at the appropriate point in time. Countries with a quantified emission limitation or reduction commitment (QELRC; listed in Annex B of the KP) are therefore, of no concern. Countries hosting projects of finite duration on the other hand may need to accept the type of temporary credits that are now used to account for CDM credits from afforestation and reforestation project activities.

2.2.2 Baseline, base year and/or base period

Base year versus base period
In the case of Annex I countries, currently emission and/or removal levels for cropland and grazing land management and revegetation are calculated on a net-net basis (see chapter 2.2.5) comparing emissions and removals to the levels that occurred in a single base year (1990 for most countries with a target). However, results of stock changes or non-CO_2 GHG emissions from a single year may reflect fluxes which are much higher or lower than characteristic for a given piece of land or area due to inter-annual variability of fluxes. Multiplication of this single-year value subsequently by five to compare it to emissions/removals during the CP further magnifies this problem (Schlamadinger et al., 2006 forthcoming).

For net-net accounting, the use of a longer base period would help to avoid this problem (the potential for unrepresentative values being used as the baseline against which future emission reduction/sink enhancement efforts are assessed). A base period of five to ten years can better capture inter-annual variability within the longer time frame, and consequently provide a more realistic representation of emissions and removals for a given piece of land or area.

Alternatively, in the case of short accounting periods, longer measurement periods (e.g., 5 or 10 year intervals of forest inventories) would lead to the same practical outcome as the formal use of longer accounting periods. (Canadell et al., forthcoming).

Baseline
A business as usual scenario or reference case for projects with an obligation to demonstrate additionality under the Kyoto flexibility mechanisms Joint Implementation (JI) and Clean Development Mechanism (CDM) – what would have happened in the absence of the project on the same location in the same period of time – should not be confused with a base year or base period against which changes in carbon stocks and non-CO_2 GHG emissions are assessed: the latter is always in the past whilst the former is in the present or the future. Hence, accounting at the national level uses gross-net or net-net accounting (see section 2.2.5), whilst the concept of "baseline scenarios" is used for project mechanisms JI and CDM (project developers must verifiably demonstrate that the chosen baseline scenario represents the most likely course of action without the CDM, and that the project case only occurs due to the CDM (additionality)).

Choosing base periods means electing an emissions level against which progress is going to be monitored, and for which potentially (financial) rewards are going to be issued. It has been suggested by some that the base period or reference level may actually be a benchmark for the future which may be informed by past emissions and trends, but may not be a true representation of a base period. This is particularly relevant if credits are awarded for reducing emission levels for instance of deforestation, but also for non-AFOLU sectors benchmarks are considered.

Figure 2 illustrates how the net annual carbon flux has developed over time per continent or large country whereby positive values indicate a net removal or sink. This clearly shows that different countries may want to elect different base period: because low emission levels or high removals in the base period mean limited scope for improvement, the domestic contribution of AFOLU to reduce net emissions is harder to achieve and possibly lower in absolute terms in comparison to an earlier chosen base period. If a benchmark (or reference level) approach is used, based on projections, then this problem does not exist. For example, if a country had low emissions in the past, but is expected to have high emissions in the future according to prevailing trends, then a future target or benchmark could well reflect that.

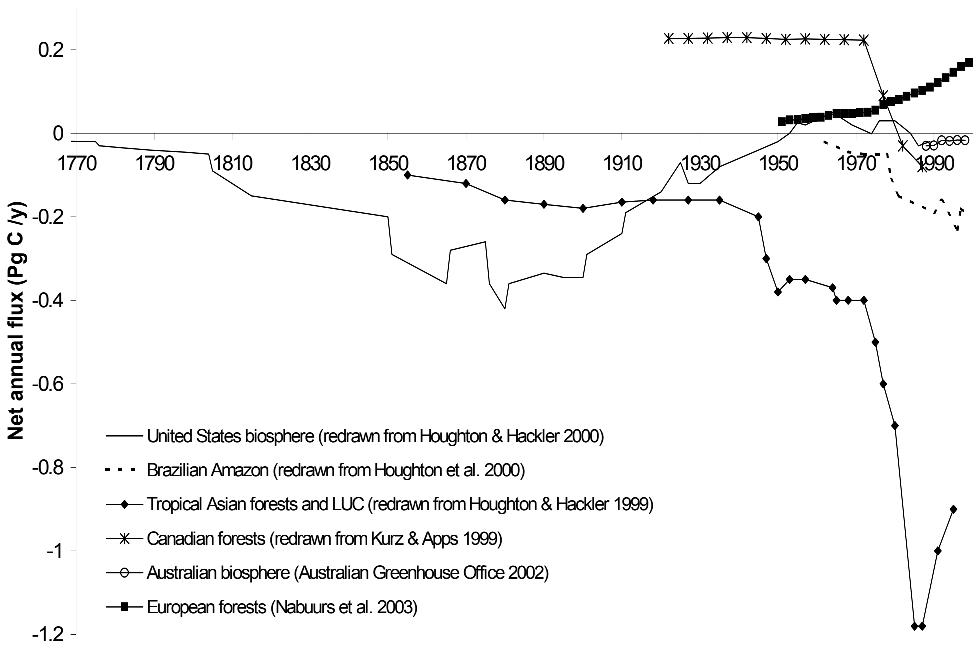

Figure 2: Historic functioning of the biosphere per continent or large country (Nabuurs, 2004).

Note: the net flux for Canada is the result of changes in natural dynamics, while for the other continents the dynamics are the result of land use changes and vegetation rebound.

Although at 1st sight applying a base period seems to have major advantages compared to the use of baselines, setting a base period alone is not sufficient: targets need to be set as well. When setting targets, projections and future trends need to be taken into consideration. Otherwise targets may be too soft or too stringent. Setting targets on the basis of projections requires a good understanding of what might come. In the AFOLU sector – as is the case in some other sectors – reliable projections are sometimes hard to make. Therefore, there may be dangers in such an approach.

2.2.3 Inter-annual variability

The global amplitude of variation in C fluxes associated with the terrestrial biosphere was estimated to be about 4 to 5 PgC yr^{-1} for the 1990s (IPCC, 2001), a large share of which is attributed to variability of fire emissions (van der Werf et al., 2004). This is equivalent to about 1% of global terrestrial biomass and 60-80% of global anthropogenic emissions. Figure 13 and 14 in chapter 8 provide an illustration of the possible inter-annual variability in deforestation and related emissions. Even if averaged over several years, the interannual variability in biospheric C fluxes can exceed by far the changes in CO_2 emissions from other human sectors in many countries. Knowing this, however, does not necessarily mean that for instance forest inventories detect a large share of this inter-annual variability, due to the sometimes traditional large measurement intervals, in particular in forestry where inventory cycles of 10 years are not uncommon.

The message here corresponds to the same argument brought forward in section 2.2.2 with respect to base periods: short base periods may reflect fluxes which are much higher or lower than characteristic for a given piece of land or area (e.g. 1995-1999 for Indonesia) whilst longer base periods are better but may still harbour out of the ordinary trends. A balance will need to be struck between a base period that is long enough but will still enable countries to demonstrate improved performance during a commitment or target period.

2.2.4 Age class distribution or “legacy effect”

The age class structure is the frequency distribution of forest area over age and is a product of past practices. The current age class structure of a region can determine whether a forest region currently or in the future is a source or a sink or what effect additional forest management would have. For example, the age class structure of Chinese forests reflects evidently historic intensive management with an age class distribution shifted to young forests that have been established only some decades ago (see figure 3a) whilst the US forest structure is more evenly distributed (see figure 3b).

Fig. 3a: China

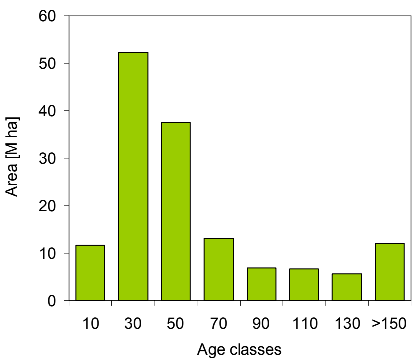

Fig. 3b: USA

Figure 3. Age class distribution of Chinese and American production forests (Source: Böttcher, forthcoming)

Böttcher (forthcoming) estimated the effect of forest management practices and age class structure. A Normal Forest scenario simulates the C balance of forests in case of an even age class distribution (neglecting past practise effects). In a “normal forest” every age class covers the same forest area. It is a forest structure that supplies continuously the same amount of wood and is thus sustainable from the production’s point of view. The carbon flux under these conditions subtracted from carbon fluxes under business as usual, i.e. the age-class structure, reveals the effect of past practises or “the legacy effect” (see figure 4).

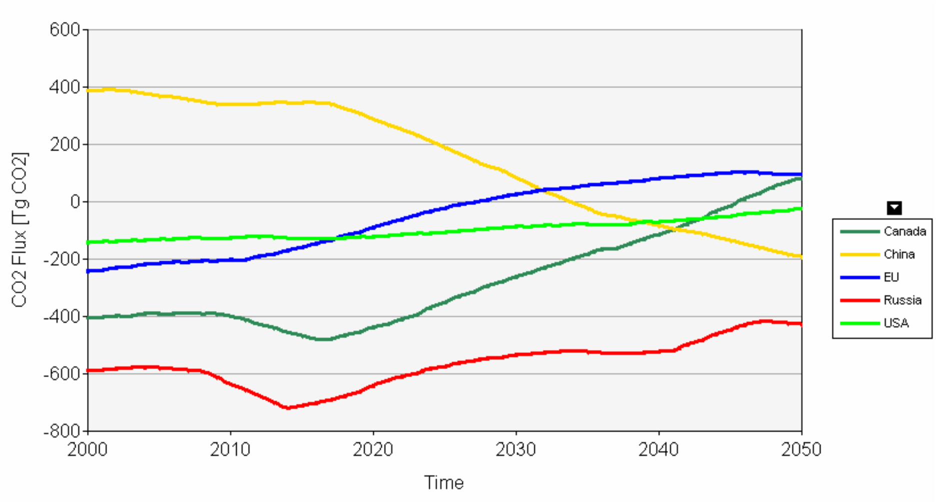

Figure 4. Additional emissions (positive values) or additional sinks (negative values) if age class distribution would be that of a ‘Normal’ Forest (Business as Usual - Normal Forest scenario) (Böttcher, forthcoming)

China, with a large amount of young forests, would have up to 400 Tg CO_2 more emissions during the period 2000-2020 under a normal forest structure compared to the current situation. This effect is diminishing over time, i.e. it converges towards zero, but possibly at very long timescales depending on the local speed of growth of the forest.

Legacy effects differ per country. In addition, there is no solution to take account of uneven age class distributions within one commitment period except through gross-net accounting (see section 2.2.4). Effects will only level off if such areas are included long enough under a particular accounting regime. Therefore, it can be expected that some countries may show a stronger preference for gross-net accounting for this reason, then other countries.

In summary, if targets are set in future on the basis of projections, age-class distributions could be factored into the calculations. However, information on the age class structure of forests might not be available for most tropical countries.

2.2.5 Net-net and gross-net accounting

CO_2 emissions from the combustion of fossil fuels and non-CO_2 GHG emissions are calculated and accounted for on a “net-net basis” in the 1st commitment period of the Kyoto Protocol (CP1: 2008-2012). This means: emissions in CP1 are compared against the emissions in the base year (1990 for most countries) times five (the number of year in CP1). Emissions and removals from cropland management, grazing land management, and revegetation will also be accounted on this net-net basis during CP1.

Figure 5 shows three scenarios of emissions or removals resulting from cropland, grazing land management or revegetation. Any of the three scenarios as presented in that figure will result in net credits under Article 3.4. If the lines were decreasing over time this would lead to a debit under net-net accounting. Hence, emissions to the atmosphere can be reduced over time (line C), removals from the atmosphere can be increased over time (line A), or emissions can be turned into removals (line B): all such “improvements” to a Party’s overall emissions profile will still assist it in meeting its commitment equally.

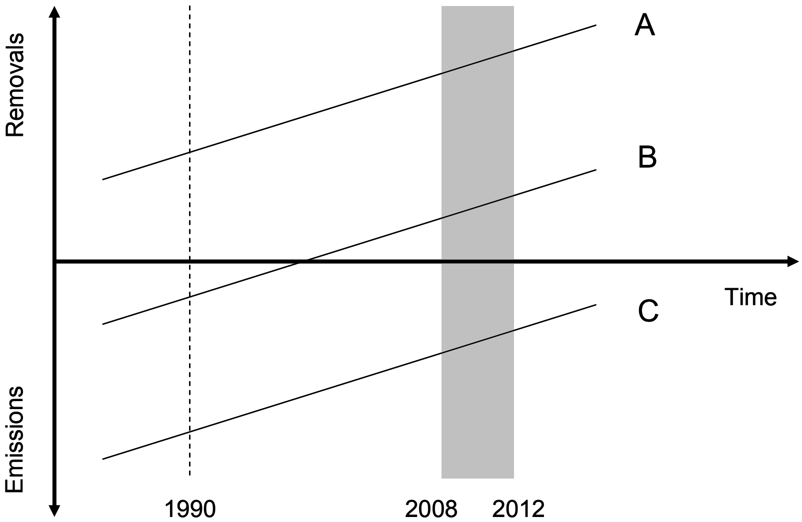

Figure 5: Net-net accounting on croplands and grazing lands.

Net-net accounting implies that once the mitigation benefits of an LULUCF activity decline, the increase in emissions or decrease in sequestration will have to be compensated by measures in other sectors. Declining mitigation benefits are not necessarily the result of recent management interventions, but can also be a *legacy effect* : the effect of past management practices. In agriculture this is not very likely, because changes in carbon pools occur relatively frequent and fast. However, in managed forests for example, if a country has an uneven age-class distribution in its forests, then, as the dominant age class approaches maturity, the rate of sequestration by the forest will decrease. As a result, the country would incur a debit if net-net accounting was applied. But as many Annex B countries have initiated conservation policies decades ago, many forests could be reaching this level of carbon sequestration saturation soon. As this situation would cause debits under net-net accounting, even without a country having taken any adverse land-use decisions, gross-net accounting was adopted for the 1st commitment period under the Kyoto Protocol for forest management.

Gross-net accounting only considers emissions and removals during the commitment period without comparing the emissions and removals with those in a base year or base period. Gross-net accounting is applied to afforestation, reforestation and deforestation under Article 3.3 as well to forest management under Article 3.4.[2] If a LULUCF activity leads to net emissions in the commitment period, these emissions must be added to emissions from non-LULUCF sectors. If the LULUCF activity leads to net removals in the commitment period, irrespective of the carbon flows in the base period, these removals can be subtracted from emissions from non-LULUCF sectors. Gross-net accounting will, therefore, assist in meeting targets even where relative LULUCF removals from an activity are diminishing over time. On the other hand, even if LULUCF emissions are being reduced over time, a Party will have debits. These rules are now clear, agreed amongst Parties and remain relevant for future regime options where net emission reductions may be rewarded. Although it may be beneficial to stick to these rules for the next foreseeable future (e.g. because targets can be set more precise if accounting rules are fixed), the current rules do not provide much incentive for improving forest management which is explained in next sections.

2 A special rule is included in the second sentence of Article 3.7 of the Kyoto Protocol for countries, for whom emissions from land-use change and forestry constituted a net source of greenhouse gas emissions in 1990. These countries must include in their 1990 emissions base year or period the emissions and removals from land-use change related only to deforestation. In effect, this introduces net-net accounting for deforestation in these countries.

2.2.6 “Factoring out”

Factoring out refers to the process of separating direct human-induced effects on carbon pools (e.g. no-till practices, extension of rotation length in forestry) from indirect human-induced effects (e.g. increased nitrogen deposition or elevated CO_2 levels in the atmosphere), natural effects (e.g. naturally occurring forest fires, inter-annual climate variability) and past management practices (e.g. conservation strategies initiated some decades ago, or intense forest management in the past, etc.).

Gross-net accounting raises concerns about the impacts of indirect human-induced effects, natural effects, and effects of past management practices because gross-net accounting does not compare rates of sequestration between the base year or base period and the commitment period. Therefore, there is no “cancellation effect”: cancellation effect meaning that if it is present on both sides of the equation, the effect is cancelled out in the overall result.

Natural and indirect effects (e.g. 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. Unintended ”windfall” credits may be problematic because, if allowed to count toward commitments, LULUCF removals could distort the ease to meet commitments among countries. [3] This could be corrected if the windfall credits could be predicted and included when setting the targets, raising the overall targets. However, making such predictions is, with the current state of the science, a daunting, if not impossible task.

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 pre-1990 age-class effects. Therefore, “factoring out” measures do not need to be applied to afforestation and reforestation. When net-net accounting is used, long-term trends in impacts on carbon fluxes from increased temperatures, CO_2 levels in the atmosphere or nitrogen deposition will tend to cancel out between periods. Consequently, net-net accounting reduces the amount of removals from indirect and natural effects entering the accounting.

2.2.7 Land-based versus activity-based accounting

The IPCC Special Report on LULUCF, in informing the negotiations that lead to the Marrakech Accords, introduced the concepts of land-based and activity-based accounting. **Land-based accounting** means that there is a “trigger activity” that occurs on a specific piece of land (such as afforestation, reforestation, deforestation, cropland management, etc.). Once the land thereby qualifies for accounting, all carbon stock changes and non-CO_2 GHG emissions must be included in the reports. The only exception is that carbon stocks that are increasing can be conservatively omitted from accounting. By including all stock changes and non-CO_2 GHG emissions, indirect and natural effects, as well as pre-1990 activities may enter the estimates of emissions and removals. Some of these effects may be factored out by other means as explained above (e.g, net-net accounting). However, the fact remains that large amounts of lands may be included in the accounting where direct-human induced effects may not be the dominant factor, thus introducing the potential for credits and debits that are not related to human action.

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[3] The desire to exclude indirect and natural effects from Kyoto Protocol accounting was expressed in the guiding principles saying 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. 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 equal to 15% of projected removals, or 3% of base year emissions, whichever was less, placed on credits from forest management under Article 3.4. One disadvantage of this solution is that in countries with removals in the commitment period above the cap, credits are independent of any new efforts to improve the forest carbon balance.

Activity-based accounting would take the specific mitigation activities as its starting point. For example, a country could define certain activities that it elects to improve the national GHG balance, such as reforestation, conservation tillage, forest fertilization, forest species selection, etc. Only those lands where the specific mitigation activities have occurred would enter the accounting. This would greatly reduce the land base that is included in the accounting, thereby reducing indirect and natural effects. Furthermore, the impacts of the activities would not be measured as the full stock change and non-CO_2 GHG emissions on the lands affected by the activities; only the change in carbon stocks, or the change in GHG emissions that is directly related to the activity would be included. This further minimizes indirect and natural effects. The GHG response to these activities would usually be derived from general research, and monitoring would concentrate on detection of activities: the determination of activity data. A discount would need to be applied to account for business-as-usual conduct of these activities.

For example, in a certain region it could be found that converting from conventional till to no-till agriculture stores an additional 10 tonnes of carbon over a period of 20 years. Countries would then need to monitor the amount of land that was converted to no-till agriculture between the base year and the commitment period and would multiply this by (a) the GHG benefits per ha per year and (b) a discount for business-as-usual rate of conversion from conventional to no-till, in order to derive the annual GHG credits during the commitment period.

It is also possible to mix land-based and activity-based accounting, to provide even greater flexibility to countries while not jeopardizing the environmental integrity of the system. Countries could be required to account for carbon-stock depleting activities (like forest degradation, deforestation, or conversion of grasslands to croplands) on a net-net basis, following the land-based accounting framework. In addition, countries could voluntarily elect carbon-stock enhancing activities, according to their own definitions and priorities that would be crediting using activity-based accounting.

2.3 In summary

In this wilderness of methodological and scientific issues the question arises what agenda follows from this? To navigate through that wilderness a couple of summarising points are made here that are relevant to AFOLU in future climate change mitigation regimes.

- it is recommendable to agree to the rules governing the use of AFOLU before setting targets;
- targets should ideally be based on realistic projections of the AFOLU mitigation potential that can be realised in future. Country-specific data and information are required to determine such projections;
- country-specific circumstances do matter, must be taken into account and countries' sovereignty must be respected;
- dealing with uncertainty has improved due to the IPCC Good Practice Guidance (IPCC, 2003) and the new IPCC Inventory Guidelines (IPCC, 2006), but some level of uncertainty will remain. This can to a large extend be solved by pragmatic political solutions or accounting rules;
- choosing a base period or reference level against which net emission reductions are calculated determines the scope for improvement in the future. As historic emission profiles differ from country to country, no single formula exists to determine a reference emissions level that will be acceptable to all countries;
- Inter-annual variability may be significant and may not always be detected by inventories. If land is included continuously under an accounting regime, positive and negative biases will both be accounted for;
- Age-class distribution due to past management practices of forests (legacy effect) differ from country to country and cannot be solved in one commitment period, except if gross-net accounting is applied. This however, opens the possibility to generate unintended windfall credits. On the other side, to deal with "factoring out", net-net accounting would be the preferred option. Accounting rules must therefore, be designed carefully so as to avoid undesirable outcomes; and,

- Land-based and activity-based accounting can be mixed to provide even greater flexibility to countries while not jeopardizing the environmental integrity of the system.
- The need for default emission factors at disaggregated levels is still urgent. On average activity data can be collected by the countries themselves.

3 Mitigation Options in the AFOLU Sector

Now the assessment has been made what barriers and system flaws prohibit the realisation of the full climate change mitigation potential, it is time to look at what the potential actually is. Agriculture and forest strategies offer significant potential for achieving much-needed GHG emission reductions/uptake at a global scale. In addition to the significant quantitative climate change mitigation contribution that agriculture and forests can make, many of the practices that increase terrestrial carbon sequestration and reduce agricultural emissions and emissions from deforestation and forest degradation provide vital ancillary benefits, from improved productivity to reduced energy inputs to water conservation, reduced conventional air pollutants, and improved habitat for wildlife. Moreover, the inclusion of sinks in a future climate change regime has the potential to engage the talents and innovative energies of large numbers of rural people all over the world in what will need to be a global effort to combat climate change while promoting sustainable rural (and urban) communities. Scientists and economists have repeatedly demonstrated the economic salience of climate change mitigation in agriculture and forestry at national levels, with analyses that indicate that in many regions around the world, providing carbon co-benefits is economically competitive with various current (carbon-emitting or carbon-depleting) alternative land uses.

This chapter reviews the mitigation strategies that can be used to mitigate climate change, it presents the potential of those strategies in different parts of the world, it names the most important barriers why only a small percentage of the technical potential will be realised in the next foreseeable future if nothing changes, and suggestions are made how some of these barriers may be tackled.

Both sections on Agriculture and Forestry deal with all of the above, where possible following the same template. But due to sector specificity some deviations from that template occur. A third sections deals with bio-energy and bio-products.

3.1 Agriculture

3.1.1 Agricultural GHG mitigation

Most previous analyses have considered barriers only at the broad activity level (e.g. cropland management). Such aggregation is essential for estimating global mitigation potentials (Smith et al., 2006a), but in order to assess barriers and to tailor specific strategies to overcome these barriers, individual practices and specific management changes need to be considered. Table 1 lists the mitigation practices considered in this analysis.

Table 1: Broad activities, agricultural practices and specific management changes that can influence GHG emissions from agriculture, as considered in this study.

Activity	**Practice**	**Specific management change**[4]
Cropland management	Agronomy	Increased productivity
		Rotations
		Catch crops
		Less fallow
		More legumes
		Deintensification
		Integrated Pest Management
		Improved cultivars
	Nutrient management	Fertilizer placement
		Fertilizer timing
		Precision farming
		Reduced fertilizer rates
		Fertilizer free zones
		Slow release fertilizers
		Nitrification inhibitors
	Tillage / residue management	Reduced tillage
		Zero tillage
		Reduced residue removal
		Reduced residue burning
	Upland water management	Irrigation
		Drainage
	Rice management	Improved water management
		Improved fertilisation
		Improved cultivars
	Set-aside and land use change	Set aside
		Wetlands
	Agroforestry	Tree crops inc. Shelterbelts etc.
Grazing land management	Livestock grazing intensity	Livestock grazing intensity
	Fertilization	Fertilization
	Fire management	Fire management
	Species introduction	Species introduction
	More legumes	More legumes
	Increased productivity	Increased productivity
Organic soils[5]	Restoration	Rewetting / abandonment
Degraded lands	Restoration	Restoration
Livestock management	Improved feeding practices	Concentrates
		Fat in the diet
		Increased digestibility
		Optimise protein intake
		Mechanical treatment

[4] Some specific management changes are context sensitive: they are not always leading to lower overall emissions of all GHG gases, e.g. in case of wetland restoration increases in methane emissions may occur.

[5] Wetlands, including peat ecosystems, occupy 4-6% of the global land surface but contain 20-25% of the world's organic soil carbon. Wetland management thereby potentially constitutes an important mitigation option.

	Specific agents and dietary additives	Ionophores Propionate precursors Probiotics Bovine somatotrophin (BSt) Halogenated compounds Antibiotics Methane vaccine
	Breeding and structural changes	Improved livestock through breeding Improved fertility Lifetime management
Manure / biosolid management	More efficient use of manure on soils	More efficient use of manure Storage Trapping Slurry cooling Controlled decomposition Anaerobic digestion
Bioenergy	Energy crops	Fossil fuel offsets Soil C under energy crops
	Residues & dung	Combustion for energy
Enhanced energy efficiency	Enhanced energy efficiency	Enhanced energy efficiency

The activities are described in more detail in appendix 1.

3.1.2 Agricultural GHG mitigation potential

Globally, there is significant economic potential[6] for GHG mitigation in the agricultural sector with total potentials (all GHGs for the year 2030) of 1900-2100, 2400-2600, 3100-3300 Mt CO_2-eq yr^{-1} at 0-20, 0-50 and 0-100 USD t CO_2-eq.$^{-1}$. Total biophysical potentials[7] for the same year are 5500-6000 Mt CO_2-eq yr^{-1} (Smith et al., 2006a). The ranges represent the differences among IPCC SRES scenarios (A1b, A2, B1 and B2; Smith et al., 2006a). Of the global mitigation potential, a large proportion lays in non-Annex I countries or economies in transition, with 80% of the global total agricultural mitigation potential found in non-Annex I countries. Figure 6 shows the mitigation potential found in non-OECD countries as a proportion of the global total for each agricultural mitigation activity.

[6] The economic potential means: the potential that could be achieved on the land available at a specified price paid for carbon dioxide equivalents.
[7] The biophysical potential is the same as the technical potential and means: the potential that could be achieved on the land available if there were no economic or other barriers.

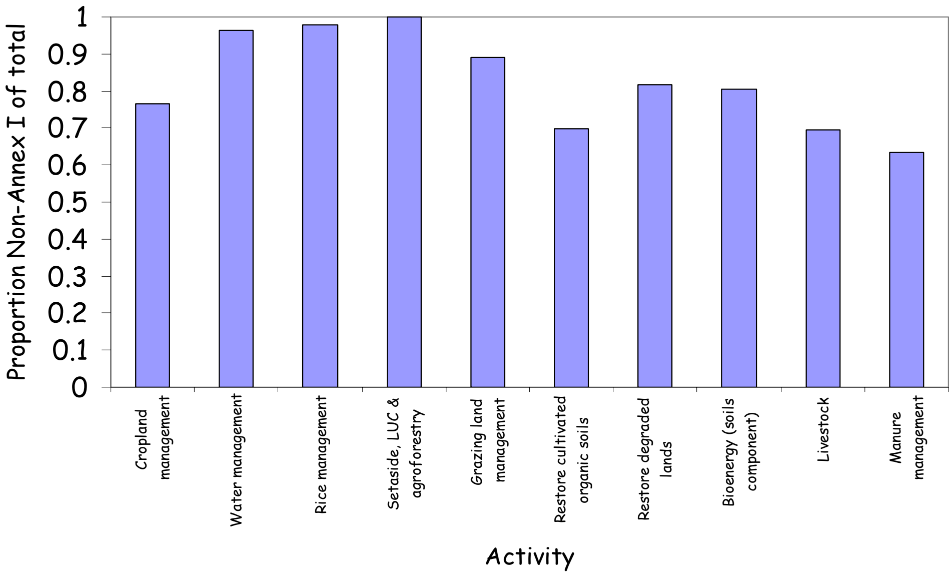

Figure 6: Mitigation potential found in non-Annex I countries as a proportion of the global total for each agricultural mitigation activity, calculated from values given in Smith et al. (2006a).

Figure 7 shows the mitigation potential in Annex I countries for each practice as a proportion of the potential available in non-Annex I countries. Cropland management options in Annex I countries amount to about 30% of those available in non-Annex I countries, with equivalent figures for livestock options and options and restoration of organic soils of 40%, and 60% for manure management options. Potentials in Annex I countries are about 20-25% of non-Annex I potentials for soil C under bio-energy and restoration of degraded lands, about 10% for grazing land management but very low (<2%) for rice management, water management, set-aside management and agro-forestry, the vast majority of which is possible in non-Annex I countries. The breakdown of mitigation potential (at 0-100 USD t CO_2-eq.$^{-1}$) is given for each region for each practice in Figure 8. The most important mitigation options are: restoration of cultivated organic soils (1) and degraded lands (2), and rice management (3); predominantly in Asia (1, 2 and 3), the Russian Federation (1 and 2), South America (2) and Europe (1 and 2).

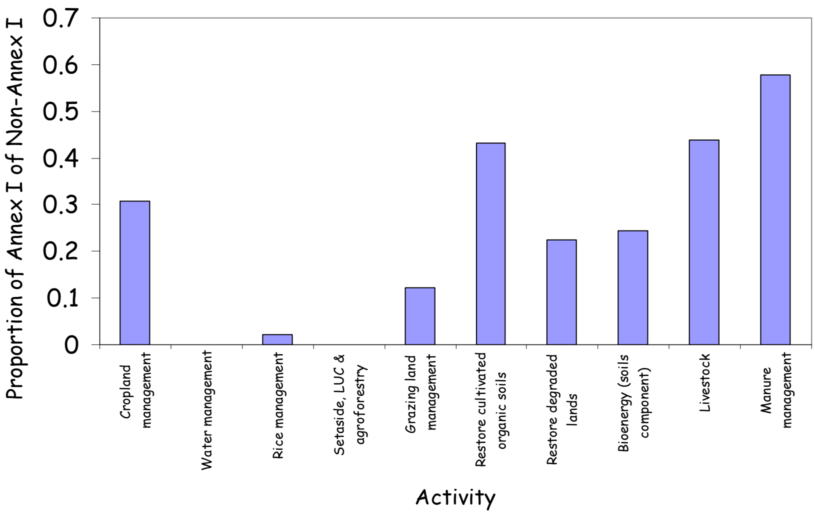

Figure 7: Mitigation potential in Annex I countries for each practice as a proportion of the potential available in non-Annex I countries, calculated from values given in Smith et al. (2006a).

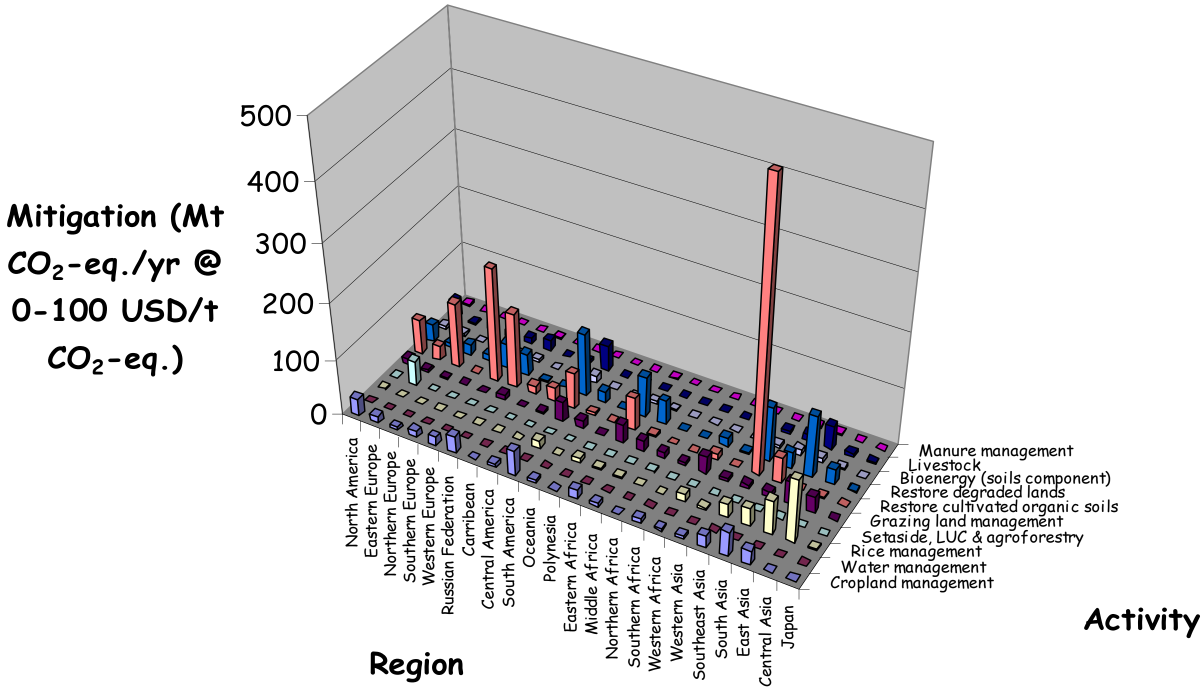

Figure 8: Mitigation potential at 0-100 USD t CO_2-eq.$^{-1}$ of each agricultural mitigation practice in each of the FAO/IIASA (2000) Agro Ecological Zones global regions, using figures from analysis presented in Smith et al. (2006a).

Given the importance of agricultural GHG mitigation, it is important to identify the barriers to implementation found in these countries and to develop strategies to overcome them (see the following sections for a discussion on the barriers).[8]

3.1.3 General barriers to implementation

There are numerous barriers to implementation of these mitigation measures which will impede adoption and implementation and prevent the potentials above being realised (Smith et al., 2006b). The commonly-mentioned barriers to adoption of C sequestration activities on agricultural lands include the following:

Permanence: Carbon sequestration in soils or terrestrial biomass only remove carbon from the atmosphere until the maximum capacity for the ecosystem is reached, which may take 15 to 33 years, depending on management practice and system (West and Post 2002). A subsequent change in management can reverse the gains in C sequestration over a similar period of time. Sequestration is a rapidly and cheaply deployable interim measure until more capital-intensive developments, and longer-lasting actions become available (Sands and McCarl 2005). Not all

[8] Recent studies (Paustian et al., 2006; Richards et al.,2006) indicate that if US farmers widely adopt the best management techniques to store carbon and undertake cost-effective reductions in N_2O and CH_4, an estimated 70 to 220 MMT of carbon could be stored in US agricultural soils annually, and aggregate US GHG emissions could be reduced by 5 to 14%, at moderate carbon prices (up to $50/tC, or $13 /t$CO_2$). With technological advances bio-fuels could displace a significant fraction of fossil fuels and thereby reduce the current US GHG emissions 9 to 24%. This illustrates the importance of overcoming barriers to implementation.

agricultural mitigation options are impermanent: reduction in N_2O and CH_4 emissions are non-saturating, and avoided emissions as a result of agricultural energy efficiency gains or substitution of fossil fuels by bio-energy are permanent.

Additionality: Many of the agricultural mitigation possibilities are already well known, and some are financially viable in their own right, so an obstacle may arise in identifying how much activity is additional to ongoing activities.

Uncertainty: This has two components: mechanism uncertainty and measurement uncertainty. Uncertainty about the complex biological and ecological processes involved in trace gas emissions and carbon storage in agricultural systems makes investors more wary of these options than the more clear-cut industrial mitigation activities. This barrier can be reduced by investment in research. Secondly, agricultural systems exhibit substantial variability between seasons, and between locations. These translate to high variability in offset quantities at the farm level, which can be reduced by increasing the geographical extent and duration of the accounting unit. Thus multi-region, multi-year contracts are needed (McCarl *et al.* 2006) to overcome this barrier.

Leakage: Adoption of certain agricultural mitigation practices may reduce production within implementing regions. In the face of sustained high demand for the products, the production can shift to regions unconstrained by GHG mitigation objectives, resulting in no net reduction of emissions. 'Wall-to-wall' accounting is a mechanism to detect leakage and cancel it out within an accounting region; between regions, leakage correction factors may need to be employed (Murray *et al.* 2004). It should be noted that those systems that tend to keep practices in place, also tend to limit leakage.

Beyond the above widely-discussed items, a number of other implementation issues arise:

Transaction costs: Farmers will not adopt otherwise unprofitable agricultural mitigation practices in the absence of policies or incentives. Under an incentive-based system such as a carbon market, the amount of money that farmers receive is not the market price, but the market price less any costs involved in getting the commodity to the market, here termed a brokerage cost. This may be substantial, and is an increasing fraction of the market price as the amount of carbon involved decreases, creating a serious entry barrier for small-holders. For example, a 50 kt contract needs 25 kha under soil carbon management (uptake roughly 2 t CO_2 ha^{-1} yr^{-1}). In non-Annex I countries in particular, this could involve many thousands of farmers. The process of passing the money and obligations back and forth involves substantial transaction costs, which increases with the number of participants. The brokerage costs of crop insurance, which involves many farmers assembled and sold to one insurance agent, amount to 25% of the market price. Smith *et al.* (2005) have projected that, despite significant potential, soil C sequestration in Europe by 2010 will be negligible due to, among other factors, high transaction costs. By contrast, Richards *et al.* (2006) have projected that given sensible incentives, significant soil C sequestration could be achieved in the US.

Measurement and monitoring costs: Mooney *et al.* (2004) argue that such costs are likely to be small (under 2% of the value of a contract), but other studies disagree (Smith 2004a). In general, measurement costs per C-credit sold decrease as the quantity of C sequestered and area sampled increase in size. Methodological advances in measuring percentage soil C at the field and regional scales may reduce costs and increase the sensitivity of change detection (Izaurralde and Rice 2006), but calculations of the C stock change also require measurement of changes in soil bulk density, for which cheap or remote methods are not yet readily available, but some are in development (Izaurralde and Rice 2006, Gehl and Rice 2007).

Property rights: Both property rights and the lack of a clear single-party land ownership in certain areas may inhibit implementation of management changes.

Other constraints: Other possible constraints or barriers to implementation include the availability of capital, the rate of capital stock turnover, the rate of penetration of bio-energy stocks into the marketplace, risk attitudes, need for new knowledge, availability of extension-service-supported technology dissemination, consistency with traditional practices, pressure for competing uses of agricultural land and water, demand for agricultural products, high costs for certain enabling technologies (e.g. soil tests before fertilization in China) and ease of compliance (e.g. straw burning in China is quicker than residue removal, so farmers favour straw burning).

Specific barriers considered in this study in more detail fall into five categories, economic, risk-related, political / bureaucratic, logistical and educational / societal barriers. The barriers considered are given in Table 2.

Table 2. Barriers considered in this report

Broad category of barrier	**Barrier**
Economic	Cost of land
	Competing land use
	Continued poverty
	Lack of existing capacity
	(Low) price of carbon
	Population growth
	Transaction costs
	Monitoring costs
Risk-related	Delay on returns / slow system response / permanence
	Leakage / fire / natural variation
Political / bureaucratic	Lack of political will
	Slow land planning bureaucracy
	Accounting rules complex / unclear & loopholes
Logistical	Different or scattered owners / different interests
	Large areas unmanaged
	Inaccessible areas
	Biological unsuitability
Educational / societal	Stakeholder perception
	Traditional sector
	Sector / legislation is new

3.1.4 Barriers to implementation of specific practices and management changes

The main barriers to each agricultural mitigation measure are listed in tables 3, 4 and 5 for Annex I countries, non-Annex I countries and economies in transition, respectively.

Table 3 Applicability of agricultural mitigation measures used in Annex I countries, and barriers affecting implementation in these countries.

					Economic								Risk		Political			Logistical				Educational		
Activity	**Practice**	**Specific management change**	**Other management specific barriers**	**Applicability in Annex I countries**	**Cost of land**	**Competing land use**	**Continued poverty**	**Lack of existing capacity**	**(Low) price of carbon**	**Population growth**	**Transaction costs**	**Monitoring costs**	**Delay on returns / slow system response / permanence**	**Leakage / fire / natural variation**	**Lack of political will**	**Slow land planning bureaucracy**	**Accounting rules complex / unclear & loopholes**	**Different or scattered owners / different interests**	**Large areas unmanaged**	**Inaccessible areas**	**Biological unsuitability**	**Stakeholder perception**	**Traditional sector**	**Sector / legislation is new**
Cropland management	Agronomy	Increased productivity	A	Medium							X	X			X			X						
		Rotations	B	Medium							X	X			X			X						
		Catch crops		High											X			X			X		X	
		Less fallow		High											X			X			X	X	X	
		More legumes		High											X			X						
		Deintensification		High							X	X	X	X				X				X	X	X
		Integrated Pest Management		High														X						
		Improved cultivars		High							X	X						X						
	Nutrient management	Fertilizer placement		High							X	X						X						
		Fertilizer timing		High							X	X						X						
		Precision farming	C	Medium							X	X						X						
		Reduced fertilizer rates		High							X	X						X						
		Fertilizer free zones		High							X	X						X						
		Slow release fertilizers	D	Medium							X	X						X						
		Nitrification inhibitors	D	Low							X	X						X						
	Tillage / residue management	Reduced tillage		High							X	X	X	X			X	X				X	X	
		Zero tillage	M	Medium							X	X	X	X			X	X				X	X	
		Reduced residue removal		High							X	X	X	X			X	X				X	X	

					Economic								Risk		Political			Logistical				Educational		
Activity	**Practice**	**Specific management change**	**Other management specific barriers**	**Applicability in Annex I countries**	**Cost of land**	**Competing land use**	**Continued poverty**	**Lack of existing capacity**	**(Low) price of carbon**	**Population growth**	**Transaction costs**	**Monitoring costs**	**Delay on returns / slow system response / permanence**	**Leakage / fire / natural variation**	**Lack of political will**	**Slow land planning bureaucracy**	**Accounting rules complex / unclear & loopholes**	**Different or scattered owners / different interests**	**Large areas unmanaged**	**Inaccessible areas**	**Biological unsuitability**	**Stakeholder perception**	**Traditional sector**	**Sector / legislation is new**
		Reduced residue burning		High							X	X	X	X			X	X				X	X	
	Upland water management	Irrigation	E	Low														X			X			
		Drainage	F	Medium														X			X			
	Rice management	Improved water management	G	Low							X	X						X					X	
		Improved fertilisation	G	Low							X	X						X					X	
		Improved cultivars	G	Low							X	X						X					X	
	Set-aside and land use change	Set aside		High							X	X	X	X				X				X	X	X
		Wetlands		High							X	X						X						
	Agroforestry	Tree crops inc. Shelterbelts etc.		Medium							X	X	X	X				X				X	X	X
Grazing land management	Livestock grazing intensity	Livestock grazing intensity		Medium							X	X						X				X	X	X
	Fertilization	Fertilization		High							X	X						X						
	Fire management	Fire management		Medium							X	X						X				X	X	
	Species introduction	Species introduction		Medium														X						
	More legumes	More legumes		High											X			X						
	Increased productivity	Increased productivity	A	Medium							X	X			X			X						
Organic soils	Restoration	Rewetting /		High	X	X			X		X	X			X			X						

					Economic								Risk		Political			Logistical				Educational		
Activity	**Practice**	**Specific management change**	**Other management specific barriers**	**Applicability in Annex I countries**	**Cost of land**	**Competing land use**	**Continued poverty**	**Lack of existing capacity**	**(Low) price of carbon**	**Population growth**	**Transaction costs**	**Monitoring costs**	**Delay on returns / slow system response / permanence**	**Leakage / fire / natural variation**	**Lack of political will**	**Slow land planning bureaucracy**	**Accounting rules complex / unclear & loopholes**	**Different or scattered owners / different interests**	**Large areas unmanaged**	**Inaccessible areas**	**Biological unsuitability**	**Stakeholder perception**	**Traditional sector**	**Sector / legislation is new**
		abandonment	H																					
Degraded lands	Restoration	Restoration	G	Medium	X	X			X		X	X						X						
Livestock management	Improved feeding practices	Concentrates		Medium														X				X	X	
		Fat in the diet		Medium														X				X	X	
		Increased digestibility		Medium														X				X	X	
		Optimise protein intake		Medium														X				X	X	
		Mechanical treatment	C	Low														X				X	X	
	Specific agents and dietary additives	Ionophores	I	Low														X				X	X	X
		Propionate precursors	I	Low														X				X	X	X
		Probiotics	I	Low														X				X	X	X
		Bovine somatotrophin (BSt)	I	Low														X				X	X	X
		Halogenated compounds	I	Low														X				X	X	X
		Antibiotics	I	Low														X				X	X	X
		Methane vaccine	I	Low														X				X	X	X
	Breeding and structural changes	Improved livestock breeding	J	Medium														X					X	
		Improved fertility	J	Medium														X					X	
		Lifetime management	J	Medium														X					X	
Manure /	More efficient	More efficient use of		High								X	X					X				X		

					Economic								Risk		Political			Logistical				Educational		
Activity	**Practice**	**Specific management change**	**Other management specific barriers**	**Applicability in Annex I countries**	**Cost of land**	**Competing land use**	**Continued poverty**	**Lack of existing capacity**	**(Low) price of carbon**	**Population growth**	**Transaction costs**	**Monitoring costs**	**Delay on returns / slow system response / permanence**	**Leakage / fire / natural variation**	**Lack of political will**	**Slow land planning bureaucracy**	**Accounting rules complex / unclear & loopholes**	**Different or scattered owners / different interests**	**Large areas unmanaged**	**Inaccessible areas**	**Biological unsuitability**	**Stakeholder perception**	**Traditional sector**	**Sector / legislation is new**
biosolid management	use of manure on soils	manure																						
		Storage	C	Medium								X	X					X				X		
		Trapping	C	Medium								X	X					X						
		Slurry cooling	E	Low								X	X					X						
		Controlled decomposition	C	Low								X	X					X						
		Anaerobic digestion	C	Medium								X	X					X						
Bio-energy	Energy crops	Fossil fuel offsets	K	High	X	X		X	X									X				X	X	
		Soil C under energy crops	K	Medium	X	X		X	X									X				X	X	
	Residues & dung	Combustion for energy	L	Low														X						
Enhanced energy efficiency	Enhanced energy efficiency	Enhanced energy efficiency		Medium																				

A Productivity already high
B Rotations already efficient
C Expensive
D Limited success and expensive
E Very expensive
F Costly but improved productivity
G Limited area
H Large areas - high cost but high return
I Consumer resistance; costly
J Already lots of breeding
K Investment cost and pay back time
L Little developed world dung
M Limited by suitability and equipment

Table 4 Applicability of agricultural mitigation measures used in non-Annex I countries, and barriers affecting implementation in these countries.

					Economic								**Risk**		**Political**			**Logistical**				**Educational**		
Activity	**Practice**	**Specific management change**	**Other management specific barriers**	**Applicability in Non-Annex I countries**	**Cost of land**	**Competing land use**	**Continued poverty**	**Lack of existing capacity**	**(Low) price of carbon**	**Population growth**	**Transaction costs**	**Monitoring costs**	**Delay on returns / slow system response / permanence**	**Leakage / fire / natural variation**	**Lack of political will**	**Slow land planning bureaucracy**	**Accounting rules complex / unclear & loopholes**	**Different or scattered owners / different interests**	**Large areas unmanaged**	**Inaccessible areas**	**Biological unsuitability**	**Stakeholder perception**	**Traditional sector**	**Sector / legislation is new**
Cropland management	Agronomy	Increased productivity		High		X	X	X	X	X	X	X			X			X						
		Rotations		High		X	X		X	X	X	X			X			X						
		Catch crops	1	Low		X	X		X	X					X			X			X		X	
		Less fallow	2	Medium			X		X						X			X			X	X	X	
		More legumes		Medium			X		X						X			X						
		Deintensification	3	Low	X	X	X		X	X	X	X	X	X				X				X	X	X
		Integrated Pest Management	4	Low			X	X	X									X						
		Improved cultivars		High			X	X	X		X	X						X						
	Nutrient management	Fertilizer placement	5	Low			X	X	X		X	X						X						
		Fertilizer timing		High							X	X						X						
		Precision farming	6	Low			X	X	X		X	X						X						
		Reduced fertilizer rates	7	Low	X	X				X	X	X						X						
		Fertilizer free zones	7	Low	X	X				X	X	X						X						
		Slow release fertilizers	9	Low			X		X		X	X						X						
		Nitrification inhibitors	9	Low			X		X		X	X						X						
	Tillage / residue management	Reduced tillage		High		X	X		X	X	X	X	X	X			X	X				X	X	
		Zero tillage	10	Low		X	X		X	X	X	X	X	X			X	X				X	X	
		Reduced residue removal	11	Low							X	X	X	X			X	X				X	X	
		Reduced residue burning	12	High							X	X	X	X			X	X				X	X	

					Economic								Risk		Political			Logistical				Educational		
Activity	**Practice**	**Specific management change**	**Other management specific barriers**	**Applicability in Non-Annex I countries**	**Cost of land**	**Competing land use**	**Continued poverty**	**Lack of existing capacity**	**(Low) price of carbon**	**Population growth**	**Transaction costs**	**Monitoring costs**	**Delay on returns / slow system response / permanence**	**Leakage / fire / natural variation**	**Lack of political will**	**Slow land planning bureaucracy**	**Accounting rules complex / unclear & loopholes**	**Different or scattered owners / different interests**	**Large areas unmanaged**	**Inaccessible areas**	**Biological unsuitability**	**Stakeholder perception**	**Traditional sector**	**Sector / legislation is new**
	Upland water management	Irrigation	13	Low			X		X									X			X			
		Drainage	14	Low		X	X		X	X								X			X			
	Rice management	Improved water management	15	Medium		X	X		X	X	X	X						X					X	
		Improved fertilisation		High		X	X		X	X	X	X						X					X	
		Improved cultivars		High		X	X		X	X	X	X						X					X	
	Set-aside and land use change	Set aside	16	Low	X	X				X	X	X	X	X				X				X	X	X
		Wetlands	16	Low	X	X				X	X	X						X						
	Agroforestry	Tree crops inc. Shelterbelts etc.		High	X	X				X	X	X	X	X				X				X	X	X
Grazing land management	Livestock grazing intensity	Livestock grazing intensity	17	Low	X	X				X	X	X						X				X	X	X
	Fertilization	Fertilization	18	Low		X	X		X	X	X	X						X						
	Fire management	Fire management	19	Low			X		X		X	X						X				X	X	
	Species introduction	Species introduction	20	Low		X	X		X	X								X						
	More legumes	More legumes		?		X				X					X			X						
	Increased productivity	Increased productivity	21	High		X	X			X	X	X			X			X						
Organic soils	Restoration	Rewetting / abandonment	22	Low	X	X			X	X	X	X			X			X						
Degraded lands	Restoration	Restoration	23	High	X	X			X	X	X	X						X						

					Economic								Risk		Political			Logistical				Educational		
Activity	**Practice**	**Specific management change**	**Other management specific barriers**	**Applicability in Non-Annex I countries**	**Cost of land**	**Competing land use**	**Continued poverty**	**Lack of existing capacity**	**(Low) price of carbon**	**Population growth**	**Transaction costs**	**Monitoring costs**	**Delay on returns / slow system response / permanence**	**Leakage / fire / natural variation**	**Lack of political will**	**Slow land planning bureaucracy**	**Accounting rules complex / unclear & loopholes**	**Different or scattered owners / different interests**	**Large areas unmanaged**	**Inaccessible areas**	**Biological unsuitability**	**Stakeholder perception**	**Traditional sector**	**Sector / legislation is new**
Livestock management	Improved feeding practices	Concentrates	14	Low			X	X	X									X				X	X	
		Fat in the diet	14	Low			X	X	X									X				X	X	
		Increased digestibility	14	Low			X	X	X									X				X	X	
		Optimise protein intake	14	Low			X	X	X									X				X	X	
		Mechanical treatment	14	Low			X	X	X									X				X	X	
	Specific agents & dietary additives	Ionophores	14	Low			X	X	X									X				X	X	X
		Propionate precursors	14	Low			X	X	X									X				X	X	X
		Probiotics	14	Low			X	X	X									X				X	X	X
		Bovine somatotrophin (BSt)	14	Low			X	X	X									X				X	X	X
		Halogenated compounds	14	Low			X	X	X									X				X	X	X
		Antibiotics	14	Low			X	X	X									X				X	X	X
		Methane vaccine	14	Low			X	X	X									X				X	X	X
	Breeding and structural changes	Improved livestock breeding	24	Medium			X	X	X									X					X	
		Improved fertility	25	Low			X	X	X									X					X	
		Lifetime management	25	Low			X	X	X									X					X	
Manure / biosolid management	More efficient use of manure on soils	More efficient use of manure	26	Medium			X			X		X	X					X				X		
		Storage	27	Low			X	X		X		X	X					X				X		
		Trapping	27	Low			X	X		X		X	X					X						

Activity	Practice	Specific management change	Other management specific barriers	Applicability in Non-Annex I countries	Economic								Risk		Political			Logistical				Educational		
					Cost of land	Competing land use	Continued poverty	Lack of existing capacity	(Low) price of carbon	Population growth	Transaction costs	Monitoring costs	Delay on returns / slow system response / permanence	Leakage / fire / natural variation	Lack of political will	Slow land planning bureaucracy	Accounting rules complex / unclear & loopholes	Different or scattered owners / different interests	Large areas unmanaged	Inaccessible areas	Biological unsuitability	Stakeholder perception	Traditional sector	Sector / legislation is new
		Slurry cooling	27	Low			X	X		X		X	X					X						
		Controlled decomposition	27	Low			X	X		X		X	X					X						
		Anaerobic digestion	27	Low			X	X		X		X	X					X						
Bioenergy	Energy crops	Fossil fuel offsets	28	High	X	X	X	X	X	X								X				X	X	
		Soil C under energy crops	28	High	X	X	X	X	X	X		X	X					X				X	X	
	Residues & dung	Combustion for energy	29	Medium			X											X				X	X	
Enahnaced energy efficiency	Enahnaced energy efficiency	Enahnaced energy efficiency		Medium			X	X		X														

1 Already multiple cropping
2 Can be limited by water
3 Food shortage
4 Cost of pesticides & herbicides
5 Cost of fertilizer and equipment
6 Cost of equipment prohibitive
7 More fertilizer needed for production
9 Limited success and expensive
10 Limited by suitability and equipment
11 Alternative uses for residues
12 Unless already used for fuel
13 Water scarce
14 Expensive
15 Mid season drainage already used extensively
16 Land needed for food production
17 Already low; farming systems small
18 Fertilizer expensive
19 Hard to control
20 More native species used; cost
21 Depending on fertiliser costs
22 Small areas; high costs
23 Large areas; low costs
24 Breeds less developed but less intensively managed
25 Not intensively managed
26 Other uses for dung (e.g. fuel)
27 Non-intensively managed already; expensive
28 Investment cost and pay back time
29 Alternative uses / traditional

Table 5 Applicability of agricultural mitigation measures used in countries with economies in transition, and barriers affecting implementation in these countries.

					Economic								Risk		Political			Logistical				Educational		
Activity	**Practice**	**Specific management change**	**Other management specific barriers**	**Applicability in Non-Annex I countries**	**Cost of land**	**Competing land use**	**Continued poverty**	**Lack of existing capacity**	**(Low) price of carbon**	**Population growth**	**Transaction costs**	**Monitoring costs**	**Delay on returns / slow system response / permanence**	**Leakage / fire / natural variation**	**Lack of political will**	**Slow land planning bureaucracy**	**Accounting rules complex / unclear & loopholes**	**Different or scattered owners / different interests**	**Large areas unmanaged**	**Inaccessible areas**	**Biological unsuitability**	**Stakeholder perception**	**Traditional sector**	**Sector / legislation is new**
Cropland management	Agronomy	Increased productivity		High		X	X	X	X	X	X	X			X			X						
		Rotations		High		X	X		X	X	X	X			X			X						
		Catch crops		Low		X	X		X	X					X			X			X		X	
		Less fallow	1	Medium			X		X						X			X			X	X	X	
		More legumes		Medium			X		X						X			X						
		Deintensification	2	Low	X	X	X		X	X	X	X	X	X				X				X	X	X
		Integrated Pest Management	3	Low			X	X	X									X						
		Improved cultivars		High			X	X	X		X	X						X						
	Nutrient management	Fertilizer placement	4	Low			X	X	X		X	X						X						
		Fertilizer timing		High							X	X						X						
		Precision farming	5	Low			X	X	X		X	X						X						
		Reduced fertilizer rates	6	Low	X	X				X	X	X						X						
		Fertilizer free zones	6	Low	X	X				X	X	X						X						
		Slow release fertilizers	7	Low			X		X		X	X						X						
		Nitrification inhibitors	7	Low			X		X		X	X						X						
	Tillage / residue management	Reduced tillage		High		X	X		X	X	X	X	X	X			X	X				X	X	
		Zero tillage	8	Low		X	X		X	X	X	X	X	X			X	X				X	X	
		Reduced residue removal	9	Low							X	X	X	X			X	X				X	X	
		Reduced residue burning	10	High							X	X	X	X			X	X				X	X	

					Economic								Risk		Political			Logistical				Educational		
Activity	**Practice**	**Specific management change**	**Other management specific barriers**	**Applicability in Non-Annex I countries**	**Cost of land**	**Competing land use**	**Continued poverty**	**Lack of existing capacity**	**(Low) price of carbon**	**Population growth**	**Transaction costs**	**Monitoring costs**	**Delay on returns / slow system response / permanence**	**Leakage / fire / natural variation**	**Lack of political will**	**Slow land planning bureaucracy**	**Accounting rules complex / unclear & loopholes**	**Different or scattered owners / different interests**	**Large areas unmanaged**	**Inaccessible areas**	**Biological unsuitability**	**Stakeholder perception**	**Traditional sector**	**Sector / legislation is new**
	Upland water management	Irrigation	11	Low			X		X									X			X			
		Drainage	12	Low		X	X		X	X								X			X			
	Rice management	Improved water management	13	Medium		X	X		X	X	X	X						X					X	
		Improved fertilisation		High		X	X		X	X	X	X						X					X	
		Improved cultivars		High		X	X		X	X	X	X						X					X	
	Set-aside and land use change	Set aside	14	Low	X	X				X	X	X	X	X				X				X	X	X
		Wetlands	14	Low	X	X				X	X	X						X						
	Agroforestry	Tree crops inc. Shelterbelts etc.		High	X	X				X	X	X	X	X				X				X	X	X
Grazing land management	Livestock grazing intensity	Livestock grazing intensity	15	Low	X	X				X	X	X						X				X	X	X
	Fertilization	Fertilization	16	Low		X	X		X	X	X	X						X						
	Fire management	Fire management	17	Low			X		X		X	X						X				X	X	
	Species introduction	Species introduction		Low		X	X		X	X								X						
	More legumes	More legumes		?		X				X					X			X						
	Increased productivity	Increased productivity	18	High		X	X			X	X	X			X			X						
Organic soils	Restoration	Rewetting / abandonment	19	Low	X	X			X	X	X	X			X			X						
Degraded lands	Restoration	Restoration	20	High	X	X			X	X	X	X						X						

					Economic								Risk		Political			Logistical				Educational		
Activity	**Practice**	**Specific management change**	**Other management specific barriers**	**Applicability in Non-Annex I countries**	**Cost of land**	**Competing land use**	**Continued poverty**	**Lack of existing capacity**	**(Low) price of carbon**	**Population growth**	**Transaction costs**	**Monitoring costs**	**Delay on returns / slow system response / permanence**	**Leakage / fire / natural variation**	**Lack of political will**	**Slow land planning bureaucracy**	**Accounting rules complex / unclear & loopholes**	**Different or scattered owners / different interests**	**Large areas unmanaged**	**Inaccessible areas**	**Biological unsuitability**	**Stakeholder perception**	**Traditional sector**	**Sector / legislation is new**
Livestock management	Improved feeding practices	Concentrates	21	Low			X	X	X									X				X	X	
		Fat in the diet	21	Low			X	X	X									X				X	X	
		Increased digestibility	21	Low			X	X	X									X				X	X	
		Optimise protein intake	21	Low			X	X	X									X				X	X	
		Mechanical treatment	21	Low			X	X	X									X				X	X	
	Specific agents & dietary additives	Ionophores	12	Low			X	X	X									X				X	X	X
		Propionate precursors	12	Low			X	X	X									X				X	X	X
		Probiotics	12	Low			X	X	X									X				X	X	X
		Bovine somatotrophin (BSt)	12	Low			X	X	X									X				X	X	X
		Halogenated compounds	12	Low			X	X	X									X				X	X	X
		Antibiotics	12	Low			X	X	X									X				X	X	X
		Methane vaccine	12	Low			X	X	X									X				X	X	X
	Breeding and structural changes	Improved livestock breeding		Medium			X	X	X									X					X	
		Improved fertility		Low			X	X	X									X					X	
		Lifetime management		Low			X	X	X									X					X	
Manure / biosolid management	More efficient use of manure on soils	More efficient use of manure		Medium			X			X		X	X					X				X		
		Storage	12	Low			X	X		X		X	X					X				X		

					Economic								Risk		Political			Logistical				Educational		
Activity	**Practice**	**Specific management change**	**Other management specific barriers**	**Applicability in Non-Annex I countries**	**Cost of land**	**Competing land use**	**Continued poverty**	**Lack of existing capacity**	**(Low) price of carbon**	**Population growth**	**Transaction costs**	**Monitoring costs**	**Delay on returns / slow system response / permanence**	**Leakage / fire / natural variation**	**Lack of political will**	**Slow land planning bureaucracy**	**Accounting rules complex / unclear & loopholes**	**Different or scattered owners / different interests**	**Large areas unmanaged**	**Inaccessible areas**	**Biological unsuitability**	**Stakeholder perception**	**Traditional sector**	**Sector / legislation is new**
		Trapping	12	Low			X	X		X		X	X					X						
		Slurry cooling	12	Low			X	X		X		X	X					X						
		Controlled decomposition	12	Low			X	X		X		X	X					X						
		Anaerobic digestion	12	Low			X	X		X		X	X					X						
Bio-energy	Energy crops	Fossil fuel offsets	22	High	X	X	X	X	X	X								X				X	X	
		Soil C under energy crops	22	High	X	X	X	X	X	X		X	X					X				X	X	
	Residues & dung	Combustion for energy	23	Medium			X											X				X	X	
Enhanced energy efficiency	Enhanced energy efficiency	Enhanced energy efficiency		Medium			X	X		X														

1 Can be limited by water
2 Food shortage
3 Cost of pesticides & herbicides
4 Cost of fertilizer and equipment
5 Cost of equipment prohibitive
6 More fertilizer needed for production
7 Limited success and expensive
8 Limited by suitability and equipment
9 Alternative uses for residues
10 Unless already used for fuel
11 Water scarce
12 Expensive
13 Mid season drainage already used extensively
14 Land needed for food production
15 Already low; farming systems small
16 Fertilizer expensive
17 Hard to control
18 Depending on fertiliser costs
19 Small areas; high costs
20 Large areas; low costs
21 High costs
22 Investment cost and pay back time
23 Alternative uses and traditional practice

As seen from Tables 3, 4 and 5, transaction and monitoring costs can be barriers in all regions of the world, but other economic barriers such as cost of land are important barriers mostly in non-Annex I countries and countries with economies in transition, even though some landowners in Annex I countries with high population densities will argue that the establishment of shopping malls and condominium developments is economically more appealing!

In non-Annex I countries, continued poverty, lack of existing capacity and population growth continue to prevent application of management practices that optimise yields and profits, before even considering mitigation. An example of this is in many of the practices to reduce enteric livestock emissions. Whilst they may be suited to relatively intensively managed livestock in Annex I countries, most could not be considered in many non-Annex I countries where adequate animal nutrition will be the first priority.

Because of continued population growth in the non-Annex I world, competition from other land use is a barrier to implementation. In the Annex I countries, competition from other land uses is a serious barrier, in particular for dedicated bio-energy crop production and practices that require agriculture to be abandoned in particular areas, such as on highly organic soils. In Annex I countries, a limitation on the applicability of mitigation measures can be that agriculture is already managed relatively effectively, for example with respect to fertilisation, whilst in other parts of the Annex I countries significant potential for mitigation still exists (Richards, 2006).

The characteristics of risk-related barriers are similar in all regions. The delay in returns from investment in mitigation and the possibility of leakage / sink reversal increase the risk to farmers and land managers in all economic regions.

The lack of political will to encourage mitigation is also a significant factor in all economic regions. Smith et al. (2006b) showed that most mitigation that currently occurs is a co-benefit of non-climate policy, often via other environmental policies put in place to promote e.g. water quality, air quality, soil fertility, conservation benefits etc. Indeed, Smith et al. (2005) showed that even in Annex I countries (the European Union), little of agriculture's mitigation potential is projected to be realised by 2010 due to lack of incentives to encourage mitigation practices. Bureaucracy can be a significant barrier in all regions, but is especially prevalent in areas where land planning decisions are slow.

Large unmanaged areas and inaccessibility are barriers mainly in non-Annex I countries and countries with economies in transition, with most Annex I countries having a communications and transport infrastructure to minimise this barrier, despite the very large areas covered in some of those Annex I countries.

In terms of educational / societal barriers, traditional practice and stakeholder perception continue to be barriers in all economic regions, though the regional characteristics of these barriers varies greatly. Stakeholder perception is also very different in different regions. Barriers concerning the implementation of bio-energy provide a good example of regional differences. Traditional bio-energy in many non-Annex I countries is regarded as a "poor person's fuel" which presents a barrier to its use, whilst in many Annex I countries, there may be some public resistance to dedicated energy crop monocultures due to their perceived aesthetic impact in rural areas. Barriers may present differently in different regions.

In addition to the barriers presented under the general categories above, many potential mitigation measures present very specific barriers. For example, irrigation might increase productivity and thus return more carbon to the soil, thereby sequestering soil carbon. However, in arid areas, competition for water may be a significant barrier. Whilst this will affect arid regions of Annex I countries, it is likely to present the greatest barrier in arid non-Annex I countries. There are also trade-offs between measures, such as use of animal manure for energy production (dung burning in the developing world) or use as a soil amendment. Such barriers are also more likely to arise in non-Annex I countries. Smith et al. (2006b) review some of these trade-offs in more detail.

3.1.5 Possible measures to overcome barriers to implementation in non-Annex I countries

The most significant barriers to implementation of mitigation measures in non-Annex I countries (and for some economies in transition) are economic, mostly driven by poverty, which some areas may be exacerbated by a growing population. In non-Annex I countries many farmers / land managers are poor and struggle to make a living from agriculture, with food security and child malnutrition still prevalent in poor countries (Conway and Toenniessen, 1999). Given the challenges many farmers in non-Annex I countries already facing, climate change mitigation is a low priority. To begin to overcome these barriers, within the agricultural sector, global sharing of innovative technologies for efficient use of land resources and agricultural chemicals, to eliminate poverty and malnutrition, will significantly help in removing barriers that currently prevent implementation of mitigation measures in agriculture (Smith et al., 2006b). Capacity building and education in the use of innovative technologies and best management practices would also serve to reduce the barriers.

More broadly, macro-economic policies to reduce debt and to alleviate poverty in non-Annex I countries, through encouraging sustainable economic growth and sustainable development, would serve to remove barriers to the implementation of climate mitigation measures in agriculture. Farmers can only be expected to consider climate mitigation when the threat of poverty and hunger are removed. Mitigation measures that also improve food security and profitability (such as improved use of fertiliser) would be more favourable than those which have no economic or agronomic benefit. Such practices are often referred to as “win-win” options, and strategies to implement such measures can be encouraged on a “no regrets” basis (Smith & Powlson, 2003; Smith 2004b). Smith et al. (2006b) list measures which have co-benefits (as well as those which have trade-offs) as summarised in Table 6.

Mitigation measures should be considered within a broader framework of sustainable development. Policies to encourage sustainable development will make agricultural mitigation in non-Annex I countries more achievable. Current macro-economic frameworks do not always support sustainable development policies at the local level currently. More broadly, macro-economic policies to reduce debt and to alleviate poverty in non-Annex I countries, through encouraging sustainable economic growth and sustainable development, are desperately needed. Ideally policies associated with fair trade, subsidies for agriculture in Annex I countries and interest rates on loans and foreign debt would all need to be reconsidered with the intend to foster sustainable development. This may provide an environment in which climate change mitigation in agricultural could be considered in Non-Annex I countries.

Table 6. *Summary of possible co-benefits and trade-offs of mitigation options in agriculture. '+' denotes a positive effect (benefit); '-' denotes a negative effect (trade-off). The co-benefits and trade-offs may vary among regions. Economic costs and benefits are often key driving variables (from Smith et al., 2006b).*

Measure	Examples	Food security (productivity)	Water quality	Water conservation	Soil quality	Air quality	Bio-diversity, wildlife habitat	Energy conservation	Conservation of other biomes	Aesthetic/ amenity value
Cropland management	Agronomy	+	+/-	+/-	+	+/-	+/-	-	+	+/-
	Nutrient management	-/+	+		+	+		+		
	Tillage/residue management	+	+/-	+	+		+	+		
	Water management (irrigation, drainage)	+	+/-	+/-	+/-			-	+	
	Rice management	+	+	+/-		+/-			+	
	Agro-forestry	+/-	+/-	-			+	+		
	Set-aside, land-use change	-	+	+	+	+	+	+	-	+
Grazing land management/ pasture improvement	Grazing intensity	+/-			+		+			+
	Increased productivity (e.g. fertilization)	+	+/-							
	Nutrient management	+	+/-	+	+		+	-	+	+/-
	Fire management	+	+			-	+/-			+/-
	Species introduction (including legumes)	+			+			+		
Management of organic soils	Avoid drainage of / restore wetlands	-			+		+	+	-	+
Restoration of degraded lands	Erosion control, organic amendments, nutrient amendments	+	+		+		+		+	+
Livestock management	Improved feeding practices	+			+/-				+	
	Specific agents and dietary additives	+								
	Longer term structural and management changes and animal breeding	+								
Manure/biosolid management	Improved storage and handling	+	+/-		+	+/-				
	Anaerobic digestion					+		+		
	More efficient use as nutrient source	+	+		+	+		+		
Bio-energy	Energy crops, solid, liquid, biogas, residues	-					-	+	-	
	Pertinent references (footnotes)	*a*	*b*	*c*	*d*	*e*	*F*	*g*	*h*	*i*

[a] Foley *et al*. 2005 ; Lal 2001, 2004a ; [b] Mosier 2002; Freibauer *et al*. 2004 ; Paustian *et al*. 2004 ; Cerri *et al*. 2004 ; [c] Lal 2004b ; Dias de Oliveira *et al*. 2005; Rockström 2003 ; [d] Lal, 2001; Janzen 2005; Cassman *et al*. 2003; Cerri *et al*. 2004; Wander & Nissen 2004 ; [e] Mosier 2001, 2002; Paustian *et al*. 2004 ; [f] Foley *et al*. 2005; Dias de Oliveira *et al*. 2005; Freibauer *et al*. 2004; Falloon *et al*. 2004; Huston & Marland 2003; Totten *et al*. 2003; [g] Lal *et al*. 2003 ; West & Marland 2003; [h] Balmford *et al*. 2005; Trewavas 2001 ; Green *et al*. 2005 ; West & Marland 2003, Freibauer *et al*. 2004.

Competition with other land uses will also be a barrier for many options. Overcoming this barrier will necessitate a holistic consideration of mitigation potential for the land-use sector. It is important that forestry and agricultural land management options are considered within the same framework to optimise mitigation solutions. Costs of verification and monitoring could be reduced by clear guidelines on how to measure, report and verify GHG emissions from agriculture. Transaction costs, on the other hand, will be more difficult to address. The process of passing the money and obligations back and forth involves substantial transaction costs, which increases with the number of participants. Given the large number of small-holder farmers in many non-Annex I countries, the transaction costs are likely to be higher even than in Annex I countries, where costs can amount to 25% of the market price (Smith et al., 2006b). Organisations such as farmers' collectives, may help to reduce this significant barrier. Farmers in non-Annex I countries are in touch with each other, through local magazines or community meetings, providing forums for these groups to set up consortia of interested forefront players. In order for these collectives to work, regimes need to be in place already and it is essential that the credits are actually paid to the local owner.

For a number of practices, especially those involving carbon sequestration, risk related barriers such as delay on returns and potential for leakage and sink reversal, can be significant barriers. Education, emphasising the long term nature of the sink, could help to overcome this barrier, but fiscal policies (guaranteed markets, risk insurance) might also be required.

Education / societal barriers affect many practices in many regions. There is often a societal preference for traditional farming practices and where mitigation measures alter traditional practice radically (not all practices do), education would help to reduce barriers to their implementation.

3.2 Forestry

From previous sections it is clear that the options in forestry in the future depend quite strongly on the current state of the forest, and the issues that are now at stake. Furthermore, the past 5 to 10 decades have usually formed the present state of the forest, and thus historical developments very much shape the opportunities.

Mitigation options in forestry are usually grouped in a) reducing emissions from deforestation and degradation; b) increasing the area of forests; c) increasing the density of existing forests; and/or, in combination with d) using the emission substitution effect of harvested wood products or bio energy. (IPCC 2001, de Wit *et al.*, 1999; Caspersen *et al.*, 2000; Post *et al.*, 2000; Johnson *et al.*, 2001; Guo *et al.*, 2002; Freeman *et al.*, 2005, Benitez et al. 2006, Sathaye et al. 2006, Sohngen and Sedjo 2006). Although large uncertainty remains concerning the mitigation potential in detail, and in relation to the natural dynamics in forests, a fair number of studies is available that has roughly estimated the mitigation potential of larger regions.

Regarding the question 'what is the best mitigation option to employ?' there is never one single answer. This fully depends on the region, the issues at stake, the state of the forest, and other demands on the forest and forest land, etc. In regions where forests are intensively managed, optimal mixes of continued harvesting while maintaining stocks, and continued production of wood for products and bio-energy may be preferred. In other regions continued preservation of natural forests may be preferred, while at the same time alternative forms of livelihood are created elsewhere, in combination with restoration of degraded forests into forests that supply the locals with goods and services.

3.2.1 Mitigations measures in forestry

Table 7 estimates the mitigation potential in a semi quantitative way.

Table 7: Broad categories of options and an indication of their potential. 'Large' indicates >500 Mt CO_2 y^{-1} by 2030; 'Medium' indicates: 250-500 Mt CO_2 y^{-1} by 2030; 'Small' indicates: 100-250 Mt CO_2 y^{-1} by 2030; and, 'Very small' indicates: <100 Mt CO_2 y^{-1} by 2030.

Region	Measure (broad)	Technical Mitigation Potential (Mt CO_2 y^{-1})
OECD North America	Afforestation	Medium
OECD North America	Reducing Deforestation	Very small
OECD North America	Forest Management	Large
OECD North America	Bio-energy	Medium
Europe	Afforestation	Small
Europe	Reducing Deforestation	Very small
Europe	Forest Management	Small
Europe	Bio-energy	Small
OECD Pacific	Afforestation	Small
OECD Pacific	Reducing Deforestation	Small
OECD Pacific	Forest Management	Small
OECD Pacific	Bio-energy	Very small
Centrally Planned Asia	Afforestation	Medium
Centrally Planned Asia	Reducing Deforestation	Samll
Centrally Planned Asia	Forest Management	Medium
Centrally Planned Asia	Bio-energy	Small
Countries in Transition	Afforestation	Medium
Countries in Transition	Reducing Deforestation	Small
Countries in Transition	Forest Management	Medium
Countries in Transition	Bio-energy	Medium
Central & South America	Afforestation	Medium
Central & South America	Reducing Deforestation	Large
Central & South America	Forest Management	Medium
Central & South America	Bio-energy	Medium
Africa	Afforestation	Medium
Africa	Reducing Deforestation	Large
Africa	Forest Management	Medium
Africa	Bio-energy	Medium
Other Asia	Afforestation	Medium
Other Asia	Reducing Deforestation	Large
Other Asia	Forest Management	Medium
Other Asia	Bio-energy	Medium
Middle East	Afforestation	Very small
Middle East	Reducing Deforestation	Very small
Middle East	Forest Management	Very small
Middle East	Bio-energy	Very small

In regions where the forest cover is already fairly abundant, and the stocks already high, the options are very limited. One can only concentrate on avoiding degradation (if it may occur) and on maintaining the current sink in e.g. OECD North America and Europe. Furthermore (very) small options occur in afforestation, and bio energy. In countries with economies in transition, and centrally planned Asia, medium sized opportunities may be found in afforestation, forest management and bio energy options. Clearly in countries in transition, the avoidance of natural disturbance is of importance. In Centrally planned Asia, afforestation in combination with the avoidance of land degradation is of importance.

Much larger opportunities can be found in the tropical regions in avoidance of emissions from deforestation and degradation. For all three major tropical regions this potential is estimated as 'large' i.e. more than 500 Mt CO_2 y^{-1} by 2030.

All together the economic potential can be estimated in the range of 2000 – 4000 Mt CO_2 y^{-1} by 2030; this against all prices. Other approaches (like top-down global models) project usually a larger economic potential (Benitez et al. 2006, Sathaye et al. 2006, Strengers et al. in press). They reach economic potentials of some 10,000 – 15,000 Mt CO_2 y^{-1} in 2030. These quantifications are very high. Probably because they do not take into account risks, institutional barriers, and time lags in responses of land owners.

3.2.2 Barriers to implementation of specific practices and management changes

This overall economic potential in the forestry sector can be regarded as significant in comparison to total global CO_2 emissions (excl AFOLU) of some 20,000 – 25,000 Mt CO_2 per year (Table 12). Despite low costs, and many positive side effects of forestry mitigation, not much has happened in terms of mitigation activities.

Barriers have been identified (see table 2 in section 3.1.3 for the full list) that also seem to hinder large scale employment of the forestry mitigation options. These barriers would need to be overcome in order to make forestry a successful part of the future climate regime.

Also in forestry, some of these barriers will be hard to tackle and have to do with general developments and trends in society, e.g. the poverty in some non-Annex I countries, and the resulting pressure on land. These are barriers that are outside the climate change regimes, and can possible only be tackled within time frames of multiple decades. However, future climate change regimes may be able to help in reducing these major barriers, in providing income to the local by paying for carbon credits, etc, although the significance of the role of future climate change regimes will depend on many factors.

Other barriers are more closely related to the present climate change regime, and have to do with the uncertainty in rules since the KP came into existence in 1997. These barriers have been discussed in more detail in previous sections, but one needs to be singled out here, one that is also relevant to the agricultural sector: the biosphere is ‘owned’ by millions of land owners. For instance half of European forests is owned by some 10 million private forest owners. The other half of European forest land is publicly owned and in the possession of the forest industry. Hence, it is hard to reach all owners and to set up effective systems to promote climate change mitigation through forestry in Europe.

Table 8, 9 and 10 give an overview of which of the barriers apply to each region and each mitigation measure. Table 8 contains OECD countries; table 9 non-Annex I countries; and, table 10 Economies in Transition.

Table 8: Forestry mitigation measures and barriers affecting implementation for OECD countries

				Economic								Risk		Political			Logistical				Educational		
Activity	**Practice**	**Other management specific barriers**	**Applicability in Annex I countries**	**Cost of land**	**Competing land use**	**Continued poverty**	**Lack of existing capacity**	**(Low) price of carbon**	**Population growth**	**Transaction costs**	**Monitoring costs**	**Delay on returns / slow system response / permanence**	**Leakage/fire/natural variation**	**Lack of political will**	**Slow land planning bureaucracy**	**Accounting rules complex / unclear & loopholes**	**Different or scattered owners / different interests**	**Large areas unmanaged**	**Inaccessible areas**	**Biological unsuitability**	**Stakeholder perception**	**Traditional sector**	**Sector / legislation is new**
OECD NA	Afforestation		medium	x	x			x		x	x	x		x	x	x				x	x		
OECD NA	REDD	*a*	very small					x		x	x		x	x	x	x	x						
OECD NA	Forest Management	*b*	large					x		x	x	x	x	x		x	x	x	x	x	x	x	x
OECD NA	Bio-energy		medium	x	x			x					x	x	x		x	x		x		x	x
Europe	Afforestation		small	x	x			x		x	x	x		x	x	x				x	x		
Europe	REDD	*a*	very small					x		x	x		x	x	x	x	x						
Europe	Forest Management	*b*	small					x		x	x	x	x	x		x	x			x	x	x	x
Europe	Bio-energy		small	x	x			x					x	x	x		x	x		x		x	x
OECD Pacific	Afforestation		small	x	x			x		x	x	x		x	x	x				x	x		
OECD Pacific	REDD	*a*	small					x		x	x		x	x	x	x	x						
OECD Pacific	Forest Management	*b*	small					x		x	x	x	x	x		x	x			x	x	x	x
OECD Pacific	Bio-energy		very small	x	x			x					x	x	x		x	x		x		x	x

a deforestation is a scattered process at a fine resolution.
b the impacts of management changes are probably small, and hard to measure
Large: >500 Mt CO_2 y^{-1}, Medium: 250-500 Mt CO_2 y^{-1}, Small: 100-250 Mt CO_2 y^{-1} by 2030, Very small: <100 Mt CO_2 y^{-1}. All by 2030.

Table 9: Forestry mitigation measures and barriers affecting implementation for non-Annex I countries

				Economic								Risk		Political			Logistical				Educational		
Activity	Practice	Other specific management barriers	Applicability in non-Annex I countries	Cost of land	Competing land use	Continued poverty	Lack of existing capacity	(Low) price of carbon	Population growth	Transaction costs	Monitoring costs	Delay on returns / slow system response / permanence	Leakage / fire / natural variation	Lack of political will	Slow land planning bureaucracy	Accounting rules complex / unclear & loopholes	Different or scattered owners / different interests	Large areas unmanaged	Inaccessible areas	Biological unsuitability	Stakeholder perception	Traditional sector	Sector / legislation is new
C&S America	Afforestation		medium			x	x	x		x	x	x	x	x		x		x	x	x			x
C&S America	REDD		large			x	x	x	x	x	x		x	x	x	x	x	x					
C&S America	Forest Management	*a*	medium				x	x		x	x	x	x	x		x	x	x	x	x	x	x	x
C&S America	Bio-energy		medium			x	x	x					x	x	x		x	x	x	x			
Africa	Afforestation		medium			x	x	x		x	x	x	x	x		x		x	x	x			x
Africa	REDD		large			x	x	x	x	x	x		x	x	x	x	x	x					
Africa	Forest Management	*a*	medium				x	x		x	x	x	x	x		x	x	x	x	x	x	x	x
Africa	Bio-energy		medium			x	x	x					x	x	x		x	x	x	x			
Other Asia	Afforestation		medium			x	x	x		x	x	x	x	x		x		x	x	x			x
Other Asia	REDD		large			x	x	x	x	x	x		x	x	x	x	x	x					
Other Asia	Forest Management	*a*	medium				x	x		x	x	x	x	x		x	x	x	x	x	x	x	x
Other Asia	Bio-energy		medium			x	x	x					x	x	x		x	x	x	x			
Middle East	Afforestation		very small			x	x	x		x	x	x	x	x		x		x	x	x			x
Middle East	REDD		very small			x	x	x	x	x	x		x	x	x	x	x	x					
e East	Forest Management	*a*	very small				x	x		x	x	x	x	x		x	x	x	x	x	x	x	x
Middle East	Bio-energy		very small			x	x	x					x	x	x		x	x	x	x			

a Most regions are unmanaged; this hampers management changes.

Large: >500 Mt CO_2 y^{-1} by 2030, Medium: 250-500 Mt CO_2 y^{-1} by 2030, Small: 100-250 Mt CO_2 y^{-1} by 2030, Very small: <100 Mt CO_2 y^{-1} by 2030

Table 10: Forestry mitigation measures and barriers affecting implementation for economies in transition

				Economic								Risk		Political			Logistical				Educational		
Activity	**Practice**	**Other management specific barriers**	**Applicability in economies in transition**	**Cost of land**	**Competing land use**	**Continued poverty**	**Lack of existing capacity**	**(Low) price of carbon**	**Population growth**	**Transaction costs**	**Monitoring costs**	**Delay on returns / slow system response / permanence**	**Leakage / fire / natural variation**	**Lack of political will**	**Slow land planning bureaucracy**	**Accounting rules complex / unclear & loopholes**	**Different or scattered owners / different interests**	**Large areas unmanaged**	**Inaccessible areas**	**Biological unsuitability**	**Stakeholder perception**	**Traditional sector**	**Sector / legislation is new**
Cent. Planned Asia	Afforestation		medium		x		x	x		x	x	x	x	x	x	x		x	x	x		x	x
Cent. Planned Asia	REDD	*a*	small				x	x		x	x		x	x		x			x			x	x
Cent. Planned Asia	Forest Management		medium				x	x		x	x	x	x	x		x		x	x	x	x	x	x
Cent. Planned Asia	Bio-energy		small				x	x					x	x	x		x	x	x	x		x	x
Countries in Transition	Afforestation		medium		x		x	x		x	x	x	x	x	x	x		x	x	x		x	x
Countries in Transition	REDD	*a*	small				x	x		x	x		x	x		x			x			x	x
Countries in Transition	Forest Management		medium				x	x		x	x	x	x	x		x		x	x	x	x	x	x
Countries in Transition	Bio-energy		medium				x	x					x	x	x		x	x	x	x		x	x

a deforestation is a scattered process at a fine resolution
Large: >500 Mt CO_2 y^{-1}, Medium: 250-500 Mt CO_2 y^{-1}, Small: 100-250 Mt CO_2 y^{-1} by 2030, Very small: <100 Mt CO_2 y^{-1}. All by 2030.

The tables 8 to 10 show that often many barriers apply; there is never a single named barrier. Furthermore, barriers are related which makes it difficult to measure success when having tackled one barrier. In the tropical regions the list of barriers is the longest and generally more of the types of barriers that are outside the climate regimes, e.g. poverty and/or the lack of capacity. Political will is another important non-climate regime related barrier but not exclusively applicable to non-Annex I countries.

3.2.3 Possible measures to overcome barriers to implementation

Climate change regimes have the most options to overcome barriers in the groups: political/bureaucratic, logistical and educational.

Barriers that are probably the most obvious to overcome are those that belong to the group of political/bureaucratic, where policy makers can be held responsible to a large extend for setting up the barriers in the first place. Ideally, simple rules would be available that govern the future treatment of AFOLU, where the full biosphere is included. This would reduce the fine-tuning of rules that has taken place over recent years. Policy makers will have to accept uncertainty to some extend as well, in order to overcome barriers. This may mean that not every single plot of land may need to be identified and inventoried. E.g. one will have to accept general rules, and general (average) carbon sequestration rates, whilst activity data could still be collected in sufficient detail. Detrimental to the full realisation of the mitigation potential in the AFOLU sector would be if rules change every 5 years.

Political will and capacity-related barriers are also an areas where future regimes and policy makers can have a significant impact. Building capacity for instance could be facilitated by cooperation, trainings and by setting-up (bilateral) agreements with others to learn from each other. This, however, requires political will which may emerge once policy makers fully understand how the issue of climate change, including and in particular in relation to AFOLU, is not a single and faraway topic, but something that needs to root in many areas of governance. It has relations to many sectors and stakeholders and once firmly embedded in day to day business, a sound AFOLU sector and its co-benefits will proof its indispensability and usefulness.

Some of the logistical barriers may pose a greater challenge. For instance, ownership structures cannot be changed, or the remoteness of a forest area cannot be overcome easily except by building infrastructure. Regarding the former however, as in agriculture, there is always some level of organisation in these owner groups and new ways of stewardship over natural resources need to be employed. These communities may be the first access to reaching stewardship groups and in setting up consortia of interested forefront players. This requires that the climate change regime is up and running and that the rewards/credits actually reach the local owners and stewards. If this hampers, then goodwill may be lost.

3.3 Bio-energy, bio-products and the relationship with AFOLU

Chapters 3.1 and 3.2 have described different management options to increase carbon stocks in agriculture and forestry, but have also touched upon the potentials that exist to produce sustainable biomass as a replacement for fossil fuels. This section relates the different options to each other, including trade-offs and synergies, and describes how a future AFOLU regime could take a more comprehensive approach, taking into account the role of bio-energy.

Looking at possible relationships between carbon sequestration and carbon substitution (through the use of bio-energy and bio-based products), the following objectives can be identified:

- Where carbon stocks are at low levels initially (for example, croplands with carbon-depleted soils; afforestation and reforestation of non-forest lands), the cultivation of perennial

herbaceous or woody biomass for energy can have a dual benefit: enhancing terrestrial carbon stocks and providing renewable biomass to replace fossil fuels;
- Where existing forests or other carbon-dense land-uses are changed to phase in or increase the production of biomass energy and other bio-products, there may be a depleting effect on carbon stocks. An example would be the conversion of tropical rainforests for palm oil plantations, with the idea of producing liquid bio-fuels. Another example of conflicting objectives is a strategy to maximize carbon stocks on lands subject to forest management under KP Article 3.4, which may not always be consistent with a strategy to maximize production of biomass (as timber and for energy); and,
- Where biomass waste is used as an energy source, the effect on carbon stocks is likely to be limited, whilst there may be other benefits such as the avoidance of methane emissions from anaerobic decomposition.

There are trade-offs and synergies between “substitution” (replacing fossil fuels with bio-energy products) and “sequestration”. Generally, the longer the time horizon of interest, and the more efficiently biomass can be used to replace fossil fuels, the more attractive the productive uses (bio-energy and bio-products) appear (Schlamadinger and Marland, 1999) due to two reasons. First, any sequestration strategy is limited by the amount of land and by the amount of carbon that can be stored on a unit of land (Schlamadinger and Marland, 2000), whereas, for bio-energy or bio-products, the same substitution effect can be achieved upon each harvesting event, without saturation limits. Secondly, while carbon sequestration is a reversible process (“non-permanence”, see section 2.2.1) the replacement of fossil fuels results in more permanent benefits for the atmosphere.

Currently, the production of bio-energy in industrialized countries utilizes mainly agricultural or forestry residues, besides industrial residues, but it is expected that a greater share of dedicated energy crops will be grown specifically for biomass production in the future. However, a large share of such dedicated bio-energy crops is likely to be grown in Eastern Europe and non-Annex I countries[9]. In national GHG inventories, bio-energy is treated as CO_2 neutral in the energy sector, whereas any carbon stock losses in AFOLU (it is independent of where this is, and in the future the distinction Annex I or non Annex I may diminish), due to unsustainable production schemes, would show up in the AFOLU part of the inventory. However, if a large proportion of the biomass is produced in countries without a cap on AFOLU, losses of carbon stocks for bio-energy are not taken into account. This situation may change if and when accounting for traded wood products and biomass fuels in national GHG inventories is revisited.

The full relationship between bio-energy and AFOLU is only slowly beginning to be understood by policymakers and regulators. For example, the fact that only afforestation and reforestation are eligible activities under the CDM has led to a situation whereby most renewable energy and energy efficiency projects in non-Annex I countries with little fossil fuel consumption (but relying on fuelwood, charcoal and other fuels that are often produced in a non-renewable way) are excluded. Such bio-energy projects could include:
- Increasing the efficiency of traditional fuelwood and charcoal production and use, for example through efficiency improvements in cooking stoves;
- Replacing non-renewable wood fuels with renewable biomass fuels (such as biogas for cooking or heating; or wood from sustainable plantations) or other renewable energy such as wind, solar, hydro; and,
- Replacing non-renewable wood fuel or charcoal with clean-burning high-efficiency fossil technologies, such as LPG or kerosene stoves.

To remedy this exclusion of such beneficial projects, the CDM Executive Board has recently adopted a definition of “renewable biomass” (see annex 1 to the minutes of the 23rd meeting of the CDM Executive Board, http://cdm.unfccc.int/EB/023/eb23_repan18.pdf), which stipulates in

[9] Using non-energy bio-products (timber being a prime example, but increasingly other uses of biomass are discussed, including in the context of bio-refineries) is also a way to reduce net GHG emissions to the atmosphere, to the extent that these materials can replace other, more energy and GHG intensive products, such as steel, concrete, glass, aluminium, etc. but this is not dealt with in detail in this report.

detail that certain biomass residues can be considered CO_2 neutral, whereas biomass that is directly drawn from agricultural or forest uses and not produced sustainably (i.e., leads to a depletion of terrestrial carbon stocks) is not admissible in a CDM bio-energy context, unless the losses of carbon stocks are taken into account.

Similarly, the increasing import of biomass into the EU, for meeting Kyoto targets and triggered by a variety of EU directives (renewable electricity directive, liquid bio-fuels directive, EU ETS directive), has ignited discussions about how to demonstrate whether the imported biomass was produced from sustainable sources (ETTF, 2006).

3.4 Concluding comments regarding mitigation options in the AFOLU sector

In this chapter we have dealt with forestry and agriculture as if they were separate sectors. This is of course not the case, they are intensively linked, e.g. through agri-macro economic measures that a country may take, will have an influence on forestry as well. Furthermore they are intensively linked in land-use types as agro forestry, but also in the bio-energy options, e.g. making use of residues from agriculture and forestry, etc. However, since most of the literature is organised by these two major land cover types, and because some of the mitigation options are very different in approach, this distinction was followed here as well.

We confirm here that the economic mitigation potential in forestry and agriculture (including bio-energy) is very significant. The potential is slightly higher in agriculture than in forestry. The largest single potential can be found in forestry through the reduction of emissions from deforestation and forest degradation.

Many barriers prevent successful implementation of measures. Many of these we find originate from the current climate regimes and can be tackled in future regimes. Successful policies should aim at making carbon mitigation a by-product of sustainable development (SD) strategies. It is very unlikely that measures will be taken just because of carbon, or that carbon alone will be able to pay for the full costs of the measures.

From the bio-energy perspective, it may be clear that a future approach to AFOLU should be more integrated with policies that promote the use of bio-energy. If countries were given more flexibility in the way how they implement AFOLU in national accounting (e.g. activity-based accounting), they could better balance the objectives of productive uses versus carbon sequestration. A broader inclusion of AFOLU (on a voluntary basis) in non-Annex I countries may also help to provide greater incentives for energy-sector activities related to traditional biomass uses, such as efficiency enhancement and fuel switching.

4 Assessment criteria

The previous chapters have assessed what the main barriers are to full realisation of the climate change mitigation potential of AFOLU and quantified that potential for different parts of the world. It is now time to determine on the basis of that knowledge what criteria would need to be met by a future climate change mitigation regime to tap into a greater proportion of the mitigation potential of the AFOLU sector.

4.1 Generic assessment criteria

A number of authors have evaluated proposals for future international climate regimes based on a set of evaluation criteria, including Torvanger and Godal, 1999; Philibert and Pershing, 2001; Berk et al., 2002; den Elzen, 2002; Torvanger and Ringius, 2002; Aldy et al., 2003; den Elzen et al., 2003; Höhne et al., 2003; Bodansky, 2004; Torvanger and Godal, 2004; Höhne et al., 2005; Baron and Ellis, 2006; Höhne, 2006.

There is broad agreement that criteria for assessing future international climate agreements can be divided into four groups: environmental criteria, economic criteria, distributional/equity criteria and technical/institutional criteria, although definitions of these categories may differ. A detailed synthesis of the specific criteria from the above mentioned publications under these four broad categories based on Höhne et al., 2005, is included in Appendix 2.

4.2 Assessment criteria specific to AFOLU

Several studies evaluated options for land use, land-use change and forestry under a future regime according to a list of criteria, which include Trines, 2004; Schlamadinger et al., 2006; Freibauer et al., forthcoming.

These assessments have added criteria or objectives that are specific for the AFOLU sector and the current rules for it. Table 11 summarizes these AFOLU-specific criteria specific and describes briefly the key questions addressed by each criterion. For example the future rules should be based on sound science, should contribute to the conservation of biodiversity and protect areas that have intensive feedback with regional and larger scale climate. In addition they should address specifics of the emissions from this sector: the inter-annual variability, the different time scales for enhancement and loss of C stocks and the possible non-permanent nature of carbon sequestration. Lastly, they highlight that future rules should consider the need to factor out direct human-induced from indirect human-induced and natural effects (see also Chapter 2).

The criteria on the list may be of varying importance to the various players or may even be mutually exclusive but considering the possible role of AFOLU to the achievement of the ultimate objective of the UNFCCC, it is clear that the overruling criterion should be the encouragement of sovereign nations' participation.

Table 11: Overview of criteria to assess approaches for the inclusion of AFOLU in future climate regimes

Category of criteria **Sub-criteria**	**Key question**
Environmental criteria	***Can the approach contribute optimally to safeguard the fulfilment of the ultimate objective of the Convention (Article 2), i.e. stabilization of greenhouse gas concentrations that prevent dangerous interference with the climate system?***
(1) Putting emphasis on environmental effectiveness	Does the approach put environmental effectiveness as the core of future rules
(2) Comprehensiveness of system	Is the approach a comprehensive system that includes the most important sources and storage pools of GHG gases, is it comprehensive over time and in space, also dealing with inter-annual variability?
(3) Addressing Non-permanence	Does the approach adequately account for losses of carbon after its storage had been accounted for? Does the approach consider that sequestration can be slow while emissions can be fast, e.g. through fires?
(4) Avoiding or accounting for leakage effects	Does the approach minimize that emission reduction efforts in one activity are negated by increasing emissions in another activity or at another place? If such leakage is not prevented, is it adequately accounted for?
(5) Avoiding unintentional “hot air” or “windfall profits”	Does the approach prevent that a country unintentionally receives more emission rights than it would emit under a business-as-usual scenario?[10]
(6) Co-benefits: sustainable development and biodiversity	Does the approach create synergies with sustainable development or can it domestically cause conflict over development pathways
(7) Avoiding irreversible damages	Does the approach promote taking collective responsibility to avoid irreversible loss of natural resources?
(8) Protection of areas important to climate	Does the approach protect areas which have especially intensive feedback with regional and larger scale climate
Economic criteria	***Can the approach ensure that global emission reduction efforts can be achieved in an efficient and cost-effective way and lead to positive economic side effects?***
(1) Minimizing negative economic effects	Does the approach foster innovation and competition, keeping down costs? Does the approach allow flexibility to harvest temporal and geographical differences in marginal costs (e.g. through "banking" and trading), giving countries sufficient flexibility to reach their commitments while minimizing aggregate costs?
(2) Promoting sustainable economic growth	Does the approach encourage positive economic growth while driving emissions down/sequestration up?
(3) Address competitiveness concerns	Does the approach minimize distortions through different national requirements on emissions for internationally competing industries (e.g. in the food industry or bio-energy sector)
(4) Innovation/certainty about costs	Does the approach stimulate and encourage innovation, which is the most crucial element in avoiding the risk of unexpected high costs, and/or unintended unevenly distributed burdens?
Distributional and equity criteria	***Does the approach satisfy major equity principles so that it is seen as fair and just?***
(1) Meeting equity principle “Needs”	Is the opportunity given to all countries to satisfy their basic development needs?
(2) Meeting equity principle “Capability”	Are the countries required to act those that have the capability to do so or are the countries not being capable on their own assisted in order to obtain this capacity?

[10] Some argue that a regime may intentionally include surplus allowances (“hot air”) as a compensation or incentive mechanism.

Category of criteria **Sub-criteria**	**Key question**
(3) Meeting equity principle "Equal rights"	Does the regime take into account the principle of equal rights of all people to use the atmosphere and to have access to natural resources?
(4) Meeting equity principle "Comparable efforts"	Does the regime anticipate comparable efforts from similar countries to mitigate climate change?
(5) Meeting equity principle "Sovereignty"	Does the approach take into account that states are sovereign, can rule over the use of their land, and are different national circumstances taken into account?
(6) Compensation of those stakeholders incurring costs/owning rights	Are the profits of emission reductions/removals benefiting those that contributed to achieving it (national level)? Are the "rightful owners" compensated for their role as guardians / stewards of their natural resources
Technical and institutional criteria	***Is the approach designed in an efficient way?***
(1) Based on sound science	Are the methods based on latest available scientific information on the carbon cycle?
(2) Factoring-out of natural and human induced effects	Does the approach separate or take account of natural, indirectly and directly human induced effects?
(3) Can build upon and use many agreed elements of the existing UNFCCC/Kyoto system	Can the approach be built upon or use key elements of the UNFCCC/Kyoto system such as a) basket of gases, b) Kyoto mechanisms, c) national systems and d) negotiation structure?
(4) Implementation requirements	Is the approach built in a way that it avoids or limits fraud and corruption?
(5) Moderate political requirements for the negotiation process	Is the approach simple and requires a low number of separate decisions by international bodies? Do the decisions cover a clear and manageable future time frame?
(6) Inherent stability of the regime	Is the approach flexible enough to ensure countries' continued participating also in the case of unexpected events? Is the risk minimised that countries "walk away" from the agreement? Is it self-propelling?
(7) Increasing level of participation	Does the approach promote countries to increase their level of participation in the regime?

At this stage of the report the following items have been discussed:

- Where we "went wrong" in the past;
- What the climate change mitigation potential is in terms of types of activities that can be undertaken and where that potential is located predominantly geographically; and,
- What criteria a future climate change mitigation regime should meet to optimise the broadest participation of countries in the regime and the realisation of the biggest possible share of the potential in a fair and equitable way.

The next step is to assess what options are available in terms of climate change mitigation regimes.

5 Climate Change Mitigation Regimes

This section provides an overview of the essential elements of a future international agreement on climate change. It includes a review of elements discussed in published literature and in various informal processes. Bodansky, 2004; Kameyama, 2004; Blok et al., 2005; Philibert, 2005 provide overviews of the huge number of approaches that are being proposed. This chapter concentrates on those elements that are specifically relevant for the AFOLU sector.

The most important elements for designing an international regime for mitigation of climate change include the following elements, which provide a structure for this chapter:

Types of commitments and ways of participation: Currently, industrialised nations and some transition economies participate in the Kyoto Protocol through binding quantified emission limitation or reduction commitments, creating a tradable commodity. Trading emissions, or emission reductions has proven a powerful mechanism. In future other types of commitments and ways of participation could be applied as well, e.g. intensity targets, non-binding targets or policies and measures, some of which may be integrated in market-based frameworks.

Differentiation of emission targets – allocation: For proposals that include emission reduction targets it is necessary to set the level of the reductions for individual countries. How should this “burden sharing” or allocation level be determined? Against what base year or base period should that be measured? And should that base year or base period be the same for every participating nation? Etc. etc. General approaches to the differentiation of targets are listed in appendix 3. Discussing them individually is beyond the scope of this report.

Participation: the group of nations that limit or decrease their emissions needs to be broadened and the cut in absolute global emissions needs to deepen if dangerous climate change is to be prevented. Hence, industrialized countries’ absolute emissions need to decline in the very near future and developing countries’ emissions must not rise as much as currently expected and in the longer run these emission levels must also decrease: an increasing number of countries needs to take on increasingly stringent commitments. Incentives to bring about this broadening and deepening of participation are discussed in later sections.

5.1 Types of commitments – WAYS OF PARTICIPATION

Several options are proposed in the following sections for countries under a future climate agreement. It is possible that an international framework for the post-2012 period is not limited to one type of commitment but that various options are possible. In such a case countries could choose the way of participation in the regime in a way that suits best. This is discussed in more details in relation to AFOLU in the next chapter.

The options presented here are not specific to AFOLU and are ordered by decreasing comprehensiveness. Only the last three options (sustainable policies and measures; transnational-sectoral agreements; and technology research and development) are approaches not relying on emissions trading as a market-mechanism to stimulate action, and therefore, other incentives may need to be employed.

5.1.1 Legally binding quantified emission limitation and reduction commitments (QELRC):

A logical follow up of the Kyoto Protocol would be to maintain the current structure under which some countries have legally binding national absolute emission reduction commitments.

In the current system some of the Parties that have ratified the KP have legally binding QELRCs but only certain LULUCF activities and limited amounts of net removals may contribute to the determination whether the target is met. Several issues would need to be decided for the future rules, in particular regarding further expanding or condensing the list of activities or practices that are included – or even consider to include all (managed) lands - and the accounting rules.

Another possibility could be to create a separate QELRC for the AFOLU sector if that would help to encourage participation. It could even be envisaged that some countries only have a QELRC for AFOLU and not for other sectors, enabling current non-Annex I countries to increase their level of participation in the regime (see also appendix 4). It could also allow temporarily for modest growth targets if, for instance, non-Annex I countries foresee serious growth of their livestock or agricultural emissions in a business as usual scenario.

In terms of a growth target, EDF (1997) and others (e.g. Dudek & Goffman, 1997; Dudek et al. 1998; Oppenheimer & Petsonk, 2004) have proposed a "Development Premium" or "Environmental Capital Endowment", which is basically allocating early adopters of a QELRC an initial endowment of “environmental capital” in the form of assigned amount units (AAUs) set at a level at or above their business as usual emissions trajectory, based on reasonable macroeconomic analysis of expected emissions, or set at a level equal to their historical emissions plus a fixed percentage for growth. The allocation provides a revolving fund for financing for mitigation; the more emissions are reduced below that set level, the more surplus emission allowances are generated.

5.1.2 Intensity targets[11]:

As alternative to absolute national emission targets it has been proposed that emission targets are expressed as variables of e.g. GHG emissions per unit of GDP or of physical production, e.g. emissions per tonne of steel produced. It has to be realised that reductions in emissions intensity do not necessarily correspond to reductions in absolute emissions for a nation.

For the AFOLU sector the link of emissions to national GDP is not always apparent: while in some nations deforestation for instance may occur in tandem with increases in GDP, in other nations drivers of deforestation are associated with poverty/declining per capita income. Other physical variables do not seem to be relevant in this context. Therefore, intensity targets do not seem appropriate for the AFOLU sector.

5.1.3 Dual targets, target range or target corridor (Philibert and Pershing, 2001; Kim and Baumert., 2002):

As the future emissions are uncertain, two emission targets are defined: (1) a “selling target”: allows countries to sell into an international market if their national emissions fall below this level; and (2) a “buying target” (proposed to be set significantly higher than the selling target) which, if exceeded, would require nations to purchase allowances from the international market.

As AFOLU emissions and removals per country also depend on natural and indirect human-induced effects such as droughts, storms, fires and pests, such targets or the corridor would need to be limited to specified levels of emissions and removals resulting from the specific activities or practices undertaken in AFOLU. As practicable methodologies to factor out such natural and indirect human-induced effect are hitherto non-existent, this type of commitment may be impossible to implement for AFOLU (see also section 2.2.6).

[11] This section is based on Hargrave et al., 1998; Baumert et al., 1999; Lutter, 2000; Müller et al., 2001; Bouille and Girardin, 2002; Chan-Woo, 2002; Lisowski, 2002; OECD/IEA, 2002; Ellerman and Wing, 2003; Höhne et al., 2003; Müller and Müller-Fürstenberger, 2003; Jotzo and Pezzey, 2005; Pizer, 2005; and Kolstad, 2006.

In the case of reducing emissions from deforestation and/or forest degradation however, Schlamadinger et al. (2005) propose the use of a corridor. Such a corridor would reflect: the uncertainty of future emissions; the risk of countries easily falling out of a mechanism if their emissions exceed a pre-defined target; and, the risk of large windfall profits arising if emissions happened to be significantly below the target even without specific measures.

5.1.4 „No lose“, “non-binding”[12] or one way target (Philibert, 2000):

A less stringent type of emission target would be that excess emission allowances can be sold if the target is reached, while no additional emission allowances would have to be bought if the target is not met. However, the target would be set at or below the business as usual scenario. This structure offers incentives to participate for countries not prepared to take on full commitments, but still interested in joining the global trading regime. In any “no lose” target, a global market price would only exist if there is other demand – i.e., countries that have binding targets and allocations below BAU levels.

Such no lose targets could apply for the national total emissions (including AFOLU) or for the AFOLU sector only, based on a sectoral reference level (see also the “Compensated Reduction” proposal discussed in chapter 8). This could be a first step for a country with a high or growing emissions level in this sector to participate in the global system. It could be attractive for instance for countries with high emissions from deforestation that want to participate in the system (Persson and Azar, 2004) or countries where the agricultural sector is growing, resulting in economic growth and more emissions (see also appendix 4). Obviously the danger arises that the business as usual scenario turns out to be an underestimate, in which case the country is further from compliance than anticipated and may give up on any attempts to reduce emissions.

5.1.5 Sectoral CDM or sectoral crediting mechanism[13]:

Very similar to the no lose target for a particular sector would be a sectoral CDM: if emissions of a particular sector are below a baseline, excess allowances can be sold. This measure could be seen as an extension or broadening of activities currently allowed under the CDM.

AFOLU activities under the KP’s CDM are restricted to afforestation and reforestation and are accounted using temporary units that have to be replaced once expired. One option would be to allow the total AFOLU sector of a country to be a large CDM project. A Sectoral CDM would be effectively the same as a ‘no lose target’ at BAU level, only that it would be administered and decided through the CDM Executive Board and not the COP/MOP. This approach would necessitate, however, political agreement over projections of business as usual emission/removal levels, which could prove challenging. Moreover, credits generated through the CDM can be added to the emission allowances of the acquiring country, hence, this measure would not result in additional emission reductions at a global level. An option within this general approach would be to also allow the crediting of only one particular activity or practice (e.g.: reducing deforestation or CO_2 emission reductions in agriculture).

5.1.6 **Sustainable policies and measures** (Winkler et al., 2002; Baumert et al., 2005):

While preparing and implementing development plans, countries would integrate policies and measures to sustainably reduce greenhouse gas emissions (e.g., implementation of mass transit systems or measures improving fire control). The commitment is usually not framed in terms of emissions reduced, but in terms of the policies implemented.

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12 “Non-binding” targets are also interpreted by some as indicative limits that do not allow trading at all.

13 References include: Philibert and Pershing, 2001; Samaniego and Figueres, 2002; Bosi and Ellis, 2005; Ellis and Baron, 2005; and Sterk and Wittneben, 2005.

For the AFOLU sector some developing countries could commit to certain policies that are aimed to reduce emissions from unsustainable agriculture or forestry, for instance through appropriate land-use planning (see also appendix 4). Individual policies and measures for land managers could either be voluntary or mandatory, and targets could either be qualitative or quantitative. Compliance could be rewarded by for instance, the international community with external financial assistance from: Foundations; NGO; ODA: bi- or multi lateral; through implementing agencies (UNDP, GEF, etc.); or public-private partnerships.

5.1.7 **Trans-national sectoral agreements** (Watson et al., 2005):

It has also been proposed that separate international agreements should be agreed for separate sectors. For example, energy efficiency standards for cars could be agreed by governments and car manufacturers, or emissions standards could be agreed for the global cement industry.

For the AFOLU sector, the agreement could relate e.g. to a certain level of carbon stock changes and non-CO_2 GHG emissions in the respective countries: e.g. a forest treaty or convention, not linked to the UNFCCC or KP. An option along these lines is beyond the scope of this report as it would not involve the COP or COP/MOP.

5.1.8 **Technology research and development** (Edmonds and Wise, 1999; Barrett, 2003):

Countries could cooperate on enhanced coordinated technology research and development.

In the context of AFOLU a large number of areas for cooperation on research and development exist. In the area of emission reductions and removals most technologies are quite well know, although in the agricultural sector a lot of progress can still be made with for instance livestock management or the use of improved cultivars. In the area of monitoring however, many challenges still remain, e.g. : Remote Sensing (RS) technologies (radar, lidar) or applications (e.g. Geographic Information Systems (GIS)), modelling (e.g. GEOMOD for projections of both the intensity and location of deforestation in future) and monitoring technologies and practices, including setting up national systems. In fact, technical cooperation may well be essential for, for instance, moving forward the debate on including reductions in emissions from deforestation and forest degradation in a future climate change mitigation (CCM) regime.

5.1.9 Summing up, options that seem possible for the AFOLU sector are:

1. quantified emission limitation and reduction commitments;
2. no lose targets;
3. a sectoral CDM or crediting mechanism;
4. an expanded list of eligible CDM project activities;
5. sustainable policies and measures; and,
6. technology research and development.

Chapter 6 will elaborate these options further.

5.2 Participation in FUTURE CLIMATE CHANGE MITIGATION REGIMES

Many studies[14] have proposed systems whereby a differentiation is made between groups of countries that participate in the same system but are located in different stages and have stage-specific types of targets. Usually it is proposed that countries move between stages as a function of indicators. Of the long list of indicators that have been proposed, the most frequently suggested are per capita emissions, emissions per unit of GDP or a combination of the two. For AFOLU emissions per GDP do not seem appropriate as emissions and/or removals in the AFOLU sector are usually not linked to GDP.

Table 12 provides numbers illustrating the importance of LULUCF emissions in the emission profile of a range of Annex I and non-Annex I countries. High positive numbers in the column "Percentage of LUCF emissions compared to emissions of other sectors" show a relative high importance of emissions from land use in the respective country, while high negative numbers show that a relatively big proportion of non-LUCF emissions can be compensated by a sink in the land-use sector. For several countries (e.g. Indonesia, Papua New Guinea), the inclusion or exclusion of LUCF emissions substantially changes the total and per capita emissions. Therefore, the use of different indicators might lead to different results regarding the attribution of countries to stages.

For this example, the dataset from Houghton (2003) has been used which may be different from other datasets on emissions from LUCF.

[14] Claussen and McNeilly, 1998; Gupta, 1998; Berk and den Elzen, 2001; USEPA, 2002; Blanchard et al., 2003; CAN, 2003; Criqui et al., 2003; den Elzen et al., 2003; Gupta, 2003; Höhne et al., 2003; Ott et al., 2004; Blok et al., 2005; den Elzen, 2005; den Elzen et al., 2005b; Höhne et al., 2005; Höhne and Ullrich, 2005; Michaelowa et al., 2005; and Den Elzen et al., 2006.

Table 12: Increases in GHG per capita emissions when LUCF is included for Annex I and non-Annex I countries

Country ANNEX I only	GHG without LUCF ($MtCO_2$–eq) (A)	GHG with LUCF ($MtCO_2$–eq) (B)	% of LUCF emissions compared to non LUCF emissions (negative sign = removal) C=(B-A)/A*100	Per capita GHG emissions without LUCF (tCO_2-eq/ capita)	Per capita GHG emissions with LUCF (tCO_2-eq/ capita)
Australia	515	550	7	26,20	27,98
Austria	92	79	-14	11,35	9,77
Belarus	72	56	-23	7,24	5,61
Belgium	148	144	-2	14,28	13,95
Bulgaria	69	62	-10	8,79	7,89
Canada	740	696	-6	23,60	22,20
Croatia	30	14	-51	6,73	3,26
Czech Republic	145	142	-3	14,26	13,88
Denmark	75	74	-2	14,04	13,82
Estonia	21	13	-41	15,75	9,33
Finland	86	68	-21	16,46	13,04
France	557	505	-9	9,37	8,48
Germany	1018	982	-4	12,33	11,90
Greece	138	132	-4	12,51	12,00
Hungary	83	79	-5	8,19	7,80
Iceland	3.0	2.8	-7	10,45	9,72
Ireland	68	67	-1	17,19	16,94
Italy	570	488	-14	9,88	8,46
Japan	1339	1339	0	10,51	10,51
Latvia	10.5	2.3	-78	4,50	1,00
Liechtenstein	0	0	0	7,65	7,65
Lithuania	17	10	-41	4,96	2,94
Luxembourg	11.3	11.0	-2	25,43	24,80
Monaco	0	0	0	3,99	3,99
Netherlands	215	218	1	13,31	13,48
New Zealand	75	52	-30	19,13	13,32
Norway	55	34	-38	12,07	7,46
Poland	370	320	-14	9,68	8,36
Portugal	81	88	9	7,83	8,51
Romania	143	126	-12	6,55	5,78
Russian Fed.	1873	1664	-11	13,00	11,55
Slovakia	52	47	-9	9,61	8,72
Slovenia	20	14	-28	9,93	7,14
Spain	402	362	-10	9,83	8,85
Sweden	71	49	-30	7,91	5,50
Switzerland	52	50	-3	7,17	6,92
Ukraine	527	471	-11	10,82	9,67
United Kingdom	651	650	0	10,99	10,97
USA	6894	6072	-12	23,91	21,06

Country Non-Annex I only	GHG without LUCF ($MtCO_2$–eq) (A)	GHG with LUCF ($MtCO_2$–eq) (B)	Percentage of LUCF emissions compared to emissions of other sectors[15] (C=B-A/A*100)	Per capita GHG emissions without LUCF (tCO_2-eq/ capita)	Per capita GHG emissions with LUCF (tCO_2-eq/ capita)
Indonesia	495	3058	518	2.4	14.8
Brazil	841	2213	163	4.9	13.0
Malaysia	168	867	416	7.2	37.3
Myanmar	82	508	520	1.7	10.6
Venezuela	241	385	60	10.0	15.9
Congo, Dem. Repub.	53	370	598	1.0	7.3
Nigeria	163	357	119	1.3	2.8
Colombia	161	267	66	3.8	6.3
Peru	70	257	267	2.7	9.9
Zambia	19	254	1.237	1.8	25.2
Philippines	131	226	73	1.7	2.9
Papua New Guinea	9	155	1.622	1.7	30.1
Nepal	31	154	397	1.3	6.7
Sudan	100	130	30	3.2	4.2
Cambodia	69	125	81	5.7	10.4
Bolivia	39	123	215	4.7	14.7
Côte d'Ivoire	17	108	535	1.0	6.7
Cameroon	27	104	285	1.8	7.0
Ecuador	40	99	148	3.1	7.8

Source: For non-Annex I Parties: LUCF from Houghton which includes only land-use change. All other sectors from IEA and EDGAR as taken from the CAIT tool (WRI, 2006). For Annex I Parties: UNFCCC emission data 2003 where LUCF usually includes removals by agricultural soils. Population year 2002 as taken from the CAIT tool (WRI, 2006)

Another way of presenting data on this issue is provided by the Climate Analysis Indicator Tool (CAIT) of the World Resources Institute (WRI) and shown by figure 9 and 10 below. This shows the list of top 30 emitting countries in the LUCF sector ranked according to total emissions including LUCF and ranked on the basis of LUCF emissions. The numbers for these two figures are taken from a different data set that those used above. Those for Annex I are taken from the UNFCCC database and are emission levels from the 2003 GHG inventories. These are different to those from Houghton as Houghton does not include all sources and sinks. The UNFCCC numbers are also incomplete but in a different way. Therefore, the figures should be considered merely illustrative.

What this indicates is that all but 2 countries in the top 10 are developing countries without QELRCs. These top 10 include some of the most important emerging economies, such as Indonesia, Brazil, China and India, which by 2020 will have absolute emission levels that are equal to or exceed the levels of the current biggest polluters of the world. This underlines the importance, the urgency and essentially, the necessity, of broadening and deepening the participation of non-Annex I countries through the inclusion of the AFOLU sector, if global climate change is to be tackled effectively.
Some countries may argue that in order to develop forests are physically in the way or are an easy source of income that can contribute to development. This may be perceived equitable and just since Annex I countries may have done so in the past and in doing so greatly contributed to the current problem. From the pragmatic point of view, and the perspective of global survival on the other hand, a fair and rewarding way of including ALOFU emissions in the tropics has to be found.

15 Data for A and B are rounded; therefore, rounding errors may occur as compared to C.

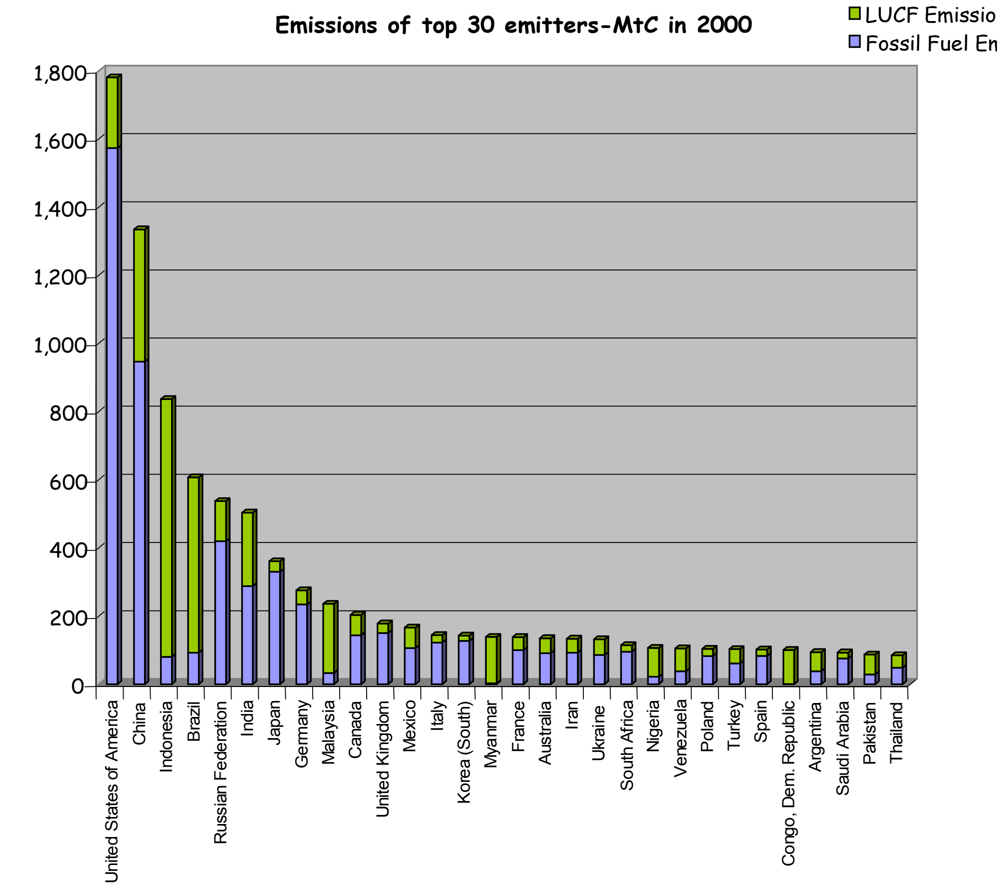

Figure 9 Top 30 emitting nations, 2000 (different dataset compared to previous table).

Or, if countries are ranked according to their LUCF emissions...

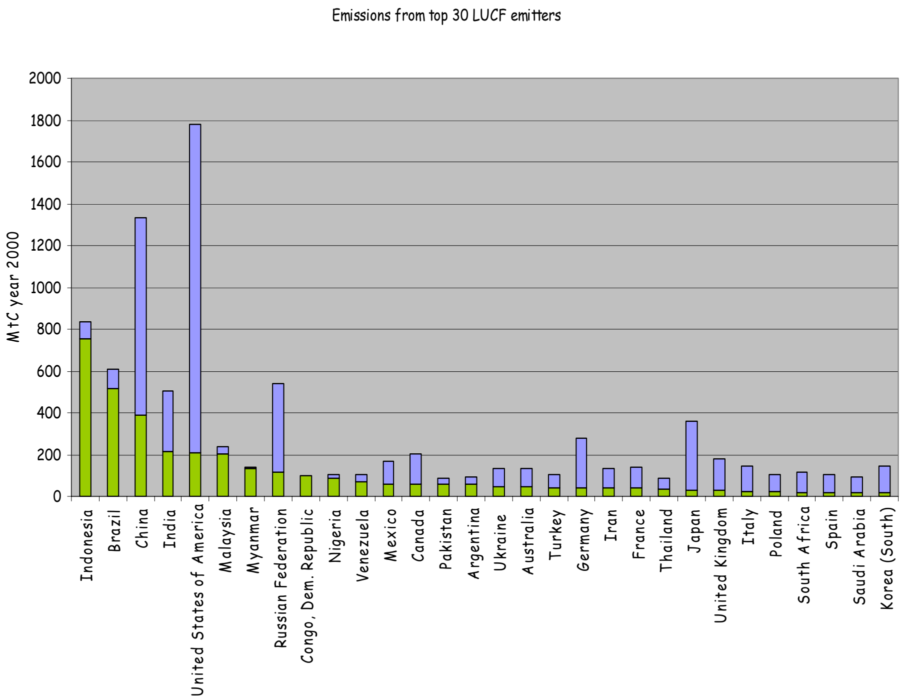

Figure 10: Same top 30 emitting nations, 2000, ranked according to LUCF emissions.

Appendix 4 contains a limited amount of quantitative projections for the top 4 countries.

6 Options for the AFOLU sector

The previous section concluded by illustrating that the participation of particular countries in a future climate change mitigation (CCM) regime through the inclusion of the AFOLU sector is important and therefore, needs to be enhanced. However, it is unreasonable to expect these countries to take on a QELRC as if they were Annex I Parties, not least because the level of (economic) development and the institutional and mitigative capacity of this list of countries varies so strongly that it is impossible to find a one-size-fits-all solution: tailor-made options need to be developed for specific groups of countries.

As mentioned in section 5.1.9, a list of policy options to encourage broader participation could include, but is not limited to: quantified emission limitation and reduction commitments; no lose targets; a sectoral CDM or crediting mechanism; an extended list of eligible CDM activities; sustainable policies and measures; and technology research and development. The policy options are not mutually exclusive and do not necessarily follow naturally one after the other. For instance, sustainable policies and measures, technology research and development and a no lose target can all be deployed simultaneously by or within one country. Therefore, the list is a suite of policy options from which a country can choose one or more options. In the following sections these policy options are elaborated in more detail in increasing order of stringency.

6.1 Policy Option 1: Capacity Building, Technology Research and Development

6.1.1 The concept

If countries do not have the capacity to inventory, monitor and control particular emissions and removals in the AFOLU sector, the willingness to commit to a target in that area will understandably be very low. Therefore, a first concern should be to assist countries to build the capacity to set-up national systems to inventory and monitor emissions and removals from AFOLU. To start to control the sector's emissions and removals assistance should be provided to develop or improve and implement appropriate land-use planning and land-use policies.
Capacity building is not a new area of work under the UNFCCC and its KP. When designing a future CCM regime, however, this specific area of work could be emphasized for the AFOLU sector.

A second step would then be to concentrate on the more specific Technology Research and Development. For instance in the area of: low emission management practices (e.g. livestock management or improved cultivars in forestry or agriculture), Remote Sensing (RS) technologies (radar, lidar) or applications (e.g. Geographic Information Systems (GIS)), modelling (e.g. GEOMOD for projections of both the intensity and location of deforestation in future) and monitoring technologies and practices.

Ways and means that we are currently already familiar with under the UNFCCC and its KP (e.g. "Transfer of Technology", Joint Implementation, but also public – private partnerships) can serve as a model for this stage when designing a future CCM regime.

It cannot be emphasized enough that the capacity of developing countries to inventory, monitor and control AFOLU emissions and removals is essential to increase their level of involvement in a future CCM regime, and is essential to ever achieve the ultimate objective of the UNFCCC. Besides that, appropriate land-use planning contributes to the in-country sustainable development process. Therefore, this type and level of (technical) cooperation and assistance is of critical importance.

6.1.2 Funding and Benefits

Submissions that were made by Parties this year (UNFCCC, 2006) in the context of agenda item 6 (Reducing Emissions from Deforestation in developing countries) suggested that bilateral and multilateral ODA be made available to help countries build technical capacity for addressing emissions from deforestation. This suggestion could well be amplified to cover the entire AFOLU sector. Furthermore, many of the Parties that made submissions, favoured some type of market mechanism as the means of providing compensation to countries that reduce deforestation, and more countries appeared to favour this approach at the Workshop held in Rome in August 2006, although a few also prefer providing compensation via ODA, bilateral and multilateral agreements, public-private partnerships or other mechanisms.

Under UNFCCC Articles 3.3, 3.4 and 4.7, Parties could coordinate assistance. In the case of Reducing Emissions from Deforestation (and possibly forest degradation) or wetlands this could be supplemented with debt-for-nature swaps. Other options include *inter alia* revolving funds, advanced payments, and new donor programmes. Moreover, some donors and some recipient countries might agree that, if for instance carbon saving from reducing emissions from deforestation were to become tradable in the future, and if the development assistance enabled the recipients to earn tradable units, then the recipients would transfer those units to the donors at an agreed price.

Could development assistance provide significant compensation to nations that reduce net emissions from the AFOLU sector? Concentrating on deforestation for a moment, and depending on the size of the donations and the size of the recipient country, some donations might be of sufficient size to provide significant compensation. Early analyses indicate, however, that the available compensation would be much larger via the market. For example, taking a weighted average of carbon market prices in 2004-2005 of $5.63/t/$CO_2$, if Brazil reduced its deforestation by 10% over five years, these reductions could earn $495 million per year, or $2.47 billion over five years. (Moutinho, Schwartzman, & Santilli, 2005)
The benefits for non-Annex I countries to apply this option would be the access to funding and (technical) assistance to build-up their capacity and national system.

6.1.3 The countries

This stage will be especially relevant to the Least Developed Countries (LDCs) and those countries with a relatively low technical and institutional capacity to inventory and monitor AFOLU emissions and removals.

6.2 Policy Option 2: Sustainable Policies and Measures (P&Ms)

6.2.1 The concept

In addition to using policy option 1, countries could implement policies aimed at sustainably reducing emissions and enhancing removals in the AFOLU sector. The commitment would basically consist of preparing and implementing climate-friendly national development plans, for instance, reducing emissions from unsustainable agriculture or forestry through appropriate land-use planning. Sustainable P&Ms are probably required in combination with most other policy options as well, as action is not normally undertaken without some form of coercion.

Options range from wholly voluntary to wholly mandatory, e.g.: the commitment to implement policies is voluntary and there is no specified methodology for meeting the target; to a situation whereby the government establishes a mandatory commitment and specifies how farmers and foresters have to achieve the commitment; and anything in between.
Furthermore, the commitment can be qualitative or its effect on emissions can be specified but quantified emission reduction and removals (i.e. sectoral baseline) would not necessarily result

in tradable emission permits. If sustainable P&Ms are not implemented, other incentives may be required to persuade land managers to adhere to methods that favour climate change mitigation.

Table 13 illustrates how a suite of sustainable P&M options could be employed to provide incentives. These options could be useful to both non-Annex I countries and Annex I countries. The table provides examples of such options as they are proposed or implemented in the US.

Table 13: Sustainable Policies and Measures: a typology of options for addressing agricultural sinks CCM with examples from the US.

Target	Method	Example	Strengths, Weaknesses and Costs
Voluntary	Flexible	Voluntary programme: US Gov't-supported research on biotic carbon sequestration at abandoned coal mines. The Gov't role is inspirational and to provide research funding	S: Low cost to government W: CCM difficult to quantify. Few incentives for participation.
		Extension service provides no-till info; gov't maintains a carbon registry. S. 1255, proposed US Carbon Sequestration and Reporting Act (introduced 2001, not enacted). The Gov't role would be to provide information.	S: Moderate cost to gov't. W: Few incentives for participation.
	Specified	Gov't payments for designated agriculture practices. US Conservation and Wetlands Reserve Programs. S. 1066, proposed US revolving loan program for forest carbon activities on non-industrial private forest lands (2000, not enacted). The Gov't role would be the provider of payments.	S: Farmer knows what practices to use. W: CCM difficult to quantify
Mandatory	Flexible	Biofuel production mandates, enacted in US (2005) and EU (2003). The Gov't role is to establish the mandate.	S: Gov't quantifies CCM. W: No guaranteed market for biofuels.
	Can be both flexible or mandatory	Mandatory sectoral emission targets for agriculture; gov't may also specify practices. There is no example to date in the US but the Gov't role would be to establish the mandate.	S: Emissions from agricultural sector are capped. W: Farmers likely to oppose caps; technology practices reduce innovation, drive-up the costs.
Mandatory qualitative	Specified	Gov't mandates best available agricultural on-farm technologies and practices and runs a compliance regime.	W: High cost to gov't. W: Gov't mandates discourage innovation. Cost: Gov't must inspect each farm to determine compliance.
Mandatory	Flexible	Farmers & forest dwellers or managers who boost CCM can earn tradable units. US: S. 2724, proposed Clean Air Planning Act of 2006. UK: National Farmers' Union proposal. Compensated Reduction of Forest Destruction/Degradation. The Gov't's role would be to establish rules for quantifying CCM.	S: Low cost to gov't; gov't quantifies CCM. Cost: Gov't must develop clear quantification rules.

As options become more prescriptive, the need for a serious compliance and reward system increases. If payments are made by governments to individual landholders, an internal system of subsidies or internal carbon credits is introduced. For such a system of tradable credits to work, a demand for the units is required. A process could be envisaged by which transitions could be made from trading regimes which are 100% domestic (for instance financed by ODA, public-private partnerships, or bi/multilateral assistance), to systems with links between two or more domestic trading regimes, to trading regimes with much larger numbers of participating countries as under Article 17 of the KP.

6.2.2 Funding and Benefits

Sustainable P&Ms can be funded in different ways. In industrialised countries some could be funded through the regular national budget planning, for instance voluntary programmes or extension work, but the same P&Ms could be funded in developing countries through bilateral agreements, multi-lateral development channels or through specific programmes of implementing agencies (World Bank, UNDP, GEF, etc.), such as *inter alia*: the integrated land management programme of the World Bank or the Partnership Programme for Sustainable Land Management of the GEF.

In the case of mandatory targets, in particular when methods are specified, it is reasonable to compensate farmers and foresters for either their efforts or declines in yield associated with the methods: "command and control" measure without (financial) compensation have a poor implementation track record. Thus, compliance should be rewarded by the government somehow.

The benefits for developing countries to implement sustainable P&Ms is they could start to implement appropriate land-use planning whilst at the same time develop economic activities in a more sustainable manner. This has great advantages for both the population as well as the country as a whole. When successful in this stage, the next stage comes into play at a time that the country can feel comfortable with controlling land-use activities on its territory. It is no longer dependent on help from outside to drive economic sectors in a desirable direction.

6.2.3 The countries

Countries prepared to participate in the post-2012 climate regime in this stage, would already have a satisfactory technical and institutional capacity to monitor and inventory AFOLU emissions and removals, but would not be able yet to take over a national emission targets comprising the AFOLU sector. For political reasons, some countries have so far rejected the idea of any kind of emission target for the post-2012 period and so they may not wish to employ policy options 3 or 4, but they may be interested in introducing sustainable P&Ms. The higher the technical and institutional capacity to inventory and monitor AFOLU emissions and removals of the respective country, the more prescriptive the sustainable P&Ms should be. A (national) mandatory set of sustainable P&Ms could for example serve as a testing ground for countries without having to commit itself to quantitative AFOLU targets at the international level.

6.3 Policy Option 3: Extended list of eligible AFOLU CDM project activities

This option is relatively simple as it remains a flexibility mechanism that can be used optionally and side by side with other options. There would be no objection to CDM projects taking place in countries that are also applying for instance sustainable P&M, or that is receiving assistance with building capacity or implementing a national system; on the contrary, it would be helpful for countries to familiarise itself with CDM type projects in the AFOLU sector.

6.3.1 The concept

Currently, eligible CDM project activities in the AFOLU sector are limited to afforestation and reforestation, and reduction of non-CO_2 gases in agriculture. One option would be to continue with the CCM regime as it is right now in general under the provisions of the KP and the Marrakesh Accords, but to extend the list of activities that are eligible under the CDM to include for instance reducing emissions from deforestation or reducing CO_2 emissions in agriculture.
The major obstacle for the inclusion of options other than afforestation and reforestation was the issue of project baselines and leakage (although some may cite a longer list here). In particular baseline setting remains a red herring. This has been discussed in more detail in section 2.2.

Recently some forest conservation projects have emerged, of which the Noel Kempff Climate Action Programme in Bolivia is probably the most well known. This project developed serious anti-leakage strategies and baseline methodologies, includes a substantial indigenous community component, and invited an official Designated Operational Entity to conduct validation and verification assessments as if it were a eligible project type under the CDM (see also http://www.noelkempff.com/). This project demonstrates that in particular cases Reducing Emissions from Deforestation and forest Degradation (REDD) project activities may successfully meet all CDM requirements. The same goes for CO_2 emission reduction project activities in agriculture.

6.3.2 Funding and Benefits

Sources for funding would remain predominantly private sector investments, although some CDM projects have emerged as offspring from assistance in the area of capacity building.
Projects in both forestry and agriculture potentially have significant co-benefits, both for the environment as well as local land managers and society.

6.3.3 The countries

Countries that can benefit from this option will in general be those favoured by the private sector for safe investments. Countries with poor governance records or that are politically unstable will not be on the top of that list. So far, CDM projects are not equally distributed over the non-Annex I countries. This will be discussed in more detail in section 7.3.

6.4 Policy Option 4: Sectoral Targets

In the previous chapter, two types of sectoral targets are presented: a sectoral CDM or crediting mechanism and a sectoral 'no-lose' target. These are effectively the same with the difference being that the Sectoral CDM would be administered and decided through the CDM Executive Board and the no-lose target through the COP or COP/MOP.

Both options include a national baseline, where benefits are rewarded to a country and not to a project or individual land manager. Operationalising this option will be built-up of various efforts; efforts to improve performance on either public land or privately-owned land. Together all these efforts add up to the national total. Distributing benefits may therefore, need to take place along the same lines only in the reverse direction: the improved performance of the individual landholdings need to be determined to distribute benefits in a fair manner. This will be discussed in more detail in section 8.2.

As it is unlikely that the options Sectoral CDM or "no-lose target" will function simultaneously in one country, these approaches are considered separately and described here as options 4A & 4B.

6.4.1 The concept

Option 4A: Sectoral CDM:
This stage is building on from the CDM Mechanism devised under the KP. Emission reductions/removals enhancement over a national AFOLU baseline generate tradable credits which can be sold on the market: the total AFOLU sector of a country or a clearly defined subset (e.g. forestation, or reducing emissions from agriculture) would need to be seen as one CDM project. The current CDM, together with proposals that have been presented in relation to reducing emissions from deforestation, could function as input for the design of such a mechanism.

Option 4B: No-lose target (at or below BAU):

In this option, a national target would be set for the AFOLU sector as a whole or for a clearly defined subset of the sector, at, or at a level mildly below the Business As Usual (BAU) level. If the country performs better than the target, it can sell the surplus on the market. It will, however, not be sanctioned if it does not achieve the target.

6.4.2 Funding and Benefits

Funding activities would be through the sale of carbon credits. This is also the biggest benefit of this option: participation in the carbon market. When looking at the funds that need to flow to the South to achieve the net emission reductions that are required to achieve the ultimate objective of the Convention, there can be little doubt that this option is a desirable place to be for a non-Annex I country.

6.4.3 The countries

The technical and institutional requirements for the development and monitoring of the national reference level would restrict participating countries to those with a relatively high technical and institutional capacity to monitor, inventory and control AFOLU emission and removals. Although, developing countries could only profit from participating in the climate regime by taking on a no-lose target (no sanctions in case of non-compliance), political concerns to commit to quantitative targets at the international level often outweigh potential economic benefits.

6.5 Policy Option 5: Quantified Emission Limitation and Reduction Commitments - QELRC

6.5.1 The concept

The next level up from the previous option would be to take on a QELRC for selected AFOLU activities. This could work identical to the current arrangements for Annex A sectors under the KP. Such AFOLU activities would basically become an activity on that Annex A list. Including individual AFOLU activities in this way has the advantage that the target is included in the overall target for a country: it is an integral part of the QELRC of a country, but countries would not necessarily be obliged to take on all activities in the AFOLU sector directly. For instance, if a country feels more comfortable taking on the livestock sector but doesn't control deforestation enough yet, it can already increase its level of participation to include some activities. Once it is ready to do more, other activities can be added to the overall QELRC.

Both Annex I countries and non-Annex I countries could take on a target for AFOLU activities on a voluntary basis. For Annex I Parties, this would be besides activities under Art.3.3 (Afforestation, Reforestation and Deforestation: ARD) and Art.3.4 of the KP (Art.3.4 is voluntary during the first commitment period (CP1), but mandatory beyond CP1). Non-Annex I countries could make their own selection but in addition, they could choose not to take on a QELRC if they feel they are not ready yet.

This stage does include a more stringent compliance regime: if countries cannot fulfil their target, it will have to compensate this with emission reductions in other sectors or by buying of credits on the international market.

The rules for how to include the selected AFOLU activities could either be along the lines of the current rules for Annex I Parties, or by applying wall-to-wall, full carbon accounting. Pros and cons of these approaches have been discussed in chapter 2.2.

Another option would be to provide a list of certain “carbon depleting” activities that could be mandatory to be accounted for if a country wanted to engage in AFOLU. As a next step these countries could voluntarily also add carbon-stock enhancing activities (such as afforestation and reforestation, revegetation, carbon accumulation on grasslands or croplands, etc.). (Schlamadinger et al., 2006b).

6.5.2 Funding and Benefits

Funding would be through the regular national budget, emissions trading, and/or for non-Annex I countries other types of financial assistance.

6.5.3 The countries

In the short-term, those countries committing to binding, quantitative targets in general will most likely be current Annex I countries. In the mid-term, additional countries may use this option but account only for certain AFOLU activities, which they can monitor well, extending the list of activities as time moves on.

6.6 In summary

Option 1 (capacity building (CB) and technology research and development (technology R&D)) will be beneficial for many non-Annex I countries and quite some of them already successfully seek such assistance and benefit from it. The Least Developed Countries (LDCs) may be less successful in generating such activities, even though they may need it most. In general LDCs can use options 1, 2 and 3 (CB/tech.R&D, sustainable P&M and extended list of CDM) whereby CDM activities would ideally be in the agricultural sector whereby many co-benefits can arise next to increased food production. The sooner LDCs and in general non-Annex I countries employ options 1 to 3, the sooner the economic benefits from option 4 and 5 come within reach as well.

Other non-Annex I countries can, in addition to option 1 to 3, employ option 4: sectoral targets (sectoral CDM or no-lose targets). This is the case in particular for countries with relatively high levels of technical and institutional capacity to monitor, inventory and control AFOLU emissions and removals. Unless political concerns over taking on targets outweighs potential benefits, quite a number of non-Annex I countries could move in this direction already in a post 2012 era.

Some non-Annex I countries may in fact already be able to benefit from option 5: taking on a QELRC in the AFOLU sector. The barrier to do so may predominantly be of a political nature. More about actual potentials of the top 4 emitting nations can be found in appendix 4.

7 Assessing the options against the criteria

In this section, the proposed options for participating in the post-2012 climate regime through AFOLU will be evaluated against the criteria introduced in chapter 4. The purpose of this exercise is to assess the options in a systematic way to find the optimal approach which will satisfy as many criteria as possible, and will thus have the greatest chances of being successfully implemented.

In the following sections, we address each criterion, starting with the scenario that best fits the respective criterion. We refer to the most important sub-criteria under each category in Table 11 of section 4.2 but do not address all the subcriteria listed.
This evaluation is certainly bound to be a subjective one: other views and evaluations may be possible. This section may however, be instructive as one of the possible points of view.

7.1 Environmental criteria

QELRCs with full accounting of all AFOLU activities fulfils the criteria of environmental effectiveness best, as it would provide certainty of the emission level of this sector. The inter-annual variability of the emissions due to e.g. forest fires or pests could however, introduce uncertainty.

QELRCs only including a limited list of activity would be the second best option. As they would cover only certain AFOLU emissions sources, it would be more difficult to reach a predefined concentration level.

No-lose targets would be able to contribute to reducing net AFOLU emissions in the participating countries, but they are not capable of capping emissions at a predefined level.

Sectoral CDM as well as the extended list of CDM activities would reduce emissions in the host country but the net effect to the atmosphere would be zero, as the generated credits can be used by other countries to offset their own emissions: a zero-sum transaction. There would only be a net positive effect, if the additional supply of credits due to the sectoral CDM would be taken into account to set more stringent post-2012 QELRCs.

Sustainable P&Ms would reduce emissions but would not be able to guarantee a particular emission level. Their contribution to reducing emissions or enhancing removals in the AFOLU sector depends very much on the measures taken.

Capacity building, technology and R&D would have no direct effect on the environmental effectiveness in terms of emission reduction, but would contribute to preparing countries for taking such measures in the future.

7.2 Economic criteria

The optimal approach from an economic point of view would require a distribution of reductions so that the global costs are minimised. Furthermore, it would give participating nations sufficient flexibility to reach their commitments, provide certainty on the costs of taking on commitments, and it would offer the widest ambit for innovation, fostering competition to develop better, cheaper, faster ways of reducing emissions and enhancing removals.

Emission trading meets these criteria and can be applied to all the options that include all options which ensure that reductions are taking place where they are cheapest (QELRCs, no-lose targets, sectoral CDM and the extended CDM activity list).

Sustainable P&Ms would be restricted to the country and would not allow this sector to be included in the global carbon market. The policies can stimulate positive side effects, however. The option of capacity building and R&D would be neutral in this regard.

7.3 Distributional and equity criteria

The assessment according to distributional and equity criteria is difficult to make for the options without specifying which countries opt for what options and what their respective reductions are. For options with QELRCs or a sectoral no-lose target, in principle the distributional and equity criteria must be appropriately addressed at the macro level. Regarding equity, the stringency of the target might be more relevant than the option chosen.

In the case of a sectoral CDM one could argue that this favours countries whose economies have developed to the extend that allows for participation in a reasonable mature market environment. Some countries (e.g. the least developed countries) may on the other hand not be ready to engage is a sectoral CDM and therefore, its benefits are foregone for the time being for these countries. Relying only on the CDM is therefore, not in support of an equitable distribution of activities and benefits.

Sustainable P&Ms are domestic affairs. One has to assume that sustainability in this respect is interpreted by governments in such a way so as not to disadvantage particular groups of its society. However, a government can choose its own balance between the weight given to any of the three sustainability pillars (economic, social and environmental aspects), which may favour short term economic benefits over long term environmental and/or social benefits. Hence, it depends on the type of sustainable P&Ms whether distributional and equity criteria are met.

With respect to technology R&D, experience indicates that recipient nations should harbour no illusions that in the absence of a market, development assistance or private sector investments in technology R&D will start to flourish simply because of environmental concerns. Only if R&D or the transfer of technology leads to the generation of tradable emission reductions in the AFOLU sector, will finances start to flow from industrialised countries towards the other nations.

7.4 Technical and institutional criteria

The options capacity building and R&D can, from the technical point of view, easily be implemented. For sustainable P&Ms, mechanisms for monitoring or the implementation of the policies would have to be installed, but in general these requirements are low.
All options need reliable methodologies for monitoring emissions but in particular for the sectoral CDM and no lose targets this is relevant. These monitoring methodologies are starting to become available on a project level in developing countries but are not yet sufficiently reliable on a country level.

QELRCs with limited activities or with the full sector would need in addition very robust methods to project emissions into the future as to avoid unintended windfall profits or very stringent targets. In addition, the extended CDM may require projections of future activities to determine the potential to offset emissions elsewhere. These methods are yet to become available.

In general most of the technical and institutional criteria can be met. A question mark could be placed along side the criterion of “factoring out” for options with a QELRC or no-lose target, but Parties have found an acceptable, pragmatic way of dealing with this issue before and are likely to do that again in future.

In the case of policy options without a market drive or without QELRCs it can be expected that the inherent stability of the approach breaks-down in cases of unexpected events, because there are not many incentives for outside coercion on the country to ‘stay on track’. The same may be valid for the criterion of increasing levels of participation: without a market drive or

QELRCs there may not be much persuasion. On the other hand, if it brings countries closer to participating in the market, this may well be enough temptation.

7.5 Scoring the options against the predetermined criteria

Table 14 summarizes the scoring of the options against the criteria as described above. It illustrates that binding, quantitative targets (QELRCs) seem to be complying best with the criteria. Their drawback is however their lower scores with regard to technical and intuitional criteria. The next best option - based on our evaluation - would be the no-lose target which does not reach the level of environmental effectiveness of QELRCs (not possible to reach a predefined level of GHG concentration in the atmosphere), but is to some extent superior to the latter regarding the technical and institutional criteria (e.g. by enhancing the level of participation).

Options involving only the (sectoral) CDM do not lead to net emission reductions beyond those of the combined QELRCs of a regime, thus scoring lower than sectoral no-lose targets on the environmental criteria. Furthermore, the negative score regarding equity is due to the disadvantages for less developed countries which will not be ready to engage in this market yet.

Sustainable policies and measures would follow in fourth place. Their advantage is related to a relatively good fulfilment of the technical and institutional criteria, while having no significant disadvantages with regard to environment, economic and equity issues. The exact scoring will however depend on the respective P&M chosen.

Table 14: Scoring of options/stages against criteria

Criteria	Capacity Building and Techn. R&D	Sust. P&M	Ext. list of CDM activitie s	Sectoral targets		QELRC	
				Sect. CDM	Sect. no-lose target	With limited AFOLU activity list	With full AFOLU sector
Environmental	n.a.	-/0	-/0	-/0	0	+	+
Economic	n.a.	0	+	+	+	+	+
Distributional and equity	-	0	-	-	+	+	+
Technical and institutional	+	+	-	0	0	-	-

+: satisfying the criterion
0: uneven
-: not satisfying the criterion
n.a.: not applicable

Capacity building and Technology R&D would fulfil especially technical and institutional criteria. The scoring of capacity building and technology R&D as well as sustainable P&Ms should however not diminish the importance of their role in a future climate regime. As mentioned, options are not mutually exclusive, and the latter two options have thus a rather complementary role in preparing countries for taking over quantitative commitments at later stages. Options including market mechanisms and QELRCs however remain the main incentive for countries to participate.

8 Operationalisation of the mitigation option reducing emissions from deforestation and forest degradation (REDD)

In the introductory chapter three processes under the UNFCCC and its KP were mentioned that are relevant to the discussion regarding AFOLU and future CCM regimes and therefore, to this report. This chapter concentrates on one of these processes but in an extended form: the COP agenda item is dealing with reducing emissions from deforestation in developing countries, whilst this chapter deals with both deforestation and degradation, and is not limiting this to developing countries.

From the previous chapters, and as so often cited already, a significant share of global GHG emissions come from forest degradation and deforestation, predominantly in developing countries. Continuing to exclude these emissions from the international policy framework increases the risk that nations loose the option to meet the objective of Article 2 of the UNFCCC, i.e. stabilization of atmospheric concentrations of GHG. It is known that if we are to keep options open to stabilise GHG concentrations in the atmosphere at a level that prohibits dangerous interference with the climate system, for instance at 450e-550e ppmv, substantial reductions from the baseline will be required in middle income non-Annex I regions by 2025, in addition to those achieved by Annex I countries (Berk, 2004; O'Neill & Oppenheimer, 2002; Tirpak et al., 2005). Controlling emissions from deforestation and degradation may be a central option in this regard, given the fact that ALOFU emissions are such a large proportion of non-Annex I emissions. But there are opportunities too for lower income non-Annex I countries to participate in such activities and make a major contribution in achieving Article 2 and many other objectives of the Convention and its Kyoto Protocol. For this reason, a separate chapter on Reducing Emissions from Deforestation and forest Degradation (REDD) has been prepared.

This chapter will review a number of relevant aspects of REDD. REDD is however, an innovative and fast moving subject, and new perspectives may arise even before the time this report goes to press. We can only hope that the information contained by this chapter is pertinent at the time it is released, and we cannot claim to be comprehensive on the subject. The chapter will elaborate; 1) the proposals that have been made recently regarding the inclusion of REDD under a future CCM regime; 2) current understanding as regards drivers of deforestation; 3) the importance of stakeholder involvement and their possible role; 4) instruments for controlling deforestation and degradation; and, 5) the abilities and limitations of Remote Sensing (RS) in quantifying REDD.

A couple of striking citations illustrate the urgency of reducing emissions from deforestation: “Deforestation, mainly conversion of forests to agricultural land, continues at an alarmingly high rate: about 13 million hectares per year.” (FAO, 2005.) Current annual rates of tropical deforestation from Brazil and Indonesia alone would equal four-fifths of the emission reductions gained by implementing the Kyoto Protocol. (Santilli et al., 2005.) Forest destruction emits as much or more than all the cars, trucks and power plants in the entire US (Petsonk & Silva-Chavez, 2006) and deforestation is the largest source of emissions in many developing countries. Figure 9 and 10 in chapter 5 also illustrate very clearly the importance of ALOFU emissions in non-Annex I countries.

But Parties are increasingly interested in reaching consensus on addressing these emissions. At COP11 in Montreal (Nov/Dec, 2005), the UNFCCC Parties launched a two-year process to consider relevant scientific, technical, and policy issues, and invited submissions proposing options for addressing them. (UNFCCC, 2005) Here we briefly review two options identified in the 2006 submissions.

8.1 Proposals for the inclusion of reducing emissions from deforestation in developing countries

8.1.1 Compensated Reduction (CR)

Compensated reductions (CR) as presented by Santilli et al (2005) proposes that non-Annex I countries may, on a voluntary basis, elect to reduce their national emissions from deforestation. The original proposal suggests a baseline starting from 1990 or even 1980, but argues that exact periods will need to be negotiated to allow for country-specific situations as well as inter-annual variability. A historical baseline would be constructed on the basis of area of forest cover, according to locally specific definitions of forest based on canopy cover, as detected, primarily, from remote sensing, and extrapolated to the future. Reductions in emission from deforestation during the commitment period could then be credited and sold to governments or international carbon investors at the end of the relevant period. A country that has been credited for reducing emissions from deforestation would agree to stabilizing, or to further reducing, deforestation rates in the subsequent commitment periods (Santilli et al. 2005) – the 'once in, always in' clause. (Skutsch et al., 2006) (see figure 11).

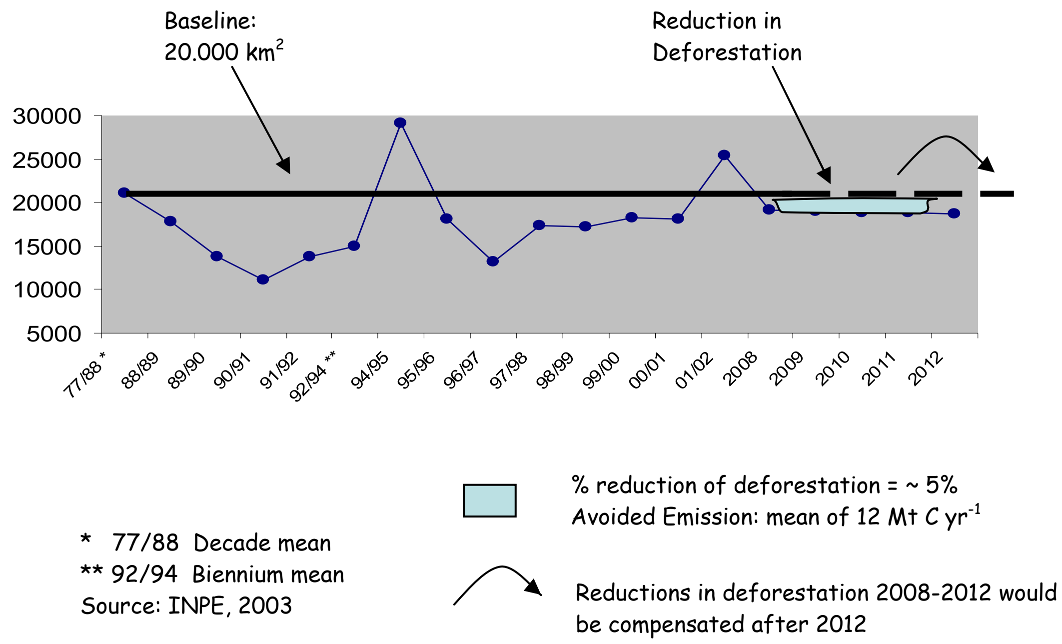

Figure 11: Example of baseline for CR. Vertical axis shows area of forest lost in a given year (ha). Thick line is baseline and pale area (2008-2012) indicates reductions that could be compensated. (Source: IPAM, Environmental Defense)

An alternative formulation of this model (Figure 12) constructs the baseline on the basis of deforestation during a given period in the past (t_0-t_1).

In advancing the proposal, the authors sought to create large-scale incentives to reduce tropical deforestation, to encourage broader developing country participation, and to leverage support for continued efforts to address climate change beyond 2012. (Santilli et al, 2005). The proponents envisioned that under CR, developing countries that reduce deforestation rates could be compensated with tradable emissions allowances.

CR addresses many of the issues that had plagued efforts to address deforestation through project-based crediting. For example, under a project-based approach, it is difficult to address leakage: the risk that although forest has been protected in one area, it could be chopped down in another, and that issuing tradable credits for emission reductions in the project area could thus result in an increase in total emissions. By rewarding nations that reduce deforestation at the national level, CR avoids intra-country leakage, and provides a better basis for addressing other types of leakage. Similarly, under a project-based approach, it may be difficult to project how much deforestation would otherwise occur at a project site in the absence of the project, yet such counterfactual calculations are essential for awarding credit. By calculating base periods from historical data, CR avoids this problem. (Moutinho & Schwartzman, 2005).

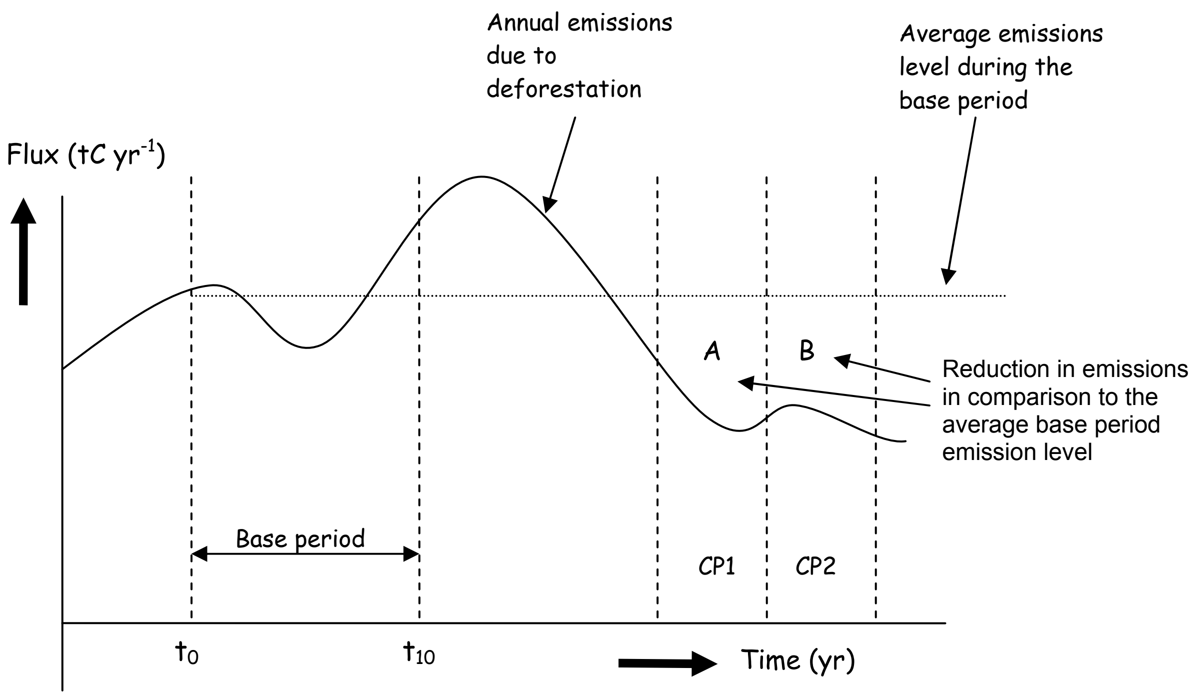

Figure 12: Schematic representation of the compensated reduction proposal. The solid line indicates annual emission levels due to deforestation. The dotted horizontal line is the average emissions level during the base period. Area A is the reduction in emissions during the 1st commitment period below the base period's emission level. Area B is the same but in the 2nd commitment period, if there was to be one.

Since a national-level approach must cover large forest areas at repeated intervals, with results available on a time scale that is relevant for decisions about carbon markets, CR is premised on robust and effective monitoring systems for establishing base periods, monitoring and verification of forest cover, and quantification of emissions from deforestation and degradation. Emissions quantification, in turn, is based not only on the area of forest change, but also the associated biomass loss (Brown, 2002; DeFries et al., 2006).

Systems for monitoring **deforestation** at a national level must measure changes throughout all forested areas, use consistent methodologies at repeated intervals, and verify results with ground-based or very high resolution remote observations (DeFries et al, 2006). Consequently, for monitoring deforestation at national levels, the interpretation of remotely sensed data backed up by ground-based observations is "the only practicable approach". (DeFries et al., 2006)

Monitoring **degradation**, which may also occur over large areas and may give rise to significant emissions (Asner et al, 2005), is more difficult. However, using new algorithms in the analysis of high resolution images and very high resolution data, a variety of approaches have been developed and demonstrated through pilot projects (DeFries et al., 2006). To take the next step, i.e., to move from two-dimensional calculations of forest loss, to the carbon stock changes (3-dimentional) and emissions that occur as a result of deforestation/forest degradation, the IPCC has compiled methods and good practice guidance (IPCC, 2003; IPCC, 2006). See section 8.6 for a more extensive discussion of quantification issues and an analysis of the strengths and limitations of various approaches for addressing them, including those related to remote sensing.

Some economic analyses indicate that if CR were adopted and reductions in deforestation were eligible for compensation via the carbon market, then in a number of countries with high deforestation rates, market prices for carbon could make forest protection economically competitive with various alternative land uses – i.e., many people who live in forests would be able to earn more money by protecting the forest than they could by chopping it down. (Silva-Chavez 2005; Osafo 2005; Del Carmen Diaz & Schwartzman 2005). Others may be less optimistic (Persson and Azar, n.d.) or suggest that carbon payments might be more effective in reducing degradation than deforestation (Skutsch and Muriyarso, 2006). Clearly the situation will vary very much according to the local opportunity costs. Much more work is however needed to see under what economic conditions financial compensation for carbon can compete with deforestation and degradation. Most important is to understand how the monetary value of carbon might be added to other economic incentives to create attractive packages, for example by combining carbon payments with agro-forestry or ecotourism.

How to deal with countries that have low deforestation rates remains a challenge for now. After all, low emission levels in the base period means there is only limited scope for improvement. Low deforestation rate in the base period may be either because there is not much forest left or because deforestation rates had earlier been reduced because of well implemented forest protection measures. In such cases the CR proposal suggests applying base periods that go back further in time, or to issue "premiums": additional increments of tradable allowances which could help finance development that protects forests while promoting economic growth. (Environmental Defense, 1997; Dudek & Goffman, 1997; Dudek & Goffman, 1998; Oppenheimer & Petsonk, 2004).

In the context of emissions from deforestation and degradation, Schlamadinger et al. (2005) have proposed a corridor to reflect the uncertainty of future emissions, the risk of countries easily falling out of a mechanism if their emissions exceed a pre-defined target, and the risk of large windfall profits arising if emissions happened to be significantly below the target even without specific measures.

This corridor could be derived using historical emissions, emission trends, and trends in underlying causes. If actual emissions are above the corridor, no credits can be sold but neither is there any liability (no-regret targets). If the actual emissions are within the corridor, the amount of credits per tonne of emissions by which the country “undershoots” the ceiling, varies between zero (when the deforestation/degradation rate is at the ceiling of the corridor) and one (when the deforestation/degradation rate is at the bottom of the corridor). This corridor approach reduces hot air and reduces the risk of missing a single-level target and can be combined with the “no lose” concept.

8.1.2 Joint Research Centre (JRC) Proposal

The submission of the Institute for Environment and Sustainability for the European Commission Joint Research Centre (JRC), which builds on the basic ideas of CR, suggested that instead of country-specific base periods for those countries, base periods be constructed relative to global average rates of land conversion (Mollicone et al, 2006).

JRC identifies three categories of conversion – from *intact forest* (pristine, untouched primary forest) to *non-intact forest* (forest which shows signs of human intervention); from *non-intact forest* to *non-forest* (defined on a canopy cover criterion); and from *intact forest* to *non-forest:* this option clearly distinguishes a forest degradation phase.

JRC introduces two schemes: one to encourage countries with high forest conversion rates to reduce them; the other to encourage countries with low conversion rates to maintain them. A global baseline rate would be used to distinguish between the two groups of countries.

For each land conversion type, a country's Reduced Conversion Rate would be calculated to provide a quantitative expression of the country's efforts to reduce deforestation rates where they are high, or maintain low rates of deforestation when they are low. (Chenost, 2006)

JRC further proposed that compensation or crediting be in temporary certified emission reductions (tCERs), shifting the liability to the buyer of such credits, and eliminating the need for participating countries to commit to reduce deforestation in the future. (Mollicone et al., 2006)

8.2 The need to involve stakeholders

In the discussions surrounding policy for crediting of reduced emissions from deforestation and possibly degradation, the issue of what policies and measures could and should be used by developing countries in their drive to reduce deforestation has largely been left as a black box. Most non-Annex I countries would probably see it as a matter of subsidiarity or country sovereignty; a question that is not for international policy-making and regulation, but only of their own concern. Nevertheless it is equally likely that the international community will require some transparency on this issue, both to give credibility to the carbon credits claimed (through an understanding of how they have been produced) and to assure buyers that the carbon is 'good carbon' – e.g. not produced at the cost of deprivation of poor groups in society or loss of other environmental values. How much transparency is demanded and provided is a matter to be worked out at international level, and this is one of the many criteria that is included in overall assessments of rules for AFOLU (see table 11 in chapter 4).

8.2.1 From the national baseline to local activities: a "nested system"

Although in the context of REDD and the CR and JRC models there is much talk of measuring and rewarding average national deforestation against a single national baseline, in reality it is likely that countries will have to operationalise reduced deforestation and forest degradation through a package of both policies and measures, and at least in part on the basis of a set of internal projects, whose effectiveness would need to be compared and evaluated, and which would require infrastructure and decision-making on sharing of financial compensation.

Referring back to Figure 12, the total claimable area A & B under the dotted line on the graph would in reality have been created by a variety of different policies, measures and activities. These could involve some general or enabling measures and some which are directed to particular land parcels, so that the list might for example include:

1. Revision of forest law
2. Increased monitoring and data base capacity in forest department
3. Increased staffing in local forest offices
4. Improved land-use planning and integrated conservation and development programmes;
5. Market-oriented instruments, including Payment for Environmental Services (PES) and carbon offset projects;
6. Improved farming techniques (less new agricultural land required);
7. Shift from traditional forestry practices to Sustainable Forest Management (SFM);
8. Transfer of responsibility for open-access forest to community authorities;
9. Projects financed by NGOs, bilateral assistance, multi-lateral donor funds;
10. Establishment of environmental trust funds at national or regional level to channel financial resources from different origins, share risks, and decentralize financial resources to the local level; and,
11. Taxation schemes and public awareness campaigns.

The net emission reduction represents a composite of activities all "nested" under that national total, a random selection of which is shown in figure 13.

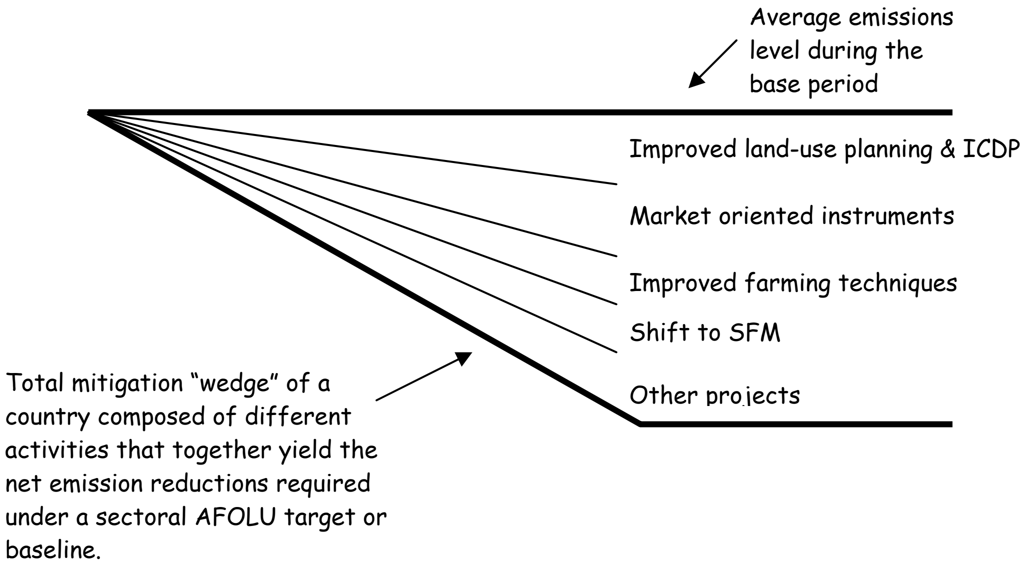

Figure 13: Suite of activities undertaken in one country to reduce net emissions.

If financial benefits generated with the sale of that excess of allowances need to be distributed amongst stakeholders involved in the various activities an appropriate key needs to be devised, most likely on the basis of activity-specific performance rates. *De facto*, the national achievement is thereby split up in project-type of initiatives, and sovereign governments may wish to consider what types of initiatives could be called upon.

In the list above, it is noted that such activities could include *inter alia* government carbon purchasing schemes (through payments for environmental services, PES[16]). This does not refer to international mechanisms (Verweij 2002; Gutman 2003) but rather the kinds of measures that could be used domestically, at national level, in a systematic and coordinated effort by national level government towards REDD. In this, particular emphasis is given to what these measures would imply for the involvement of different groups of stakeholders. For it is widely accepted that the effectiveness of 'command and control' measures in forestry is limited. For sustainable management of the national forest estate as a whole, it is clearly necessary to actively involve 'stakeholders' – those people, communities, companies, organisations and authorities who are *de facto* using forest land, regardless of its formal ownership – by using largely positive policies and measures (incentives, persuasion) which encourage the desired end result (reduced deforestation/degradation). The challenge is to find combinations of incentives, including carbon payment, which are effective in changing behaviour of these stakeholders because they make economic sense.

A further relevant question is to what extent the costs of such policies and measures can be covered by the financial resources that international sales of, or funding related to, carbon offsets could generate[17]. To answer these questions it is first necessary to have a clear understanding of what the causes of deforestation and degradation are, and which stakeholders are involved in these processes.

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16 For the purposes of this paper, PES implies a system of voluntary transactions for particular environmental services, which are bought, in this case, by the state. For a fuller definition, see Wunder, 2005.

17 This is quite independent of the question about how such international finance is arranged. We assume here simply that a country will in some way receive finance for REDD carbon savings from outside purchasers or donors, and use at least part of these financial resources to fund the policies and measure at home.

8.3 Drivers of deforestation

There have been very many studies looking into the causes of deforestation. The background papers prepared for the UNFCCC workshop on REDD (UNFCCC 2006a) for example compile the causes of deforestation given by countries themselves in their national communications. Many such reports confuse proximate causes (such as clearance for agriculture) with drivers (higher agricultural prices, population growth); these are however, clearly distinguished in the analysis that follows (UNFCCCb). It is the underlying drivers which are of most concern, and comprehensive reviews of these by CIFOR (Angelsen and Kaimowitz 1999, Kaimowitz and Angelsen 1998) indicate that although some well-known factors such as roads, higher agricultural prices and shortage of off-farm employment opportunities tend to be correlated with forest clearance, many other factors which are popularly thought to be causes, particularly poverty, are not consistently related in any way. Several studies have shown clearly that although there is a tendency for poorer people to live in the vicinity of forests (Sunderlin, Angelsen et al. 2005), most forest clearance for agriculture is done by better off individuals who have at least the small amount of capital necessary to do this (Skutsch 1994; Agudelo, Rivera et al. 2003).

Growing national wealth may be positively or negatively correlated with deforestation, although there is some evidence that economic liberalisation and structural adjustment policies in the 1980’s and early 1990’s increased pressure on forests (Angelsen and Kaimowitz, 1999). These studies indicate that the picture is very complicated and causes are difficult to determine and to generalise both within and across countries. Possibly one of the reasons for this lack of clarity is because deforestation is usually considered to be one variable.

As a first very rough attempt to improve on this, we consider two different types of deforestation (‘governed’ and ‘ungoverned’) to get a clearer understanding of the underlying processes (Schlamadinger, Bird and Johns, 2006). Moreover, almost all the literature focuses on deforestation, but since from the point of view of carbon stocks degradation is also an important issue, this will be reviewed as a separate process. It is important to understand that degradation is not always necessarily an earlier stage in the process of deforestation; degradation may be caused by quite different drivers and carried out by quite different actors.

While is it generally acknowledged by practitioners that internationally available statistics on deforestation, such as those compiled annually by FAO (eg FAO 2006), depend on national reporting and leave a great deal to be desired as regards reliability, it must be noted that reliable statistics on degradation are lacking for many nations; most countries do not keep records on degradation in any form.

8.3.1 Governed deforestation

A large part of the deforestation observed in most developing countries is what might be called ‘governed’ deforestation. It concerns forest that is cleared because of planned expansion of agricultural area, permitted logging, urban expansion and construction of infrastructure (roads, electricity grid, reservoirs etc). The decision to clear has been made rationally by the appropriate authorities and it is seen as an essential element of the country’s strategy for modernisation and economic growth. It is also dependent on events which change the international market: changes in the soy bean subsidies to US farmers and the Chinese decision to reduce logging domestically because of risks of floods and to purchase timber abroad instead, may both affect the rate of governed deforestation in countries like Brazil.

Many governments will be unwilling to reduce this type of forest clearance for the sake of carbon conservation; at best, they could work towards rationalising it by comprehensive land use planning and coordination across sectors to minimise unnecessary losses (particularly as regards road construction), and stimulate types of agriculture which have higher per area output and/or are more carbon conserving or sustainable logging.

The primary stakeholders involved in processes of governed deforestation, in addition to the national and regional governments themselves, tend to be medium and larger agricultural concerns, industries, construction companies, timber companies and municipalities.

Changing the rate of governed deforestation would require policy changes at various levels as regards permits and concessions, not just in theory but also in practice. But doing this is very difficult because of the high economic stakes and the political pressure applied by the organisations concerned, some of whom will also be supported from outside the country.

8.3.2 Ungoverned deforestation.

Ungoverned deforestation is clearance which is not sanctioned, and usually takes place at the frontiers of forest. The stakeholders are individual farmers or small agricultural concerns working more or less on their own accord although in many cases an 'agent' organises the deal, and it sometimes occurs with corrupt complicity and a 'blind-eye' from local authorities. These farmers, as noted above, are generally not the poorest of the poor, but have some capital to work with.

Ungoverned deforestation tends to correlate spatially with drivers such as (a) roads (b) population density and it is linked to market forces, in that it takes place where the financial returns to the individual from conversion of forest to crops, to plantations and to grazing are far higher than the financial returns to forestry. In addition there are areas of tropical forest that are being stripped for logs, by other stakeholders: companies (which may be small or large) operating illegally or semi-legally, again because of the high rents that can be obtained. In these kinds of systems there are also beneficiaries among intermediaries (traders, transporters, officials). It is well known that construction of roads for logging is a stimulus to further forest clearance by individuals for agriculture. Human-induced fire may be another factor which results in ungoverned deforestation.

Dealing with ungoverned deforestation is difficult because standard rules and regulations are by-passed by the stakeholders, and there would have to be a strong economic motive against the deforestation to halt it.

8.3.3 Degradation

In addition to wholesale loss of forest biomass due to clearance of whole patches (deforestation) there is also major loss of biomass going on in many countries as a result of degradation, in which biomass in the forest is progressively thinned out, although the area would still be considered 'forest' until a particular threshold has been passed (e.g. when canopy cover drops below 10%, which it may never do).

As will be pointed out in section 8.6, degradation has not been given much consideration or quantified in most countries in the past. It is much more difficult to detect than deforestation, as it does not show up so easily on remote sensing images, and unlike deforestation it may take place far from roads and is not therefore easily visible from the ground either. Recently, Asner et al. (2006) showed for an area of over 2 million square kilometres in the Brazilian Amazon that at least 76% of all selective harvest practices resulted in high levels of canopy damage, in the period from 1999 to 2004. Within four years after logging, the deforestation rate of selectively logged areas was 5.4% per year.

Degradation is not necessarily correlated with infrastructure, but may relate to population density and lack of alternative job opportunities, and it occurs mainly on forest land which is *de facto* open access. The process is gradual, and ungoverned, but unlike ungoverned deforestation it is not necessarily the result of single decisions made by particular individuals or companies for their own maximisation of profit on individualised land, but of gradual over-use by a large number of people of what is considered 'no man's land'. Grazing in the forest (which inhibits regrowth), selective logging of timber species, over-cutting of firewood and poles, charcoal production, occurrence of fire and shifting agriculture in cycles which do not give sufficient time for recovery are the direct causes.

The stakeholders are local people who are generally very aware of the long run effects of these processes on the forest but are driven to continue them (a) because they are necessary for their livelihoods and (b) because in most cases there is no locally operating authority which could halt the tragedy scenario, most often because the forest is nominally property of the state, not of the authorities at community level.

While the stakeholders operate as individuals and the forest is an open access resource, there is very little that can be done to reduce degradation, but if they are organised into units which can manage the forest collectively, and if the rights and responsibilities over the forest are effectively handed over to such units, then there is considerable scope for change (Poffenberger 1990; Hobley 1996).

The returns to degradation are usually not very high in economic terms, and experience has shown that communities can often be encouraged to reverse it once they are put in charge of the forest and a locally accepted authority, such as an elected village forest committee, is set up. It is difficult to estimate how much forest is under such community management at present. 27 of India's states have programmes of Joint Forest Management, which cover 17m ha (India's total forest area is around 64m), and involve 75,000 villages (Ravinathan and Sudha, 2004), but many other countries (Nepal, Mexico, Tanzania, Cameroon, Sudan, to mention just a few) have community forest management schemes too. In Colombia, indigenous communities hold almost 25% of the national territory and own and administer more than 80% of the forest areas (Van der Hammen, 2003). In the Brazilian Amazon region, indigenous territories declared sofar cover more than 20% of the region. Analysis of satellite images showed that with some exceptions, these indigenous territories provide protection against logging in the five major timber producing states of the Brazilian Amazon (Asner et al., 2005). According to White and Martin (2002), community reserves represent at least 8% of all developing country forests, and community ownership a further 14%, meaning that 22% of all developing country forests are under community control. The extent to which sustainable management is carried out in these areas is unclear, but the potential is present.

8.4 Instruments for controlling deforestation and degradation

There are potentially a very large number of policies and measures that countries could use in their drive to involve stakeholders in reducing deforestation and degradation. An overview of these is provided in one of the papers prepared for the UNFCCC workshop on REDD (UNFCCC, 2006b). In this, measures are divided into those that relate to price and demand for agricultural and forestry products; those related to costs and risks of deforestation; those relating to land tenure and finally related to SFM. Here a different approach is taken, with the focus on how measures relate to different stakeholders.

Command and control types of measures, taxation schemes, and public awareness campaigns have not demonstrated themselves to be very effective at controlling the actions of different forest stakeholders in the past, but there are other measures in which national government authorities play a major role; integrated conservation and development programmes (ICDPs) for example in which government spends money on community facilities in return for certain agreements as regards environmental protection.

However, in recent years market-oriented instruments have increasingly been promoted (Ferraro and Simpson 2002; Landell-Mills and Porras 2002; Pagiola, Bishop et al. 2002; Swingland 2002; Wunder 2005). Experience with Payments for Environmental Services (PES) is still fairly limited and is concentrated in a few countries, notably Costa Rica and a handful of other Latin American countries, and it has had mixed results (Pagiola, Bishop et al. 2002; Miranda, Porras and Morena, 2003; Wunder 2005). PES needs to be further developed and refined, but has proven its potential as an instrument for compensating local land users for the opportunity costs of sustainable forest management or the cost of specific agricultural practices. Many PES systems are set up as individual projects with international finance or at watershed level as arrangements among local stakeholders, but there is no reason why countries could not run their own internal PES systems, as experience in Costa Rica and Mexico shows. In Costa Rica, a national carbon tax on fossil fuel consumption is the most important source of finance of the national PES system.

Box 2: typology of PES systems

Two different types of PES may be distinguished: PES systems in which payments are essentially based on qualitative changes in the way forest is managed, and paid on the basis of area treated, and PES in which payment is based on quantitative assessment of product or output. The literature does not distinguish clearly between these, although Wunder (2005) differentiates between area-based PES and product schemes which pay a ‘green-premium’ through certification. The differences between these measures are significant however. CDM afforestation and reforestation projects are paid on output, strictly on the actual volume of carbon offsets that are produced; the Fondo Bioclimatico (Scolel Té) project in Mexico in which farmers earn from carbon credits through agroforestry in their coffee plantations is another example (Nelson and de Jong 2003; Corbera 2005). However, in most PES systems participants are paid simply on the basis of area and activity, for example, the Costa Rican FONAFIFO PES forest protection programme pays farmers per hectare of forest they retain. Although there are checks made to ensure the forest is still standing, the payment is flat rate. In the Mexican PES system under FONAFOR, a similar payment system is used even for the case of forest protection for maintenance of carbon stock, although the proposals submitted do have to make estimates of the amount of carbon that will be saved.

There are a number of enabling conditions which are necessary if a PES system directed at community forest management is to be successful. If not already in place, a legal framework for empowering communities over forest is essential. A database focussing on degradation and carbon losses would have to be set up and maintained at national level, and fully mapped, which would allow better planning and prioritisation of areas to be included. Quite possibly elements in this data system would have to be modelled. In addition, there would be need for an administrative system by which changes in carbon stock monitored by local communities could be verified and rewarded.

Setting up any PES system brings with it costs and this means that part of the international price of the carbon would be required for overheads. The larger the programme however, the greater the economies of scale. It is almost impossible to estimate what the real costs will be, in advance, until some experience with carbon payments is gained in order to judge how effective they may be as incentives for reducing degradation. One should however not underestimate the practical difficulties of designing a PES system which is both effective from a climate point of view and locally fair/equitable/acceptable. Not all forest is equally threatened by deforestation and degradation, and systems would have to be devised to target those forest areas which in the absence of such a system, would be most likely to be lost. This means that in addition to national baselines, local baselines could be needed.

Certification systems are different again. They provide a topping-up of the sale price of a product certified as having “added value”, e.g. organic food. But in the case of certified timber, it may not always lead to higher prices. Here it is more a guarantee that the producer gains access to particular markets. For example, the large DIY chains in Europe (B&Q in the UK, Gamma in the Netherlands) have committed themselves to selling 100% certified timber under the Forest Stewardship Council (FSC) Standard. Such certification schemes provide assurance that the timber has been produced in a system that maintains qualities such as sustainable forest management (SFM), good employment conditions, economically viable business, etc. There are many such projects around the world as the market for certified wood is increasing in developed countries. By June 2006 over 76 million ha had been certified under the FSC scheme, through 835 certificates in 72 countries (www.fsc.org). Since increased carbon storage is a by-product of most forms of SFM, the possibility arises of the national government adding the financial value of this additional carbon into the equation, thus making certified SFM more economically attractive. Essentially, this boils down to adding PES onto an existing or new SFM initiative. If this were done for an individual CDM-type project there might be questions regarding additionality, but if it is part of a national-wide sectoral approach, then this should not be an issue. Adding certification costs to timber does lower the profit margins however. If such costs are factored into the sales prices, competition with “traditional” grown or harvested timber may be tougher, leading to negative incentives for good forest management and potential carbon leakage.

8.5 What sorts of instruments work best?

Several criteria should be considered when comparing alternative instruments, such as which group of stakeholders they suit, and for what processes they would be appropriate; their effectiveness, and cost efficiency, also taking into account transaction costs; their practicability in physical and in institutional terms (also in terms of legitimacy within existing political systems), and secondary objectives: particularly, do they meet other goals such as poverty alleviation and equity considerations, which may in some cases, though not all, be a requirement.

A review of literature to assess possible national measures against these criteria was made and is summarised in table 15 below. Since the aim is to provide an overview, simplifications and generalisations have been made as regards types of measures and kinds of stakeholders. The ‘specific measures’ (column 3) are direct instruments, whose effects could at least to some extent be traced to quantitative changes in carbon stock. But for these to be implemented, there will be many other enabling and supporting measures needed (column 8), whose effects will be more general and not directly traceable to stock changes.

Table 15: Results of literature review to assess possible national measures against criteria mentioned in section 7.5.

	Main stakeholders	**Specific measures**	**Effectiveness**	**Cost efficiency**	**Practicability/ac-ceptability**	**Poverty and equity**	**General and enabling measures**
Governed deforestation	Agricultural companies/large and medium farmers	Restrict planning permission	Very effective if seriously applied	Breakeven price depends on market prices of carbon as compared with market prices for timber & agricultural products.	Uncertain. Political and economic pressures for land for development will be hard to resist. Views of major stakeholders will depend on various factors, including carbon market prices.	Depends greatly on specific circumstances in implementing nation. Employment may shift from logging/land conversion to SFM/carbon measurement and monitoring	Comprehensive land use planning New forest legislation protecting more forest areas Heavy national taxes on forest land clearance PES systems, which may be bundled with SFM programmes
	Industry, building contractors						
	Logging companies	Restrict concessions					
		Bundling PES carbon purchase with SFM certification and/or conditional concessions	Not yet tried; depends on developments in market for sustainably produced timber	Unclear. Economies of scale will be important. Carbon will offer only a small topping up on overall sales value	If voluntary, should be acceptable; conditional concessions may be difficult to introduce	Shifts may occur	
	Lower tiers of government	Share in revenues/fines	Moderate	Could be considerable	Good	Probably no change	
Ungoverned deforestation	Medium farmers	PES carbon purchase system (output based)	Might encourage more carbon storage in agricultural systems (agroforestry) but unlike to stop clearance completely	Returns to clearance will be higher than financial value of carbon in most cases	Heavy overheads and transaction costs but baseline simple (based on full clearance)	Experience shows that larger farmers will participate more than smaller, poorer farmers; NGOs can however play an important role in bundling small-scale projects	Greatly increased on-the-ground monitoring Fast track land tenure Alternative employment creation in danger areas
		PES carbon purchase system (area based)	Ditto	Ditto; moreover overall cost effectiveness probably lower than output based systems			

	Main stakeholders	Specific measures	Effectiveness	Cost efficiency	Practicability/ac-ceptability	Poverty and equity	General and enabling measures
	Intermediaries	-	-	-	Will strongly resist unless registered and 'retrained' as intermediaries for PES		Land teunure
	Logging companies	Bundling carbon payments with SFM certification	Combined value of certified timber and carbon may in some cases be attractive	Unsure	Voluntary participation	No change	
	Local governments	Financial incentives to monitor and reduce forest clearance	Could be significant	Unsure	Good	Smaller, less powerful farmers/companies will be targeted first	
Degradation	Rural communities as units	PES community carbon purchase system (output based)	Limited experience up to now, but could be effective in countries where degradation is a major contributor to carbon stock loss	Transaction costs could be a problem, but opportunity costs are generally much more in line with value of carbon delivered	Voluntary participation. Transaction costs could be reduced if communities are involved in the measurement and monitoring of carbon themselves. Baselines could be simplified by using horizontal projections from point data and top-down/bottom up expert knowledge systems	Brings funds to poorest and most remote communities Unclear how funds will be distributed within the communities themselves	Establishment of community tenure rights over forest Establishment of local level degradation baselines National database of degradation rates Prioritization of areas PES administrative system
		PES community carbon purchase system (area based)	Not yet tried, in principle less effective than output based system	Transaction costs will be lower than in output payment system but overall cost effectiveness probably lower			
		Bundling carbon with SFM certification	Could be effective in larger community forests, but depends on markets for sustainable timber	Transaction costs for SFM are high so could only be cost effective in large scale units	Voluntary participation		

	Main stakeholders	Specific measures	Effectiveness	Cost efficiency	Practicability/ac-ceptability	Poverty and equity	General and enabling measures
		ICDPs	Have not been found very effective in the past; unlikely to result in huge carbon savings	Experience indicates not very cost effective	There has not been a problem of acceptability as such. Transaction costs and baseline as for PES		
	Civil society/NGOs	Training and registration of local organisations to support PES (carbon measuring and monitoring etc)	Works well where supported by a project. Unclear whether costs could be supported out of carbon revenues in a purely market system	Much more cost effective than external 'professional' or government support	Creates work for environmentally active groups		

8.6 Remote Sensing: strengths and limitations

Quantifying net emissions and removals from deforestation and forest degradation requires data on 2 important variables: area change (land cover change: 2-dimensional (ha)) and changes in carbon stocks (3-dimensional (tC/ha)). At the Rome 2006 UNFCCC Workshop on reducing emissions from deforestation in developing countries, it was acknowledged that tools, methods and data are available, and the science is robust, to estimate emissions from deforestation. It was also acknowledged that guidance needs to be elaborated how to combine such tools and methods under a broad range of different conditions.

It is clear that land cover changes can be detected by remote sensing (RS). Although this is more complicated for detecting and quantifying changes in carbon stocks, Richards et al. (2006) argue that on-site carbon changes [in agriculture and the forest sector] can be measured and monitored with both accuracy and precision.

Besides directly human-induced changes in land cover, RS also observes the result of other processes that can cause land cover area change, such as:

- occurrence of pests and diseases, hurricanes, floods, natural fires or other environmental hazards; and,
- changes in land cover area induced by climate change, e.g. expansion of forest area northwards and southwards in respectively the Northern and Southern hemispheres, thawing of permafrost, and desertification.

Hence, to distinguish direct human-induced changes in land cover from other causes, whether with a positive or negative impact on carbon stocks, ancillary data would be required.
This section looks into the 2D and 3D aspects in separate sections.

8.6.1 Detecting Land Cover Change[18]: 2D

For discrimination of land cover types, both optical remote sensing and radar have been successful. If optical remote sensing techniques (that capture solar energy reflected from the Earth's surface at visible, near and middle infrared wavelengths) are used, the minimum area for which change can be detected is determined by the spatial resolution of the sensor.

For an assessment of the accuracy of land cover classifications, the hierarchical scheme of Anderson et al. (1976) is relevant: level I: broad land cover classes such as forests, agricultural land and settlements are distinguished; and level II: land cover classes discriminated in more detail (e.g. different forest types, open versus dense forest). The IPCC Good Practice Guidance of 2003 applies a classification into six broad land cover categories, including forest land, grassland, cropland, wetlands, settlements and other land, which thus corresponds to a level I classification.

When using Landsat 7 Enhanced Thematic Mapper (ETM+) or Landsat TM images at a 30 m resolution, an accuracy of around 90% can be reached for level-I classification (see for assessment of forest changes e.g. Wayman et al., 2001; Woodcock et al., 2001). It is important to note that the ETM+ sensor is currently out of operation until 2010. When SPOT multispectral (XS) imagery is used, comparable or slightly higher accuracies can be reached (e.g. 91.5% accuracy for level-I land cover classification in Michigan, USA, reported by Salajanu & Olson (2001). Level-II land cover classification generally results in lower accuracies than level-I, typically ranging between about 65% and 85% for different optical sensors (Bird et al., 2000; Salajanu & Olson, 2001).

[18] For a review of the potential of different operational sensors to provide data according to the requirements of the Kyoto Protocol see also Rosenqvist et al. (2003), Patenaude et al. (2005) and DeFries et al. (2005).

Brazil and India have had well-developed observation systems for more than ten years (INPE, 2005; Forest Survey of India, 2004). Brazil, for instance, uses the PRODES monitoring system and applies 1.44 ha (16 pixels) as the minimum area for which deforestation can be detected using 30 m resolution Landsat data (Câmara et al., 2006). National-level forest monitoring systems are a feasible goal for many other developing countries (Mollicone et al., 2003; DeFries et al., 2005; DeFries et al., 2006).

The most recent assessment, conducted by the Global Observation of Forest Cover-Global Observation of Land Dynamics (GOFC-GOLD) program of the Global Terrestrial Observing System, under the auspices of ICSU, UNEP, UNESCO, WMO and FAO, found that "accuracies of 80 to 95 percent are achievable for monitoring with high resolution imagery to discriminate between forest and non-forest," and identified a range of observational tools, systems and methodologies for achieving accurate results at varying costs, noting that "no single method is appropriate for all national circumstances. Many methods can produce adequate results. The key requirements to ensure consistency of results across countries lies in verification that the methods are reproducible, provide consistent results when applied at different times, and meet standards for assessment of mapping accuracy." (DeFries et al., 2006) The authors went on to note that accountability and transparency can be guaranteed through peer review. Obviously, a trade-off exists between the spatial resolution of imagery and costs of monitoring per square kilometer (Patenaude et al., 2005).

With coarse resolution satellite images (250 m – 1 km) available from AVHRR, SPOT, Terra, Aqua and ENVISAT satellites, large land cover change events can be detected over small time intervals. MODIS (Moderate Resolution Imaging Spectrometer) is particularly useful to detect deforestation areas larger than 10 ha (Morton et al., 2005). The Brazilian Space Research Institute INPE has an operational early warning system on the basis of Terra MODIS remote sensing data for near real-time detection of large deforestation events. For the European Corine database of land cover changes, the minimum mapping unit was set to 5 ha, to study changes from 1990 to 2000 using 100 m resolution images (Land and Ecosystem Accounting project, http://dataservice.eea.eu.int).

For detection of small changes in land cover at national scale, very high accuracies are needed. The signal is often not larger than the noise in the combined datasets, as discussed by Fuller et al. (2003). In order to reduce uncertainty, quantitative information on the extent and geographical location of significant land cover and land use changes needs to be improved. Optical remote sensing data can be used for stratification purposes, to detect hotspots of land cover change, and to quantify land cover area changes at level I, in relation to a limited number of broad land cover classes.

The availability of different types of satellite images varies geographically. National capabilities to acquire and analyze these images may also vary. Therefore, each nation should look for a proper combination of different methods, and visual interpretation of aerial photographs may be one of the methods to be applied. Depending on the type of land cover changes and their location, countries may opt for statistical sampling, wall-to-wall mapping, analysis of hotspots of land cover changes, or a combination (DeFries, 2006). A nested approach is preferred (see also table 16).

The historical data available are adequate to develop baselines of land cover change for the decade of the 1990's. The NASA Geocover Landsat database is freely available for the 1990's and 2000 and can be used for nation-wide analyses. For the current decade, international coordination is required to assemble images from different high resolution sensors (Landsat, IRS, ASTER, other sensors) in order to obtain sufficient coverage, due to technical problems with the ETM+ sensor (DeFries, 2005). There are current plans for the launch of a Landsat-like sensor after 2010, which would satisfy data requirements for the decade to come.

8.6.2 Detecting Carbon Stock Changes: 3D

Monitoring *degradation,* which occurs over large areas and may give rise to significant emissions (Asner et al, 2005), is more difficult; however, using high resolution data, a variety of approaches have been developed and demonstrated through pilot projects (DeFries et al., 2006). To take the next step, i.e., to move from two-dimensional calculations of forest loss/forest degradation, to the carbon stock changes and emissions that occur as a result of deforestation/forest degradation, the IPCC has compiled methods and good practice guidance (IPCC, 2003; IPCC, 2006).

Plot-based carbon stock measurements
Forest statistical data are often used in modeling carbon uptake by forests. An advantage of this approach is that carbon in litter, belowground biomass and soil organic matter are often also calculated. However, management and yield are often assumed to be the homogeneous across the country (see Patenaude et al., 2005, for the UK) without considering variation in climate or soil fertility. Dead woody debris is often not considered, while the removal by this component may be considerable (Kolchugina & Vinson, 1998). When using forest inventory data, the main source of uncertainty is often the omission of one or more important carbon pools such as belowground biomass, litter, coarse debris, or soils. All carbon exchanges among these pools, and between these and the atmosphere, should be estimated.

Standard data and guidelines for carbon pool measurement are already available through the IPCC Good Practice Guidance Report (IPCC, 2003). As long as locally collected data are not available, these data can be used, although the uncertainty might be higher. For example, using default root:shoot ratios (IPCC, 2003) without supplementary field data can easily result in over- or underestimation of net carbon sequestration.

Significant progress has been made in the field of tree allometry measurements (refer to e.g. Brown, 2002). Measurements on trees in permanent plots can be converted to aboveground biomass using established biomass expansion factors or allometric regression equations. A compilation of existing root biomass data for different forest types in different biomes generated a significant regression equation that can be used to have an approximate estimate of belowground biomass based on aboveground biomass. It is however expected that the ratio between aboveground and belowground biomass varies with latitude for non-forest ecosystems. New and experimental methods such as Leaf Area Index (using hemispherical cameras at ground level) may in the future simplify and strengthen ground base measures of biomass and carbon.

Plot based carbon stock measurements are an essential method and should always be used complementary to remote sensing techniques. Furthermore, data on carbon uptake for other ecosystems than forests are frequently not available. Major assumptions are currently made in the derivation of carbon stock estimates, such as the characteristics of the original natural ecosystems in different ecological zones, and the application of a limited number of pre- or post-conversion carbon densities.

Available remote sensing techniques for measuring aboveground biomass
Direct estimation of carbon stocks through remote sensing could in the near future enable timely observation of changes in these stocks. Several experimental techniques that have proven to be successful need to be further operationalized and scaled up to make this possible. Monitoring forest degradation, the gradual thinning of forest biomass, is still difficult (Skutsch et al., forthcoming) and requires high resolution images. The signal of optical sensors tends to saturate at intermediate to high biomass levels, and therefore degraded, more open forest patches can frequently not be distinguished from dense forests. Visual interpretation of optical images can be done to assess canopy damage. The patterns of log landings and other logging infrastructure are often visible on satellite images. More advanced image processing algorithms can also be used: Asner et al. (2005) developed an automated approach for the analysis of ETM+ satellite data including pattern recognition techniques and detection of forest canopy openings, surface debris and bare soil due to forest disturbances. This allowed the effective

detection and quantification of selective logging across the five timber producing states in the Brazilian Amazon. Asner et al. (2005) concluded that traditional methods of analysis had missed about 50% of the canopy damage caused by timber harvesting.

Radar data can be used to detect forest degradation, but this technique requires further development (DeFries, 2006). More effective solutions for distinguishing degraded from intact forests are currently being developed and have been demonstrated in pilot projects. Their implementation in operational monitoring systems requires the continuity of high resolution imagery and annual monitoring to capture the dynamics of carbon stocks in the process of degradation (DeFries, 2006). Patenaude et al. (2005) stressed the need for the launch of satellite missions specifically designed for carbon stock monitoring.

Various studies have demonstrated the possibility of estimating forest biomass from remotely sensed data (Lu 2005, Drake et al. 2003, Foody et al. 2001, Roy and Ravan 1996). However, limitations of remote sensing for this purpose include the necessity to collect ground survey data to develop and ground-truth remotely sensed predictions of biomass and the inability to generalize results and predictive relationships across geographically and ecologically different places (Lu 2005, Drake et al. 2003, Foody et al. 2003).

A recent, active remote sensing technique operates on a principle called Light Detection and Ranging (LiDAR). This technique has successfully been applied in a range of different forest types to assess tree height profiles, aboveground biomass, timber volumes and crown properties (Patenaude et al., 2004). Details of the technique are described by Lefsky et al. (2002, 2005). If LiDAR would become available from satellite platforms, this is a very promising data source for monitoring of forest degradation, although the costs are at present very high and the skills to employ the method are scarce.

Table 16 summarises different techniques and data sources that need to be employed to monitor land cover change and changes in carbon stocks at various scales.

Table 16: A nested approach to monitoring land cover changes and related changes in carbon stocks integrating different techniques and data sources (adapted after figure 2 from DeFries et al. (2006)).

	Technique or type of sensor	**Output**
Global observations		
Detection of major hotspots of land cover change	Medium resolution sensors (250-1000 m), e.g. MODIS/MERIS	Hotspots of land cover change: large fire and deforestation events (> 10 ha) Near real-time
Regional /national observations		
Stratification into homogeneous regions	- High resolution sensors (10-60 m), e.g. Landsat, SPOT, CBERS - Existing (digital) maps	Eco-regions, climatic regions Per decade or more
Wall-to-wall mapping	- High resolution sensors (10-60 m), e.g. Landsat, SPOT, CBERS - Ancillary data, field verification	Medium scale maps, areas of directly human-induced land cover change (5-10 ha) (Inter-)annually and construction of a historic baseline
Sampling hotspots of land cover change Forest degradation mapping	- Aerial photography - Digital/visual interpretation of high resolution images - Very high resolution sensors (< 5 m), e.g. IKONOS, Quickbird Radar (SAR) and/or LiDAR	Fine scale maps, areas of directly human-induced land cover change, including forest degradation (<0.5-1 ha) Remote sensing derived estimates of carbon stocks
Plot-based observations		
In-situ estimation of changes in carbon stocks	- Plot based sampling - Forest inventories, FAO statistics - Existing standard data IPCC (2003)	Quantified (averted) emissions and removals of carbon in relation to directly human-induced land cover change

9.6.3 Options for accounting for emissions from degradation

As noted above, emissions from forest degradation may be more difficult to quantify than emissions from deforestation, because degradation can be more difficult to detect with remote sensing. At a minimum, however, policy options for addressing these emissions should certainly encourage nations that wish to undertake the needed measures to reduce deforestation to do so and to prove that they have achieved reductions in deforestation that justify compensation for the corresponding emission reductions. In this way, policy options can encourage nations to undertake measures and monitoring, as well as in actual implementation.
Where, with current technologies, emissions from forest degradation are extremely difficult to detect and quantify, there are several additional options for addressing these emissions:

- First, in countries where the two processes of deforestation and degradation are linked such that degradation generally, over time, leads to deforestation, as seems be the case in much of Amazonia (Asner et al. 2006), and Central Africa (Zhang et al. 2005), then quantifying emissions from deforestation should generally, over time, also "catch" emissions from degradation. Consequently, there is no need to quantify degradation emissions separately.

- ❖ Second, in countries where there appears to be a relatively stable ratio between deforestation and degradation (for example, for every 10,000 ha deforested, 1,000 ha are degraded - so, a 10:1 ratio), then any reduction of deforestation will likely also result in a decrease in degradation. If this relationship ratio holds, then when reductions in deforestation are compensated, the atmosphere benefits by receiving less deforestation and degradation emissions. Again, there is no need to quantify degradation emissions separately.
- ❖ Third, in regions/countries in which degradation emissions are relatively minor, a country may choose not to spend resources quantifying degradation and simply receive compensation for reducing deforestation emissions.
- ❖ Finally, in countries where it appears that reducing deforestation might, *ceteris paribus*, result in significant increases in degradation (or where there is no clear relationship between deforestation and degradation), and where emissions from degradation are significant, a country wishing to receive compensation for reducing deforestation should also consider measuring and quantifying degradation, and seeking compensation for reducing degradation as well. In that case, degradation would need to be measured separately with a method that provides measures of loss in biomass due to degradatory practices and can, thus, be related to carbon loss to the atmosphere.

8.7 In summary

The Reduced Emissions from Deforestation in developing countries policy which is now under discussion offers a real way forward as regards including ALOFU in non-Annex I countries in the future, and the Compensated Reductions model and the Joint Research Centre proposal have been very helpful in bringing practical suggestions to the table regarding how such a policy could be implemented. Its precise formulation, including important issues such as how the baseline is established, whether the credits are permanent or temporary, and whether it would operate as an extension of CDM or through an alternative market mechanism based on a separate ALOFU target, or indeed under some other kind of financing, is however still to be determined by the UNFCCC Parties.

Forest degradation is potentially another important source of emissions that may require to be addressed in future. However, methodologies to do so, for now, are a separate issue as monitoring carbon stocks is far more complicated.

If a policy to reward reducing emissions from deforestation is adopted, individual countries who wish to participate will have to construct packages of policies, measures and activities which suit the domestic situation and which will be effective in changing the behaviour of stakeholders who are currently involved in activities which result in deforestation.

Laws and regulations promulgated by central government as regards use of forest land (‘command and control’) are often ineffective: they are ignored by a large part of the population. This is not to say they are pointless: on the contrary, a solid base of forest law and planned protection areas is an essential element for the long term survival of forest. It forms a necessary, though not sufficient condition. What is needed in addition are positive measures which encourage stakeholders to follow the laws and the forest plans. The fact that carbon credits generated through a reduction in deforestation would have a market value, could be used as a lever in this process. Payment for environmental services, by which individual stakeholders receive some financial compensation for carbon which they retain, could be a powerful measure. There are already some prototype carbon payments systems in existence from which much may be learned.

The opportunity costs to stakeholders of retaining full forest as a land use rather than either deforesting or degrading it, vary from country to country and site to site, also depending on the breakeven price of carbon in the presence of a carbon market, so it is difficult to assess whether any given price level for carbon would be sufficient to offset them. In all probability, to use carbon as an effective financial incentive to counter deforestation it is likely that combining it in some way with other incentives will be the most effective. One possibility is as an 'add-on' to certified sustainable forest management (SFM) or to agricultural certification schemes (e.g., shade-grown coffee or cacao), or in areas where eco-tourism is being developed; another could be to make grants for land tenure conditional to e.g. specific types of agricultural practice: conditional grants for land tenure (for example, specifying types of agriculture which are relatively carbon intensive, such as agro-forestry), although there might still be a problem enforcing this. Experiences have shown that it is possible to bundle different environmental services (biodiversity and hydrological services) with carbon, but the markets are different and operate at different scale levels. Environmental trust funds can be established however, to bundle payments for different environmental services from different sources, including ODA, GEF and major international conservation NGOs.

In designing measures for REDD it will be important to distinguish between deforestation and degradation, which are typically carried out for different reasons by different sets of stakeholders. Even though in some instance the returns on forest degradation may be much lower than the returns to deforestation, there are also real opportunities to reduce carbon emissions from degradation by targeting degradation processes on open-access forest areas. This requires a community approach in which control over the forest is largely handed over to community authorities (albeit with some planning and monitoring functions retained by the forest department) – a process which is on-going in a number of countries already. It further requires a PES system in which the increasing forest biomass in each community forest is measured such that the community may be paid proportionately. Here again, national-level approaches appear promising, since they have the potential to drive investment into those areas that are most seriously threatened by degradation. It may be noted that there are good opportunities for anti-degradation programmes in areas of dry tropical forest, as well as in rainforest area.

A possible obstacle for successful inclusion of efforts to reduce emissions from forest degradation (as against deforestation) relates to transaction costs, which may be high because of the need for on-the-ground measurement, since remote sensing on its own is not ideal on all points for quantifying rates of degradation. However, there is growing evidence that much of this measurement can be done by the local people themselves, which should considerably reduce the costs (Skutsch 2005; Nelson and de Jong 2003). NGOs may play an important role in aggregating small-scale projects that can interact with the international carbon market.

Remote sensing will however, be essential for measuring changes in land cover because of the high temporal resolution imagery offered by many satellites, the relatively low cost of imagery (compared to conducting expensive field inventories) and the large ground area that can be represented within a single image. Various studies have demonstrated the possibility of estimating forest cover from remotely sensed data; the main hurdles are budgetary, logistical and political rather than technical.

With respect to forest degradation, as stated before, ground survey data is essential to develop and ground-truth remotely sensed predictions of biomass; remote sensing is not strong as regards generalizing results and predicting relationships across geographically and ecologically different places. The predictions of biomass based on remote sensing need extensive field survey and are site-specific: results cannot be extrapolated to other areas.

Capabilities exist today to measure much of the emissions from deforestation, using data on carbon stocks in the above-ground biomass of trees and using the models and default data in the IPCC Good Practice Guidance (IPCC 2003), but sufficient forest inventories are lacking for a number of countries, and strengthening inventories and remote sensing capabilities to enable completion of the "3D" calculations will depend on international commitments to provide resources to deploy new sensors, acquire high resolution imagery, provide access to data, and convert these into biomass estimates. Protocols for the monitoring of carbon fluxes at national scale level need to be further developed. A nested approach to monitoring land cover changes and related changes in carbon stocks integrating different techniques and data sources at global, national and local scale levels is required.

For example, it could be possible to use a ‘top-down/bottom-up’ approach to establish emission levels at the starting point of an activity, in which remotely sensed data is combined with expert systems data, that is to say, with qualitative and quantitative but systematic data gathered from locally produced maps of the area and ‘people-in-the-know’ - local key informants, both from formal science backgrounds (foresters, ecologists familiar with the area) and from indigenous knowledge sources (local residents). In other words, analysis of satellite data, combined with local expertise and field validation, provide a practical way of producing the necessary data using current technology.

In essence, monitoring and quantifying deforestation using RS is possible already today, whilst quantifying forest degradation needs to be backed up by field data.

9 Conclusions and recommendations

9.1 Conclusions

If nations want to keep the option open to achieve the ultimate objective of the UNFCCC in a timely manner, the AFOLU sector should be included more comprehensively in a post 2012 climate change mitigation regime. The current (re)consideration of the possible, desirable contribution of AFOLU post 2012 is justified because: the current approach is fragmented, both spatially and in terms of pools and gases that are included; it does not provide enough incentives for countries and other stakeholders to make great efforts; it does not encourage the participation of countries where most emissions in the AFOLU sector occur; and it has complicated rules, modalities and guidelines (some would even say flawed).

To include AFOLU more comprehensively in future more and/or new policy options need to be available, so as to: stimulate countries that are currently not included in Annex I of the Kyoto Protocol to increase their level of participation whilst seeking synergies with general development objectives of such countries; take into consideration country-specific circumstances and capacities; and allow a broader list of activities in the AFOLU sector to contribute to the mitigation of climate change under UNFCCC.

The policy options must, and to a large extend, can be designed in such a way that "mistakes" that were made in the past (e.g. setting targets before agreeing to the rules) **and complicated rules are avoided as much as possible** (see chapter 3 for an overview).

The total biophysical potential in agriculture is 5500-6000 Mt CO_2-eq yr^{-1} (Smith et al., 2006a); the projections of the overall economic potential in the forestry sector span a broader range: 2000 – 4000 Mt CO_2 y^{-1} by 2030 to 10.000-15.000 Mt CO_2 y^{-1} by 2030, the latter derived from top-down global models (Benitez et al. 2006, Strengers et al. in press). Of the global mitigation potential, a large proportion lays in non-Annex I countries or economies in transition, with 80% of the global total agricultural mitigation potential found in non-Annex I countries.

The most important mitigation options in agriculture are: restoration of cultivated organic soils (1) and degraded lands (2), and rice management (3). These options are predominantly applicable to Asia (1, 2 and 3), the Russian Federation (1 and 2), South America (2) and Europe (1 and 2) with **80% of the global total agricultural mitigation potential found in non-Annex I countries. The most important options in forestry are: reducing deforestation (by far!) and forest management.** Reducing deforestation is predominantly applicable in Central and South America, Africa and Asia and forest management in OECD North America. In general, **options with the highest potential in forestry can be found in tropical regions**. Degradation of forests may also prove to be a major source of emissions, but reliable data on the exact magnitude is currently not available.

Despite low costs and many positive side effects, not much of the mitigation potential in agriculture and forestry has been realised to date due to barriers. Barriers are categorised as economic; risk-related; political/bureaucratic; logistical; and educational and most mitigation options are hindered by more then one barrier, some of which are interrelated. The list of barriers is longest in tropical regions and the barriers are generally more related to non-climate issues: e.g. political will, poverty and/or lack of capacity. **If these barriers persist no significant mitigation will be achieved, even if good policy options are available**. Political will, however, may relate to fears in non-Annex 1 countries that economic growth will be hindered when land-use change is halted; **solutions are needed which provide economic opportunities as well as carbon conservation.**

Policy options will need to meet a number of criteria identified in this report (see chapter 4) in order to enhance the chances that they will lead to a broader participation of countries through the AFOLU sector in mitigating climate change by deeper commitments. **The most important criteria that policy options need to meet are: promotion of a broader and increasing level of participation; respect for country sovereignty and country-specific circumstances; a practical and comprehensive system; not impinge on country's development; and reward the rightful stakeholders.**

Policy options for the AFOLU sector include: quantified emission limitation and reduction commitments (QELRCs); no-lose targets; a sectoral CDM or crediting mechanism; an expanded list of eligible CDM project activities; sustainable policies and measures; and, technology research and development. The policy options are not mutually exclusive and do not necessarily follow naturally one after the other (e.g. sustainable policies and measures, technology research and development and a no-lose target can all be deployed simultaneously by or within one country): **the list is a suite of policy options from which a country could choose one or more options.**

Potentially all of the policy options can meet the predetermined criteria however; there is no guarantee that any of them will: this will depend on further rules governing the options. A couple of points can be made though. Only the policy options that include QELRCs provide insight as to when predefined concentration levels in the atmosphere can be reached. Options involving only the CDM do not lead to net emission reductions beyond those of the combined QELRCs of a regime: they are offsets. A sectoral CDM will favour countries whose economies have developed to the extent that allows for participation in a reasonable mature market environment. This is unlikely to include the least developed countries that will, therefore, miss out on the benefits: relying only on a CDM type policy option will not foster an equitable distribution of opportunities and benefits. Technology R&D will also not promote equity unless it generates tradable emission reductions in the AFOLU sector: then finances will start to flow from industrialised countries towards the other nations. Until then the private sector will favour in particular politically stable countries with a reasonable degree of economic development for their investments. Comparing policy options with respect to the criterion of increasing levels of participation: without a market drive or QELRCs there may not be a strong incentive for countries to participate. On the other hand, if it brings countries closer to participating in such a market, this may well be a good start. (see also chapter 7)

By far the biggest mitigation potential in forestry is reducing emissions from deforestation as deforestation, mainly conversion of forests to agricultural land, continues at a rate of about 13 million hectares per year (FAO, 2005). **The proposals made recently to operationalise this as a mitigation option are promising and the technical problems relating to baseline construction and monitoring can be overcome.** Countries that want to employ this mitigation option should have a national system in place that can cope with quantifying deforestation, probably by remote sensing. Via policy options presented in chapter 6 assistance could be provided to build such national systems. Countries that wish to take specific actions in the area of reducing forest degradation must have stronger inventory systems in place that can also quantify carbon stock changes and not only land cover change. **When designing measures to operationalise the option to credit reducing emissions from deforestation, it will be essential to include systems to distribute payments for carbon benefits to those stakeholders that actually established the net emission reductions.**

Remote sensing will be essential to establish baselines and monitor progress in reducing emissions from deforestation. There will be considerable need to build capacity in this regard in many non-Annex I countries. Remote sensing on its own will not be sufficient to determine carbon stock changes and will need to be backed up by plot-based carbon stock measurements, if reducing forest degradation were to be considered a viable climate change mitigation strategy as well. There are a number of new and innovative technologies which could be useful in the near future, such as LiDAR. LiDAR has successfully been applied in a range of different forest types to assess tree height profiles, aboveground biomass, timber volumes and crown properties. At present

however, the costs are still very high and the skills to employ the method are scarce. To achieve nationwide application significant resources will be required.

Remote sensing has recently, experimentally been used successfully to detect canopy disturbances. Combined with available field data, the level of canopy disturbance has been linked reliably to logging intensities. Logging intensities can be translated into quantified biomass losses. Therefore, the role of remote sensing for quantifying forest degradation may become even greater.

The challenge for climate policy that depends on government subsidies is that public funding will not be sufficient to address the scale of the problem in the AFOLU sector. Policies that integrate emission reductions/uptake into carbon markets hold more promise. To participate in such a market a CDM-type mechanism is the least that is required, but to increase the contribution of AFOLU to UNFCCC's Art.2 objective, some countries may need to take on QELRCs in that sector in the very near future. To determine a target, an estimate needs to be made regarding the realistic future potential.

To better understand the potential contribution of AFOLU in a future climate change mitigation regime, more country-specific data and information should become available.

Targets in the future, that include emission reductions and removals in the AFOLU sector, must be reasonable tough but achievable. This will result in fair carbon prices that will invite the appropriate levels of investment. This requires the right balance between broadening and deepening the level of participation, and the stringency of the overall target. To allow market mechanisms to function properly, besides the already mentioned barriers, macro-economic barriers should also be minimised in order to realise the largest possible proportion of the full mitigation potential. Other issues, for instance the case whereby countries that have had low deforestation rates in the past, can be dealt with relatively easy by choosing particular reference net emission levels, possibly even based on projections of emissions in the future.

9.2 Recommendations

Policy options and mitigation potentials:

1. Policies must be developed that consider all land uses (forestry, agriculture and wetlands) together;
2. Mitigation policies should ideally be developed within the wider framework of sustainable development;
3. To achieve mitigation through the AFOLU sector, removing macro-economic barriers (e.g. related to fair trade, agricultural subsidies in Annex I countries and interests on loans and foreign debt) is a prerequisite;
4. To achieve a broader and deeper participation of countries in a future climate change mitigation regime, options must be available that fit the individual countries and their development objectives;
5. A particular focus on reducing emissions from deforestation and restoration of cultivated organic soils and degraded lands is justified, amongst other things, due to the exceptional high potentials to contribute to the achievement of Article 2 of the UNFCCC;
6. For the post 2012 era, AFOLU net emission reductions and removals should be an integral part of the overall greenhouse gas emission reduction target (ideally after the rules governing the use of AFOLU are determined). That target can be more stringent, ceteris paribus, to optimally foster action and optimise the use of market-based mechanisms; and,
7. A design of a future climate change mitigation regime for AFOLU must try to avoid mistakes made in the past and many rules, modalities and guidelines can be improved on the basis of lessons learned.

Science and Technology:

1. To set an overall AFOLU target, projections are urgently needed. One way of accomplishing that is to request more detailed country-specific data and information provided by countries in their national communications; and,
2. To be able to compare estimates and projections on the basis of country-specific data and information, a harmonised approach in terms of terminology and methods is required.

In relation to REDD:

1. Such strategies should distinguish between local processes of governed and ungoverned deforestation (and degradation (see also chapter 8)), and should incorporate different measures to address them as they have different drivers and stakeholders;
2. Domestic activities will (in part) be undertaken locally, nested within an overall national programme or strategy which may also include broader measures (law enforcement, training, etc);
3. Anti-deforestation measures may best be directed to companies/organizations and individuals;
4. Fighting forest degradation may work best if measures are directed to communities and integrated into programmes of devolution of control of forests to communities (community-based forest management);
5. To distribute economic returns to the rightful stakeholders, successful Payment for Environmental Services (PES) systems need to be designed; and,
6. In order to build experience a number of pilot projects should be launched in the shortest possible timeframe. In addition, consideration should be given to rewarding “an early start” in this policy area, comparable to that used for the CDM in the past.

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Appendix 1 Description of agricultural GHG mitigation activities, practices and management options (adapted from Smith et al., 2006a)

1. Cropland management

Croplands, because they are often intensively managed, offer many opportunities to impose practices that reduce net emissions of GHGs (Table 1). Mitigation practices in cropland management include the following partly-overlapping categories:

a. *Agronomy:*

Improved agronomic practices that increase yields and generate higher inputs of residue C can lead to increased soil C storage (Follett 2001). Examples of such practices include: using improved crop varieties; extending crop rotations, notably those with perennial crops which allocate more C below-ground; and avoiding or reducing use of bare (unplanted) fallow (West & Post 2002; Smith 2004a,b; Lal 2003, 2004; Freibauer et al. 2004). Adding more nutrients, when deficient, can also promote soil C gains (Alvarez 2005), but the benefits from N fertilizer can be offset by higher emissions of N_2O from soils and CO_2 from fertilizer manufacture (Schlesinger, 1999; Robertson & Grace 2004; Gregorich et al. 2005).

Emissions can also be reduced by adopting less intensive cropping systems, which reduce reliance on pesticides and other inputs (and therefore the GHG cost of their production: Paustian et al. 2004). An important example is the use of rotations with legume crops (West & Post 2002; Izaurralde et al. 2001), which reduce reliance on inputs of N, though legume-derived N can also be a source of N_2O (Rochette & Janzen 2005)

A third group of agronomic practices are those that provide temporary vegetative cover between agricultural crops. These ‘catch’ or ‘cover’ crops add C to soils (Barthès et al. 2004; Freibauer et al. 2004) and may also extract plant-available N unused by the preceding crop, thereby reducing N_2O emissions.

b. *Nutrient management:*

Nitrogen applied in fertilizers and manures is not always used efficiently by crops (Galloway et al. 2003; Cassman et al. 2003). Improving this efficiency can reduce emissions of N_2O, generated by soil microbes largely from surplus N, and it can indirectly reduce emissions of CO_2 from N fertilizer manufacture (Schlesinger, 1999). Practices that improve N use efficiency include: adjusting application rates based on precise estimation of crop needs (e.g. precision farming); using slow-release fertilizer forms or nitrification inhibitors (which slow the microbial processes leading to N_2O formation); avoiding time delays between N application and plant N uptake (improved timing); placing the N more precisely into the soil to make it more accessible to crops roots; avoiding excess N applications, or eliminating N applications where possible (Robertson 2004; Dalal et al. 2003; Paustian et al. 2004; Cole et al. 1997; Monteny et al. 2006).

c. *Tillage/ residue management:*

Advances in weed control methods and farm machinery now allow many crops to be grown with minimal tillage (reduced tillage) or without tillage (no-till). These practices are now increasingly used throughout the world (e.g. Cerri et al. 2004). Since soil disturbance tends to stimulate soil C losses through enhanced decomposition and erosion, reduced- or no-till agriculture often results in soil C gain, though not always (West & Post 2002; Ogle et al. 2005; Gregorich et al. 2005; Alvarez 2005). Adopting reduced or no-till may also affect emissions of N_2O, but the net effects are inconsistent and not well-quantified globally (Smith & Conen 2004; Helgason et al. 2005; Li et al. 2005; Cassman et al. 2003). The effect of reduced tillage on N_2O emissions may depend on soil and climatic conditions: in some areas reduced tillage promotes N_2O emissions; elsewhere it may reduce emissions or have no measurable influence (Marland et al. 2001).

Systems that retain crop residues also tend to increase soil C because these residues are the precursors for soil organic matter, the main store of carbon in the soil. Avoiding the burning of residues, for instance mechanising the harvesting of sugarcane, which eliminates the need for pre-harvest burning (Cerri et al. 2004), also avoids emissions of aerosols and GHGs generated from fire.

d. *Water management:*
About 18% of the worlds croplands now receive supplementary water through irrigation (Millennium Ecosystem Assessment 2005). Expanding this area, or using more effective irrigation measures can enhance C storage in soils through enhanced yields and residue returns (Follett 2001; Lal 2004a). But some of these gains may be offset by CO_2 from energy used to deliver the water (Schlesinger 1999; Mosier et al. 2005) or from N_2O emissions from higher moisture and fertilizer N inputs (Liebig et al. 2005), though the latter effect has not been widely measured.
Drainage of agricultural lands in humid regions can promote productivity (and hence soil C) and perhaps also suppress N_2O emissions by improving aeration (Monteny et al. 2006). Any nitrogen lost through drainage, however, may be susceptible to loss as N_2O (Reay et al. 2003).

e. *Rice management:*
Cultivated wetland rice soils emit significant quantities of methane (Yan et al. 2003). Emissions during the growing season can be reduced by many practices (Yagi et al. 1997; Wassmann et al. 2000; Aulakh et al. 2001). For example, draining the wetland rice once or several times during the growing season effectively reduces CH_4 emissions (Smith & Conen 2004; Yan et al. 2005), although this benefit may be partly offset by higher N_2O emissions, and the practice may be constrained by water supply. Rice cultivars with low exudation rates could offer an important methane mitigation option (Aulakh et al. 2001). In the off-rice season, methane emissions can be reduced by improved water management, especially by keeping the soil as dry as possible and avoiding water-logging (Cai et al. 2000, 2003; Kang et al. 2002; Xu et al. 2003).
Methane emissions can also be reduced by adjusting the timing of organic residue additions (e.g. incorporating organic materials in the dry period rather than in flooded periods; Xu et al. 2000; Cai & Xu 2004), by composting the residues before incorporation, or by producing biogas for use as fuel for energy production (Wang & Shangguan 1996; Wassmann et al. 2000).

f. *Agro-forestry:*
Agro-forestry is the production of livestock or food crops on land that also grows trees, either for timber, firewood, or other tree products. It includes shelter belts and riparian zones/buffer strips with woody species. The standing stock of carbon above ground is usually higher than the equivalent land use without trees, and planting trees may also increase the soil carbon sequestration (Oelbermann et al. 2004; Guo & Gifford 2002; Mutuo et al. 2005; Paul et al. 2003), though the effects on N_2O and CH_4 emissions are not well known (Albrecht & Kandji 2003).

g. *Land cover (use) change:*
One of the most effective methods of reducing emissions is to allow or encourage the reversion of cropland to another land cover, typically one similar to the native vegetation. The conversion can occur over the entire land area ('set-asides'), or in localized spots, such as grassed waterways, field margins, or shelterbelts (Follett 2001; Freibauer et al. 2004; Lal 2004a; Falloon et al. 2004; Ogle et al. 2003). Such land cover change often increases storage of C; for example, converting arable cropland to grassland typically results in the accrual of soil C because of lower soil disturbance and reduced C removal in harvested products. Compared to cultivated lands, grasslands may also have reduced N_2O emissions from lower N inputs, and higher rates of CH_4 oxidation, though recovery of oxidation may be slow (Paustian et al. 2004).
Similarly, converting drained croplands back to wetlands can result in rapid accumulation of soil carbon (removal of atmospheric CO_2), although this conversion may stimulate CH_4 emissions, because water-logging creates anaerobic conditions (Paustian et al. 2004).

Planting trees can also reduce emissions, but these practices are considered under agro-forestry (see above) afforestation or reforestation.
Because land cover (or use) conversion comes at the expense of lost agricultural productivity, it is usually an option only on surplus agricultural land or on croplands of marginal productivity.

2. Grazing land management and pasture improvement
Grazing lands occupy much larger areas than croplands (FAOSTAT 2006), but are usually managed less intensively. The following list provides some examples of practices to reduce GHG emissions and enhance removals.

a. *Grazing intensity:*
The intensity and timing of grazing can influence the growth, C allocation, and flora of grasslands, thereby affecting the amount of C accrual in soils (Conant et al. 2001; 2005; Freibauer et al. 2004; Conant & Paustian 2002; Reeder et al. 2004). Carbon accrual on optimally grazed lands is often greater than on un-grazed or over-grazed lands (Liebig et al. 2005; Rice & Owensby 2001). The effects are inconsistent, however, owing to the many types of grazing practices employed and the diversity of plant species, soils, and climates involved (Schuman et al. 2001; Derner et al. 2006). The influence of grazing intensity on emission of non-CO_2 gases is not well-established, apart from the indirect effects from adjustments in livestock numbers.

b. *Increased productivity (including fertilization):*
As for croplands, C storage in grazing lands can be improved by a variety of measures that promote productivity. For instance, alleviating nutrient deficiencies by fertilizer or organic amendments increases plant litter returns and, hence, soil C storage (Schnabel et al. 2001; Conant et al. 2001). Adding nitrogen, however, may stimulate N_2O emissions (Conant et al. 2005) thereby offsetting some of the benefits. Irrigating grasslands, similarly, can promote soil C gains (Conant et al. 2001), though the net effect of this practice depends also on emissions from energy use and other related activities on the irrigated land (Schlesinger 1999).

c. *Nutrient management:*
Practices that tailor nutrient additions to plant uptake, like those described for croplands, can reduce emissions of N_2O (Dalal et al. 2003; Follett et al. 2001). Management of nutrients on grazing lands, however, may be complicated by deposition of faeces and urine from livestock, which are not as easily controlled nor as uniformly applied as nutritive amendments in croplands (Oenema et al. 2005).

d. *Fire management:*
Biomass burning (not to be confused with bio-energy, where biomass is combusted off-site for energy) contributes to climate change in several ways. Firstly, it releases GHGs, notably CH_4, and to a lesser extent, N_2O (the CO_2 released is of recent origin, is re-absorbed by vegetation and is usually not counted). Secondly, it generates hydrocarbon and reactive nitrogen emissions, which react to form tropospheric ozone. Smoke contains a range of aerosols which can have either warming or cooling effects on the atmosphere though the net effect is thought to be positive radiant forcing (Andreae et al. 2005; Jones et al. 2003; Venkataraman et al. 2005; Andreae, 2001; Andreae & Merlet, 2001; Anderson et al. 2003; Menon et al. 2002). Thirdly, fire blackens the land surface, reducing its albedo for several weeks, causing a warming (Beringer et al. 2003). Fourthly, burning can affect the proportions of woody versus grass cover, notably in savannas, which occupy about an eighth of the global land surface. Reducing the frequency or intensity of fires typically leads to increased tree and shrub cover, resulting in higher landscape C density in soil and biomass (Scholes & van der Merwe 1996). This woody-plant encroachment mechanism is higher initially, but saturates over 20-50 years, whereas avoided CH_4 and N_2O emissions are ongoing as long as the fires are suppressed.

Mitigation of radiant forcing involves reducing the frequency or extent of fires through more effective fire suppression (Korontzi et al. 2003); reducing the fuel load by vegetation management; and burning at a time of year when less CH_4 and N_2O are emitted (Korontzi et al. 2003). Although most agricultural-zone fires are ignited by humans, there is evidence that the area burned is ultimately under climatic control (van Wilgen et al. 2004). In the absence of human ignition, the fire prone ecosystems would be lit by other agents.

e. *Species introduction:*
Introducing grass species with higher productivity or C allocation to deeper roots has been shown to increase soil C. For example, establishment of deep-rooted grasses in savannas has been reported to yield very high rates of C accrual (Fisher et al. 1994), although the applicability of these results has not been widely confirmed (Conant et al. 2001; Davidson et al. 1995). Introducing legumes into grazing lands can promote soil C storage (Soussana et al. 2004), through enhanced productivity from the associated N inputs, and perhaps also reduce N_2O emissions, if the biological N_2 fixation displaces the need for fertilizer N.

Lands used for grazing also emit GHGs from the livestock, notably CH_4 from ruminants and from their manures. Practices for reducing these emissions are considered under 'Livestock management' (section 2.5).

3. Management of organic soils
Organic soils contain high densities of C, accumulated over many centuries, because decomposition is suppressed by absence of oxygen under flooded conditions. To be used for agriculture, these soils are drained, which aerates the soil, favouring decomposition and therefore high fluxes of CO_2 and N_2O. Methane emissions are usually suppressed after draining, but this effect is far outweighed by pronounced increases in N_2O and CO_2 (Kasimir-Klemedtsson et al. 1997). Emissions on drained organic soils can be reduced to some extent by practices such as avoiding row crops and tubers, avoiding deep ploughing, and maintaining a more shallow water table, but the most important mitigation practice, probably, is avoiding the drainage of these soils in the first place, or re-establishing a high water table where GHG emissions are still high (Freibauer et al. 2004).

4. Restoration of degraded lands
A large fraction of agricultural lands have been degraded by erosion, excessive disturbance, organic matter loss, salinisation, acidification, or other processes that curtail productivity (Batjes 1999; Foley et al. 2005; Lal 2001, 2003, 2004b). Often the C storage in these soils can be at least partly restored by practices that reclaim productivity, including: re-vegetation (e.g. planting grasses); improving fertility by nutrient amendments; applying organic substrates such as manures, bio-solids, and composts; reducing tillage and retaining crop residues; and conserving water (Lal 2001, 2004b; Bruce et al. 1999; Olsson & Ardö 2002; Paustian et al. 2004). Where these practices involve higher nitrogen amendments, the benefits of C sequestration maybe partly offset by higher N_2O emissions.

5. Livestock management
Livestock, predominantly ruminants such as cattle and sheep, are important sources of CH_4, accounting for about 18% of global anthropogenic emissions of this gas (US-EPA 2006). The methane is produced primarily by enteric fermentation and voided by eructation (Crutzen 1995; Murray et al. 1976; Kennedy & Milligan 1978). Practices for reducing CH_4 emissions from this source fall into three general categories: improved feeding practices, use of specific agents or dietary additives, and longer-term management changes and animal breeding.

a. *Improved feeding practices:*
Methane emissions can be reduced by feeding more concentrates, normally replacing forages (Blaxter and Claperton 1965; Johnson & Johnson 1995; Lovett et al. 2003; Beauchemin & McGinn, 2005). Although concentrates may increase daily methane emissions, emissions per kg feed intake and per kg product are almost invariably reduced. The net benefit, however, depends on reduced animal numbers or younger age at slaughter

for beef animals, and on how the practice affects emissions when producing and transporting the concentrates (Phetteplace et al. 2001; Lovett et al. 2006).

Other practices that can reduce CH_4 emissions include: adding oils to the diet (e.g. Machmuller et al. 2000; Jordan et al. 2004); improving pasture quality, especially in less developed regions, because it improves animal productivity, and reduces the proportion of energy lost as CH_4 (Leng 1991; McCrabb et al. 1998; Alcock & Hegarty 2005); and optimising protein intake to reduce N excretion and N_2O emissions (Clark et al. 2005).

b. Specific agents and dietary additives:
A wide range of specific agents, mostly aimed at suppressing methanogenesis, have been proposed as dietary additives to reduce CH_4 emissions:

- Ionophores are antibiotics that can reduce methane emissions (Benz & Johnson 1982; Van Nevel & Demeyer 1995; McGinn et al. 2004), but their effect may be transitory (Rumpler et al. 1986) and they have been banned in the EU.
- Halogenated compounds inhibit methanogenic bacteria (Wolin et al. 1964; van Nevel & Demeyer 1995) but their effects, too, are often transitory and they can have side effects such as reduced intake.
- Probiotics, such as yeast culture, have shown only small, insignificant effects (McGinn et al. 2004) but selecting strains specifically for methane reducing ability could improve results (Newbold & Rode 2005).
- Propionate precursors such as fumarate or malate reduce methane formation by acting as alternative hydrogen acceptors (Newbold et al. 2002), but they elicit response only at high doses and are therefore expensive (Newbold et al. 2005).
- Vaccines against methanogenic bacteria are being developed but are not yet commercially available (Wright et al. 2004).
- Bovine somototropin (BSt) and hormonal growth implants do not specifically suppress CH_4 formation, but by improving animal performance (Bauman 1992; Schmidely 1993), they can reduce emissions per kg of animal product (Johnson et al. 1991; McCrabb 2001).

c. *Longer-term management changes and animal breeding:*
Increasing productivity through breeding and better management practices spreads the energy cost of maintenance across a greater feed intake, often reducing methane output per kg of animal product (Boadi et al. 2004). With improved efficiency, meat-producing animals reach slaughter weight at a younger age, with reduced lifetime emissions (Lovett & O'Mara 2002). The whole-system effects of such practices are not entirely clear, however; for example, selecting for higher yield might reduce fertility, requiring more replacement animals (Lovett et al. 2006).

6. Manure management
Animal manures can release significant amounts of N_2O and CH_4 during storage, but the magnitude of these emissions varies. Methane emissions from manure stored in lagoons or tanks can be reduced by cooling or covering the sources, or by capturing the CH_4 emitted (Clemens and Ahlgrimm, 2001; Monteny et al. 2001, 2006; Paustian et al. 2004). The manures can also be digested anaerobically to maximize retrieval of CH_4 as an energy source (Clemens & Ahlgrimm, 2001; Clemens et al. 2006). Storing and handling the manures in solid rather than liquid form can suppress CH_4 emissions, but may increase N_2O formation (Paustian et al. 2004). Preliminary evidence suggests that covering manure heaps can reduce N_2O emissions (Chadwick 2005). For most animals worldwide there is limited opportunity for manure management, treatment, or storage – excretion happens in the field and handling for fuel or fertility amendment occurs when it is dry and methane emissions are negligible (Gonzalez-Avalos & Ruiz-Suarez, 2001). To some extent, emissions from manure might be curtailed by altering feeding practices (Külling et al. 2003), or by composting the manure (Pattey et al. 2005) but these mechanisms and the system-wide influence have not been widely explored. Manures also release GHGs, notably N_2O, after application to cropland or deposition on grazing lands, but the practices for reducing these emissions are considered above in sections 2.1 and 2.2.

7. Bioenergy

Increasingly, agricultural crops and residues are seen as sources of feed stocks for energy, to displace fossil fuels. A wide range of materials have been proposed for use, including grain, crop residue, cellulosic crops (e.g. Switchgrass, sugarcane), and various tree species (Edmonds 2004; Cerri et al. 2004; Paustian et al. 2004; Sheehan et al. 2004; Dias de Oliveira et al. 2005; Eidman 2005). These products can be burned directly, but often are processed further to generate liquid fuels such as ethanol or diesel fuel (Richter 2004). These fuels release CO_2 when burned, but this CO_2 is of recent atmospheric origin (via photosynthesis) and displaces CO_2 which otherwise would have come from fossil C. The net benefit to atmospheric CO_2, however, depends on energy used in growing and processing the bio-energy feed-stock (Spatari et al. 2005).

The interactions of an expanding bio-energy sector with other land uses, and impacts on agro-ecosystem services such as food production, biodiversity, soil and nature conservation, and carbon sequestration has not yet been adequately studied, but bottom up approaches (Smeets et al. 2006) and integrated assessment modelling (Hoogwijk et al. 2005; Hoogwijk 2004) offer opportunities to improve understanding. Latin America, Sub-Saharan Africa and Eastern Europe are promising regions for bio-energy, with additional long-term contributions from Oceania and East and NE Asia. The technical potential for biomass production may be developed at low production costs in the range of 2 USD GJ^{-1} (Hoogwijk 2004, Rogner et al. 2000).

Major transitions are required to exploit the large potential for bio-energy. Improving agricultural efficiency in developing countries is a key factor. It is still uncertain to what extent, and how fast, such transitions can be realized in different regions. Under less favourable conditions, the (regional) bio-energy potential(s) could be quite low. Also, it should be noted that technological developments (in conversion, as well as long distance biomass supply chains such as those involving intercontinental transport of biomass derived energy carriers) can dramatically improve competitiveness and efficiency of bio-energy (Faaij 2006, Hamelinck et al. 2005).

Appendix 2 Overview of general criteria to assess future climate regimes

Category of criteria **Sub-criteria**	**Key question**
Environmental criteria	***Can the approach safeguard the fulfilment of the ultimate objective of the Convention (Article 2), i.e. stabilization of greenhouse gas concentrations that prevent dangerous interference with the climate system?***
(1) Putting emphasis on environmental effectiveness	Does the approach put environmental effectiveness (e.g. greenhouse gas emission reductions) as the core of a future regime
(2) Participation of industrialized countries	Does the approach consider substantial emission reductions by key emitters in industrialized countries?
(3) Encouraging early action	Are countries that do not yet have binding commitments encouraged to keep emissions as low as possible by e.g. considering technology leapfrogging? If early actions are encouraged, are they rewarded later?
(4) Involvement of developing countries	Are emerging economies and advanced developing countries with substantial GHG emissions (gradually) involved in the reduction efforts?
(5) Comprehensiveness of system	Is the regime a comprehensive system that includes the most important GHG gases and sectors responsible for climate change?
(6) Avoiding leakage effects	Does the regime minimize that emission reduction efforts in one country/sector are negated by increasing emissions in another country or sector? If such leakage is not prevented, is it adequately accounted for?
(7) Avoiding unintentional "hot air" or "windfall profits"	Does the regime prevent that a country receives more emission rights than it would emit under a business-as-usual scenario?[19]
(8) Certainty on emissions	Does the approach provide quantitative and timed limits on global greenhouse gas emissions?
(9) Integrating sustainable development	Does the regime create synergies with sustainable development?
(10) Promoting ancillary benefits	Does the approach promote other environmental benefits such as improved air quality?
Economic criteria	***Can the approach ensure that global emission reduction efforts can be achieved in an efficient and cost-effective way and lead to positive economic side effects?***
(1) Minimizing negative economic effects	Does the approach allow distribution of commitments so that the aggregate global costs are minimized and give countries sufficient flexibility to reach their commitments?
(2) Generating positive economic side effects	Does the regime generate positive economic side effects as result of a climate friendly development?
(3) Promoting growth of developing countries	Does the regime promote / not hinder (economic) growth of developing countries thus setting positive economic growth impulses?
(4) Address competitiveness concerns	Does the approach minimize distortions through different national requirements on emissions for internationally competing emission intensive industries[20]
(5) Stimulating technological change and providing incentives for technology spill-over or deployment of technology	Can the approach stimulate the technological change necessary for the transition to a low greenhouse gas emission energy system in an efficient manner? Will these technologies be deployed also in developing countries to allow leapfrogging?

[19] A regime may intentionally include "hot air" as a compensation or incentive mechanism.

[20] E.g. the cement industry in a country with a reduction requirement may on the global market compete with the cement industry in countries without a reduction requirement.

Category of criteria **Sub-criteria**	**Key question**
(6) Certainty about costs	Does the regime allow predicting the level of costs and related economic impacts on countries to avoid the risk of unexpected high costs and/or unintended unevenly distributed burden?
Distributional and equity criteria	***Does the approach satisfy major equity principles so that it is seen as fair and just?***
(1) Meeting equity principle “Needs”	Is the opportunity given to all countries to satisfy their basic development needs?
(2) Meeting equity principle “Capability”	Are the countries required to act those that have the capability to do so or are the countries not being capable on their own assisted in order to obtain this capacity?
(3) Meeting equity principle “Responsibility”	Are the countries required to act those that are directly or indirectly responsible for the problem?
(4) Meeting equity principle “Equal rights”	Does the regime take into account the principle of equal rights of all people to use the atmosphere and to have access to natural resources?
(5) Meeting equity principle “Comparable efforts”	Does the regime anticipate comparable efforts from similar countries to mitigate climate change?
(6) Meeting equity principle “Sovereignty”	Does the approach take into account that states are sovereign? Does the approach use nations’ current emission as the basis for a future climate policy?
(7) Accounting for structural differences between countries	Are different national circumstances of countries be taken into account in the approach?
(8) Integrating adaptation	Does the regime consider specifically adaptation?
(9) Compensation of those stakeholders incurring costs	Are the profits of emission reductions/removals benefiting those that contributed to achieving it on a national level?
Technical and institutional criteria	***Is the approach designed in an efficient way?***
(1) Can build upon and use many agreed elements of the existing UNFCCC/Kyoto system	Can the regime be built upon or use key elements of the UNFCCC/Kyoto system such as a) basket of gases, b) Kyoto mechanisms, c) emission monitoring systems and d) negotiation structure?
(2) Moderate technical implementation requirements	Are all necessary data and tools available and easily verifiable? Is the regime built in a way that it avoids or limits fraud and corruption?
(3) Moderate political requirements for the negotiation process	Is the approach simple and requires a low number of separate decisions by international bodies? Do the decisions cover a clear and manageable future timeframe?
(4) Inherent stability of the regime	Is the regime flexible enough to ensure countries’ continued participating also in the case of unexpected events? Is it prevented that countries “walk away” from the agreement? Is it self-propelling?
(5) Increasing level of participation	Does the regime promote countries to increase their level of participation in the regime?

Appendix 3 Appendix 3Differentiation of emission targets - allocation

In systems, where emission levels are capped and allowances can be traded, the initial allocation or the differentiation of emission targets have to be agreed. The overall cap could either be defined top-down (fixing the level of GHG concentration in the atmosphere to be reached and then negotiate how to share the burden between the countries) or bottom-up (define the assigned amounts of countries which then add up to a certain level of allowed overall emissions). Many different allocation formulas have been proposed for future systems:

- Equal per capita allocation (Agarwal and Narain, 1991; Baer et al., 2000; Wicke, 2005)
- Contraction and convergence (Meyer, 2000; GCI, 2005)
- Basic needs or survival emissions (Aslam, 2002; Pan, 2005)
- Adjusted per capita allocation (Gupta and M Bhandari, 1999)
- Equal per capita emissions over time (Bode, 2004)
- Common but differentiated convergence (Höhne et al., 2006)
- Grandfathering (Rose et al., 1998)
- Global preference score compromise (Müller, 1999)
- Historical responsibility - The Brazilian Proposal (UNFCCC, 1997; Rose et al., 1998; Meira Filho and Gonzales Miguez, 2000; Pinguelli Rosa and Ribeiro, 2001; den Elzen and Schaeffer, 2002; den Elzen et al., 2002; Rovere et al., 2002; Andronova and Schlesinger, 2004; Pinguelli Rosa et al., 2004; Trudinger and Enting, 2004; den Elzen et al., 2005a; den Elzen et al., 2005c; Höhne and Blok, 2005; Rive et al., 2006)
- Ability to Pay (Jacoby et al., 1998; Jacoby et al., 1999; Lecoq and Crassous, 2003)
- Equal Mitigation Costs (Rose et al., 1998; Babiker and Eckhaus, 2002)
- Triptych (Blok et al., 1997; Berk and den Elzen, 1998; Groenenberg, 2002; den Elzen and Berk, 2004; Höhne et al., 2005)
- Multi-sector convergence (Sijm et al., 2001)
- Multicriteria (Blanchard et al., 1998; Ringius et al., 1998; Torvanger and Ringius, 2000; Helm and Simonis, 2001)

Of these allocation formulas, none was particularly designed for the AFOLU sector. Only the Triptych method, that provides for all countries simple common allocation methods for each sector, includes a specific consideration of the AFOLU sector. It suggests reduction of deforestation per capita emissions from current levels to zero by a defined date (e.g. 2050).

Appendix 4 Looking ahead: the AFOLU potential post-2012 under various policy options

This appendix aims, in the absence of abundant and exact country-specific data, to look ahead at the mitigation potential of the AFOLU sector in a post-2012 era using the different policy options that have been proposed in previous chapters.

Chapter 3 has shown that reducing deforestation in South America and (Other) Asia provides the biggest mitigation potential in the forestry sector. This appendix zooms-in on Brazil, Indonesia, India and China. The data that has been used for forestry is provided by the countries itself in their Initial National Communications or by national institutions.

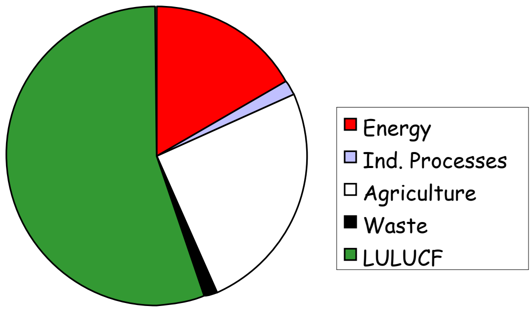
Regarding data on agriculture, it has to be emphasized the national communications only contain information on CH_4 and N_2O emissions, while CO_2 from soils is included under the category LUCF. This "problem" will disappear in future if the new IPCC 2006 inventory guidelines are going to be used as they bring together all emissions and removals in Agriculture, Forestry and Other Land Use (hence the abbreviation AFOLU) at the right spot. For now, the assessment had to be based on the category 'LUCF emissions' when analyzing data from the National Communications as the AFOLU approach has not been implemented yet, even though it is clear that significant emissions from agriculture are excluded in this way, as the majority of emissions included under agriculture are predominantly coming from livestock.

Estimates in this appendix of agricultural mitigation potentials are derived from data provided in chapter 3, which includes estimates of mitigation potentials from land management, bio-energy, livestock and manure management for 22 world regions[21]. It was decided for this exercise to concentrate on the mitigation potentials of land management options (cropland management, rice management, grazing land management, restoration of cultivated organic soils and degraded lands) – thus excluding what would be comprised under 'agriculture' in the National Communications – and to provide an estimate of the agricultural mitigation potentials for the selected countries on the basis of that material.

Brazil

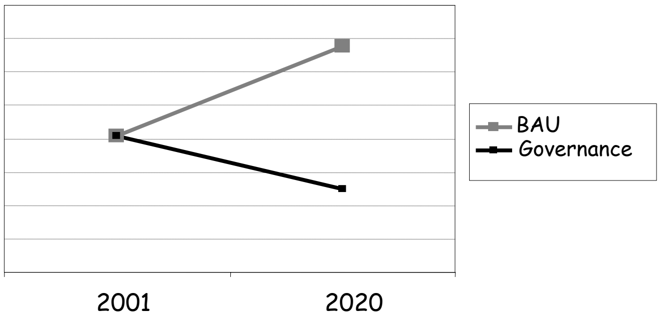
The figure below illustrates the sectoral split of emissions for the year 1994 for Brazil as reported in its Initial National communication. More than half of Brazilian GHG emissions (net emissions 818 Mt CO_2 eq. or 55 percent) take place in the LULUCF sector. In 1994, 952 Mt CO_2 eq were emitted due to deforestation, while 76 Mt CO_2 eq of emissions are derived from soils.

[21] Sources and methods used for the generation of our forestry and agricultural estimates are therefore, not really comparable.



Sectoral split of GHG emissions for Brazil (1994). Source: www.unfccc.int.

Projections of emissions and removals from AFOLU on country-level are rare, but some numbers exist on deforestation rates for the Amazon. Soares-Filho et al. (2005) used a simulation model to analyse a variety of deforestation scenarios for the Amazon. According to the BAU scenario used in this study, annual deforestation rates in the Amazon will rise until around 2025, and will smoothly decline thereafter. Under a governance scenario, the projected annual deforestation rates follow a decreasing trajectory and could be reduced by around 60 percent as compared to BAU in 2020. As a first order assumption we assume that emissions develop proportional to the deforestation rates of Soares-Filho et al. (2005) and that emissions from deforestation in 2001 would be around 1000 Mt CO_2 eq.



First order approximation of emissions from LULUCF in Brazil in the BAU and Governance scenario

In 2020, emissions would therefore, be either 600 Mt CO_2 eq. in the governance scenario or 1600 Mt CO_2 in the BAU scenario, the difference representing the annual reduction potential (1000 Mt CO_2 eq.) being in the order of total emissions of Germany. Considering different barriers, the realistic potential will probably be smaller. Although, this is a rough approximation only, it is clear that emissions from deforestation and degradation will still play a major role in the Brazilian emission profile in the future.

With regard to agriculture, a comprehensive analysis at a country-level is - maybe even more than for forestry – restricted by the availability of data and projections on emissions and removals as well as mitigation potentials from agriculture.[22] A thorough analysis is further complicated by the fact that different studies include different mitigation activities and options under the term agriculture. Deriving a rough estimate based on the regional data provided in chapter 3.1 using the simple assumption that 50%[23] of the South American agricultural

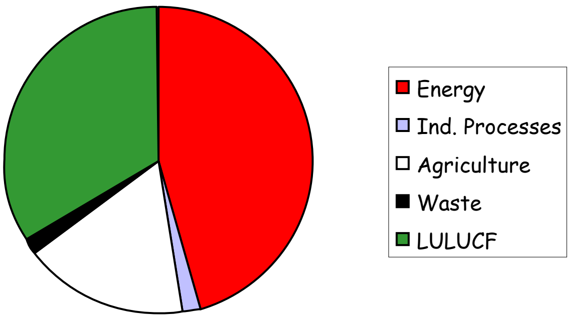
[22] Lal et al. (2006) provides relatively detailed information on carbon sequestration potentials in Latin-America on a biome-basis.

[23] Brazil´s total land area represents almost 50% of the total land area of South America.

mitigation potential of 266 Mt CO_2 eq. per year (excluding bio-energy, livestock and manure management) is located in Brazil, the magnitude of the Brazilian mitigation potential by 2020 in the agricultural area would be around 133 Mt CO_2 eq per year.[24]

Indonesia

The figure below illustrates the sectoral split of GHG emissions in 1994 as reported in Indonesia's First National Communication. Net emissions from LULUCF (164 Mt CO_2 eq.) make up around one third of Indonesia's total GHG emissions. However, the emissions from deforestation in the same year, without considering the uptake, amount to 559 Mt CO_2 eq. (order of total emission of the UK). This demonstrates the significant mitigation potential from reducing deforestation in Indonesia.



Sectoral split of GHG emissions for Indonesia (1994).
(Source: Indonesia's First National Communication)

It is estimated that about 17 percent of forest cover existing in Indonesia in 1985 has disappeared due to deforestation until 1997. Furthermore, deforestation rates are likely to have even further increased since 1997, driven by enormous forest fires of 1997-98 as well as the political and economic crisis during the late nineties (Achmaliadi et al. 2002). In the mid-term, net emission from LULUCF in Indonesia could decrease simply because the forest is depleting. If, as a simple assumption, deforestation would be as high in 2020 as in 1994 and 20% of the deforestation could be reduced, 110 Mt CO_2 per year could be avoided (more than the entire emissions of Austria). Considering that deforestation rates have probably increased, this can be considered to be a lower bound estimate. Also here, the realistic mitigation potential taking into account barriers will considerably decrease the estimate.

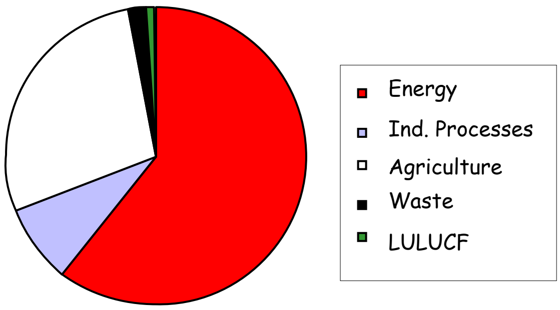
With the estimated 650 Mt CO_2 eq. yr^{-1} (excluding bioenergy, livestock and manure management), South East Asia has by far the biggest mitigation potential in the agricultural sector. Again, it is unknown which fraction of this can be attributed to Indonesia alone. Therefore, we use a simple assumption to generate an estimate of the Indonesian potential. If 40%[25] of the South East Asian agricultural potential is assumed to be located in Indonesia, 260 Mt CO_2 eq. yr^{-1} could be reduced through agriculture in this country (most of it through restoration of degraded land or cultivated organic soils).

[24] In comparison, the emissions and removals from soils in 1994 under the category LUCF as reported in the Initial National Communication amounts to 75.6 Mt Mt CO_2 eq.

[25] Around 40 % of the total land area of South East Asia belongs to Indonesia.

India

India's LULUCF emissions as reported in the National Communication represent less than 2% of overall GHG emissions, with total net emissions from LULUCF in the year 1994 of 14 Mt CO_2 eq. (gross emissions from deforestation reach a value of almost 38 Mt CO_2 eq.). From other studies it is known however, that the informal fuel wood sector (fire wood) is responsible for very large quantities of CO_2 emissions. These emissions however, do not occur in the National Inventory or Communication reports.



Sectoral split of GHG emissions for India (1994).

Using the same assumptions as for Indonesia, the mitigation potential for forestry in India would be around 7.6 Mt CO_2 eq. in 2020. It is likely that the LULUCF sector continues to represent only a small fraction of total GHG emissions in this country.

Considering the agriculture mitigation potential of South Asia (157.8 Mt CO_2 eq. per year) and assuming that 70 % of it is located in India[26], we estimate that around (by 2020) 110.5 Mt CO_2 eq. per year could be reduced through agriculture in India.[27]

China

According to China's National Communication, the Chinese LULUCF sector removed around 407 Mt CO_2 eq. from the atmosphere in 1994 and thus represented a net sink which offsets around 11% of total GHG emissions of the country. Due to a rigorous afforestation programme, China was able to increase its forest cover by around 25 percent in the period from 1990 to 2005 (FAO 2005) (see also figure 4a in chapter 3).

The estimate for the mitigation potential in the agricultural sector for East Asia is 233 Mt CO_2 eq. per year. Using the assumption that around 80% of the agricultural potential of East Asia[28] can be found in China, we get an estimate of 186.4 Mt CO_2 eq. per year (by 2020). Again, the consideration of barriers will decrease this estimate substantially.

26 India represents around 70% of the total land area of South Asia.
27 India reports emissions of 19.6 Mt CO_2 eq. from soils in the year 1994.
28 Based on the percentage of China´s land area of the total land area of East Asia.

Concluding

Adding up what is reported in this appendix is not appropriate: the data basis and the assumptions are simply too different. The need however, to start producing some estimates of what AFOLU can contribute realistically in a post-2012 era is urgent. But as always, things may not be as simple as we would like them to be. Geo-political and macro-economic developments will surely continue to affect the AFOLU sector, for instance, oil prices of 70 USD a barrel, also in relation to the international demand for energy crops, may have serious ramification for the agricultural sector and its associated emissions. The complexities however, should not prohibit serious consideration of what individual countries can possibly contribute in the near future (towards 2020 or 2030 at the most) in the AFOLU sector.